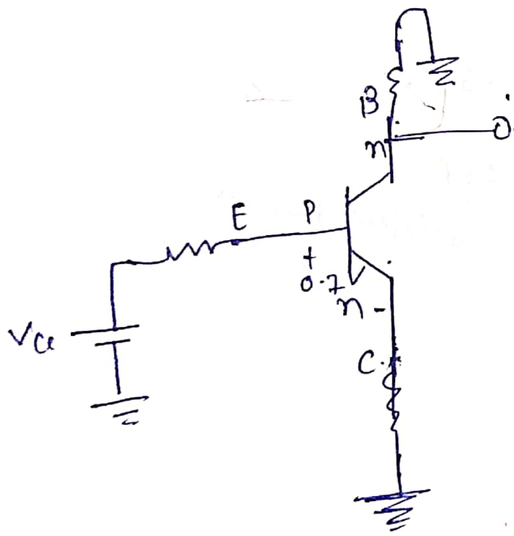
* Websites for RF & Antenna Eng. 1|08|2019

1. amurirelen.com (Applied elwave)
2. rfdesign.com
3. highfrequencyelectronic.com
4. mwjournal.com
5. mwrf.com
6. rfsworld.com
7. mrtmag.com
8. mwee.com
9. mobilehandsetdesignline.com
10. antennaonline.com
11. rfcafe.com

FCC (federal communication community.)

⇓ classify the diffn freqn.

↓ independent government agency (U.S.A) responsible for regulating the radio, t.v & phone industry. (wire, sattelite, cable)



→ ELF (Exterem low freqn)

(30Hz - 300 Hz) ⇒ Power transmission 50Hz, 220 V

⇓ velocity 3×10^8 so interms of 3

→ VF (300Hz - 3000 Hz) → voice freqn.

→ VLF (very low freqn) (3KHz - 30KHz)

⇓ used for Army, nevy, Submarin → underwat comm., millatry.

→ LF (30KHz - 300KHz) (large freqn)

⇓

→ Marin comm. → on the surface of water

→ Aeronotical comm.

→ MF (300KHz - 3MHz)(Medium freq^n.)

→ HF (3MHz - 30MHz) (High freq^n.)
⇓
Short wave.

→ VHF (30 - 300 MHz.) (very High freq^n.) →
⇓
FM - (88-108) MHz
~~at high~~ freq^n less ~~amo~~ ~~power~~ g.
2-13. (54MHz - 216MHz)

→ UHF (300 MHz - 3GHz.)
⇓ (14-81) → tv
Most of the application from this band
blutooth, own µwave, RFID Tage, wifi, GSM,
(2.4GH) (2.4G) (2.4G)
variouse industrial, Medical app;
(ISM)
→ Missiles, aircraft, cricket wicket radar
⇓
→ continuous navigation from ground station
→ airport scan
→ ~~air~~ aircraft to aircraft com.
Homework → µwave disinfection system (for gloves) ~~in~~ Medical application
→ for troubleshooting
→ for (friend of foe)

Homework → clear images (RF application.)
→ freq^n allodoment to company

Homework — At high freq^n can not generate large amount of power?

→ Now ISM?

→ Antennas in aircraft?
→ RF spa → High freq^n
→ cancer treatment
RF ⇒ uni antenna that radiates uniformly in all the direction.

→ Antenna in south - east direction.

→ $\boxed{\text{Whether prediction}}$

→ 2/08/2017

abi aircraft fly in Troposphere upto $\boxed{10\ \text{Km}}$

— Gangan yan/chandrya laucher

→ EHF (.30GHz - 300GHz) (Extrem high freq^n)

⇓

Most of defense system. (35 & 94GHz)

→ week - strong + Modulation

Bands.

L → 1 - 2 GHz.

S → 2 - 4

C → 4 - 8

X. → 8 - 12

Ku → 12 - 18

K → 18 - 27

Ka/Q → 27 - 40.

Today's TV Antenna ⇐ Ku

E/O - 60 - 90 GHz

W - 94 GHz

Tera $T = 10^{12}$ → Infrared (0.35THz - 300THz)

10^{15} : Penta

Penta $P = 10^{15}$ → Visible. (0.3PHz - 3PHz)

$E = 10^{18}$ → UV (.3PHz - 30PHz)

⇓ Exa → X-ray (30PHz - 300PHz)

⇓

0.3EHz

→ γ-ray (.0.3EHz - 3EHz)

→ Cosmic ray (3EHz - 30EHz)

MOSFET

High electron Mobility Transistor

⇓

Home HEMT
HBT } ⇒ Transistor very costly

⇓

Hyper Junction Bipolar Transistor

⇓

Junction not break down at high freq^n.

radio proximity fuse

⇓

closer

↓

for Targeting (heat the target)

⇓

need to Make optimum distance from Target

$d \simeq \lambda$ $\frac{P}{n}$ $I\ d \ll d$

600 m/s → Missile speed

?

→ aircraft speed

$$Bel = \frac{P_2}{P_1} = 100,\ 1000$$

$$dB = 10\log\left(\frac{P_2}{P_1}\right) \Rightarrow \text{task become easy.}$$

$dB = 10\log\left(\frac{P_2}{P_1}\right) = 10\log\left(\frac{V_2^2/R}{V_1^2/R}\right)$

loss & gain
↓
Power in dB

$$\boxed{dB = 20\log\left(\frac{V_2}{V_1}\right) = 20\log\left(\frac{I_2}{I_1}\right)}$$

dBm, dBW, dBmV, dBV, dBmA, dBA

$$\boxed{dBm = 10\log\left(\frac{P_2}{1mW}\right)}$$

Comparision of two Power loss & gain ⇒ dB is used.

signal / Noise → dBm

SNR → dB
signal to Noise Ratio

Noise distortion interference

Q

$\frac{P_2}{P_1}$	dB
2 : 1	→ 3
4 : 1	→ 6.
10 : 1	⇒ 10
100 : 1	→ 20
1 : 2	→ -3
1 : 4	→ -6
1 : 10	→ -10
1 : 100	→ -20

$\log_{10} 2 = 0.3$

$10\log_{10} 2 = 3$

$\frac{I_2}{I_1}$ or $\frac{V_2}{V_1}$	dB
2 : 1	→ 6
4 : 1	→ 12
10 : 1	→ 20
100 : 1	→ 40
1 : 2	→ -6
1 : 4	→ -12
1 : 10	→ -20
1 : 100	→ -40

Scanned by CamScanner

dBm, dBW, dBmV, dBV, dBmA, dBA

$$dBm = 10\log\frac{P_2}{1mW}$$

$$dBW = 10\log\frac{P_2}{1W}$$

$$dBmV = 20\log\frac{V_2}{1mV}$$

$$dBV = 20\log\frac{V_2}{1V}$$

$0 = 10 \log P_2$

10^{0}

0dBm = 1mW

10 dBm = 100mW

30 dBm = 1000mW = 1W

60 dBm = 1KW = 10^6 mW

-10 dBm = 0.1mW

-20 dBm = 0.01mW

-30 dB = 1μW

$-10 = 10\log\frac{P_2}{.01mW}$

-1 0.1 mW = P2

$1W = 10\log\frac{P_2 W}{10}$

1W = 1000mW

1mW = 10^{-3} W

0 dBW = 1W

= 1000mW

$$\boxed{\begin{aligned} 0\text{ dBW} &= 30\text{ dBm} \\ 0\text{ dBm} &= -30\text{ dBW} \end{aligned}}$$

0 dB = near total silence

15 dB = whisper

60 dB = normal conversion

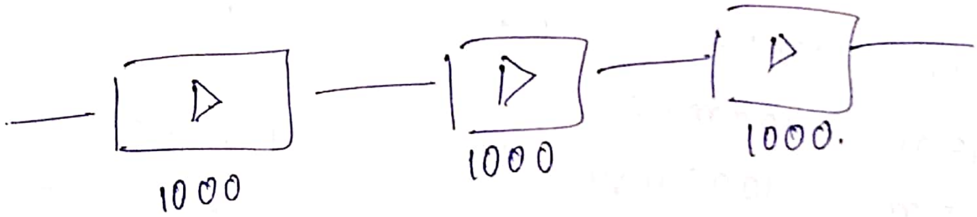
90 dB = harm horn..

110 dB = car horn

jet engine |

120 dB = jet engine / rock concert.

140 dB = fire cracker



$= 10^9$

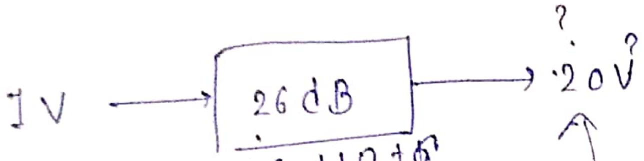
$= 90$ dB. =)

$$10 \log \frac{P_2}{P_1} = 26$$

$$20 \log \frac{V_2}{V_1} = 26.$$

$$\log_{10} \frac{V_2}{V_1} = \frac{26}{20}$$

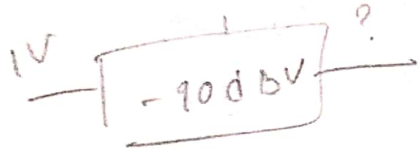
V_2



+10 +10 +6
20dB + 6 dB
×10 ×2
= 20

$-60 = 20\log\frac{V_2}{1V}$

$\frac{-60}{20} = \log_{10}\frac{V_2}{1}$



-60 dB ⇒ V_f = 1mV

$-1000 = \log \frac{V_2}{}$

10^{-3}

0.001V

-90dB ⇒ V_f : 1μV

⇓

more sensitive

as low input we get more o/p

common.

$\frac{-90}{20}$

$-9/2$

$10^{-4.5}$

2 year experi (after M.Tech) job.

16 dB

10dB = ×3.33

6dB ×2

6.66

16 dB

20dB -12dB + 20 dB -12

×10 ÷4 ×10 ÷4

~~10 ×10 ×10 ×10~~

10,000 → 20 +20 +20 +20

? = 52dB voltage gain

100×4.

40X.

1' 400

power 400? → __ dB

4 ×100 ⇒ 20 + 6

= 26

2×2 ×10×10 =

$\frac{13 dBm}{20} = \log\frac{V_2}{1mV}$

V_2 :

Scanned by CamScanner

13 dB = 10 + 3

10 mV × 2. = 20 mV.

0dBm → $\boxed{20dB}$ → 20dBm

$\frac{1}{mV} \times \frac{1}{1}$ = mV

ration in dB

(20 + 3.) dB ~~bd~~

100 × 2 = 200mW.

~~13 dB~~

26 dBm

20 + 6

100 ×.

17 dBm

20 dBm − 3 dBm

$\frac{100\,mW}{2}$ = 50mW

− ~~1~~d1

−1dB = 21 %. of Power. loss.

$10 \log_{10}(0.74)$ = −0.3 × 10

= −3 dB

°C °F K (no degree)

1) Thermal Noise (Johnsnon Noise):

$$P_n = KTB \rightarrow \text{Bandwidth}$$

Boltzman's constant $K = 1.38 \times 10^{-23}$ J/K

⇒ White Noise ⇒

2) Shot noise ⇒ shot key noise.

I_n = RMS current noise.

$$= \sqrt{2qI_{dc}B}$$

$q = 1.6 \times 10^{-19}$ C

3) Partition noise
⇓
when single current

4) ~~Transist~~ time noise
Transint
(High freq^n noise)

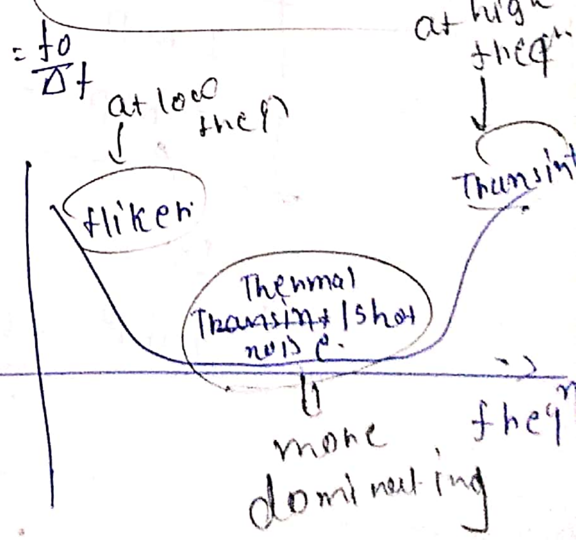
5) Fliker noise
(Low freq^n Noise) (tublight)

reflection
diffraction
~~reflection~~.
⇓
Fomrell interference
interference.

Gaganyan / Chandrayan
⇓
engine

active ⇒ need Power / mobile
passive ⇒ no need of Power
Green electronic

$Q = \frac{f_0}{\Delta f}$



6) Popcorn noise
(High freq^n noise

High freq^n → ~~less~~ reduce size Antenna

→ Antenna Radiation uniform in all direction.

* distortion

simplex sy.
half. duplex sy
full duplex
~~Full~~ F/F duplex. ⇓
full full
. just single channel for Receiving & transmitting.
(ex. Internet)

⇒ Hartley theorem
⇒ Shannon "

$$J = B\log_2\left(1+\frac{S}{N}\right) \quad \text{SINAD} \quad \frac{S}{I+N+D}$$

Ampr is. not given loss but give gain.

$$\boxed{NP(\text{Neper}) = \log_e\left(\frac{V_2}{V_1}\right)^{-1}}$$

loss $= -\ln\left(\frac{V_2}{V_1}\right)$

$$\boxed{1\,NP = 10\log e^2}$$

$$1\,NP = 8.686\ dB$$

loss

$$\boxed{1\,dB = 0.115\,Np}$$

Microwave dryer
⇓
oven.
⇓ works
2.4 GHz

. Apollo → 11
Mission

Scanned by CamScanner

liquids use in comm.

→ Fecls

→ Iso-propile alchohol.

Pehimiter

Protection.

badan

$d, \epsilon, T, B, K \xrightarrow{\text{into}} dB.$

10log ( )

everywhere to conver in dB $10\log_{10}(\ )$

⇓

accept V & I

Thermal shock.

⇓

sudden change in environment

$N_0 = P_n = KTB$

$K = 1.38 \times 10^{-23}$ J/K

$T = 27°C = 290K$

$B = ?$

$N_0/dBm = 10\log(KTB)$

$= 10\log(KT) + 10\log B$

$= 10\log\left(\frac{1.38 \times 10^{-23} \times 290}{0.001}\right) + 10\log_{10} B$

MIMP

$$\boxed{N_0 = -174\ dBm/Hz + 10\log B}$$

$\cancel{\times 10}0$

Noise ⇒ amplified like signal
noise + inherent Noise.

$\times 100$ ⇒ gain.

$N_i = 1\mu V.1 \times 100$ $\qquad$ 10×10 $\qquad$ 20×5

$= 1\mu V$

a) $S = 10\mu \times 100 = 1000\mu V.$ ⇒ 1×100

$N = 1 \times 100 = 100 + 30 = 130\,\mu V.$

$\frac{S}{N} = \frac{1000}{30} = 17.72\,dB$

b). $S = 10\,\mu V \times 10 = 100\,\mu V.$ ⇒ 10×10

$= 100\,\mu V \times 1V = 1000.$

⇒ $18.84\,dB$

c) 20×5

$S = 10 \times 20 = 200$

$N = (1\,\mu V \times 20) + 5 = 25$

$(25\,\mu V \times 5) + 1 = 126$

$\frac{S}{N} = 20\log\left(\frac{1000}{126}\right) = 17.99\,dB$

d) 5 x 20.

$S = \cdot N = (1\mu V \times 5) + 1 = 6\mu V$

$= (6\mu V \times 20) + 5 = 125$

$10 \log\left(\frac{1000}{125}\right) \therefore 18.06\,dB$

$\frac{S}{N}\uparrow \Rightarrow$ good design for comm. engineer.

→ Power in ~~Ma~~ mW

$N_0 = KT_0B$

$-174\,\frac{dBm}{Hz} + 10\log B$

→ Antenna is only ~~sin~~ device with single port.
others are two / three port.

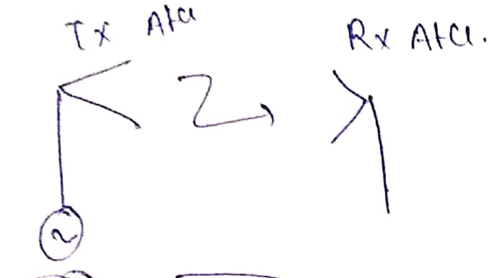
→ Antenna Measures interms of equivalent noise temp.

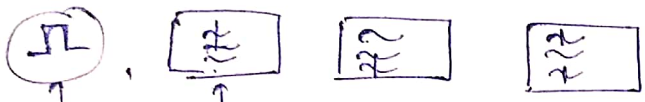
→ $N_0 = KT_eB$

Spectrum Analyser, Network Analyser.

→ $T_e = \frac{N_0}{KB}$

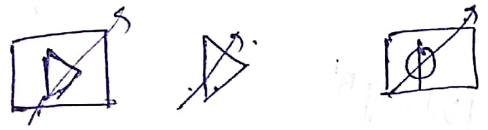
$$\boxed{T_e = \frac{N_0}{KGB}}$$



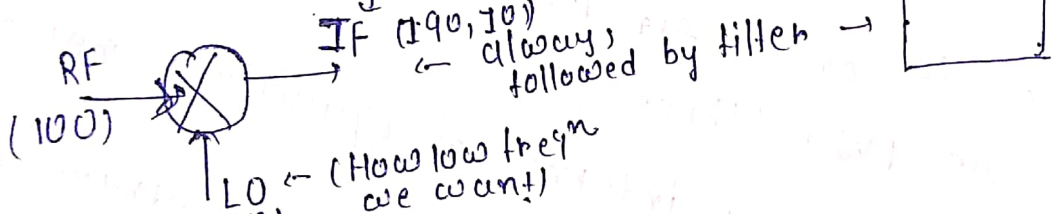


Pulse source. LPF. HPF BPF

Loss ↓



Variable Ampr



always get IF freqn

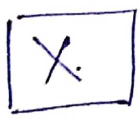
← always followed by filter →

LO ← (How low freqn we want)

(Mixing - Multiplying freqn)

⇓ (Mixer is 3 port device)

$\boxed{\text{Mixer, Modulator, Multiplier}}$ → 3 M



Modulator

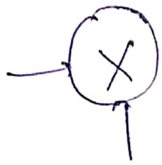
→ diffn betn carrier & Message is very high (freqn)

* Variouse Receiver

1) Homodyne Receiver
⇓
two same freq^n Mixing (dyne)
(HOMO)

$\Rightarrow$ RF $\cong$ LO

RF

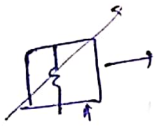


LO

2) Hetrodyne Receiver
⇓
diffrent freq

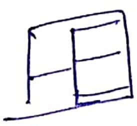
RF

LO



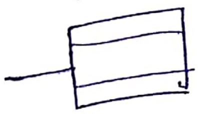
→ lossy (variable) resistor

Square-lossy



← Power splitter

1:2



3 dB power loss

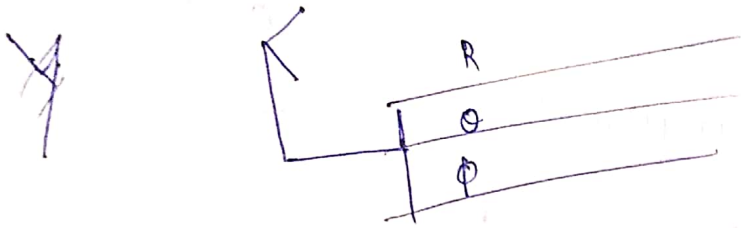
→ All devices are lossy ~~etc~~ except the Ampr

→ wifi
superhet
⇓
two/three
→ mor conversion.

→ Homodyne technology

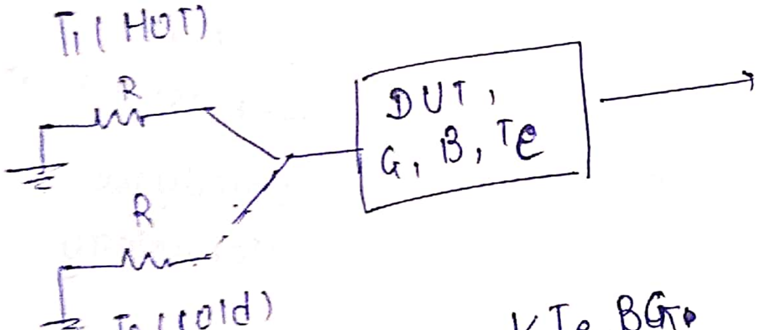
→ AGC
(Automatic gain control)
in phone.

→ channel change no change observed because of AGC



* Measure - T_e : Y-factor Method

$\boxed{\text{DUT, } G, B, T_e}$ ← device under Test
it could be Ampr,
filter, system etc.



N_1 ? → Measure of noise.

N_2 ?

$$N_1 = \underbrace{K T_{e1} B G}_{\text{i/p noise amplified by } G} + \underbrace{K T_e B G}_{\text{noise added by device internally}}$$

only change this inner Temp T_e

Output Noise contains two component always

a ~~amp^r anten~~ amp^r

$$Y = \frac{N_1}{N_2} = \frac{KBG(T_{e1} + T_e)}{KBG(T_{e2} + T_e)}$$

$$Y = \frac{T_{e1} + T_e}{T_{e2} + T_e} \geq 1$$

$$T_e = \frac{T_{e_1} - Y T_{e_2}}{Y-1}$$

→ System noise temp as low as possible.

room temp $T_{e_1} = 290K$

Liquid He = 4K → Te

diff^n is high bet^n Te_1 & Te_2

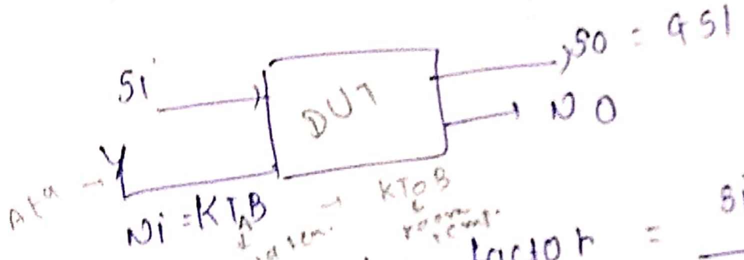
$Te_1 >> Te_2$ (much accuracy)

Liquid He = 4K

Lit N_2 = 77K

Room temp = 290K

Liquid Nytrogen = 77K

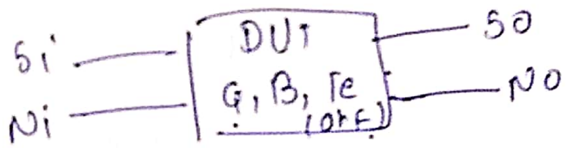


$$F = \text{Noise factor} = \frac{Si/Ni}{So/No}$$

$$F = \frac{SNRi}{SNRo} < 1 \Rightarrow \text{good system}$$

Noise factor → F

Relation bet^n F & Te



$So = G Si$

$Ni = KT_oB$

No = I/P noise amplified + Noise due to device internally amplified

$$= KT_oBG + KT_eBG$$

$$= KBG(T_o + T_e)$$

$$\boxed{No = GKB(T_o + T_e)}$$

But $F = \dfrac{S_i/N_i}{S_o/N_o}$

$$= \frac{S_i \times GKB(T_o + T_e)}{\cancel{G} S_i \times KT_oB}$$

$$\boxed{F = \frac{T_o + T_e}{T_o}}$$

$$F = 1 + \frac{T_e}{T_o} \geq 1$$

$$T_e = (F-1)T_o$$

→ For a perfect noiseless D.U.T,

$F = 1$

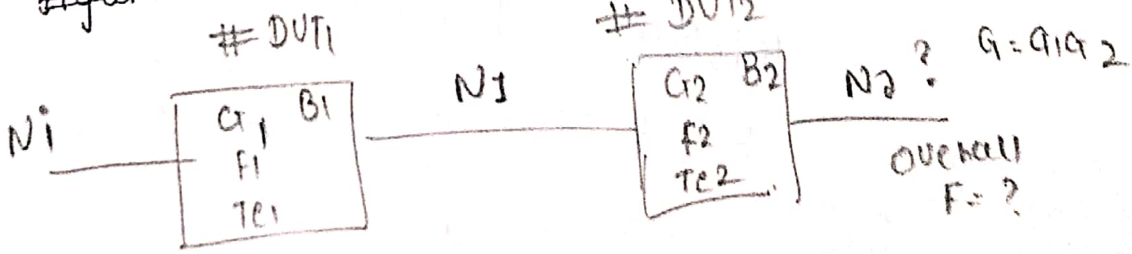
$T_e = 0K$

$NF|_{dB}$ = Noise fig = $10 \log F$

$NF = 10 \log_{10} 1 = 0\,dB$

(overall) factor → numerical value, no dB

⇒ Noise ~~figure~~ of cascaded system



$N_i = KT_oB$

$$N_1 = \underbrace{G_1 K T_o B}_{\text{i/p noise amplified}} + \underbrace{G_1 K T_{e1} B}_{\text{noise added due to internally amplified}}$$

$$N_O = G_2 N_1 + G_2 K T_{e2} B$$

$$= G_2 (G_1 K T_o B + G_1 K T_{e1} B) + G_2 K T_{e2} B$$

$$N_O = G_1 G_2 K B \left(T_o + T_{e1} + \frac{T_{e2}}{G_1} \right)$$

$$= G_1 G_2 K B (T_o + T_e)$$

$$T_e = T_{e1} + \frac{T_{e2}}{G_1}$$

$$T_e = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} + \frac{T_{e4}}{G_1 G_2 G_3}$$

We know,

$$T_e = (F-1) T_o$$

$$(F-1) T_o = (F_1 - 1) T_o + \left(\frac{F_2 - 1}{G_1} \right) T_o$$

$$F = F_1 + \frac{F_2 - 1}{G_1}$$

Overall noise factor → Friis formula.

$$F = F_1 + \frac{(F_2 - 1)}{G_1} + \frac{(F_3 - 1)}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \cdots$$

Maximum contribution from first system.

no contribution from 4th system.

→ overall noise figure.

$$NF|_{dB} = 10 \log(F)$$

$$\cancel{NF} \neq NF_1 + \cancel{N}\, \frac{F_2 - 1}{G_1} +$$

$$NF \neq NF_1 + NF_2 + \cdots$$

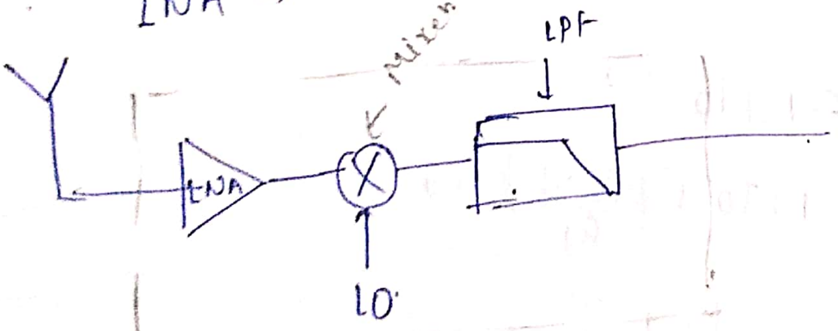
LNB ⇒ Low Noise Block.

LNA ⇒ Lower Noise Amp.

TU/V sky D th
More clearing
detect from
direct satellite

→ 3 GHz freq
used in
laptop

→ Mars mission
freq



RF frontend

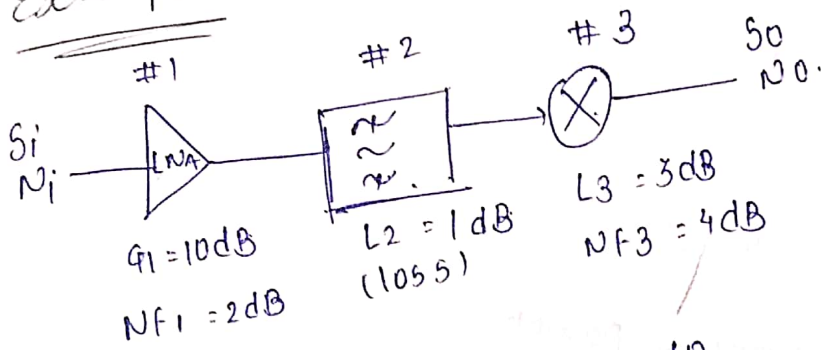
Example

Transceiver

* Analysis of RF / TRX

3.2 - 10 GHz
⇓
UWB
1km distance
small ping.

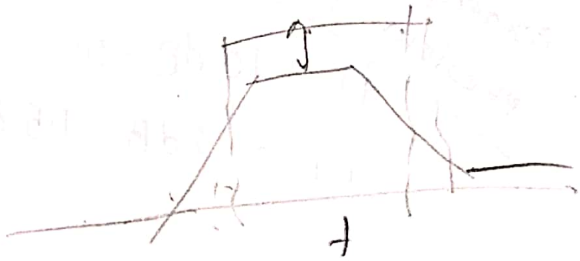
Example -1



saw tooth filter
⇓
Lossy but for
narrow band.

→ overall G = 10 - 1 - 3 = 6 dB

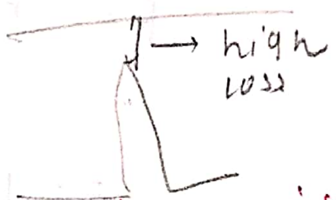
$$F = F_1 + \frac{(F_2 - 1)}{G_1} + \frac{(F_3 - 1)}{G_2 G_3}$$



$T_e = (F-1) T_0$

F.

high loss, low bandwidth



⇒ for lossy device / Passive
Noise figure (dB) = loss (dB)

⇒ for active device like ampr noise figure and loss is different.

$$T_e = (F-1)T_0$$

$$F = 1 + \frac{T_e}{T_0}$$

$$T_e = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} + \cdots$$

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots$$

⇓

overall ⇓
noise ~~figure~~ factor strong ⇒ Low noise power

example previous page soln

$G_1 = 10\,dB = 10$

$F_1 = 2\,dB = 1.58$

$G_2 = -1\,dB$ (loss) $= 0.79$

$F_2 = 1\,dB = 1.26$

$G_3 = -3\,dB = 0.5$

$F_3 = 4\,dB = 2.51$

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots$$

$$= 1.58 + \frac{1.26 - 1}{10} + \frac{2.51 - 1}{(10)(0.79)}$$

$NF = 10\log(F) = 10\log(1.8) = 2.55\,dB$