$$F = \frac{\text{available } S/N \text{ Ratio at I/P}}{\text{available } S/N \text{ Ratio at O/P}}$$

$$= \frac{P_{si}}{P_{ni}} \times \frac{P_{no}}{P_{so}} = \frac{P_{si}}{K T_0 B_n} \times \frac{P_{no}}{G P_{si}} = \frac{P_{no}}{G K T_0 B_n}$$

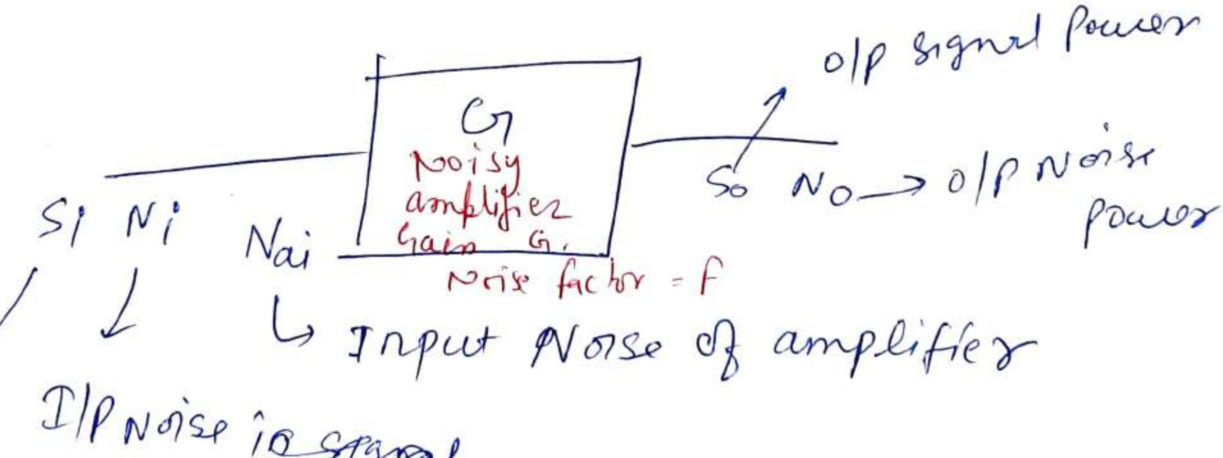
P_{si} & P_{ni} → signal & noise power at I/P

P_{so} & P_{no} → O/P

$$P_{no} = F G K T_0 B_n$$

$$F_{dB} = 10 \log F$$

Proof: Consider an Amplifier Gain G



$$S_o = G S_i$$

$$N_o = G N_i + G N_{ai}$$

$$F = \frac{(S/N)_{I/P}}{(S/N)_{O/P}}$$

$$= \frac{S_i / N_i}{G S_i / G(N_i + N_{ai})}$$

$$= \frac{N_i + N_{ai}}{N_i}$$

$$F = 1 + \frac{N_{ai}}{N_i}$$

$$\Rightarrow \boxed{N_{ai} = (F-1) N_i}$$

~~Multiply both side by~~ KB

$N_{ai} \rightarrow$ Noise at I/P of Ampulifier

$\because P_n = KTB$

$$\boxed{K T_e B = (F-1) K T_o B}$$

$$\Rightarrow \boxed{T_e = (F-1) T_o}$$

$T_e \rightarrow$ equivalent Temp of Amplifier

$T_o \rightarrow$ Reference Temp of source
or
Ambient Temp

O/P Noise $N_o = G N_i + G N_{ai}$

$$= G K T_g B + G (F-1) T_o K B$$

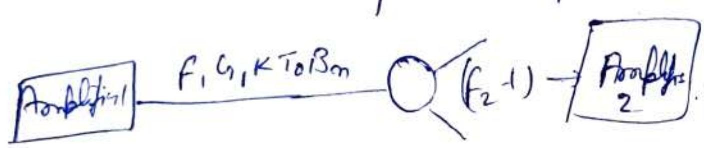
$$K T_e B = G K T_g B + G (F-1) T_o K B$$

$$\Rightarrow \boxed{T_e = G T_g + G (F-1) T_o}$$

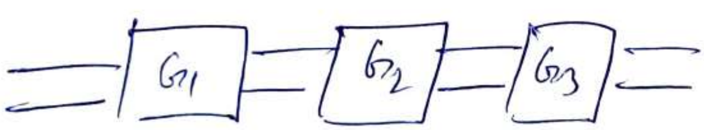
Composite Noise Figure & Composite Noise Temp

OR

NOISE FACTOR of Amplifier in cascade



(FRISS FORMULA)



$P_{no} = F G_1 G_2 G_3 K T_o B_n$

$$\boxed{F_e = F_1 + \frac{F_2-1}{G_1} + \frac{F_3-1}{G_1 G_2} + \cdots}$$ (Imp)

Subtracting 1 both side

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

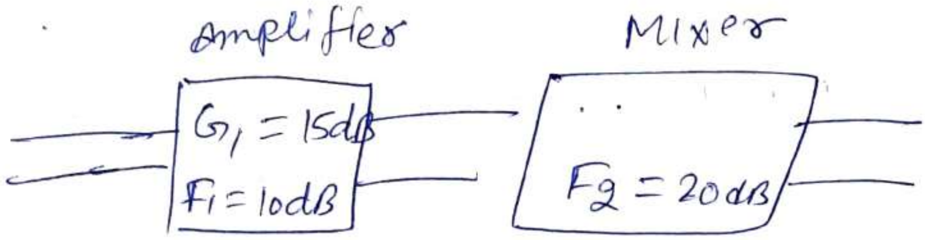
$\Rightarrow$ Multiply by KTB both side

$$\Rightarrow K T_e B (F_e-1) = KTB(F_1-1) + KTB\frac{(F_2-1)}{G_1} + \cdots$$

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

(Imp)

(Ques)



Find overall Noise figure

Ans)

$F_2 = 20dB \quad F_1 = 10dB \quad G_1 = 15dB$

$\because \boxed{dB = 10 \log F}$

$20 = 10 \log F_2 \Rightarrow F_2 = 10^2 = 100$

$10dB = 10 \log F_1 \Rightarrow F_1 = 10^1 = 10$

$15dB = 10 \log G_1 = G_1 = 10^{1.5} = 31.62$

$$F = F_1 + \frac{F_2 - 1}{G_1} = 10 + \frac{100-1}{31.62} = 13.13$$

$F_{dB} = 10 \log_{10} (13.13)$

$\boxed{F_{dB} = 11.18 dB}$

Ques: each stage has gain of 10 dB & Noise figure of 10 dB Calculate overall Noise figure of two Stage Cascaded Amplifier.

Ans)

$$G = 10 \log 10$$

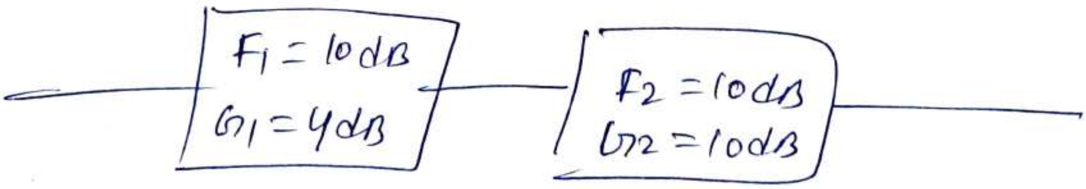
$$\boxed{G = 10}$$

$$\boxed{F = 10}$$

$$F = F_1 + \frac{F_2 - 1}{G_1} = 10 + \frac{10-1}{10} = 10.9$$

$$F_{dB} = 10 \log 10.9 = 10.37\ dB$$

Ques



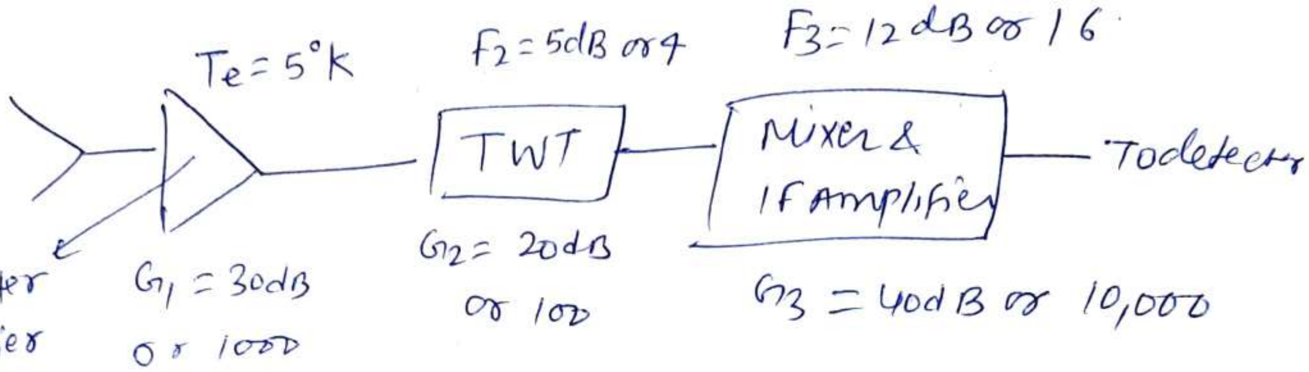
Ans)

$$F = F_1 + \frac{F_2 - 1}{G_1} = 10 + \frac{10-1}{2.5} = 13.6$$

$$F_{dB} = 10 \log(13.6) = 1039\ dB$$

Q4) Figure shows a typical Microwave Receiver, used in Satellite Communication

Calculate (i) overall Noise figure of Receiver (ii) overall equivalent temp. of the Receiver. Assume the ambient temp $T = 17°C$



Ans) First we find Noise figure of master Amplifier

$$F_1 = 1 + \frac{T_{e1}}{T_0}$$

$$= 1 + \frac{5}{290} \qquad \because T_0 = 17°C = 290°K$$

$$= 1.017$$

Now

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} = 1.017 + \frac{4-1}{1000} + \frac{16-1}{1000 \times 100}$$

$$= 1.02$$

$$F_{dB} = 10 \log (1.02) = 0.8766 \, dB$$

Now we will find overall Noise temp.

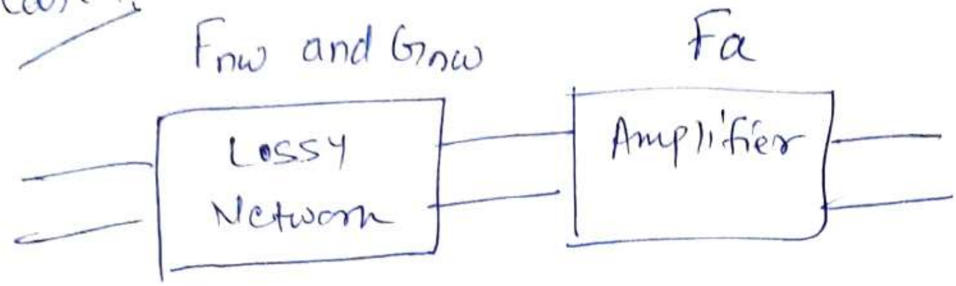
$$T_e = (F - 1) T_0 = (1.02 - 1) 290$$

$$T_e = 5.8°K$$

Type Two Numerical Problem

Noise Factor of a Lossy Network

Case 1:



$$F = F_{nw} + \frac{F_a - 1}{G_{nw}}$$

F_{nw} → Noise factor of lossy Network

G_{nw} = Gain of Lossy N/w

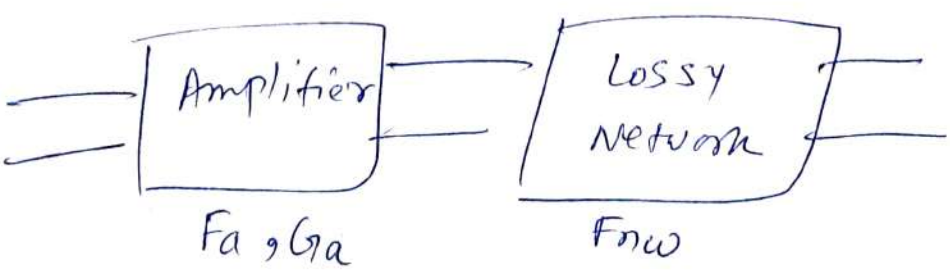
F_a → Noise factor of Amplifier

$$\boxed{G_{nw} = \frac{1}{L}} \quad \& \quad \boxed{F_{nw} = L}$$

so

$$\boxed{F = L + (F_a - 1)L}$$

Case 2



$$F = F_a + \frac{F_{nw} - 1}{G_a}$$

$\because$ $\boxed{F_{nw} = L}$ $\Rightarrow$ $\boxed{F = F_a + \frac{L-1}{G_a}}$ $\Rightarrow$ $\boxed{F = F_a}$

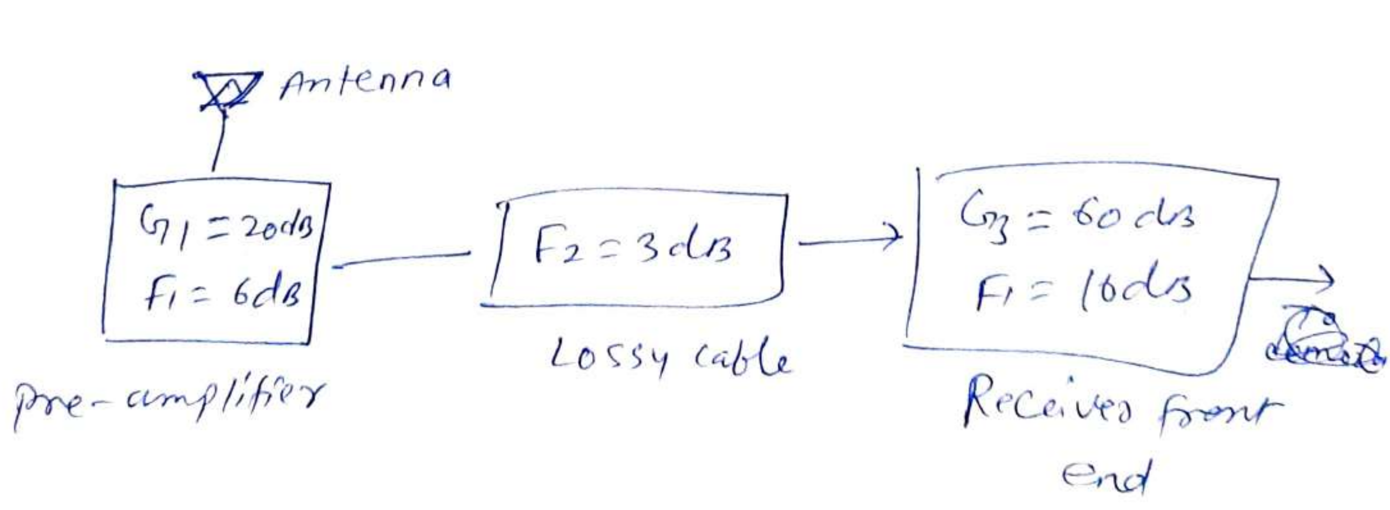
We can neglect $\frac{L-1}{G_a}$ as G_a is very large.

so $F = F_a$ [Memorise]

Ques) In TV Receiver, the antenna is often mounted on tall mast and a long loss-cable is used to connect the antenna to Receiver. To overcome the effect of lossy cable, a pre-amplifier is mounted on Antenna as shown in fig.

1) Overall Noise figure of system

II) Again find overall noise figure of system, if the gain of front-end is increased by 30dB (Assume $F = 16dB$ for front end)



Ans) $F_1 = 6dB$ $F_2 = L = 3dB$ $F_3 = 16dB$

Power Gain $G_1 = 20dB$ $G_3 = 60dB$

$F_1 = 6\,dB = 3.981$

$F_2 = L_2 = 3\,dB = 2$

$F_3 = 16\,dB = 39.81$

$G_1 = 100 \quad G_3 = 1 \times 10^6$

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

$F_2 = 2 + (39.81 - 1) \times 2 = 79.62$

~~$F = 3.981 + 79.62 = 4.772$~~

$F = 3.981 + \frac{79.62 - 1}{100} = 4.69$

$F_{dB} = 10 \log (4.69) = 6.71\,dB$

ii) If pre-amplifier is omitted and gain of front end is Increased to 80dB

$G_3 = 80\,dB \cdot \quad F_3 = 16\,dB$

Overall Noise Figure $= L + (F_3 - 1)L = 2 + (39.81 - 1) \times 2$
$= 79.62$

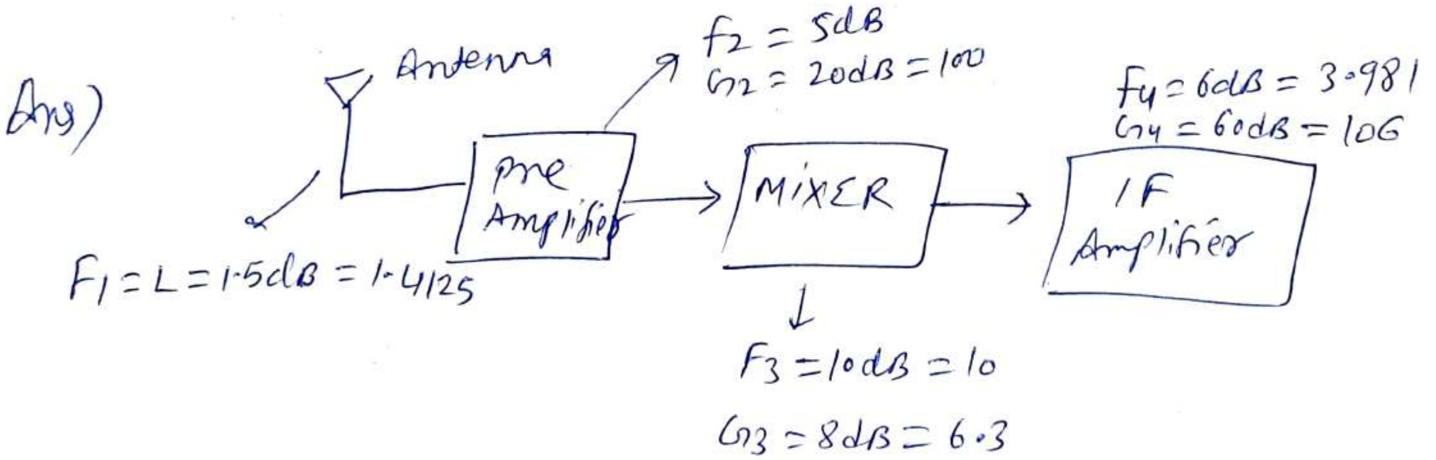
$F_{dB} = 10 \log 79.62$
$= 19.01\,dB$

Ques) Given a Receiver system consisting of a antenna with lead in cable having a loss factor of $L = 1.5\,dB = F_1$ & RF ~~am~~ pre-amplifier with Noise factor of $F_2 = 7\,dB$ and gain $20\,dB$ followed by mixer with noise factor $F_3 = 10\,dB$ & conversion gain of $8\,dB$ & finally an integrated circuit IF amplifier with noise factor of $F_4 = 6\,dB$ and gain of $60\,dB$

i) Calculate overall Noise figure & Noise Temp of system

ii) Calculate Noise figure and Noise Temp of system with pre-amplifier & cable Interchanged.

Ans)



∵ it is of type

So first calculate overall F' of Amplifier

$$F_a = F_2 + \frac{(F_3 - 1)}{G_2} + \frac{F_4 - 1}{G_2 G_3} = 5 + \frac{10-1}{100} + \frac{3.981 - 1}{100 \times 10^6} = 5.09$$

Now calculate Overall Noise figure.

$$F = L + (F_a - 1)L = 1.4125 + (5.09 - 1) \times 1.4125$$

$$= 7.1896$$

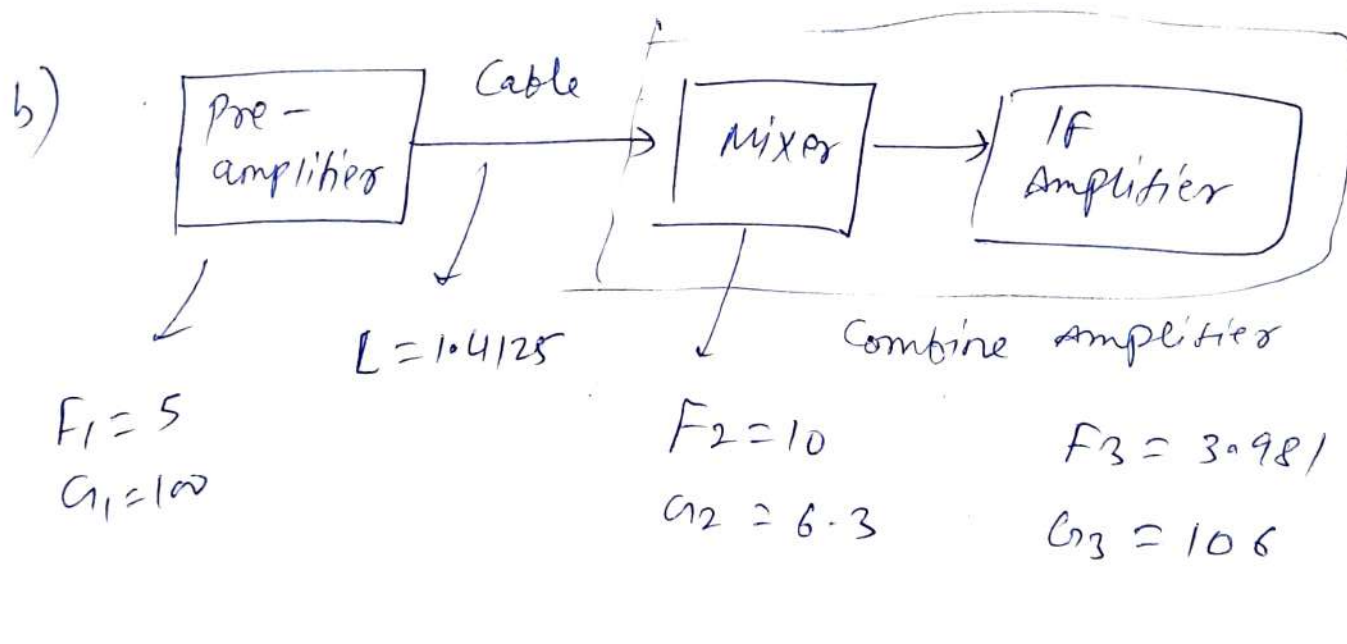
$$F_{dB} = 10 \log (7.18) = 8.57\ dB$$

iii) Noise Temp = $T_e = (F-1)\,T_0$

$$= (7.18 - 1) \times 290$$

$$= 1.795 \times 10^3\ °K$$

b)



$F_1 = 5$, $G_1 = 100$

$F_2 = 10$, $G_2 = 6.3$

$F_3 = 3.981$, $G_3 = 106$

$$F_a = F_2 + \frac{(F_3 - 1)}{G_2} = 10 + \frac{3.981 - 1}{6.3} = 10.873$$

$$F' = L + (F_a - 1)L = 15.36$$

Now $$F = F_1 + \frac{F' - 1}{G_1} = 5 + \frac{15.36 - 1}{100} = 5.14$$

Hence $F_{dB} = 10 \log (5.14) = 7.12 \, dB$

$$T_e = (F-1) T_0 = (5.14 - 1) \times 290$$

$$= 1204.54 \, ^\circ K$$