FACULTY OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

DEGREE PROGRAMME IN ELECTRONICS (MASTER'S)

Course Name: Radio Engineering 1
Homework #06

Name: Arafat Miah
Student No: 2512200
Supervisor: **Aarno Pärssinen &** Kimmo Rasilainen

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Arafat Miah
ID: 2512200.

Question:- Design a Portion of an RF receiver with Bandpass filter, Low noise Amplifier and mixer.

Filter: Insertion loss = -1.5 dB.
LNA: $G_1 = 12$dB, $NF = 2.5$dB.
Mixer M: $G = 5$dB, $NF = 8$dB.

Task (1) ⇒ In what order should these components be placed to achieve the lowest NF in the system.

⇒ First, we need to place the lowest noise figure and high gain, this will help us to reduce the overall system noise figure. Also that the noise contributions of subsequent stages are divided by the gain. Finally, the overall noise gets attenuated

Now, using the Friis Formula:-

Converting gain & NF to linear units:-

$G_F = 10^{-1.5/10} = 0.708$ $\quad F_{BF} = 10^{1.5/10} = 1.413.$

$G_A = 10^{12/10} = 15.849$ $\quad F_A = 10^{2.5/10} = 1.778$

$G_M = 10^{5/10} = 3.162$ $\quad F_M = 10^{8/10} = 6.3.$

We have three components, so we can cascod the in $(2^3 - 2) = 6$ ways.

The friis formula with G_1, G_2, G_3 and $f_1, f_2 \& f_3$ cascoded is.

$$F_{total} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}.$$

ORDER	F_{tot}'s	F_{total}	$10\log F$
F → A → M	$1.413 + \frac{1.778-1}{0.708} + \frac{6.3-1}{0.708 \times 15.849}$	2.084	4.748
F → M → A	$1.413 + \frac{6.3-1}{0.708} + \frac{1.778-1}{0.708 \times 3.162}$	0.246	0.659
A → F → M	$1.778 + \frac{1.4-1}{15.849} + \frac{6.3-1}{15.8 \times 0.708}$	2.277	3.57
A → M → F	$1.778 + \frac{6.3-1}{15.849} + \frac{1.413-1}{15.849 \times 3.162}$	2.12	3.264
M → F → A	$6.3 + \frac{1.413-1}{3.162} + \frac{1.778-1}{3.162 \times 0.708}$	6.778	8.31
M → A → F	$6.3 + \frac{1.778-1}{3.162} + \frac{1.413-1}{3.162 \times 15.849}$	6.55	8.165

Here, the connection which has the LNA then ~~with~~ the mixer and last the filter provides the minimum noise figure for the system.

Maximum Gain :-

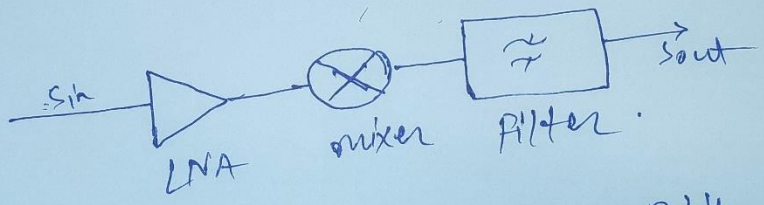
It is the product of all the stages gain and it does not depen on any kind of ordering :-

So,

$G_{total} = -1.5 + 12 + 15 = 15.5 dB.$

Conclusion :-

So, the least noise figure for the RF receiver chain is :-



The NF of this system is 3.264

Overall system gain is 15.5 dB.