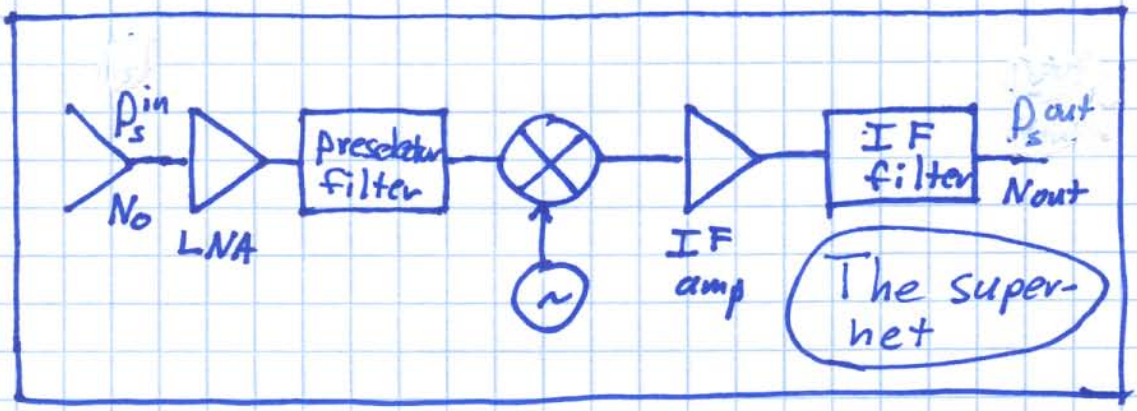
Rx Gain and Noise Figure

We can now determine the <u>overall</u> gain and noise figure for a super-het receiver!!

Consider the following example:



Let's look at each device:

1) <u>Antenna</u>

We <u>assume</u> the antenna temperature $T_A = T_0 = 290°K$, & $N_0 = -174\ dBm/Hz$

Also, the antenna couples in signal with power P_s.

2) Low Noise Amplifier (LNA)

Say this device has gain $G_1 = 10$ and noise figure $F_1 = 1.5$

3) Preselector Filter

Say this device has an insertion loss of 1dB.

$\therefore G_2 = -1dB = 0.8$

and $F_2 = 1dB = 1.26$

4) Mixer

Say this device has a conversion loss of 6dB.

$\therefore G_3 = -6dB = 0.25$

and $F_3 = 6dB = 4$

5) IF Amp

Say this device has gain of

30 dB and a noise figure of 6 dB

$\therefore$ $G_4 = 30dB = 1000$

$F_4 = 6dB = 4$

6) IF Filter

Say this device has an insertion Loss of 2dB

$\therefore$ $G_5 = -2\,dB = 0.63$

$F_5 = 2\,dB = 1.58$

The gain of the receiver is $\therefore$

$$G = G_1 G_2 G_3 G_4 G_5$$
$$= (10)(0.8)(0.25)(1000)(0.63)$$
$$= 1260 = 31\,dB$$

The noise figure of this Rx is ∞

$$F = F_1 + \frac{(F_2-1)}{G_1} + \frac{(F_3-1)}{G_1 G_2} + \frac{(F_4-1)}{G_1 G_2 G_3} + \frac{(F_5-1)}{G_1 G_2 G_3 G_4}$$

$$= 1.5 + \frac{0.26}{10} + \frac{3}{10(0.6)} + \frac{3}{10(0.8)(0.25)} + \frac{0.50}{10(0.6)(0.25)(1000)}$$

$$= 1.5 + 0.026 + 0.375 + 0.094 + 3\times10^{-4}$$

$$= 2.0$$

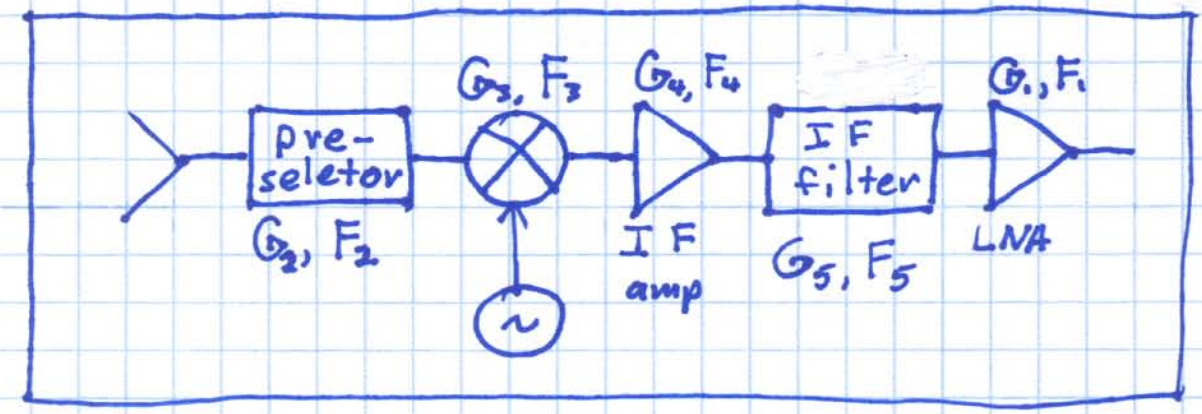
∞ The noise at the output of the IF filter is:

$$P_n^{out} = F G k T_o B$$

$$= (2.0)(1260)\, k T_o B$$

$$= \underline{10^{-17} B \text{ Watts}}$$

Let's see what happens if we move the LNA:



$$\therefore G = G_2 G_3 G_4 G_5 G_1 = 1260 = 31\,dB$$

As before!!

But, noise figure F is:

$$F = F_2 + \frac{(F_3-1)}{G_2} + \frac{(F_4-1)}{G_2 G_3} + \frac{(F_5-1)}{G_2 G_3 G_4} + \frac{(F_1-1)}{G_2 G_3 G_4 G_5}$$

$$= 1.26 + \frac{3}{0.8} + \frac{3}{0.8(0.25)} + \frac{0.58}{0.8(0.25)10^3} + \frac{0.5}{0.8(0.25)10^3 0.63}$$

$$= 1.26 + 3.75 + 15 + 0.003 + 0.004$$

$$= \underline{\underline{20 = 13\,dB}}$$

Much bigger than before!!!

$$\therefore P_n^{out} = F G K T_o B$$

$$= (20)(1260) K T_o B$$

$$= \underline{10^{-16} B \text{ Watts}}$$

10 X more noise than before!!

This example shows how important the LNA is for low-noise receiver design!