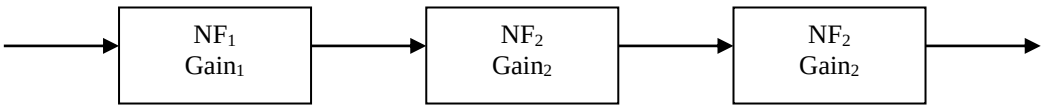
S-Parameters and Noise Figure

Take the following block diagram,



Looking at the Gains only, we would generally say that the total gain of this cascaded system is $Gain_1+Gain_2+Gain_3$.

The actual result in practice will be slightly different unless the individual stages as well as the cascaded system were all measured in a conjugate match situation.

Therefore for $Gain_{Tot}=Gain_1+Gain_2+Gain_3$ (or $Gain_1Gain_2Gain_3$ in linear terms) to be true, we must use available gain (gain with input and output conjugately matched).

Let's now look at the cascaded noise figure equation,

$$NF_{Tot} = NF_1 + \frac{NF_2 - 1}{Gain_1} + \frac{NF_3 - 1}{Gain_1 Gain_2} + ...$$

Here we have the same situation, for the equation to work, the available gains must be used.

Further to this, for the equation to work, the corresponding noise figure at the available gain must be used for each stage.

Using S-Parameters only allows the calculation of available gain. Using this on its own in any equation for removing the second stage effects of a noise figure measurement system is therefore likely to introduce more errors than it will remove.

For S-Parameters to be of any benefit, they must be used along-side the noise parameters of a device. Measuring the noise parameters of a device involves the use of a number of different impedance's or ideally a tuner unit.

Where the noise parameters are not available the best that can be achieved is to use the gain and corresponding noise figure at the same impedance, normally 50 ohms.