Application Note
Method of Broadband Noise Source Calibration

Introduction

The "Y-factor" method of measuring a mixer or receiver noise figure involves measuring the system noise power output when the input is terminated 1) with a " hot " termination of known temperature or 2) with a "cold" termination of known temperature. Then, the true mixer noise figure is calculated from this data as explained below. The noise power output of the mixer when terminated in "hot" and "cold" loads is P_{hot} and P_{cold} respectively. The "Y-factor" is computed from this information as follows:

$$dY = (P_{hot})/(P_{cold}) = (T_{hot}+T_{receiver})/(T_{cold}+T_{receiver}) \qquad (1)$$

T_{hot} and T_{cold} are the temperatures of the "hot" and "cold" load respectively.
Noise temperature $T_{receiver}$ and noise figure **NF** of receiver:

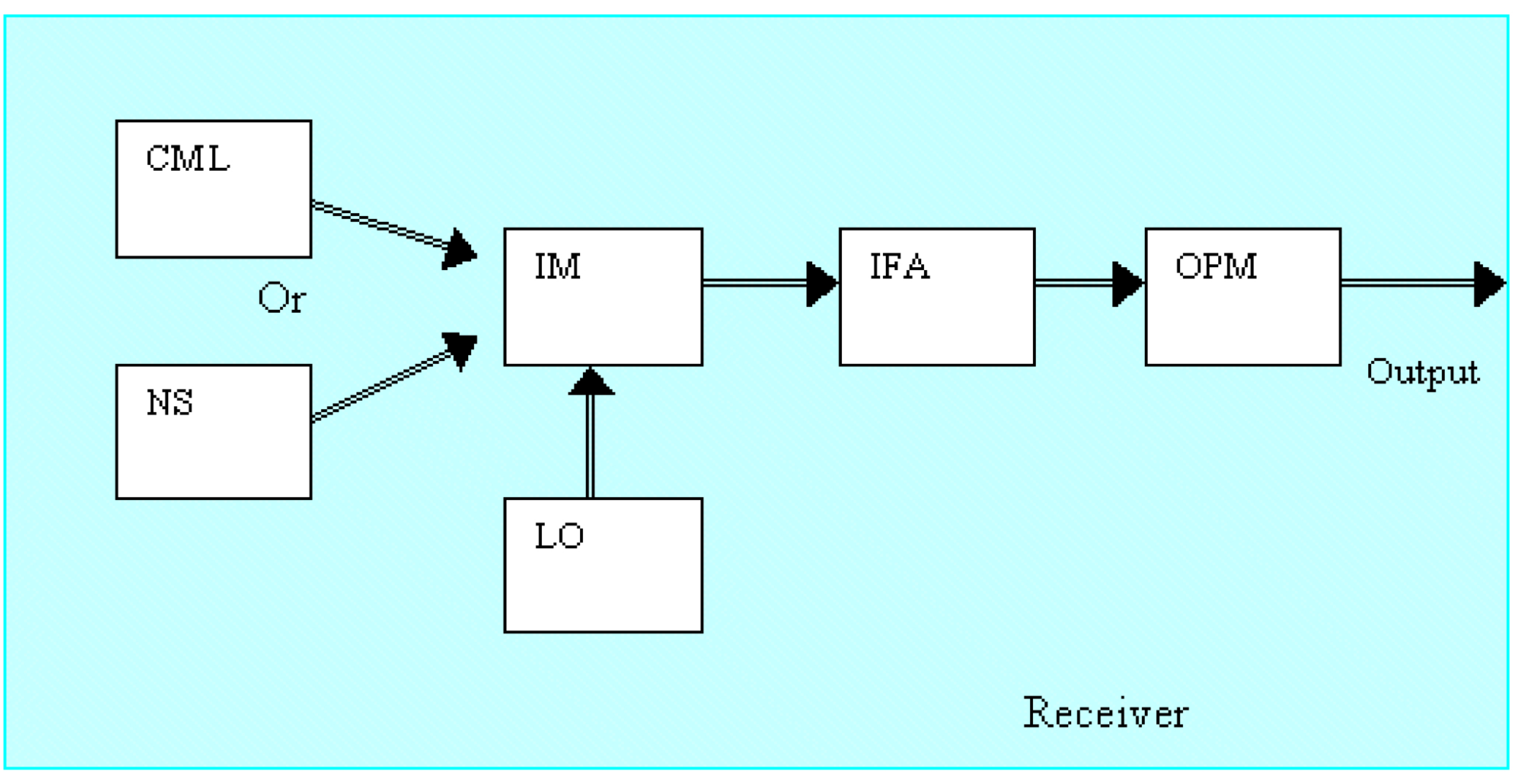
$$T_{receiver} = (T_{hot}-dY*T_{cold})/(dY-1) \qquad (2)$$

$$NF=10*Log\ (1+ T_{receiver}\ /295K) \qquad (3)$$

Equations (1, 2) present relationships between measured values P_{hot}, P_{cold} and temperatures $_{hot}$, T_{cold}, $T_{receiver}$. It means that each temperature could be calculated if other two temperatures are known and both powers are measured.

Calibration procedure

A receiver with input mixer (IM), local oscillator (LO), intermediate frequency amplifier (IFA) and output power meter (OPM) has been used for calibration. See figure below..



The calibration procedure was provided in two steps.
The first step is the calibration of the receiver using liquid nitrogen cooled matched load (CML). We measured the receiver noise performances using Y-factor technique with the room temperature 295 K as T_{hot1} and temperature of liquid nitrogen 77 K as T_{cold1} load signals. We measured P_{hot1} and P_{cold1} noise power output of a receiver and then calculated $T_{receiver}$ by the equations (4,5).

$$dY_1 = (P_{hot1})/(P_{cold1}) \qquad (4)$$

$$T_{receiver} = (T_{hot1}-dY_1*T_{cold1})/(dY_1-1) \qquad (5)$$

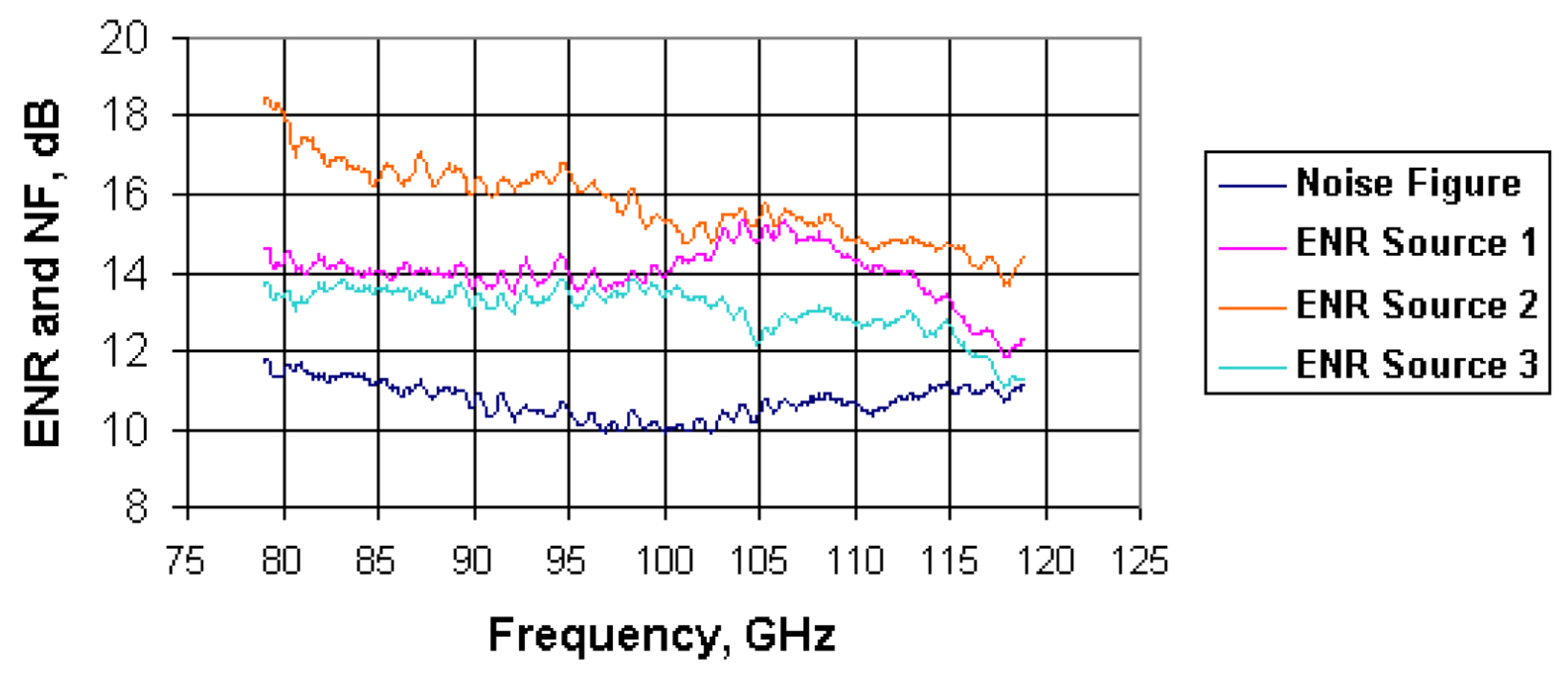
The second step is measuring of Equivalent Noise Ratio (**ENR**) of source (NS). We used room temperature 295 K as T_{cold2} and $T_{receiver}$ obtained at first step. We measured P_{hot2} and P_{cold2} noises power output of a receiver with switch off and switch on noise source respectively and then calculated T_{hot2} equations (5,6,7) In this case T_{hot2} is $T_{noise\ source}$.

$$dY_2 = (P_{hot2})/(P_{cold2}) \qquad (6)$$

$$T_{noise\ source} = T_{hot2} = dY_2*T_{cold2}+ (dY_2- 1)*T_{receiver} \qquad (7)$$

$$ENR=10*Log\ (1+T_{noise\ source}/295K) \qquad (8)$$

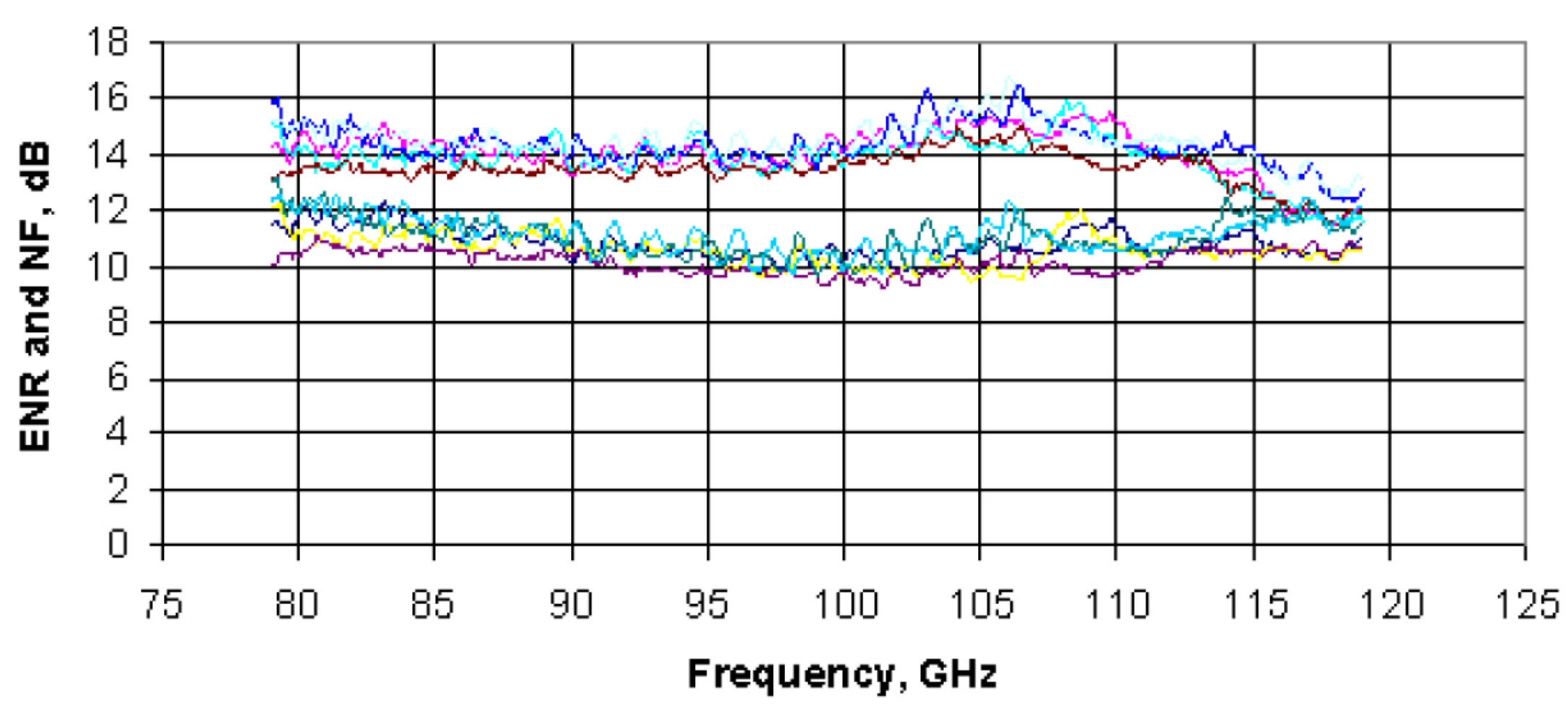
The results **ENR** and **NF** versus frequency are presented on plot and in attached tables



Equvalent Noise Ratio of noise sources and Noise Figure of receiver vs frequency

Accuracy of measurements

To estimate accuracy of measurement we carried out series of independent experiments. Results for ENR of source N1 and NF of receiver are presented on plot below. Results of 5 experiments are presented. Upper curves correspond to ENR down curves correspond to NF. In the calibration cover we present data averaged along series of experiments.



Data obtained in series of independent measurements (5 experiments)