Noise Temperature and Gain of a Balanced Antenna Driving Differential LNA's

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The ATA log-periodic antenna feed has two output terminals per polarization which are balanced with respect to ground. The desired output signal is the voltage between these two terminals. The feed terminals will also have an impedance to ground (the internal pyramid between the feed arms is the dominate ground in the vicinity of the feed) and there will be a common mode voltage from each terminal to ground. This common mode voltage is a function of the common mode gain pattern of the feed and it is believed that the common mode gain pattern of the feed integrated over all angles will be unity, the same as the desired difference mode pattern. The common mode noise will be rejected by taking a difference in an 180^{O} hybrid or balun at the output of the LNA's connected to each feed terminal.

A diagram of this configuration is shown in Figure 1 and is further described in the caption of the figure. The two-port antenna network is represented by a WYE network of impedances Z1 and Z3 with the antenna difference mode impedance equal to 2*Z1, approximately 200 ohms. It can be easily shown that the noise output of each LNA can be described by adding the noise temperature of the LNA (as determined by noise parameters) driven by impedance 2*Z3 + Z1 to the temperature of the real parts of Z3 and Z1. However, the computation of the effective noise temperature for the odd (desired) and even modes is complicated by the correlation of noise across Z3 in the two LNA outputs and the consideration of noise current flowing from one LNA into the other if Z3 is not equal to zero. The effective noise temperature analysis must also include representing all noise in the odd mode in 2*Z1 and all noise in the even node in Z3.

This problem was solved by putting the configuration shown in the lower portions of Figure 2 into microwave circuit analysis programs, Seranade and also MMICAD. The results as functions of Z1 and Z3 (considered real) are shown the top portion of Figure 2. The LNA used for these computations is the WBA9T MMIC with an off-chip input network optimized for the 0.5 to 11 GHz noise and gain. The figure shows the variation of the odd mode gain and noise as a function of frequency and impedance Z1.

In summary the effective noise temperature in the odd (desired) mode is equal to the noise of the each LNA driven by Z1, independent of Z3. The odd mode gain is equal to the gain of each LNA driven by Z1. The even mode noise is a function of both Z1 and Z3 and is described in Figure 2 for the relevant case of 2*Z1 = 200 ohms, the expected impedance of the log periodic antenna.

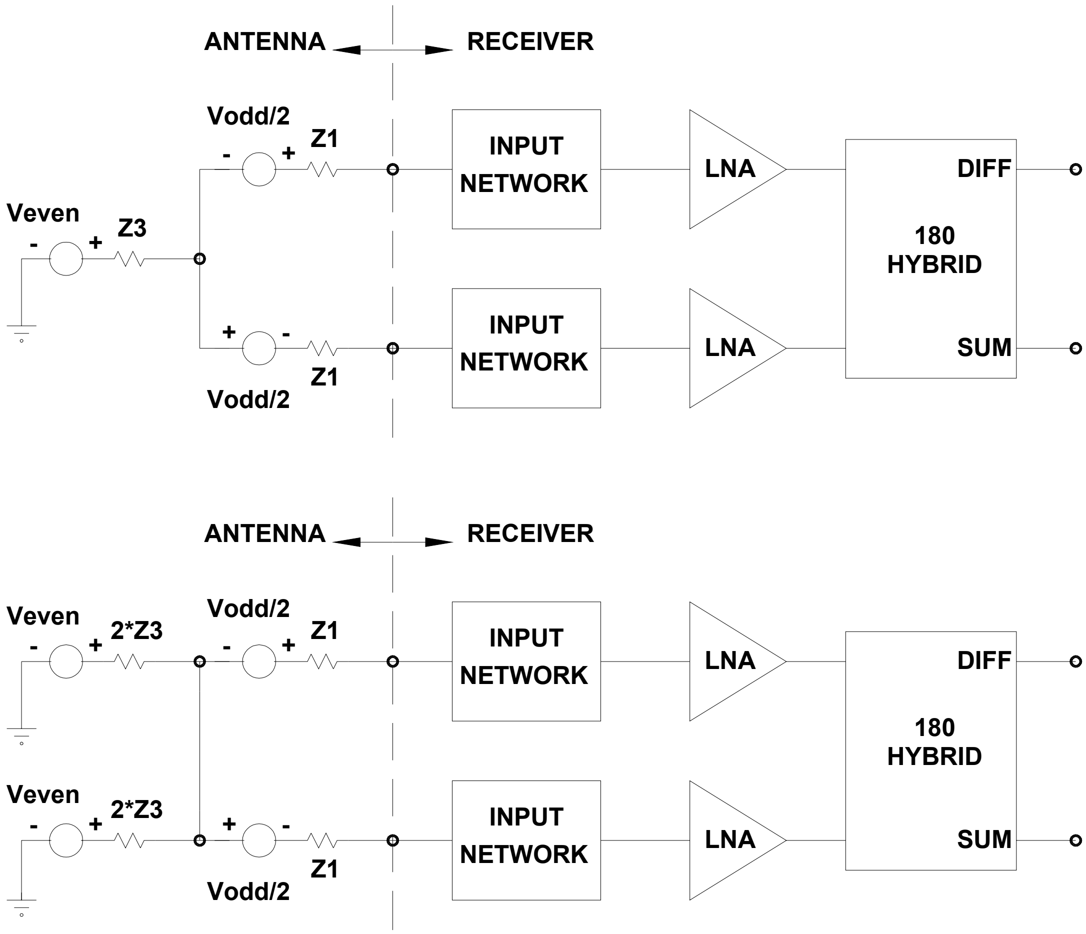

Figure 1 – At top is the circuit diagram for balanced LNA configuration. The antenna is modeled as a symmetric Wye network of two impedances, Z1 and Z3. The balanced antenna impedance is 2*Z1 and the common mode impedance is Z3. If the two antenna arms do not couple to each other Z3 will be zero (though even mode excitation as represented by Veven will still be present). It is convenient to analyze the configuration by splitting the network along the line of symmetry breaking Z3 into two 2*Z3 elements as shown in the bottom of the figure. Each LNA can then be considered as being driven by 2*Z3 + Z1 to compute the output of each LNA. The noise of each LNA can then be represented by adding this noise to the noise temperature of both Z1 and Z3. However the noise produced by Z3 cancels in the difference circuit and the resulting odd mode noise temperature is independent of Z3 as confirmed by CAD analysis. The noise in the even mode case must be represented by a temperature increase of Z3 and this depends on the temperature and value of Z1.

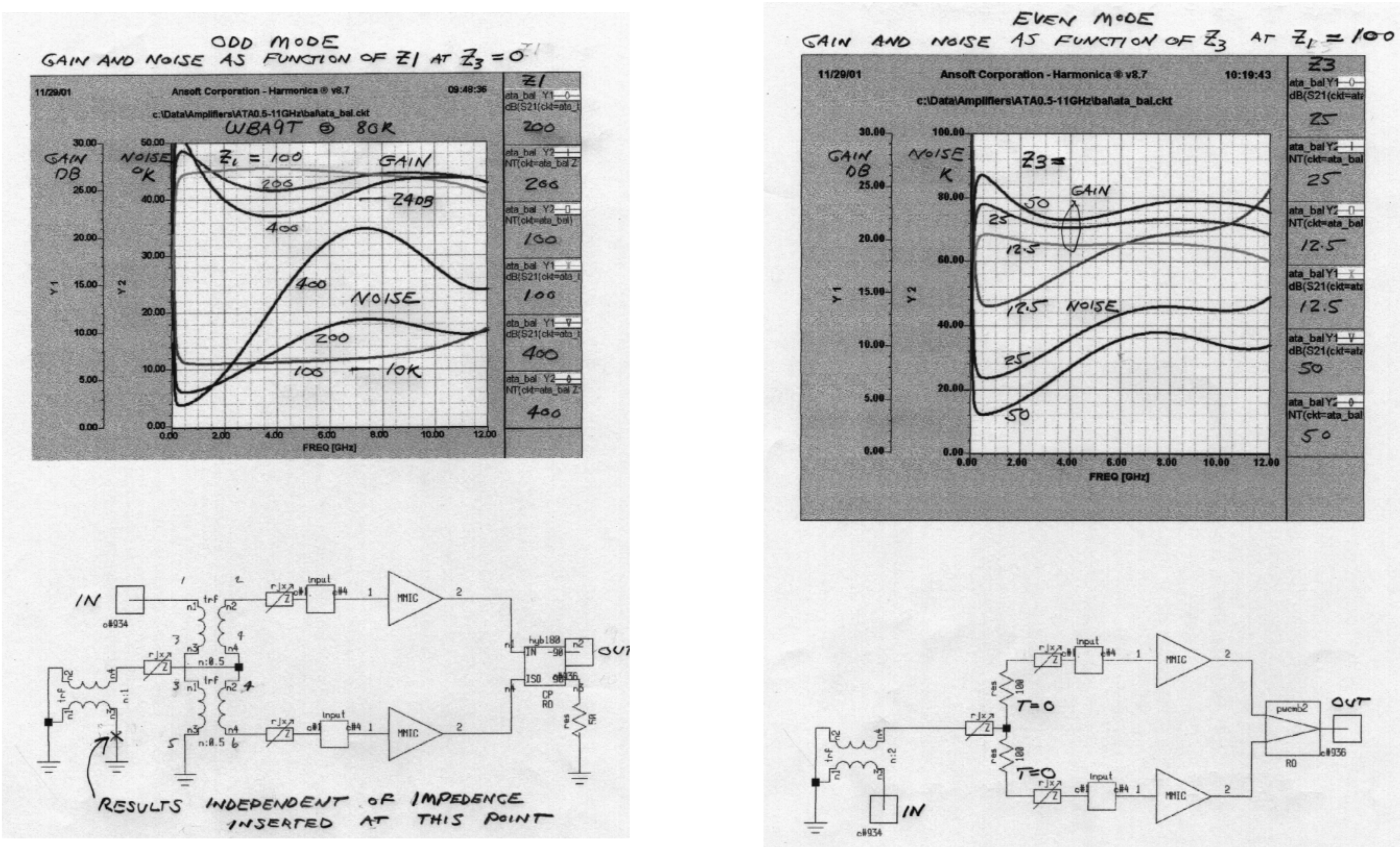

Figure 2 – At left is the odd (desired) mode noise and gain of a balanced WBA9 MMIC LNA including an off-chip input network, both at 80K, for three values of impedance Z1 (the balanced generator impedance is 2*Z1) and for any value of common mode impedance, Z3. <u>The results do not change as Z3 is varied</u>. At right is the even (common) mode noise and gain of the same circuit for three values of Z3 with Z1 fixed at 100 ohms and at a temperature of 0K. The even mode results are a function of Z1 and its temperature. These results were computed with the Ansoft Seranade software and the odd mode result was also checked with Optotek MMICAD software