To: RFI Group
From: Alan E.E. Rogers
Subject: Model of active antenna noise

The “effective” temperature delivered to the amplifier from the antenna is given by

\[ T_a'' = T_a\left(1 - |\Gamma|^2\right) \]

where

\[ \Gamma = \frac{(Z_a - Z_p^*)}{(Z_a + Z_p)} \]

and

- \( Z_a \) = impedance of the antenna
- \( Z_p \) = input impedance of preamp

This result is obtained from the ratio of the power delivered to the preamp to the power delivered to a conjugate load as follows:

The voltage across the preamp is

\[ E = Z_p\left|\frac{Z_a + Z_p}{Z_a + Z_p}\right| \]

and the current is

\[ I = \frac{1}{(Z_a + Z_p)} \]

and the power is

\[ \text{Re} \left( E\bar{I} \right) = \text{Re} \left( Z_p\left|\frac{Z_a + Z_p}{Z_a + Z_p}\right|\right) \]

while the power to a conjugate load is

\[ \text{Re} \left( Z_a\left|\frac{Z_a + Z_p}{Z_a + Z_p}\right|\right) = 1/4 \text{Re} Z_a \]

The ratio is

\[ \left( \text{Re} \left( Z_p\left|\frac{Z_a + Z_p}{Z_a + Z_p}\right|\right) \right) \left( 4 \text{Re} Z_a \right) = 1 - |\Gamma|^2 \]

When the preamp is connected to a load the “effective” temperature is

\[ T_{amb}'' = T_{amb}\left(1 - |\Gamma|^2\right) \]

Where

\[ \Gamma^2 = \frac{(R_L - Z_p^*)}{(R_L + Z_p)} \]

and \( T_{amb} \) = ambient temperature

The noise added by the preamp in each case is given by
\[ T_{\text{Rec}} = T_{\text{min}} + 4R_n \left| \Gamma_s - \Gamma_{\text{opt}} \right|^2 \left( 1 - \left| \Gamma_s \right|^2 \left| 1 + \Gamma_{\text{opt}} \right|^2 \right) \]

where \( R_n \) = normalized noise resistance (50 ohms)

\[ \approx 0.04 \text{ for ATF-54143} \]

\( \Gamma_s \) = source reflection coefficient – referred to 50 ohms

\( \Gamma_{\text{opt}} \) = optimum source reflection coefficient referred to 50 ohms.

In practice it may be convenient to normalize the output by applying a gain factor.

\[ g = T_{\text{amb}} / T'_{\text{amb}} \]

Figure 1 shows the effective antenna temperature normalized by the gain factor for a ATF-54143 preamp and the antenna described in memo 23. The input is shunted with 270 nH and the S parameters and noise parameters are interpolated from the data sheet. The sky noise with a perfect match is assumed to be 1000K at 100 MHz with spectral index of 2.6.

![Figure 1](image)

Figure 1. “Effective” antenna temperature. Lower curve is noise contribution from the amplifier.