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 \( \Gamma = \left(\frac{Z_a - Z_p^*}{Z_a + Z_p}\right) \)

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

\[ \text{Re}EI^* = \text{Re}Z_p \left(\frac{Z_a + Z_p}{Z_a^* + Z_p^*}\right)^2 \]

while the power to a conjugate load is

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

The ratio is

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

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

\[ T'_{\text{amp}} = T_{\text{amb}} \left(1 - |\Gamma|^2 \right) \]

Where \( \Gamma^2 = \left(\frac{R_L - Z_p^*}{R_L + Z_p}\right) \)

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

The noise added by the preamp in each case is given by

\[ T_{\text{Rec}} = T_{\text{min}} + 4R_n|\Gamma_s - \Gamma_{\text{opt}}|^2 \left(\frac{1}{|1 - |\Gamma_s|^2|} + |\Gamma_{\text{opt}}|^2 \right) \]
where $R_n =$ normalized noise resistance (50 ohms)

$$ \approx 0.04 \text{ for ATF-54143} $$

$\Gamma_s =$ source reflection coefficient – referred to 50 ohms

$\Gamma_{opt} =$ optimum source reflection coefficient referred to 50 ohms.

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

$$ g = \frac{T_{amb}}{T'_{amb}} $$

Figure 1 shows the effective antenna temperature normalized by the gain factor for an 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. “Effective” antenna temperature. Lower curve is noise contribution from the amplifier.](image-url)