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CONVERSION LOSS AND NOISE TEMPERATURE OF MIXERS FROM NOISE MEASUREMENTS

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Abstract

Dual-sideband conversion loss and noise temperature of a mixer can be determined from noise measurements alone from the variation of receiver noise temperature with changes in IF noise temperature. Results are presented for a 100 GHz subharmonically pumped mixer.

Introduction

Very low noise receivers can be realized above 100 Ghz with mixers using cooled metal-semiconductor or superconducting junctions followed by low-noise IF amplifiers. Both the noise temperature and conversion loss of the mixer contribute to the noise temperature of the receiver, and it is desirable, but often quite difficult, to measure both of these parameters for the mixer. We describe here a method of determining both noise temperature and conversion loss for a mixer from noise measurements alone. An advantage to this technique is that it does not require a signal generator with a known output power which is often not available for high frequencies.

The noise temperature T_R of a receiver is related to both the mixer noise temperature T_M and conversion loss L through the expression:

$$T_R = T_M + LT_{IF} \tag{1}$$

where T_{IF} is the noise temperature of the IF postamplifier. This expression is applicable if T_R, T_M and L are either single-sideband or dual-sideband values[1].

Equation 1 is a linear relation between T_R and T_F, and one can determine both T_M and L by measuring T_R for several different known values of T_{IF}. The noise temperature of the IF postamplifier can be increased by inserting a resistive attenuator between the mixer and the amplifer chain. Changing the noise temperature of a post-amplifier chain with an attenuator has been used by Martines and Sannino[2] to characterize microwave transistors from the noise measurements. The increase in IF noise temperature ΔT_{IF} resulting from the insertion of an attenuator before the IF amplifier is[3]:

$$\Delta T_{IF} = (A-1)(T_A+T_{IF}) \tag{2}$$

where A and T_A are the attenuation factor and the physical temperature of the attenuator. If the attenuator temperature is 290K the increase in IF noise figure resulting from the addition of the attenuator is[3]:

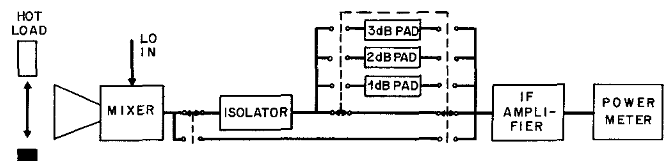
$$\Delta F_{IF} = A_{dB} \tag{3}$$

where the noise figure changes ΔF_{IF} and attenuation A_{dB} are expressed in dB. Equation 3 allows a check of the noise figure measurements of the attenuator-IF amplifier combination.

Noise Measurements

To illustrate this technique measurements were made on a 100 GHz portable receiver. The converter is a subharmonically pumped mixer operating at room temperature. The IF amplifier chain has two low-noise FET amplifiers in tandem at the input and is followed by a 1.39 GHz narrowband filter to obtain spot noise temperatures.

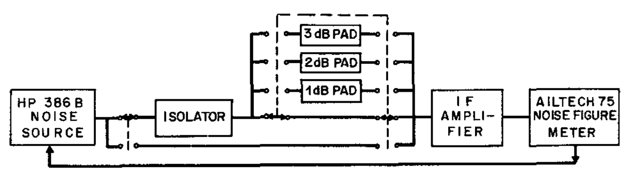
Figure 1 shows a block diagram for noise measurements on a receiver operating at millimeter wavelengths. The hot and cold loads are absorbers at room temperature and at liquid nitrogen temperature. Noise from these loads are broad band and are accepted by the receiver at both signal and image frequencies. Receiver Y-factors were measured for several different receiver conditions with the isolator alone, and the isolator with 1, 2, or 3 dB fixed attenuators. Measurements were also made with the isolator removed since the isolator is not normally used in the receiver.



RECEIVER Y-FACTOR MEASUREMENT

FIGURE 1

Noise temperatures for the IF amplifier-attenuator combinations were found from Y-factor measurements with an HP346B noise source and an AILTECH 75 noise figure meter as shown in Figure 2.



IF CHAIN Y-FACTOR MEASUREMENT

FIGURE 2

Y-factors were also measured with a 50 ohm termination at room temperature and cooled to liquid nitrogen temperature. Temperatures from the two sets of measurements agree to within six degrees. IF temperatures in following figures are those obtained with the 346B noise source. Values of attenuation for the fixed attenuators were measured with an HP8410B network analyzer at 1.39 GHz.

Results

Noise figures of the isolator-attenuator-IF amplifier combinations are plotted against measured attenuation of the attenuators in Figure 3. The line drawn through the data points has a unit slope showing that the IF noise measuring system is linear and that Equation 3 is valid.

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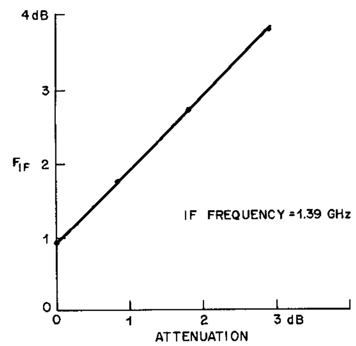

FIGURE 3

Figure 4 shows dual-sideband results for the mixer operating near 100 GHz.

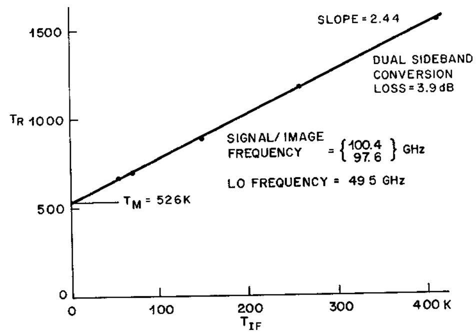

FIGURE 4

Conclusions

A simple procedure for determining dual-sideband noise temperature and conversion loss of a mixer from noise measurements has been described. Measurements can be quickly and easily made and can give good accuracy with a low-noise IF amplifier. This procedure is particularly useful for millimeter-wave mixers where power calibration of signals is difficult. Berger and Schneider[4] have reported dual-sideband conversion loss and noise temperature of a 230 GHz cryogenically cooled-mixer determined by this method.

References

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3. W. W. Mumford and E. H. Scheibe, "Noise Performance Factors in Communications Systems," Dedham, MA: Horizon House-Microwave, 1968.

4. H. S. Berger and M. V. Schneider, "Cryogenically cooled low-noise MM-wave receiver," Conference Proceedings, 7th International Conference on Infrared and Millimeter Waves and their Applications, Marseille, France, Feb., 1983.