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NASA TECH BRIEF

The Effect of Mismatched Components on Microwave Noise-Temperature Calibrations

The analysis of errors on microwave noise–temperature measurements has recently been given more attention due to increasing interest in the development of very low-noise antenna receiving systems and in the absolute accuracies to which the noise temperatures of these systems can be calibrated. Large-aperture antenna receiving systems for deep-space communications are now being developed that have zenith operating noise temperatures approaching 16° K at S band. As operating noise temperatures continue to be lowered, it becomes increasingly difficult and expensive to make further system improvements. It is often the case where improvements, made on particular system components, cannot be evaluated properly because of relatively large uncertainties that usually accompany low noise–temperature calibrations.

For an antenna receiving system, the absolute calibrations of three principal noise temperatures are of interest. These noise temperatures, which shall be referred to as component temperatures, are 1) the antenna noise temperature defined at the system front end, 2) the noise temperature of the network that connects the antenna to the receiver, and 3) the effective input noise temperature of the receiver. Although for operational purposes knowledge of the operating noise temperature is usually sufficient, it is often desirable that the operating noise temperature be separated into its component noise temperatures.

A technique is presented for analyzing the effect of mismatched components on the absolute noise–temperature calibrations of principal noise sources in a microwave receiving system. Scattering parameters are used to describe the properties of the microwave network that is connected between noise source and receiver. The calibration method discussed is the Y-factor power-ratio measurement technique involving the use of two thermal noise reference standards.

Calculations made for an operational low-noise antenna receiving system indicate that, even when components have reasonably low-voltage reflection coefficients (typically less than 0.05), peak errors due to mismatches could be as high as 70 percent and 11 percent on measured antenna and effective input noise–temperature values, respectively. For the special case where the reflected and direct wave receiver noise sources are fully correlated, the peak errors can be even larger.

Note:

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