PTB - NIST BILATERAL COMPARISON OF MICROWAVE NOISE POWER
IN COAXIAL TRANSMISSION LINE

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Abstract

The Physikalisch-Technische Bundesanstalt and the National Institute of Standards and Technology have compared microwave noise power in coaxial transmission lines. Each laboratory measured two solid state noise sources at 2.0 GHz, 4.0 GHz, and 8.0 GHz relative to their primary thermal noise standards. The agreement between laboratories is better than 0.07 dB.

Introduction

There is a significant trend in industry to construct very broadband microwave systems and equipment. This requires the use of coaxial transmission lines rather than rectangular waveguide. To evaluate many of these systems, coaxial transmission line noise standards are needed.

Essentially, two primary standards with different output levels and a comparison radiometer are required to calibrate an unknown noise source. Usually one primary standard is an ambient temperature resistive body. It is relatively easy to construct and evaluate. For the other standard, Physikalisch-Technische Bundesanstalt (PTB) laboratory chose to use a black body radiator with an output temperature higher than ambient. The National Institute of Standards and Technology (NIST) laboratory chose one lower than ambient.

Thermal noise standards at PTB and NIST

PTB and the NIST have independently developed coaxial primary noise standards and comparison radiometers. Both laboratories base their standards on the laws of black body radiation.

The PTB standard [1] uses a resistive termination at 650 K in coaxial transmission line with an APC-7 output connector. To calibrate transfer sources, an rf switched comparison radiometer with a precision IF attenuator [2] was used. The comparison accuracy of this radiometer depends fundamentally on the calibration accuracy of the precision IF attenuator.

NIST used three different primary noise standards. All three primary standards use a 77 K resistive termination in a 7 mm, 50 ohm coaxial transmission line [3]. One standard has an APC-7 output connector and two have male Type N connectors. To calibrate the transfer sources, NIST used a total power radiometer with an internal six-port reflectometer [4]. The comparison accuracy of this radiometer depends fundamentally on the linearity of the detection system.

Because PTB and NIST have taken significantly different approaches for their standards and comparison radiometers, this intercomparison of noise services is of particular interest.

The Intercomparison

The intercomparison is performed via two transfer noise sources, one from NIST, the other from PTB. The transfer sources are commercially available coaxial solid state noise sources with APC-7 output connectors. Each laboratory measured both sources at 2.0 GHz, 4.0 GHz, and 8.0 GHz relative to their primary thermal noise standards.

The transfer source supplied by PTB is one of three coaxial noise sources used for control standards. These sources are periodically recalibrated against the PTB coaxial working noise standard.

The transfer source supplied by NIST is one from a set of four sources used as check standards for the APC-7 noise calibration service. One or more of these check standards are recalibrated whenever a customer source is calibrated. The repeatability of these check standards since 1986 has been better than 0.01 dB. These check standards were also calibrated through adapters relative to the two NIST cryogenic primary standards with male Type N connectors, and relative to a similar set of four Type N check standards. Calibration frequencies of interest are 2.0, 3.95, 4.0, 8.0, and 8.2 GHz. Typical agreement and repeatability is better than 0.01 dB. The additional frequencies 3.95 GHz and 8.2 GHz were included because they can be traced back to NIST high temperature noise standards; namely, the WR284 690 K oven standard operational since 1970, and the WR90 1,270 K oven standard operational since 1967 [5]. Repeatability and agreement with the oven standards at 3.95 GHz is less than 0.01 dB, and at 8.2 GHz is less than 0.015 dB.

Results

Agreement between the two laboratories is within the stated uncertainties of the two services, namely ± 0.06 dB for NIST, and ± 0.04 dB for PTB (confidence level: 0.95).

References

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