application note 106

BIT OF BALANCED AMPLIFIERS

Built-in testing (BIT) is required in most communications systems to ensure the reliability and performance of the links. Built-in testing is used to detect faults, identify faulty components, and test standby systems. As the low-noise amplifiers and high-power amplifiers are often located at the antenna rather than at ground level, remote monitoring using BIT noise generators is desirable.

In a balanced amplifier, low noise figure and input VSWR are maintained by using 90-degree 3-dB hybrids. The hybrids are located before and after two identical parallel amplifier stages that have been optimized for low noise figure. A low-cost BIT circuit can be implemented using an NC401C noise diode in conjunction with the 90-degree hybrids.

The noise diode, a stable, well-defined, noise generating semiconductor, is placed behind the termination of the input 90-degree hybrid as shown below in Figure 1. The termination is replaced by a 20 dB attenuator, which provides a good match for the hybrids and isolates the noise diode and the amplifier.

When the noise diode is in the “Off” condition (no bias applied), no noise is generated and the amplifier performs as required. With the noise diode biased in the “On” condition, a well-defined amount of noise is generated. By detection of the change in signal level (really noise level) after the amplifier, the noise figure and gain of the amplifier and receiver block can be determined.

The noise figure simply is:

$$NF(\text{in dB}) = ENR - 10\log(Y-1) + 10\log A$$

where:

$Y = P_{oON} / P_{oOFF}$

P_{oON} = **output power of DUT with the noise source “On”**

P_{oOFF} = **output power of DUT with the noise source “Off”**

$10\log A$ = **a temperature correction factor**

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The ENR is that of the noise diode less the 20 dB of attenuation. For best measurement results, a diode with a typical ENR of 35 dB (such as the Noise Com NC401C) should be used.

At temperatures deviating significantly from 290 K, a correction (10logA) must be applied when measuring low noise figures:

$$A = 1 - [(T_c/290) - 1] \times [Y/10^{(ENR/10)}]$$

The gain (not in dB) is:

$$G_a = \frac{P_{oON} - P_{oOFF}}{k \times B \times (T_h - T_c)}$$

where:

B = the noise bandwidth of the measurement system

k = Boltzmann's constant = 1.380 X 10^{-23} J/K

T_h = 290 X [1 + $10^{(ENR/10)}$] (in degrees K)

T_c = room temperature (in degrees K)

The signal level (noise level) detector can be placed in a similar fashion as the noise diode, but in front of the output 90-degree hybrid. Similar techniques can be used for testing power amplifiers, since they are often implemented with 90-degree hybrids.

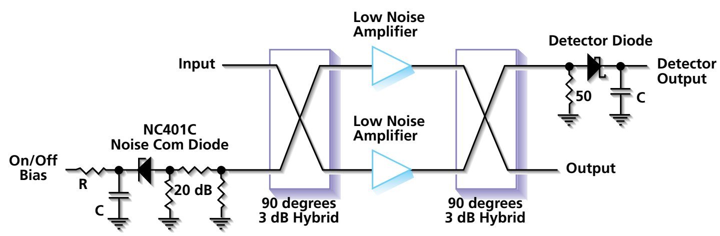

Figure 1. Balanced amplifier with BIT noise source and detector.

For more information on the NC401C, see pages 30-31.