Noisecom

Application Note

Implementation Margin of a Satellite Communication System

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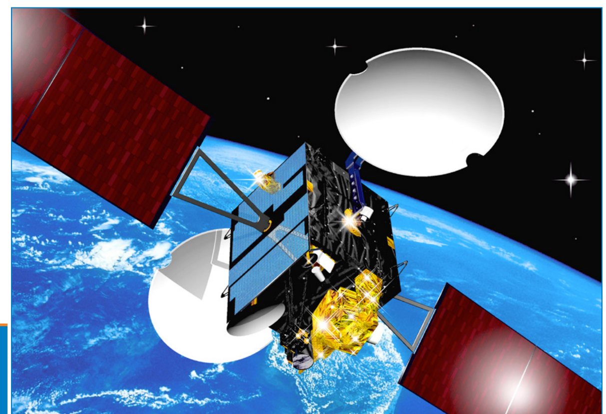

Abstract

The Implementation Margin of a satellite communication system is defined as the degradation of the signal after travelling through the up and downlink equipment. In order to find this, an EbNo generator such as the Noisecom CNG-EbNo Series can first be used to carry out an IF loopback test of the modem in order to find bit error rate (BER) values at different Eb/No ratios. A plot of these values can then be compared with the theoretical curve for the digital modulation scheme being used. The resultant difference is termed the implementation loss of the modem, and this value is used as a reference level for the second part of the test, in which the implementation margin of the complete up and downlink is found.

Implementation Margin of a Satellite Communication System

Eb/No is a dimensionless quantity, defined as the ratio (usually in dB) between the energy per bit of transmitted signal and the thermal noise power in 1Hz (kT, where k is Boltzmann's constant and T is the system noise temperature). It is similar to carrier to noise ratio (C/N), but normalised to one Hz and one bit. This normalisation means that bandwidth and bit rate are no longer of concern, and allows a comparison of bit error rate performance for different digital modulation schemes. Each modulation scheme has its own theoretical BER versus Eb/No plot, otherwise known as a waterfall curve, examples of which are shown below:

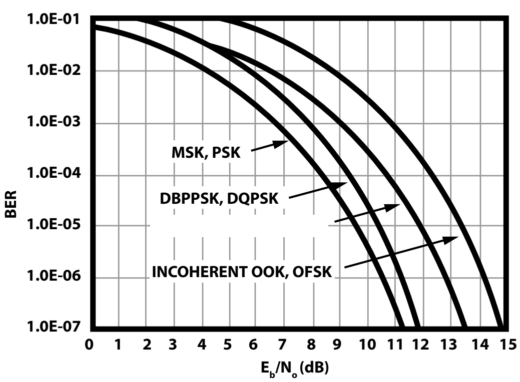

Figure 1. Theoretical BER vs. Eb/No plot for different modulation scheme

However, in the real world, system components and interference from adjacent transmitters contribute to ensure that this theoretical condition is not met.

As shown in Figure 1, bit error rate is related to Eb/No ratio, and an important measure of the integrity of a satcom system is to ensure that the bit error rate is as low as possible. Bit error rate testers (BERT) can be used to send data through a satellite system via a modem set in loopback mode, and the received signal is then analysed in order to determine the number of bit errors.

If 10,000,000 bits of data have been transmitted and one error has been detected on the received signal, this corresponds to an error rate of 1 in 10 million, or 1xE-7. In order to confidently estimate the BER for a particular Eb/No ratio, a BER test can run for a number of hours to a number of days. For this reason the output of the EbNo generator must be very stable.

Modem IF Loopback Test

For the first part of the test the up and down converters are disconnected from the system and the output of the modem is fed through the EbNo generator and back to its input, with the modem set in loopback mode.

Referring to the block diagram below, the EbNo generator injects a precise amount of noise onto the outgoing signal from the modem in order to establish an accurate Eb/No ratio at its input. The Eb/No ratio is set to a value lower than the minimum required for the modem to function and then increased to the point at which synchronisation takes place. The BERT is then used to measure bit error rate at this and higher Eb/No ratios in order to plot a waterfall curve.

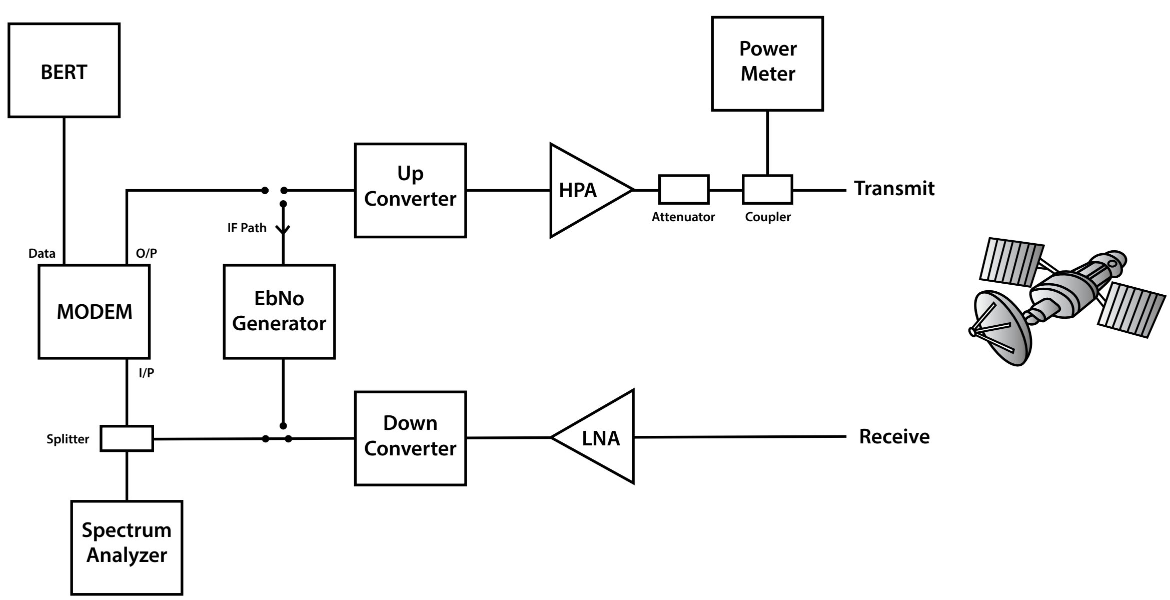

Figure 2. Block diagram for modem IF loopback test using Noisecom's CNG EbNo series instrument

RF Loopback Test of the Complete System

Referring again to the block diagram, the implementation margin of the complete up and downlink can be found by repeating the above procedure, again with the modem in loopback mode, but this time the EbNo generator is not required. Using a power meter and a precision attenuator, the power level of the transmitted signal output from the HPA is adjusted in order to set the correct Eb/No ratios at the modem's input, and so the bit error rate of the received signal is once again found. The spectrum analyser measures the C/N ratio of the incoming signal, and converts this to Eb/No using the following formula:

*Eb/No = C/N * B/R*

where B is the signal bandwidth (Hz) and R is the bit rate (bits/sec). Now a waterfall curve for the complete up/downlink can be plotted.

The Waterfall Curve and Implementation Margin

The waterfall curve derived from the test of the complete satellite system is compared to the modem IF Loopback test plot for this particular digital modulation scheme. So if Implementation Margin is 0dB then the whole system has the same performance as the modem on its own, and the theoretical best case has been achieved. The difference in plots is due to adjacent transmitter interference, atmospheric conditions, antenna pointing errors and the propagation of the signal through the up/downlink equipment.

The Implementation Margin at a certain bit error rate, in this case 1.0E-5, is shown on the graph below as the difference in dB between the theoretical and the actual Eb/No values.

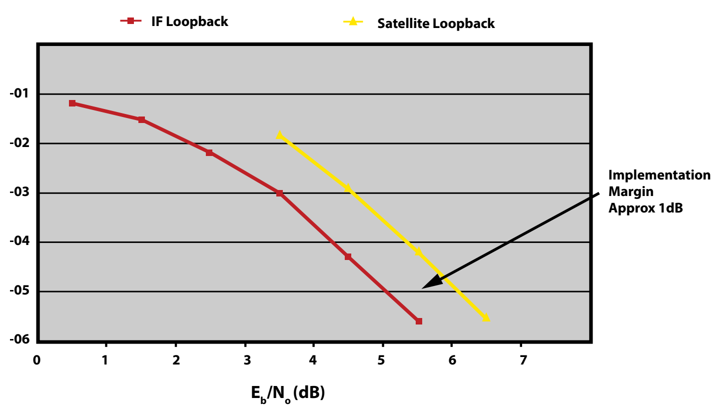

Figure 3. Implementation margin of a certain bit error rate

The whole procedure should be repeated at different data rates for the particular digital modulation scheme being used, preferably at the maximum and minimum, and at another intermediate rate.

An Implementation Margin of 1dB means that bit energy, Eb, has to be increased by 1dB in order to achieve the same BER as with the modem on its own. In other words, the noise has increased by a factor of 1dB by travelling via the system's up and downlink.

Conclusion

An EbNo generator such as the Noisecom CNG-EbNo Series is an important component in test systems whose job is to determine the effectiveness and efficiency of satellite communication links. The CNG-EbNo is a fully automated precision signal to noise generator which sets and stably maintains a highly accurate ratio between a user supplied carrier and internally generated noise. The instrument gives system, design, and test engineers in the telecommunications industry a single tool to generate precision signal to noise ratios, bringing increased confidence from repeatable and accurate test results.

References

The core of this application note was taken from "*Defence Satellite Communication System (DSCS), Earth Terminal Certification Test Procedures*".

[1] CNG-EbNo Product Page http://noisecom.com/products/instruments/cng-ebno-snr-noise-generator

[2] CNG-EbNo Datasheet http://noisecom.com/~/media/Noisecom/Datasheets/CNG_EbNo_Datasheet_PR3.ashx

[3] Application Notes http://noisecom.com/resource-library?brand=Noisecom&go=application_notes

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