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DATA COMM FOR BUSINESS

Bit and Block Error Rate Testing

Introduction

A Bit Error Rate Tester, or BERT, can give you reliable information about how well a system performs. One might conclude that the resulting bit error numbers are desired and accurate results. But just running a Bit Error Test and relying on the resulting numbers is not that simple. Block error rate testing is a better choice for most users. Why? Read further to see why this makes sense.

How might one calculate bit errors?

A bit error rate test is done over a time period. It is common for a telephone company to use a 15 minute period and then calculate the bit error rate. For example, an analog line is considered acceptable with an error rate of less than one error in a million bits (1 in 1,000,000). A 56 Kbps digital line should have an error rate of less than one error in ten million bits (1 in 10,000,000). T1 is stated in terms of hours per year.

On an analog phone line using modems, this works out to:

– 1200 bps, approximately 1 error in 15 minutes
– 9600 bps, approximately 9 errors in 15 minutes

On a 56 Kbps digital data service line, according to Qwest in a specification found here http://www.qwest.com/pcat/large_business/product/1,1016,142_4_2,00.html"

– approximately 5 errors in 15 minutes
– 99.875 percent error-free seconds and 10-7 bit error rate (BER)

On a T1 facility, an AT&T technical reference, TR 54075A and Pub 62310A, states T1 performance in terms of availability on an annual basis:

– End to end 99.90% availability, 8.76 hours down time annually
– Central office to central office, 99.95% availability, 4.38 hours down time annually
– Central office to customer premise, 99.975% availability, 2.19 hours down time annually

What might cause a bit error?

Noise is what causes bit errors. An ideal signal is noise free, but when there is noise, it can come from a wide variety of sources. Knowing what a noise source could be is most helpful in tracking down the and fixing the source of errors. Below is a brief introduction to some sources of what might cause bit errors.

Analog noise

FSK modems, (e.g. 202T, V.23) which shift between two frequencies, noise may be:

- cross talk
- microwave fade
- radio frequency interference on a microwave link
- old bad splices with high impedance
- a split transmit/ receive pair on a phone line
- signal level is too low
- signal level is too high
- impedance problems with modem or channel termination unit transformers
- impulse noise
- noisy tributary modem on a multidrop circuit

QAM or Trellis encoded modems:

- microwave fade
- too low signal levels
- too high signal levels
- split wire pairs
- impulse noise
- sudden amplitude gains or drops
- bad line splices
- cross talk
- improper clock settings on synchronous modems
- sudden frequency shifts
- error on an intermediate digital carrier channel
- noisy tributary modem on a multidrop circuit

Digital noise

- clocking mismatch on TDM links, i.e., a T1 link clocking problem
- link that is too long for the signal level (DDS, T1, E1, fiber, Ethernet, etc.)
- T1 bipolar violation
- loss of time synchronization on a T1 or E1 link
- bad wire or fiber splice
- water in a cable
- a short on an RS232/422/530 interface cable
- too high a data rate on a statistical, buffered communications link
- failure to use proper flow control on asynchronous equipment
- crossing over transmit and receive clocks on a synchronous modem link
- digital microwave fade or channel interference
- buffer overflow

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How does a test set determine a bit error?

What is a bit error depends on the hardware (the internal hardware in the tester) and some software/firmware decisions made by the designers of the tester. This is the key to why a block error rate test is usually the better choice for a user.

Test Patterns

For synchronous testing and asynchronous non-character (no start bits, parity or stop bits) testing, the 63, 511, and 2047 bit pseudo random patterns are standard. If these patterns are used for asynchronous data in a character format, with start, data, parity and stop bits, the patterns are not standard.

A common asynchronous test pattern is the Quick Brown Fox (QBF) message. This is non-standard. There is no agreement on upper and lower case, periods, carriage returns and or line feeds at the front or end of the message, etc. Each company and model of test set is likely to have its own slightly unique test patterns.

Hardware Transmitter/Receiver Issues

For test sets with a bit shift register, incoming bits will be compared to the reference bit pattern they pass through the bit shift register. This is how a bit error rate test set had to be made before USARTS and UARTS came into common use, and before the world settled on ASCII and similar 8-bit character coding as a standard.

With bit shift registers, a single bit error might register hundreds of errors on some BERT testers. A single error could cause the shift register mask to be out of synchronization. Until the pattern repeats, all the remaining bits in a pattern might be considered in error. On a 2047 bit sync pattern, that can be more than 2000 bit errors recorded, when in fact there was a single bit error. The bit error results will depend on how the test set was designed to check the pattern. A designer may choose to require the entire pattern to match, and after the first bit error, all the following bits may be considered in error if there is a bit gain or a bit loss in the patterns. Bit gain or loss is typically due to a clocking mismatch in the communications equipment.

A USART is a Universal Synchronous Asynchronous Receiver Transmitter. A UART is a Universal Asynchronous Receiver Transmitter. A modern USART can send and receive asynchronous data that is 5, 6, 7 or 8 data bits in length plus one or two stop bits, odd, even, mark, space or no parity, and a start bit.

UARTs and USARTs evaluate data on a byte or character basis, not in a long shift register. Because of this, errors will be counted in a different fashion. For example, if the start bit of an asynchronous character changes from the correct 0 start bit to a

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1, how many bit errors should be counted? The information from the UART or USARTs is not sufficient to say if there was a single bit error, or 5, or 8. It is up the the designers of the equipment to decide. And it also depends on where the next zero bit occurs (interpreted as a start bit by a UART) and the particular characters that follow.

In summary, the count of bit errors depends on the hardware in a test set and decisions by those designing the test equipment. This will vary by company, model, and engineer. This leads one to look at block error rates, rather than bit error rates to provide useful test data. Or to consider both bit and block error rates together to get a better idea of the health of a communications link.

Block Error Rates

What to do since bit errors are hardware dependent? Use a block error rate, and a bit error rate only when you know how the bit error rate effects the test results.

Block errors more accurately reflect the way most communications systems are used. For example, in a polling system, the polls and responses are blocks of data. If any single bit is bad, or most, or all, the result is the same. One poll (block) is in error, or one response (block) is in error.

The conclusion is to rely on block errors as the appropriate measure for user data. The number of block errors should be evaluated over a period of time.

Using a DCB BT-1 Test Set

The QBF test pattern, sent from a BT-1test is similar to the poll/response function used in a polling applications from a host computer to an RTU (utility industry application). This QBF pattern could be sent out and back via a loopback , or with a BT-1 at each end. A 25% rate is the closest to a polling rate. The BT-1 can send QBF once, continuous, 25%, 50% or a 75% duty cycle.

After 5, 10 or 15 minutes, the link should be error free or nearly error free. The QBF test is a data block about 60 characters long, which is a reasonable average size to simulate utility RTU traffic. With a loopback at the far end, the QBF message goes out, then comes back, simulating the half duplex nature of a polled system.

If the loopback test is 100 percent successful or has just a few errors, then an RTU should work at the same error rate on the same data channel.