BIT ERROR RATE & ITS IMPORTANCE

Cable TV networks that migrate to Digital CATV often asked - What is Bit Error Rate (BER)? How is it related to signal quality? What are the factors that effect BER?

This article provides a simple overview, with recommendations for an LCO to improve his distribution system, for Digital CATV delivery.

DIGITAL BASICS

In a digital system, the signal consists of digital data, which is transmitted as a series of 0s & 1s. 0 represents the 'Off' state, and 1 represents an 'On' state. The series of 0s & 1s are grouped together in a fixed length, or 'Words.' As an example: 0 1 0 0 0 1 0 1 1 is a ten bit word. It is important that all these bits be received exactly as transmitted.

If however, the word is received as: 0 0 1 0 1 0 1 0 1 1 then there are 3 errors (shown as underlined bits). This implies 3 errors out of 10 or a Bit Error Rate (BER) of 0.3. Usually the BER is very small, typically expressed as 10 to a negative power. For example, a typical digital CATV distribution system will have a BER of 10^-4, meaning that, out of 10,000 bits transmitted, one bit may be in error, i.e. 1 error in 10,000 bits. The higher the BER, the higher the error and the received signal will be of poor quality. The digital picture will tolerate a certain BER but beyond that limit, the picture will suddenly become unacceptable. The Picture may freeze, tear or the screen may even go completely blank.

<table>
<thead>
<tr>
<th>Parameters At Consumer Outlets For Analog And Digital Video Channels (IEC60728)</th>
<th>Value For Analog Video PAL / NTSC</th>
<th>Value For Digital Video 64QAM / 256QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter At The Subscriber’s TV Interface</td>
<td>RF Output Level</td>
<td>&gt;60 dBµV</td>
</tr>
<tr>
<td></td>
<td>SNR</td>
<td>&gt;45.5 dB</td>
</tr>
<tr>
<td></td>
<td>CSO / CTB</td>
<td>&gt;57 dB, &gt;52 dB</td>
</tr>
<tr>
<td></td>
<td>BER</td>
<td>-</td>
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</tbody>
</table>

The BER is the ratio of the number of errors divided by the total number of bits transmitted. In a practical digital system, a BER of 0.3 is huge and unacceptable. Usually the BER is very small, typically expressed as 10 to a negative power. For example, a typical digital CATV distribution system will have a BER of 10^-4, meaning that, out of 10,000 bits transmitted, one bit may be in error, i.e. 1 error in 10,000 bits. The higher the BER, the higher the error and the received signal will be of poor quality. The digital picture will tolerate a certain BER but beyond that limit, the picture will suddenly become unacceptable. The Picture may freeze, tear or the screen may even go completely blank.
In an analog system, deterioration is gradual, and the picture deteriorates progressively. However, in a digital system, the picture suddenly turns unacceptable if the BER falls below a certain level (usually, 10^-4).

Clearly, Bit Error Rate: BER is a key parameter that is used in assessing systems that transmit digital data from one location to another. Systems for which Bit Error Rate, (BER) is applicable include RF links, fibre optic data systems, Ethernet, or any system that transmits data over a network of some form where noise, interference, and distortion may cause degradation of the digital signal. Although there are some differences in the way these systems work and the way in which bit error rate is affected, the basics of bit error rate itself are still the same.

When data is transmitted over a data link, there is a possibility of errors being introduced into the system. If errors are introduced into the data, then the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and bit error rate, BER, provides an ideal way in which this can be achieved.

CAUSE OF BER
In digital transmission, bit errors represent the number of wrong / error bits received during transmission. These can occur due to:

1. Noise
2. Interference
3. Distortion
4. Bit Synchronization Errors.

BER & OVERALL SYSTEM PERFORMANCE
Bit Error Rate, (BER) assesses the full end-to-end performance of a system including the transmitter, receiver and the way in which the signal is transmitted (eg RF, Optical). As a result, BER estimates the actual performance of a system in operation to be tested, rather than testing the component parts and hoping that they will operate satisfactorily when in place.

IMPROVING BER IN CATV
Improving BER in fact implies improving the overall system performance, and is therefore not
easy. BER can be improved by reducing the data rate or improving the transmission efficiency.

In a practical Cable TV system, the BER can be improved, by various means. Typically, all these methods need to be implemented simultaneously to get good BER and therefore good digital CATV transmission.

**LOWER NOISE**

As in an analog cable TV system, noise also deteriorates the signal and the picture quality in a digital cable TV network. Noise in general is any external signal that is not part of the original signal being transmitted.

Noise can be injected into a digital cable TV network due to poor shielding of the coaxial cable being used. It is therefore important to use good quality coaxial cable with heavy braiding so that external noise cannot plunge into the cable.

The use of good quality crimp connectors that maintain good grounding contact with the coaxial cable, are also very important.

Similarly, tap-offs and splitters with good metal housing that provide electrical shielding, must be used.

**SIGNAL LEVELS**

While an analog TV set requires a minimum signal of 60 dBu, a digital set top box needs to receive a minimum signal of >47dBu for QAM64 signals and >54dBu for QAM256 signals. This signal requirement may not be as comfortable as it seems at first sight - the Headend must be set up to output approximately -6dB (QAM 256) to 10 dB lower signal levels (QAM64) for digital, to avoid overloading the line amplifiers & nodes.

**OPTICAL TRANSMISSION**

Use of fiber optic cable and optical transmitters & nodes is now wide spread on Indian Cable TV networks. Unlike RF

### Analog TV Transmission: CNR

<table>
<thead>
<tr>
<th>SNR</th>
<th>Good Picture</th>
<th>Moderate Picture</th>
<th>Poor Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 48 dB</td>
<td>&gt; 45 dB</td>
<td>45...47 dB</td>
<td>&lt; 44 dB</td>
</tr>
</tbody>
</table>

### Digital TV Transmission

With Digitally Coded Signals,
The Picture Quality Abruptly Changes From Excellent to Unacceptable or No Picture

<table>
<thead>
<tr>
<th>Modulation (e.g. 8 MHz)</th>
<th>16 QAM</th>
<th>64 QAM</th>
<th>256 QAM</th>
</tr>
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<tbody>
<tr>
<td>SNR (dB)</td>
<td>&gt; 20 dB</td>
<td>&gt; 26 dB</td>
<td>&gt; 32 dB</td>
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</table>
Transmission, Optical transmission is completely immune to electrical noise pick up. Further, optical transmission does not require frequent use of amplifiers or any other active equipment to distribute the signal. Best of all, optical transmission is far cheaper than RF transmission.

Given all these benefits it is hardly surprising that all distribution system upgrades are now done with optical networks. Ideally, the optical signal should service a node which in turn should directly service the end consumer. Hence ideally, there should be no RF amplifiers used in the CATV distribution system after the optical node.

The optical signal fed to nodes must be reduced by 2dBm to 4dBm, when a CATV distribution system is migrated from analog only to digital signal delivery.

**Ideally A Node Should Directly Service A Consumer's STB**

A good rule of thumb is that if any coaxial cable length is more than 300 meters, it should be replaced by a fiber optic cable and optical transmission used instead of RF transmission. Such practices will result in good BER

**LOWER QAM**

Digital CATV signals from the Headend utilise QAM (Quadrature Amplitude Modulation). This is decided by the Headend and cannot be altered by the LCO during re-transmission.

QAM modulation can be done at different "density" levels. QAM 64 is the least dense modulation. It carries the least amount of channels within a specified bandwidth. QAM 128 & QAM 256 offer significantly higher number of channels that can be carried in the same bandwidth.

As one can expect, QAM 256 requires much better BER than QAM 64. As a result a poor quality distribution network may not be able to properly carry a QAM 256 signal. It will result in picture freezing at the customer end. However, the same network may adequately carry QAM 64.

Typically, each STB will also need to receive 3dB higher signal levels if QAM 256 is used, compared to QAM 64.
In Cable TV networks that need to simultaneously carry analog + digital CATV signals, only a small portion (usually 20–40 analog channels) of the bandwidth is allocated for digital CATV channels. To carry at least 200 digital channels, higher modulation schemes than QAM 64 are required. Some cable TV headends have successfully experimented with carrying their “Home Stream” on QAM 64 and the other streams on higher QAM, to provide both high channel capacity and robust signal transmission even on the not-so-good quality distribution networks of their LCOs.

CONCLUSION:

As seen above, BER (Bit Error Rate) provides a good measure of evaluating whether the end subscribers' STBs receive an adequate quality of digital signal. To this extent BER and its measurement is an excellent tool.

We have also indicated above, broad outlines of some measures that must be adopted to improve the transmission quality, i.e. the Bit Error Rate (BER).

This Article Was Published Earlier In Satellite & Cable TV Magazine - Ed.