EDH — Error Detection and Handling in Digital Television

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In a previous tutorial article, we discussed quality control in a digital system. To maintain the best quality, a standard has been developed. It is called EDH, for Error Detection and Handling. The following tutorial describes this method of monitoring a digital system while it is being used for production and broadcast purposes.

The problem with digital television is that it's too good! You can't see anything wrong with it until it suddenly disappears! A picture that may appear perfect to the eye might actually have deteriorated to the point where adding only 10 meters of cable can cause the signal to become totally useless. If you try to measure the quality of a digital television signal using conventional test equipment (after having passed it through a digital-to-analog converter, of course), you may find that it looks perfect. No deterioration in picture quality can be observed, even after the signal has passed through many meters of cable, so a totally different technique must be adopted to check digital signals.

In fact, we have to look for bit errors in the signal, and this is where the Error Detection and Handling (EDH) mechanism makes its contribution to the digital world. The use of EDH testing techniques in serial digital television installations is now recommended by SMPTE in its document RP 165. It is an on-line quality check system.

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Digital Errors

An error is defined as one or more data bits whose digital value is different at the destination from what it was at the source. Such errors may be caused by faulty equipment, bad joints or, more probably, by excessive cable lengths. Figure 1 shows how the number of errors increases dramatically as the length of cable is increased. It is this rapid increase in errors (known as the "cliff effect") that must be of concern to the television engineer. Under normal circumstances, no errors whatsoever should be expected in the digital television environment, so the presence of any error may be taken as a sign that the transmission path is overstressed and in need of corrective action. This is even more important when the serial digital signal is carrying embedded audio, as noise due to bit errors is more disturbing to the ear than it is to the eye.

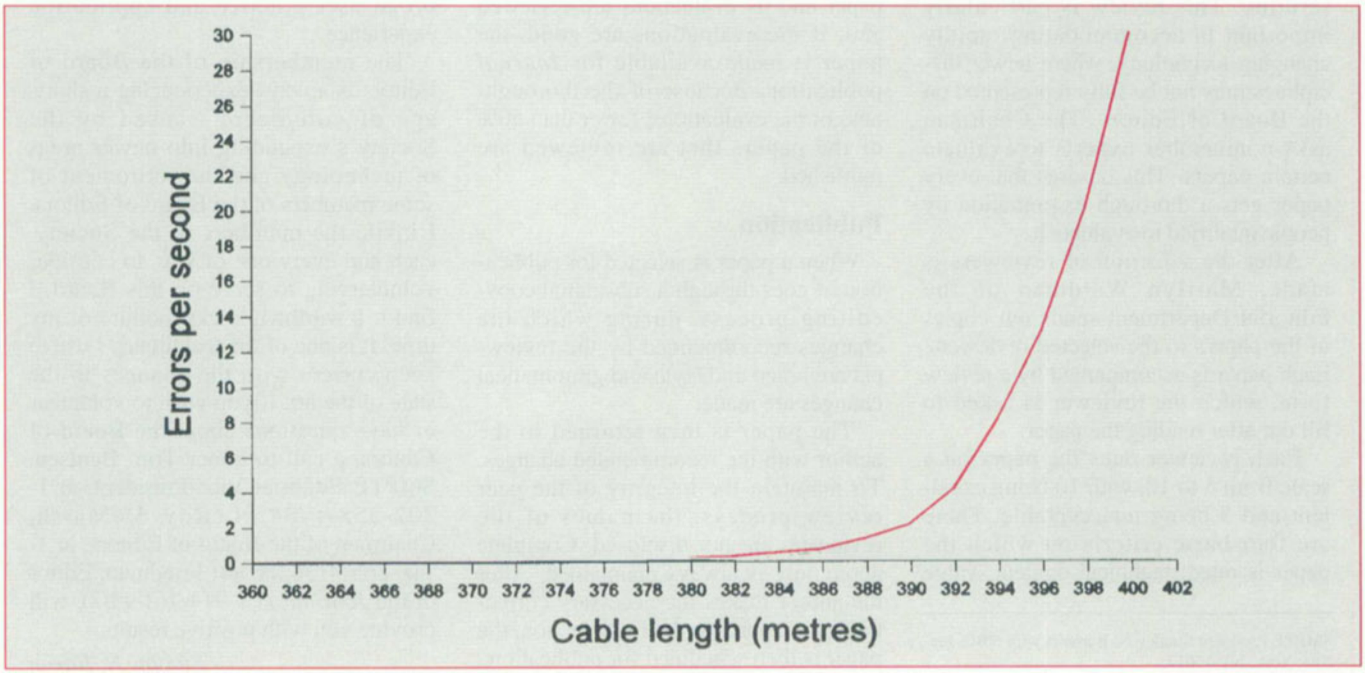

Figure 1. Errors vs. cable length (note "cliff effect").

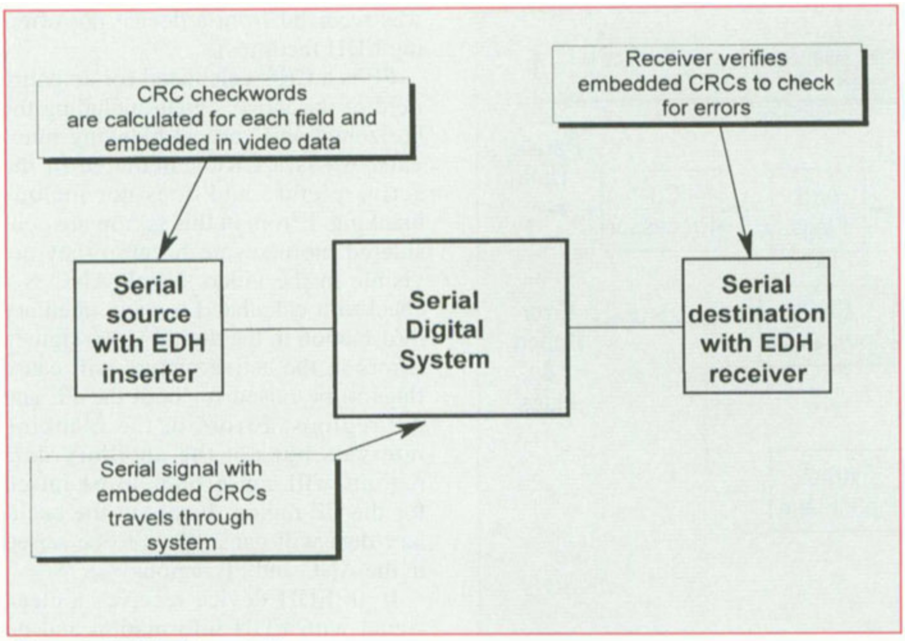

Figure 2. EDH implementation.

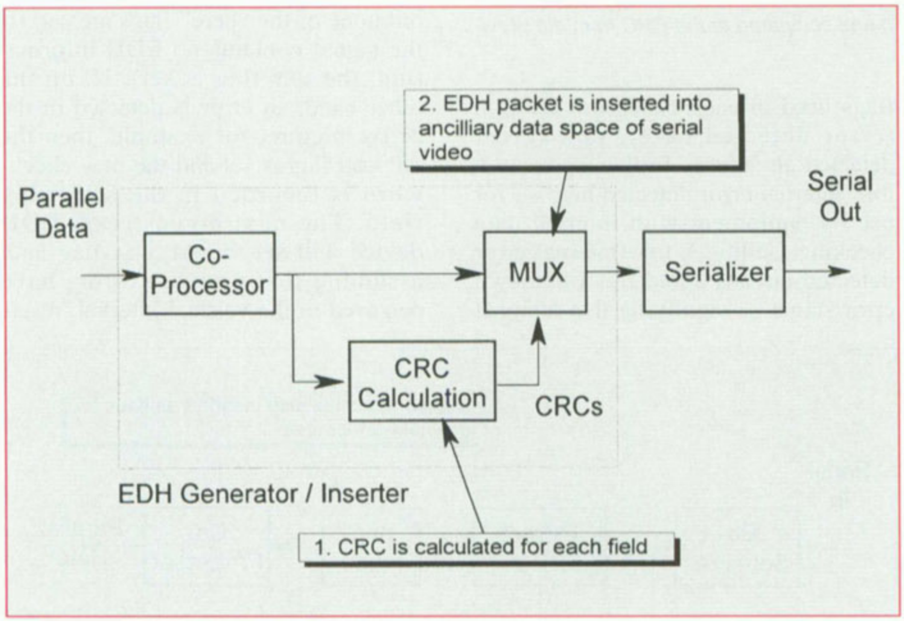

Figure 3. EDH insertion at the output of a serial digital device.

The Mysteries Of EDH

The principle of EDH is based on techniques similar to those used in digital communications. An EDH transmitter is located in front of the path under test and an EDH receiver is located at the end of the path (Fig. 2). The first EDH device "counts" the digital picture "bits" in each picture field and then inserts this information as ancillary data in the blanking interval at the beginning of the following field. The complete signal, together with the inserted integrity checking data, is then passed on through the transmission path. The second EDH device, located downstream, can repeat the same calculations to count the bits in the field and compare the result with the ancillary data contained in the signal. If the two numbers do not agree, then one or more errors have been detected. Counting the bits in the field results in what is known as a checkword. It is calculated using the CRC-CCITT polynomial generation method (cyclic redundancy code).

In communications, the goal is to faithfully reproduce the original signal without any modifications, and a simple CRC checksum can be used with a high degree of reliability to spot any errors. Unfortunately, in television, someone always seems to want to change the picture. Sometimes a producer wants to add a logo or message, and sometimes an engineer wants to add or delete vertical interval test signal (VITS). When this happens, how does the EDH device distinguish an error from a desired picture change? Well, maybe it can't, but it can raise a flag to tell the operator that there has been a change, and it can tell you if the change is in the active picture or in the blanking interval. It can also let you know if an error occurred in the last link in the chain or further upstream in the transmission path. There are other things that the EDH device can tell you and we will look at each of these things in turn — but before we get to that, what is an EDH device anyway?

EDH Insertion

Figure 3 illustrates EDH insertion at the output of a serial digital device. The parallel data is passed through a coprocessor that counts field by field and generates a CRC per field. The CRCs are "muxed," or multiplexed, into the parallel data, and then the parallel signal is serialized and transmitted down the coaxial cable to the next device.

EDH Receiving

The serial signal is received at the input of the next serial digital device. The signal is deserialized into parallel data and the CRC from the previous device is extracted. A new CRC is calculated and compared to the CRC from the previous device (Fig. 4). If the comparison fails, then an error is found, and these discrepancies are inserted as flags in the outgoing parallel data. These discrepancies can be reported to the user at this point, as well (Fig. 5).

EDH Equipment

To provide a means for checking the integrity of the serial digital trans-

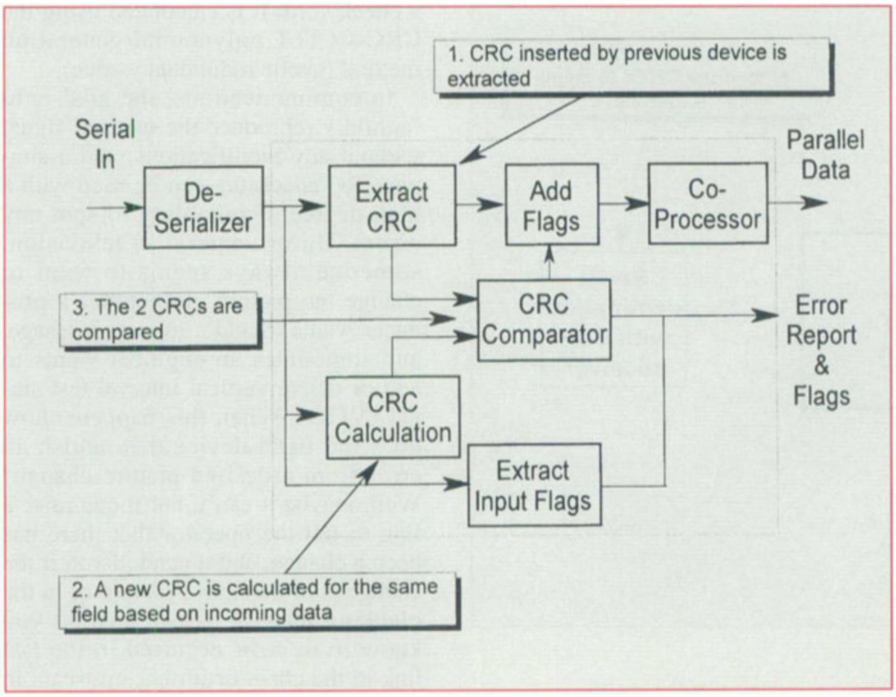

Figure 4. EDH receiving; a new CRC is calculated and compared to the CRC from the previous device.

mission path, SMPTE has issued a proposal for manufacturers to incorporate EDH circuitry in their serial transmitters and receivers to generate and detect checkwords aimed at identifying errors in the digital bit stream. It has been left to the manufacturers to determine the best ways to handle the reporting of the errors. Some new products have already emerged offering EDH signal insertion and detection capabilities. It is anticipated that, as new integrated circuits become available, EDH techniques may be applied to the inputs and outputs of most signal-processing equipment.

Full Field or Active Picture

EDH examines three areas of the picture and CRCs are calculated for the full field (FF) and active picture (AP) areas (Fig. 6). A checksum is also made for the ancillary data and is called ANC. The ancillary data region is where audio and other information is muxed into the digital video signal in the blanking intervals. (This will be discussed further in the next tutorial.)

For each of these three areas, the SMPTE document provides for the optional use of five different flags to provide system engineers with 15 different pieces of information. The five flags used in each checksum are EDH (error detected here), EDA (error detected already — further upstream), IDH (internal error detected here — for use by equipment with internal data checking facilities), IDA (internal error detected already), and UES (unknown error status — signifying that a signal was received from a device not offering EDH facilities).

FF is a CRC calculated for an entire field of the video signal, including the horizontal and vertical blanking intervals. AP is a CRC calculated in the active picture and does not include blanking. Errors in this region are considered more severe because they are visible in the video signal. ANC is a checksum calculated for any ancillary information in the digital video signal. Errors in the active picture will cause flags to be raised for both the FF and AP regions. Errors in the blanking intervals but not the ancillary data regions will cause flags to be raised for the FF region. Errors in the ancillary data will cause flags to be raised in the ANC and FF regions.

If an EDH device receives a clean signal with EDH information and no errors, the check-words are entered as ancillary data on the following field but none of the "here" flags are set. (If the signal contains no EDH information, the UES flag is set). If, on the other hand, an error is detected in the active picture, for example, then the AP EDH flag is set and the new checkword is recorded in the following field. The next downstream EDH device will set the AP EDA flag and, assuming that no more errors have occurred in the vertical interval, resets

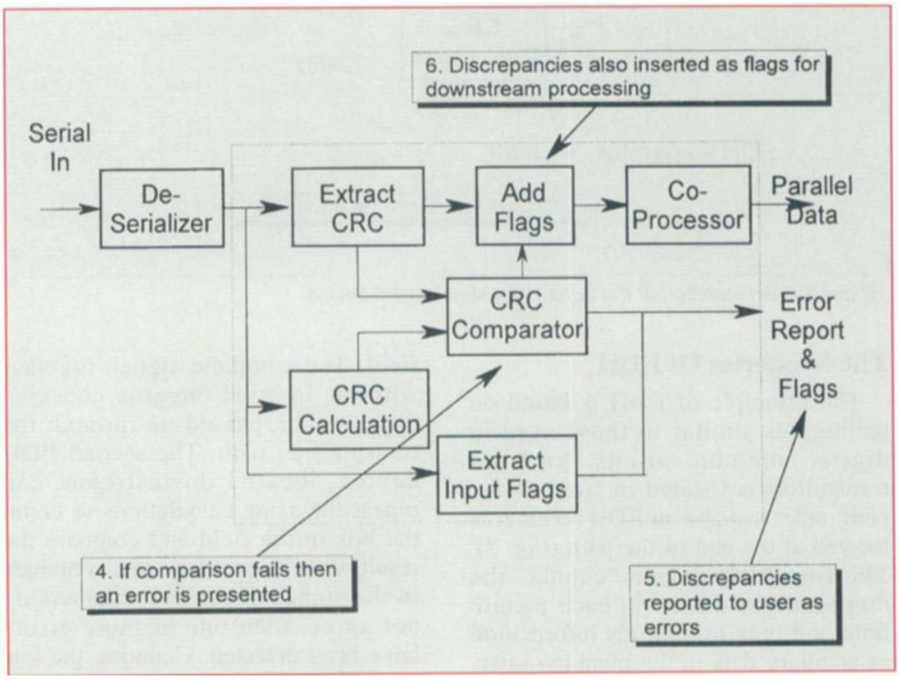

Figure 5. EDH receiving; discrepancies can be reported at this point.

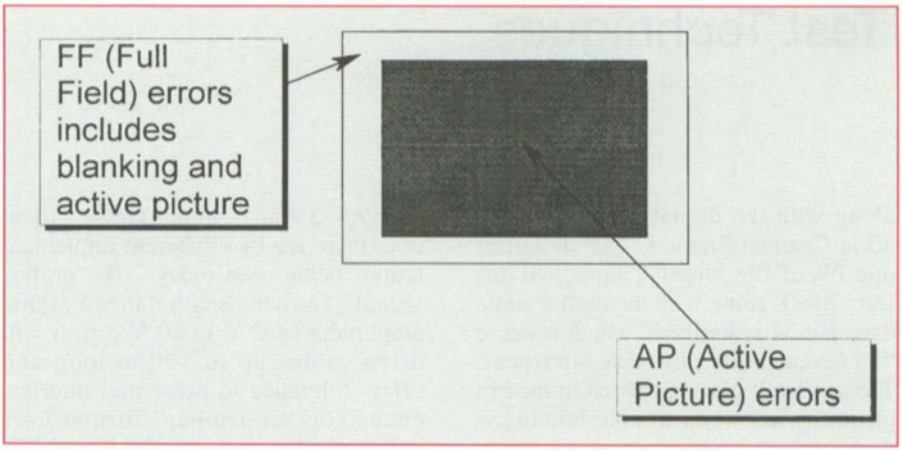

Figure 6. Full field and active picture errors.

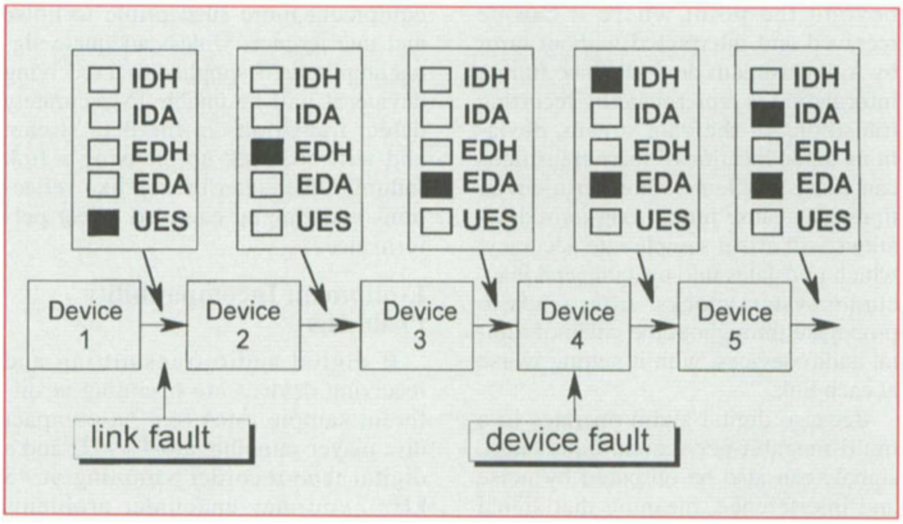

Figure 7. EDH example.

the AP EDH flag back to zero. A monitor at this point will know that there were no errors in this chain but that an error did occur in the vertical interval further upstream. The EDA flag is never reset until the error is corrected. The engineer can therefore quickly check the entire system by simply looking for the presence of an EDA flag at the end of the chain.

How It Works

Let's look at an example to get a clearer understanding of how EDH works. Figure 7 shows a hypothetical chain of five devices. In this example, we will assume that all devices are EDH-equipped. Let us consider just the FF CRC, and we will see how all five flags (EDH, EDA, IDH, IDA, and UES) will come into play.

The signal at the input to Device 1 does not carry any EDH information, so this first device raises the "Unknown Error Status" (UES) flag. At the same time a CRC calculation is made and the result is written into the ancillary data region of the signal. At the end of the first link, Device 2 detects the EDH information and may reset the UES flag, although no standard is set at this time. If no errors are detected (by analyzing the CRC information), the signal will leave Device 2 with no flags set. But let's assume that some small bit errors did occur, and that this causes Device 2 to set the outgoing "Error Detected Here" (EDH) flag. The signal (complete with new CRC information) is then passed on to Device 3. If no further errors occur in this stage, Device 3 will reset the EDH flag but raise the EDA flag to advise that "Errors (were) Detected Already" further upstream. Let's suppose that the third link is quite clean but that Device 4 detects an internal failure. The output EDH circuitry of Device 4 will leave the EDA flag set and will also set the IDH, "Internal (error) Detected Here" flag. Assuming that no further link or equipment errors occur, Device 5 will reset the IDH flag and set the IDA, "Internal (error) Detected Already" flag. At the output of Device 5, the signal will be carrying both the EDA and IDA flags. One must locate and correct both the link problem between Devices 1 and 2 and the equipment fault in Device 5.

There are some interesting analogies to be made between the analog and digital video transmission paths. In both cases, in a near-perfect world, we would need to monitor the signal only immediately prior to the transmitter. We would be quite satisfied if the analog waveform looked perfect and if the digital signal contained no EDA or IDA information. But life being the way it is, the chances are that there will from time to time be aberrations and we have to be able to determine where they originate. To achieve this in analog video, waveform monitors must be installed at strategic locations throughout the installation, but in the digital world (and here lies another distinct digital advantage) all EDH-equipped devices can be coupled to a computer network, so that all errors may be monitored from a single central monitoring station. And this station can be a standard PC with appropriate software and network interface card. Convenience indeed!

Conclusion

The implementation of EDH technology provides a comprehensive method of monitoring the performance of the serial digital transmission path. Each piece of equipment will monitor the quality of the preceding signal path at the same time as it studies its own performance with respect to signal quality. Monitoring for a complete television installation may be carried out from a central location. EDH monitoring equipment can be expected to become the digital equivalent of the vectorscopes and waveform monitors of the analog television age.