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Real-Time Bit Error Rate Analysis at Parallel Interfaces (UTOPIA) with the HP E4829B

How to use the HP E4829B custom / UTOPIA Level 1 implementation for real-time bit error rate (BER) measurements

Product Note

Product Number
HP E482xA/B, E4889A

Figure 1: HP E4829B integrated into the BSTS system

Introduction

One requirement for achieving quality of service in an ATM system is a reasonable robustness against data interference. When data interference occurs, the quality of data (video and audio) sent to a user decreases. The designer's goal is to make the complex ATM system robust enough to withstand the large number of interference mechanisms. This process starts at the component level (physical layer device), applies to sub-modules, and finally the whole system must be characterized.

The HP E4829B test system can log and extract pseudo random data (PRBS) into and from the payload of ATM cells. This is carried out at parallel interfaces. Standing alone, it can measure from parallel to parallel (UTOPIA) ports, although when it is combined with an HP E4200/E4210 BSTS system, it is possible to measure from serial to parallel ports and vice-versa (see figures 2 to 4).

For hardware and software engineers in the communications industry, designing ICs, modules, or working in system integration, the HP E4829B parallel cell / traffic generator and analyzer, which offers real-time bit error rate (BER) analysis, is the basic tool for debug and characterization at parallel interfaces (UTOPIA).

When a BSTS is already being used, the HP E4829B is the complementary product to the protocol test equipment in use. Figure 1 depicts the HP E4829B as an integral part of a broadband series test system.

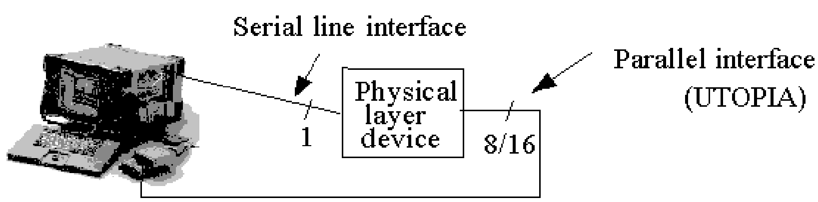

Figure 2: Test setup for a physical layer test with the HP E4829B and BSTS

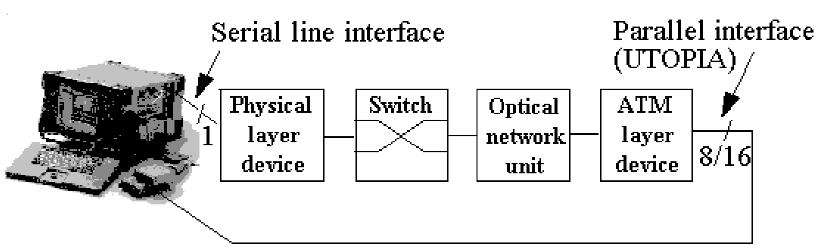

Figure 3: Test setup for an ATM system test with the HP E4829B and BSTS

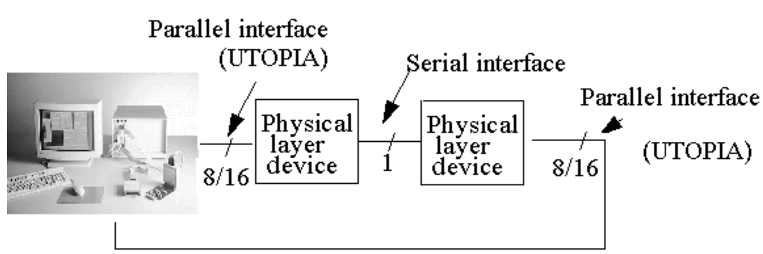

Figure 4: Test setup for a physical layer test with the HP E4829B from a parallel to parallel interface

Application

Component test

Typical devices are ICs, designed for use at the physical layer. These ICs provide one or more connections for serial ports on one side, and a parallel port (UTOPIA) on the other side.

Problems may occur with the high speed of the serial ports and analog design parts, such as PLLs.

The BER test (see figure 2) is used as the primary tool for the characterization and verification of the design, not only by designers of the IC, but also by module designers using this IC on their PC-board.

Module test

Figure 4 shows an example of a test setup for a transmission system, with the active components functioning as the transmitter and the receiver.

Potential problems are interference affecting electrical transmission systems and power loss in optical systems.

The advantage of measuring the BER from parallel to parallel ports is that the performance is characterized as a whole, and there is therefore no longer a need for a substitution method.

System test

The setup shown in Figure 3 is taken from the residential broadband application, better known as video on demand. The serial port is situated at the connection to the central video server; the parallel port is in the settop box of an end user. The system integrator's responsibility

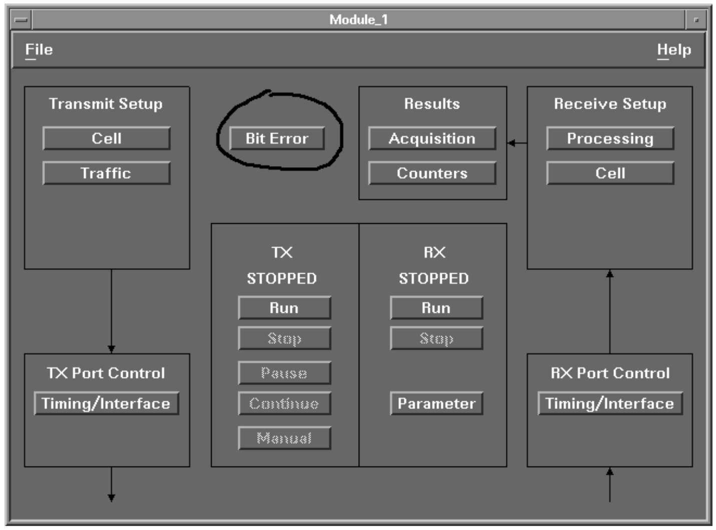

Figure 5: Main menu of the HP E4829B with a bit error rate measurement capability

is to guarantee a BER to be below a certain level, in order to achieve the desired quality of service. The measurement of the overall system is very similar to that of a physical layer IC.

How to use

Cell definition

PRBS is a segment to be selected when the cell structure is defined. Segment length can be from one byte/word up to the full length of the cell. There could also be more than one PRBS segment per cell.

In an ATM cell, the payload will be defined as PRBS, as indicated in Figure 6, and it is possible to choose from three different polynomials.

The definition of cells on the transmitter and receiver is identical. On the transmitter, the definition is used for the PRBS generator to fill the bytes/words with PRBS bits. On the receiver, it defines the bytes/words which will be used for the comparison and

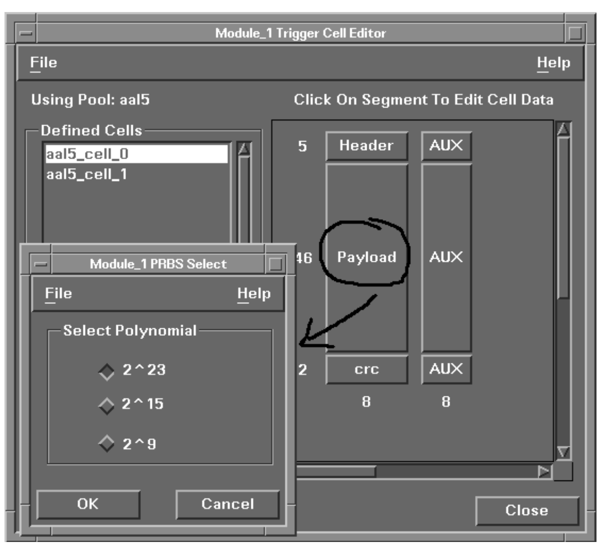

Figure 6: Cell editor of the HP E4829B with PRBS selection

calculation of the BER figure. The trigger cell can also be used to specify other parameters and to carry out the BER measurement only on certain cells (e.g. matching cells for a dedicated VPI/VCI) within the incoming cell stream.

Analysis

The processing capabilities of the HP E4829B provide a new feature, known as “detect bit errors”, which must be selected in order to carry out a BER measurement.

Results

With the BER measurement capability, an assigned result window is available. This is opened using the “bit error” button in the main menu (see figure 5). When clicking on this button, the BER result window will appear (see figure 7). This window is similar to the existing real-time counter display window, and the four additional counters are already assigned for the BER results. This result window is updated in user-defined measurement intervals after the receiver is started.

There is an additional, simplified window available, which is appropriate for long-term mesurements. Provided that the BER figure is below the user-defined threshold, cumulative figures for the time since the last synchronization and the BER are shown. The user can therefore see at a glance the success of his long-term measurement.

Background

The industry has established a measurement unit for characterizing the quality of data transmission, known as the bit error rate (BER).

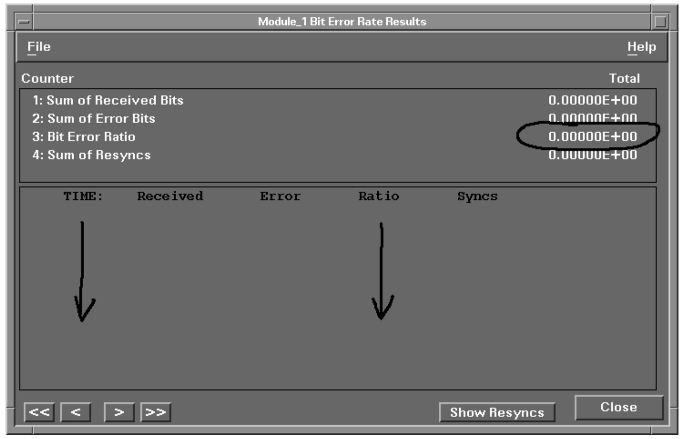

Figure 7: BER result window

This figure calculates the ratio of errored bits versus all bits transferred.

BER measurements have been used for many years in the industry, but until now, this measurement has been performed by inputting a continuous sequence of pseudo random data (PRBS) into one serial port and analyzing it at a second serial port.

The requirements for the characteristics of BER measurements must be adhered to in order to ensure compatibility between equipment produced by different manufacturers. The BER of digital transmission systems must be evaluated by the direct comparison of a pseudo random test pattern with an identical, locally generated test pattern. In addition, the ability to measure faulty time intervals is essential. The technical background and requirements are documented in ITU-T recommendations [1] and [2].

These recommendations define an error ratio measurement range from 10^{-3} to 10^{-13}. The measurement of faulty seconds and other faulty or error-free time intervals should be carried out in a defined period of time ranging from one minute to 24 hours, or continuously.

Therefore, manufacturers providing customer equipment for ATM networks must ensure that their equipment complies with international standards, as the BER is included in the pseudo standards.

Implementation

BER testing can be performed on the 8 and the 16 bit solutions of the HP E4829B.

To operate the BER application, the HP E4829B includes the following features with software revision A.1.3.0.

Enhanced PRBS segment

One of the following polynomials can be selected:

• 2^9-1, (ITU-T O.153),
• 2^{15}-1, inverse (ITU-T O.151),
• 2^{23}-1, inverse (ITU-T O.151).
This provides full compatibility with the BSTS system.

BER analysis

The receiver can generate the same polynomial for comparison with the incoming data stream, and it also provides synchronization with the incoming data before the measurement starts. This is known as the “sync” phase; for more details, see the section entitled “Theory of operation”. The advantage is that the receiver can perform a measurement starting at any point in the PRBS sequence; that is, there is no need to place the transmitter at the beginning for every single measurement.

Results

- number of received bits,
- number of errored bits,
- calculate the BER of both,
- selectable or cumulative time interval.

These results are gathered by additional counters so that all the other functions can keep on operating normally.

If the device-under-test loses synchronization or the data becomes corrupted, the error rate will increase beyond a customer-programmable threshold. This forces the system to resynchronize itself. The synchronization status is displayed in the result window.

Parameters

- polynomial.
- can be selected independently for the transmitter and the receiver (the selection at the receiver must match the polynomial of incoming data).
- measurement interval: multiples of 10 ms. This defines the update time for the result display. Internally, the results will still be polled every 10 ms and sent to a queue.
- sync threshold: if the BER figure exceeds the user-defined threshold within a measurement interval, the system will automatically perform a new synchronization. The calculation of the BER figure will start from the beginning.

Results per measurement interval

- indication of sync status: sync, out of sync or re-sync.
- number of received bits / measurement interval, polled and displayed ongoing, as in the counter display.
- number of errored bits / measurement interval, polled and displayed ongoing, as in the counter display.
- bit error ratio / measurement interval, calculated by dividing the number of errored bits by the number of received bits.

Cumulated results

The following results are all valid since the previous re-sync:
- total number of received bits,
- total number of errored bits,
- actual bit error ratio,
- number of necessary re-synchronizations since the measurement was started.

Theory of operation

Transmitter

PRBS segments are filled with bits from the PRBS generator according to the selected polynomial. Whenever the bit stream of PRBS segments of consecutive cells is re-assembled, a true PRBS sequence is obtained. The PRBS is looped infinitely, provided that the PRBS segments still have to be filled and the transmitter is not stopped. From each start of the transmitter, the PRBS sequence is the same, providing that the same polynomial is used. The segmentation of the PRBS is fixed to byte/word boundaries.

When cells with a PRBS segment are generated with different VPI/VCI settings or with different ports in a UTOPIA Level 2 environment, the re-assembled bits gathered at a certain port are no longer a true PRBS sequence. If only certain parts of the original PRBS stream are re-assembled, this is not a true PRBS sequence by nature; the segments sent to other ports are missing in that re-assembly. Therefore, it is recommended that the PRBS segment is only used in cells assigned to the port at which the BER measurement is required.

Receiver/analyzer

The definition of the PRBS segment in the trigger cell indicates to the receiver which bits to extract from the incoming cells for BER analysis. Before a measurement starts, the analyzer will synchronize the extracted PRBS bit stream; see figure 8.

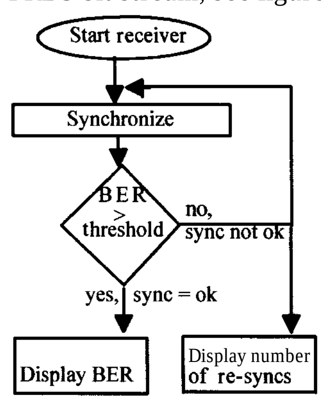

Figure 8: Synchronization process

For synchronization, the receiver will need 16 bytes/words. After synchronization, the receiver generates the bits according to the PRBS sequence for comparison with the additional bits extracted from the incoming cells. In each time interval (10ms), the number of extracted incoming bits and errored bits is counted, and the figure for the BER is calculated and compared with the user-defined threshold. If the BER exceeds the defined threshold, the system will synchronize again in the next interval; otherwise, the measurement will start or continue. A minimum BER of 10^{-2} to 10^{-3} of the device-under-test must be achieved in order to perform a measurement.

References

[1] ITU-T Recommendation O.151, Specification for instruments to measure error performance on digital systems, Red Book Volume IV.

[2] ITU-T Recommendation O.153, Basic parameters for the measurement of error performance at bit rates below the primary rate.

Related HP literature

- UTOPIA Level 2 support, product note, p/n 5965-4856E.
- cell transfer time variation measurement using the parallel cell / traffic generator and analyzer, product note, p/n 5965-5297E.

For more information:
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