



Products: Test Broadcast System R&S® SFU

Measuring Bit Error Rate using the R&S® SFU-K60 Option

Application Note

The measurement of bit error rate (BER) is an important test procedure for determining the performance of a receiving terminal. This is especially important for set top box and chipset manufacturers who need to know if their product is able to meet the specification under a predefined noise condition. This Application Note describes the technique using an Rohde & Schwarz SFU to measure the BER of digital set top boxes.



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1 Overview

Measuring the BER of a set top box requires a test instrument to inject a predefined test signal, such as a PRBS, and comparing the output signal from the set top box with that test signal. The output signal may be extracted at any point in the signal flow of the set top box. In order to capture the real effects of the noise on the transmission data, the module responsible for forward error correction (FEC) is disabled. Otherwise, all bit errors are either fully corrected or reduced. This is usually carried out by the Reed Solomon encoder/decoder. In most cases, the signal is extracted before or after the Reed Solomon(RS) decoder. If the signal is taken after the RS decoder, the decoder is disabled so that errors under measurement in the signal is not corrected.

Below drawing shows the basic principle of BER measurement.

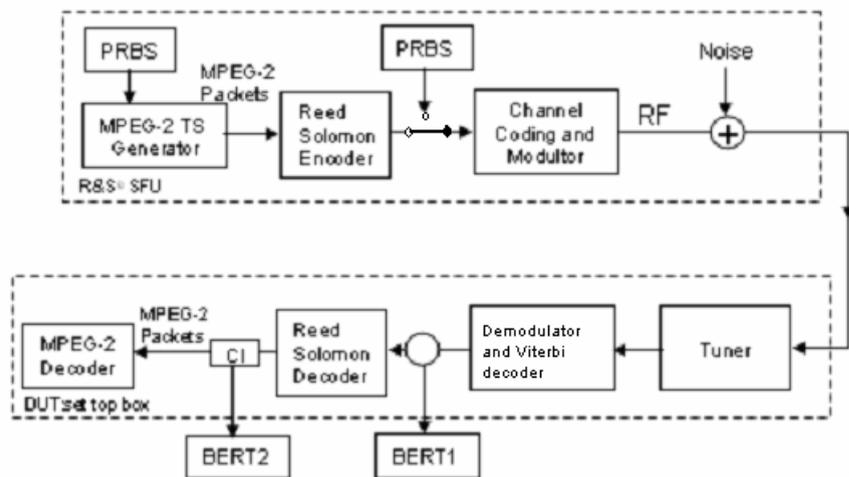


Figure 1 The basic principles of BER measurement on set top boxes. Legend: CI=Common Interface, PRBS=Pseudo-Random Binary Sequence.

Here the R&S[®] SFU can inject a PRBS stream or a stream of MPEG-2[1] packets containing a predefined payload. The BER tester (BERT) can pick up the output signal from the set top box

at 2 locations (BERT1, BERT2). BERT2 will capture the MPEG-2 packets after the RS decoder and BERT1 will extract the PRBS stream before the RS decoder.

The output signal captured by BERT1 will be compared with the PRBS signal that was injected in the R&S® SFU just after the RS encoder. On the other hand, the output signal captured by BERT2 will be compared with the MPEG-2 packets that were injected in the R&S® SFU just before the RS encoder.

The choice of the 2 BER tests is left to the user to decide.

In Digital Video Broadcasting (DVB), a BER of 2×10^{-4} before the RS decoder is specified that will produce a quasi-error free (QEF) reception at the receiver. The basic idea is to add noise, preferably AWGN (requires R&S® SFU-K40 installed in the R&S® SFU), and measure the BER at different noise levels (C/N settings on the noise generator). Thus, by comparing the output signal in the receiver just before the RS decoder with the transmitted signal, it is possible to obtain a set of deviation data to determine the equivalent noise degradation (END), which is an important receiver parameter[2].

This application note introduces the measurement option of BER using the R&S SFU Broadcast Test System which is capable of generating a set of standard test pattern sequence.

2 Measuring the BER

The aim of the R&S® SFU-K60 Option is to provide a convenient way to measure the BER performance of a digital receiving terminal. The R&S® SFU BER application is conveniently located on the front panel display and Figure 2 shows the BER window.

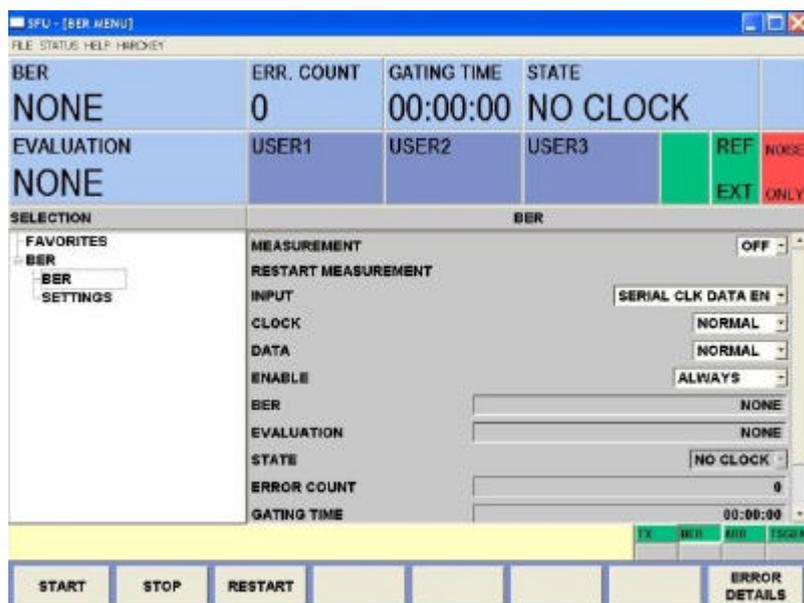


Figure 2 The BER window of the R&S® SFU

This option is completely independent from other applications such as Transmitter TX and TS Player/Recorder, which means that it can use as an independent BERT. It can be integrated with the other options such as noise and fading to provide a realistic test environment.

The selection of items in this BER window is shown in Table 1.

| Menu Item | Value | Remarks |
|-------------|--|---|
| MEASUREMENT | ON/OFF | To turn on/off BER measurement |
| INPUT | SERIAL CLK DATA EN ASI FRONT ASI REAR SPI FRONT SPI REAR | The location of the connection on the R&S SFU. The signal coming from the DUT is connected to this. |
| CLOCK | NORMAL INVERTED | Depending on the measured DUT |
| DATA | NORMAL INVERTED | Depending on the measured DUT |
| ENABLE | ALWAYS ACTIVE HIGH ACTIVE LOW | Depending on the measured DUT |
| BER | e.g. 0.00E-7 | Display of the measured bit error rate |
| EVALUATION | e.g. 6.3E9 / 1E10 | Estimated accuracy |
| STATE | SYNC | BER measurement is synchronized to the PRBS |
| ERROR COUNT | e.g. 20 | Total number of bit errors detected |
| GATING TIME | e.g. 00:15:30 | Running time of the measurement (hh:mm:ss) |
| GATING MODE | INFINITE/AUTOMATIC | Set the mode of measurement |

Table 1 The menu items of the BER measurement on the R&S® SFU. Please refer to the R&S® SFU Manual for more details.

In Table 1, a unique feature of R&S® SFU-K60 which is worth mentioning is the gating mode. For any BER measurement, the longer the measurement (gating) time, the better the confidence level of the BER reading. At low error rate, if the gating time is set too short, fewer bit errors will be caught and this gives rise to a sub-optimal reading. If you are unsure of the BER of the channel, you can set "AUTOMATIC" for this option which automatically allows a sufficient amount of gating time for errors to be captured. Hence, the gating time for a lower error rate will be longer so that an adequate number of errors can be captured and vice-versa. The gating time is calculated based on the reception of 1000 bit errors and the data rate. This feature will

ensure a more accurate reading irrespective of the noise condition.

There are 2 general test streams that are generated by the R&S® SFU for the BER measurement.

2.1 Serial stream measurements

The basic serial BER stream can be a PRBS, all ones or all zeros. The PRBS which is in compliance with ITU-T O.151 is based on the generator polynomial, $2^{23}-1$ or $2^{15}-1$. Figure 2 shows the menu on which the payload of the test stream can be selected. When the input is selected as “SERIAL CLK DATA EN”, the test signal is a continuous stream of pure PRBS without any framing structure. The clock and enable signal is taken from the DUT.

Figure 4 shows the physical connection for this serial test stream. Apart from the CLK, EN and DATA connectors, the “BER ERR OUT” interface will output a positive pulse for every detected bit error.



Figure 4 The interface at the rear of the R&S® SFU for sending the serial PRBS stream

2.2 MPEG-2 TS measurements

The second test signal is based on the MPEG-2 Transport Stream standard[1]. It is framed in a 188-byte packet structure. This test signal is selected when the input is selected as “ASI FRONT”, “ASI REAR”, “SPI FRONT” or “SPI REAR”. The ASI

interface is a 50-ohm female BNC connector and the SPI is a 25-pin parallel connector. Figure 5 shows the location of these interfaces on the R&S® SFU.

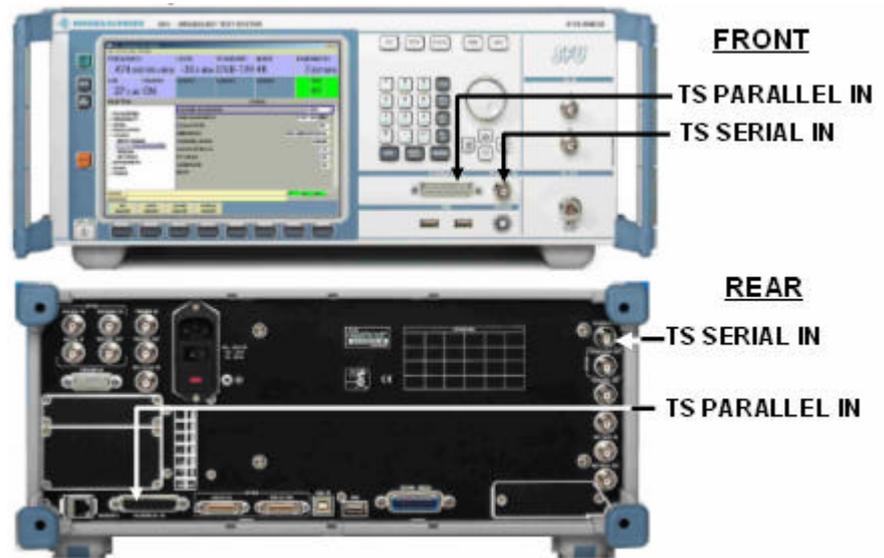


Figure 5 The physical interfaces of the BER input for MPEG-2 packets

With this interface, a user can select any of the following 3 types of test packets to generate.

The first type is a 188-byte packet with the first 4 byte set to a real TS header. The remaining 184 bytes contain the payload.

The second type is a 188-byte packet with the first byte set to 0x47(hex). The remaining 187 bytes contain the payload.

The last type is a 188-byte packet with a proper 4-byte TS header but the PID is 0x1FFF. This is the so-called null packets.

To summaries, Table 2 shows the 3 types of packets streams available for the MPEG-2 TS input. Note that with this test option, the payload may be PRBS, all zero's or all one's.

| Selection | Remarks |
|---------------------|--------------------------------|
| HEAD 184 PAYLOAD | <p>PID is not evaluated</p> |
| SYNC 187 PAYLOAD | <p>PID is not used</p> |
| STUFFING PACKET | <p>PID 0x1FFF is evaluated</p> |

Table 2 The 3 type of MPEG-2 TS based packets
 The “STUFFING PACKET” can be used when there are other live MPEG-2 TS streams in the signal. However, a note of caution is that if any bit in the PID field of the monitored transport packet is corrupted by noise, the packet will not be evaluated. This will result in an inaccurate BER measurement.

If PRBS is used in MPEG-2 packets test, the sequence will be broken into equal segments and filled into the MPEG-2 packets as payloads before sending out of the R&S® SFU. When the packets is processed at the return path back to the instrument , the PRBS stream will be re-assembled and the associated built-in PRBS counter will pause during the gaps between each packet. Nevertheless, the BER is calculated and displayed real-time on the BER window.

The type of packets chosen will depend on the test application of the DUT. Figure 6 shows the types of BER test signals that are generated by an R&S® SFU-K60 option.

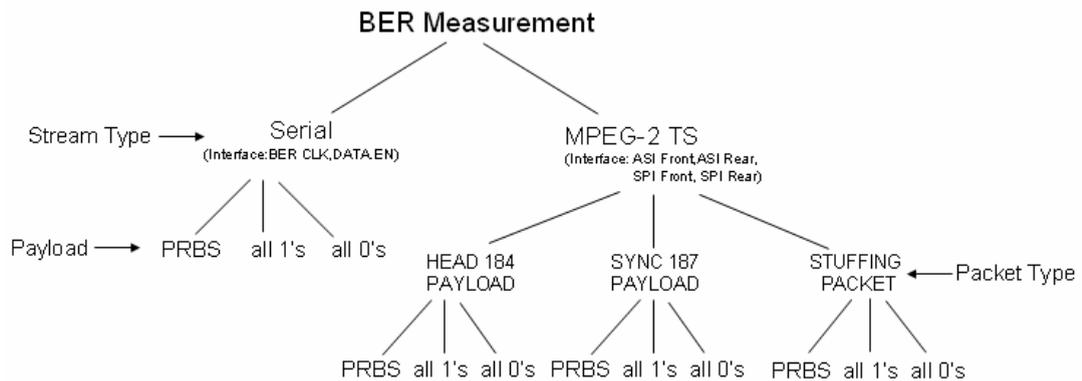


Figure 6 Types of BER test signals available in R&S® SFU-K60 option

3 Measurement Setup

Before a BER measurement is carried out, it is advisable to know the objective of the test. This will help to determine the type of packets (e.g. serial stream or MPEG-2 TS) to use in the test as well as the selected interface on the R&S® SFU. Once this is known, connect all the required cabling between the instrument and the DUT.

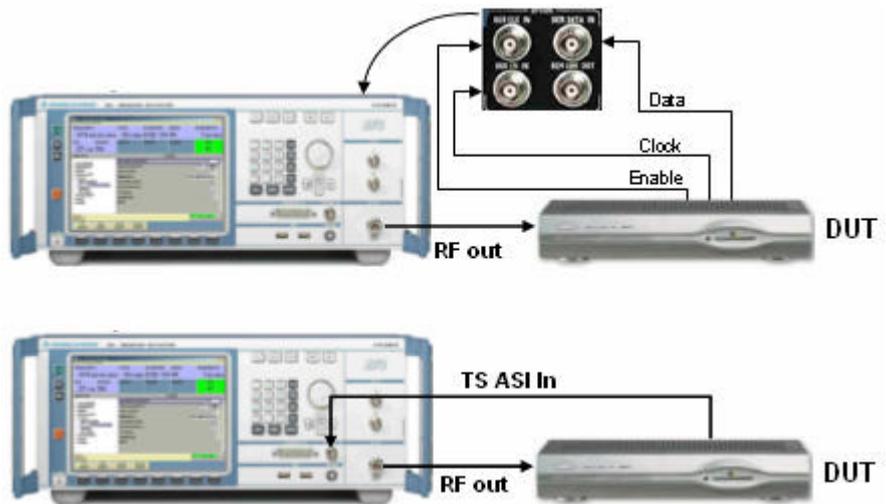


Figure 7 The connection between the R&S® SFU and the DUT. (Top) Performing a serial BER test (Bottom) Performing a MPEG-2 TS BER test

Before starting the test, it is a good practice to do a pre-test as follows:

1. Switch off the noise (requires R&S® SFU-K40 installed in the R&S® SFU) and fading (requires R&S® SFU-B30 installed in the R&S® SFU).
2. Do a BER measurement after RS with Reed Solomon ON. The result should be 0 if everything is working well.



Figure 7 The Reed Solomon encoder on the R&S® SFU can be enabled/disabled.

3. Do a BER measurement before RS with Reed Solomon OFF. The result should also be 0.

- Switch on the noise and fading (as required in your test) to see the effect on the BER reading. Figure 8 shows the BER reading on the BER window.

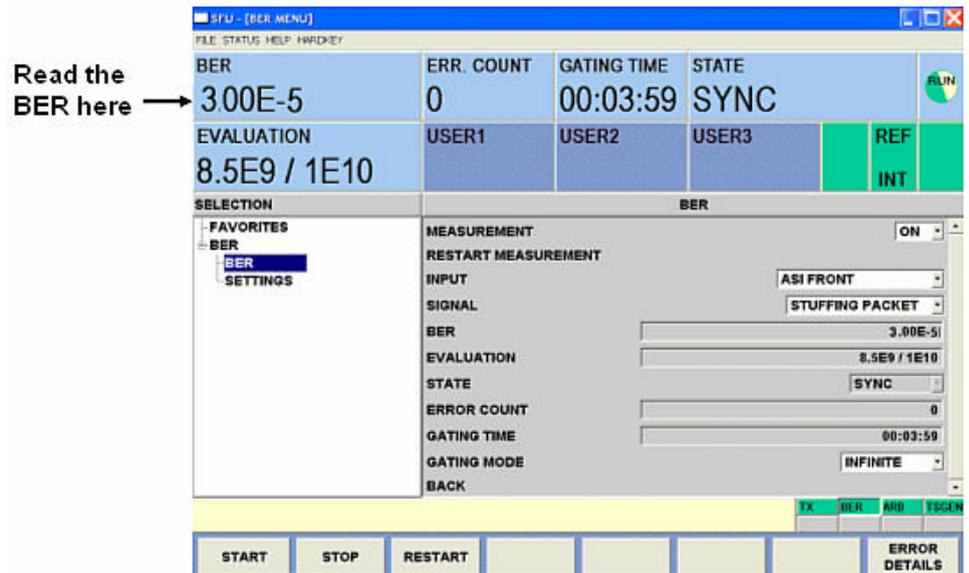


Figure 8 The real-time BER reading is displayed on the top left corner of the BER window

With this initial procedure done, proceed to change the C/N of the noise in steps or change the fading conditions in the channel simulator, depending on your test requirements and note the real-time BER reading.

4 Special Cases

There are many new digital transmission standards in the field of broadcasting.

Currently, the BER measurement option described in this application note is not available for DVB-S2[3] and DIRECTV[4] due to the measurement methods used in the R&S® SFU. In these 2 types of services, it is not possible at the current version (FW Version 1.30) to insert PRBS at the described points. Also in DIRECTV, the packets are based on a frame size of 130 bytes and does not work with an MPEG-2 format of 188 bytes.

5 Summary

The R&S® SFU-K60 Option offers great ease and flexibility for a communications engineer to assess the quality of digital transmission methods and the components involved. The combined features of an R&S® SFU to provide a built-in TS generator, noise generator and an RF output offer a set top box vendor the ease of testing his products in a short time.

6 References

[1] ISO/IEC 13818-1: "Information technology – Generic coding of moving pictures and associated audio information"

[2] Franz-Josef Zimmermann: Bit-error-rate measurement on set-top boxes, News from Rohde and Schwarz, Number 167 (2000)

[3] ETSI EN 302 307 V1.1.1, Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)

[4] See www.directv.com

7 Additional Information

Our Application Notes are regularly revised and updated. Check for any changes at <http://www.rohde-schwarz.com>.

Please send any comments or suggestions about this Application Note to: Broadcasting-TM-Applications@rohde-schwarz.com.

7 Ordering Information

| Type | Designation | Order no. |
|--------------|--|-----------------|
| R&S SFU | Broadcast Test System | 2110.2500.02 |
| R&S SFU-B1 | Coder Extension 1 | 2110.7424.02 |
| R&S SFU-B10 | Coder Extension 10 | 2110.7747.02 |
| R&S SFU-B11 | ETI Input/Output | 2110.7553.03 |
| R&S SFU-B2 | Coder Extension 2 | 2110.8089.02 |
| R&S SFU-B3 | Memory Extension 1 | 2110.7447.02 |
| R&S SFU-B30 | Fading Simulator | 2110.7530.02 |
| R&S SFU-B31 | Fading Simulator Extension to 40 Paths | 2110.7547.02 |
| R&S SFU-B4 | Memory Extension 2 | 2110.7453.02 |
| R&S SFU-B5 | User I/O | 2110.7480.02 |
| R&S SFU-B6 | Additional Hard Disk | 2110.7501.02.03 |
| R&S SFU-B90 | High Power and Overvoltage Protection | 2110.8008.02 |
| R&S SFU-K1 | DVB-T/H Coder | 2110.7301.02 |
| R&S SFU-K10 | MediaFLD Coder | 2110.7524.02 |
| R&S SFU-K108 | AMC Coder | only on request |
| R&S SFU-K11 | T-DMB/DAB Coder | 2110.7518.02 |
| R&S SFU-K120 | DMB-TH Coder | 2110.7760.02 |
| R&S SFU-K190 | ATV Standard B/G Coder | 2110.8060.02 |
| R&S SFU-K191 | ATV Standard D/K Coder | 2110.8037.02 |
| R&S SFU-K192 | ATV Standard I | 2110.8043.02 |
| R&S SFU-K193 | ATV Standard MN Coder | 2110.8066.02 |
| R&S SFU-K194 | ATV Standard L Coder | 2110.8072.02 |
| R&S SFU-K199 | Multi ATV Predefined | 2110.8089.02 |
| R&S SFU-K2 | DVB-C Coder | 2110.7324.02 |
| R&S SFU-K20 | TS Generator | 2110.7476.02 |
| R&S SFU-K21 | TS Recorder | 2110.7482.02 |
| R&S SFU-K22 | TRP Player | 2110.7499.02 |
| R&S SFU-K221 | T-DMB/DAB Streams | 2110.4348.02 |
| R&S SFU-K23 | Video Generator | 2110.7799.02 |
| R&S SFU-K3 | DVB-S/DSNG Coder | 2110.7330.02 |
| R&S SFU-K30 | Enhanced Fading | 2110.7560.02 |
| R&S SFU-K32 | DAB Gaussian Fading | 2110.7630.02 |
| R&S SFU-K35 | ARB Generator | 2110.7601.02 |
| R&S SFU-K351 | T-DMB/DAB Waveforms | 2110.4277.02 |
| R&S SFU-K352 | DVB-H Waveforms | 2110.4425.02 |
| R&S SFU-K353 | DRM Waveforms | 2110.4654.02 |
| R&S SFU-K354 | DTV Interferers | 2110.4690.02 |
| R&S SFU-K4 | ATSC/8VSB Coder | 2110.7353.02 |
| R&S SFU-K42 | Impulsive Noise | 2110.7676.02 |
| R&S SFU-K43 | Multinoise Use | 2110.7682.02 |
| R&S SFU-K5 | J.83/B Coder | 2110.7380.02 |
| R&S SFU-K6 | ISDB-T Coder | 2110.7376.02 |
| R&S SFU-K60 | BER Measurements | 2110.7782.02 |
| R&S SFU-K7 | DMB-T Coder | 2110.7382.02 |
| R&S SFU-K8 | DVB-S2 Coder | 2110.7399.02 |
| R&S SFU-K80 | Extended I/Q | 2110.7953.02 |
| R&S SFU-K81 | Realtime Disabled | 2110.7960.02 |
| R&S SFU-K82 | Realtime Enabled | 2110.7976.02 |
| R&S SFU-K9 | DIRECTV | 2110.7401.02 |
| R&S SFU-U43 | Upgrade Kit for R&S SFU-K43 | 2110.7699.02 |
| R&S DV-DVBH | DVB-H Stream Library | 2085.8704.02 |
| R&S DV-H264 | H.264 Stream Library | 2085.7650.02 |
| R&S DV-HD TV | HD TV Sequences | 2085.7650.02 |
| R&S DV-ISDBT | ISDB-T Stream Library | 2085.9146.02 |
| R&S DV-TCM | Test Card M Streams | 2085.7708.02 |



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