Reducing measurement times by means of statistical BER measurements

State-of-the-art mobile radio testers can perform a multitude of measurements almost in realtime, making further reduction of measurement times by means of conventional methods nearly impossible. Measurement speed can be increased only by applying innovative methods, such as the statistical BER/BLER measurement which, due to its unconventional approach, opens up new dimensions in receiver measurements.

Special characteristics of receiver measurements

Testing the transmitter of a mobile phone takes considerably less time than testing the receiver; this is due the characteristics of the measurand involved. With transmitter measurements, it is basically the accuracy of the tester that determines measurement accuracy, whereas with receiver measurements, measurement duration is the determining factor. Bit error ratio (BER) or block error ratio (BLER) determines the receiver quality. Bit and block errors occur randomly as a function of time, which means that the accuracy of the measured error ratio increases the longer the measurement is performed (FIG 1). An exact determination of the actual error ratio would require that measurement be performed infinitely.

This can be demonstrated by means of a numerical example: If measurement is performed for one second at a transmission rate of 1000 bit/s, and two bit errors occur, the BER will be 0.2%. Had just one bit error less occurred, the BER would have been 0.1%. If, however, 200 bit errors are measured over a period of time of 100 seconds, the BER is also 0.2%. One bit error less, however, would in this case result in a BER of 0.199%. The influence of a single bit error on the overall result thus decreases with longer measurement times.

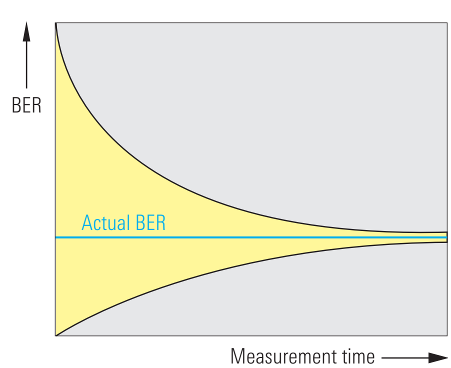


FIG 1
Measurement accuracy in relation to measurement time: the shorter the measurement time, the greater the deviation of the measurement results from the actual BER. The measurement results as a function of time are very likely to occur within the area marked in yellow.

The principle of statistical BER measurement

Statistical BER measurement does not determine the actual BER. Instead, it checks whether the receiver complies with a specified minimum quality. If the actual BER in FIG 1 is replaced by the defined limit value, and if the current BER value that is determined as a function of time is continuously checked, receiver quality can be rapidly assessed (FIG 2). As soon as the current measurement value is beyond the statistical variable bandwidth around the BER limit value, it is possible to ascertain with a certain statistical probability whether the receiver BER is better or worse than the limit value. FIG 2 also clearly shows that measurement time decreases the further the actual value departs from the limit value. This characteristic can also be used to reduce measurement time. If the receiver is developed in such a way that its BER is typically far better than the stipulated limit value, this measurement will usually be completed considerably faster in production.

In practice

The above rather simplified observations are, of course, not sufficient for implementing the statistical BER measurement in practice. If the complicated mathematical correlations behind the statistical BER measurement [*] are taken into account, the diagram in FIG 3 is obtained.

Compared to FIG 2, two substantial differences are evident: First, the pass and the fail lines intersect. If a receiver had a BER that corresponded exactly to the

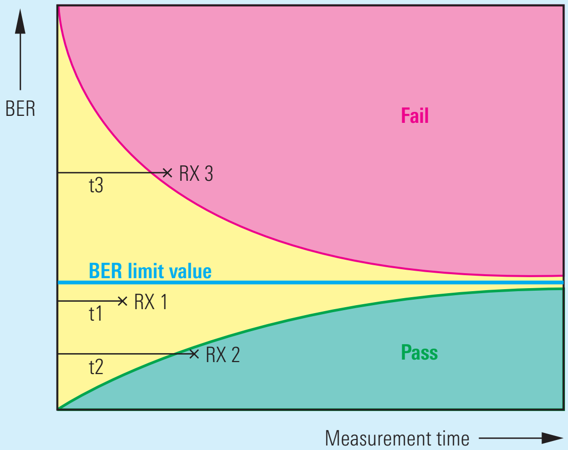


FIG 2
In the statistical BER measurement, the actual error ratio is continuously calculated and compared to the statistical result area (yellow) of the limit value. Receiver quality can be assessed once the measured value is outside the result area of the limit value. The figure shows the values of three different receivers (RX 1 to RX 3) at different measurement times (t1 to t3). In the case of RX 1 after t1, quality cannot yet be assessed because the associated measurement value is still within the result area of the limit value; measurement has to be continued. The value of the receiver RX 2 is already in the green pass area at t2. Measurement can be terminated because there is a high probability that the BER value of this receiver is better than the limit value. The value of RX 3, on the other hand, is in the red fail area at t3. This measurement can also be terminated because there is a very high probability that the BER value of this receiver is worse than the limit value.

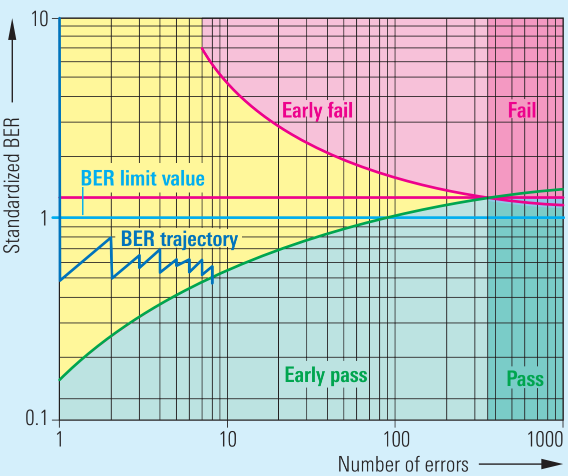


FIG 3
A time-independent evaluation diagram is used in practice. The BER standardized to the limit value is indicated vertically, and the bit and block errors are counted horizontally. The dark blue trace (BER trajectory) shows the evaluation process. As long as no new errors occur, the BER decreases constantly. If a new bit error occurs, the trace will extend by one error horizontally. At the same time, the BER deteriorates because of this error. This method is applied until the trace leaves the yellow area; measurement is then terminated and, depending on the location of the end point of the trace, the receiver BER – at a specified probability – is either better or worse than the limit value.

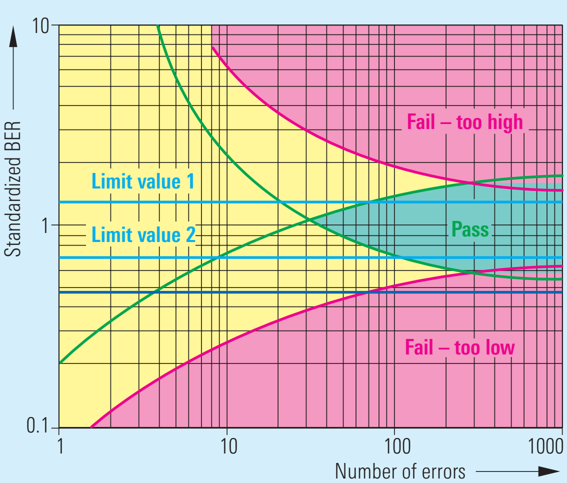


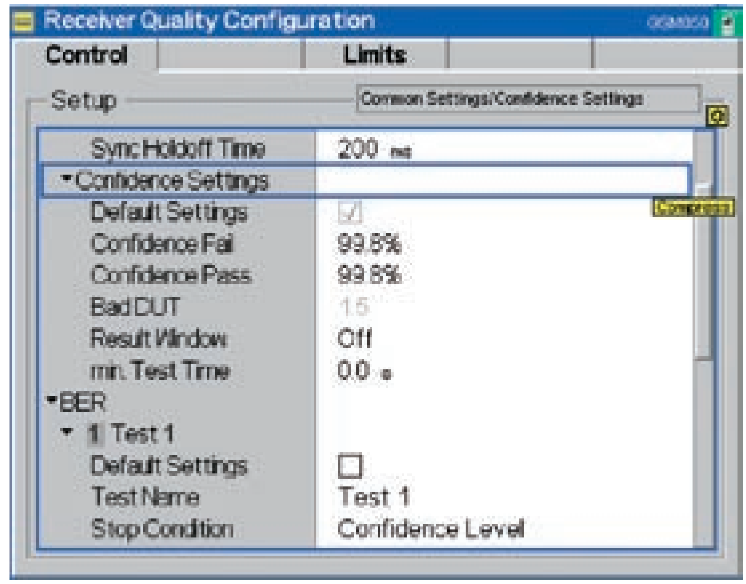
FIG 4
For the statistical BER/BLER measurement with two limit values, two diagrams with different limit values are simply placed one on top of the other. Evaluation is analogous to the measurement with just one limit value.

BER limit value, measuring the statistical BER would take an infinite amount of time. For this reason, an artificial termination criterion was introduced by simply shifting the pass limit value line a bit further up. This means basically that a slightly different limit value is used for pass evaluation than for fail evaluation. The rate of shifting is referred to as "bad DUT" factor M. The error ratio of the receiver may be M times worse than the specified error ratio in order to comply with the required pass criterion. In practice, M usually has a value of 1.5.

The second difference is that the time axis has been replaced by a number-of-errors axis. This change is easy to understand, considering that time is reflected only indirectly in the measurement accuracy. Measurement accuracy actually depends on the number of bits transmitted during measurement time. Time was therefore excluded from the diagram.

A crucial parameter of the statistical BER has not yet been considered in detail, i.e. the probability at which the forecast evaluation is likely to occur. This parameter affects the size of the diagram area in which no statement about receiver quality can be made. It is definitely a good idea to select different probabilities for the pass and fail criteria. Classifying a good receiver as bad is certainly less problematic than rating a bad receiver good. The statistical BER provides the following values as measurement results: "early fail" (premature termination of the measurement because the receiver is worse than the limit value), "fail" (after expiry of the maximum measurement time, the receiver was considered too bad), "early pass" (premature termination of the measurement because the receiver is better than the limit value) or "pass" (after expiry of the maximum measurement time, the receiver was classified good).

FIG 5
The user can set all parameters that are relevant to the statistical BER measurement on the R&S®CMU 200, and thus easily and conveniently adapt the measurement to customized requirements.



Statistical BER / BLER measurements with two limit lines

The above explanations only allow a conclusion to be made about whether a receiver is better or worse than a specified limit value. In practical use, however, the BER / BLER of a receiver may have to occur within a quality window, i.e. between two specified limit values.

This can be easily achieved by means of statistical BER: Simply place the diagram in FIG 3 with two different limit values on top of each other, thus obtaining a diagram as in FIG 4. The measurement results obtained from this diagram are the values "fail – too high" (the receiver BER is too high), "pass" (the BER is within the two limit values) or "fail – too low" (the BER is too low).

Statistical BER / BLER under fading conditions

The above applies under statistical conditions only if the bit errors occur statistically independently of each other. This is, however, not ensured under fading conditions because of the memory effect of the multipath fading channel. To obtain a correct statement with the statistical BER measurement even under fading conditions, a minimum measurement time must be complied with, which in turn depends on the fading profile used.

An approved measurement method?

Manufacturers of mobile radio equipment are faced with the question of whether the statistical BER / BLER measurement has been approved of and is thus permissible. This can be easily answered: The 3GPP standardization committee has included the measurement in the 3GPP specification [*], thus making it standard for conformance tests of receiver characteristics. The statistical BER / BLER measurements were defined both with one and with two limit values. In addition, the specification also defines the minimum measurement times for the different fading profiles.

Statistical BER measurement with the R&S®CMU 200

The Universal Radio Communication Tester R&S®CMU 200 supports the statistical BER measurement in GSM networks, both with one and with two limit values. All parameters relevant to the statistical evaluation are user-configurable (FIG 5), and can thus be easily and conveniently adapted to match customized requirements. Measurement time can be tremendously reduced. Whereas conventional GSM BER measurements require approx. 3 seconds to yield a conclusive result, the statistical BER measurement does so in just one second (approx.).

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More information and data sheet at www.rohde-schwarz.com (search term: CMU 200)

REFERENCES
[*] 3GPP specification TS 34.121 V3.12.0, Annex F.6.1, Statistical testing of receiver BER / BLER performance, pp 374 – 388