RECOMMENDATION ITU-R BT.1735

Methods for objective quality coverage assessment of digital terrestrial television broadcasting signals of System B specified in Recommendation ITU-R BT.1306

(Question ITU-R 100/6)

(2005)

Scope

The purpose of this Recommendation is to make available methods to assist in quality assessment of the coverage and service area for digital television broadcasting in System B. This Recommendation, takes into account relevant ITU-R Recommendations. For the stated purpose two methods are available.

The ITU Radiocommunication Assembly,

considering

a) that Recommendation ITU-R SM.1682 – Methods for measurements on digital broadcasting signals, specifies in § 2.6 the parameters to be measured for coverage evaluation;

b) that in Recommendation ITU-R BT.1368 planning parameters such as minimum field strength, protection ratio and relation between minimum field strength and receiver voltage input are defined and widely used by administrations;

c) that in Recommendation ITU-R P.1546 field strength prediction methods and clutter height for field evaluation are indicated and widely used by administrations;

d) that there is a need for in-field methodologies to assist administrations and Sector Members to assess the quality of digital terrestrial television broadcasting (DTTB) coverage,

further considering

a) that there is a need for simplified methodologies to assist consumer electronic equipment installers to assess the objective quality of a digital signal at the end user's receiver,

recommends

1 that the model to describe the objective quality of the coverage based on the five grade scale, as previously defined in Recommendation ITU-R BT.500, in accordance with § 3 of Annex 1 should be used;

2 that the quality scale presented in Table 1 of § 3 of Annex 1 should be used;

3 that the methods of measurement described in § 5, § 6 and § 7 of Annex 1 should be used,

further recommends

1 that the simplified model presented in Annex 2 should be used to assess the objective quality of a digital signal at the end user's receiver;

2 that the simplified quality scale presented in Table 3 of § 2 of Annex 2 should be used.

Annex 1

Standard method for objective quality coverage assessment for digital television broadcasting signals for System B

1 Objective quality assessment of the coverage

The coverage of a specific area, as determined by a prediction method, should be verified by "in-field" measurements in order to assess prediction results. In terms of quality, by means of a prediction method, it is possible to identify the coverage area using "location probability". In the same way, the "perceived quality" concept, related to the end user, could be evaluated by means of measurement methods. The digital terrestrial television reception system works on the basis of a "threshold" and the perceived quality depends on three factors: the access to the service, the time availability, the location availability.

2 Parameters to be evaluated

As reported in the current version of Recommendation ITU-R SM.1682 at § 2.6, the parameters to be evaluated are: field strength and bit error ratio (BER) after different decoding stages (here it is suggested to get the BER before Viterbi decoding – (CBER)). The corresponding BER after Viterbi decoding (VBER) is used to determine the threshold of quasi error free (QEF) condition. One more parameter should also be recorded during measurement activities. It is the modulation error ratio (MER) at the transmitting site. MER represents a synthetic form of constellation analysis. If the MER value at transmitting site is lower than an established value, e.g. 32 dB[1], the measurement activities should be stopped due to possible transmission failure.

3 The objective quality scale for System B

It is well known that field strength measured at receiving sites varies with location and receive antenna height. The variability, at fixed power flux-density (pfd), depends on amplitude and phase combination of several paths that reach the receiving antenna. Variability is more accentuated for continuous wave (CW) signals than wideband signals. The reflected paths can give either possible positive or negative contributions. Negative contributions are connected to the intersymbol interference that happens when the delay of one or more paths is greater than the guard interval. Possible positive contributions are generated when path delay is lower than the guard interval. The presence of several paths falling into the guard interval frame can result in additive or subtractive contributions depending on implementation of Viterbi soft decision, fixed or moving research window and paths phase. The intrinsic non-linearity related to Viterbi soft decision, protection levels, temporal and spatial dispersion gives as a result a low correlation between field strength and BER. Existence of a correlation law is yet to be studied.

The quality evaluation system for an analogue signal has been based on both field strength and the five quality (Q) grades subjective assessment scale. Q5 grade corresponds to "excellent", Q1 grade corresponds to "very bad". The acceptance threshold is fixed to Q3 grade. In a digital environment the situation is quite different and it is important to note the difference between compression quality evaluation methods and broadcasting coverage quality evaluation. For the compression method evaluation, such as MPEG, the five-grade assessment scale has been maintained. For the objective

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[1] Minimum MER acceptable value is still under study with possible improvement.

of broadcasting coverage quality evaluation, it would seem more difficult to maintain a method based on the five-grade scale because of rapid transition from a service to a no service condition. Nevertheless it is possible again to maintain a five-grade scale if at each grade the meaning of distance from the transition point is attributed. Evaluation of the distance from the transition point is very important because the measurement equipment is usually placed before the end user's reception system, usually composed of an antenna, distribution system and set top box. Interpretation of digital objective quality coverage assessment *is not to be confused* with interpretation of the analogue quality assessment.

For fixed reception, the five-grade scale reported in Table 1 should be used.

TABLE 1

DTTB coverage quality scale

BER / **Field strength**	**VBER > 2×10^{-4}**	**VBER ≤ 2×10^{-4} and CBER ratio ≤ 10**	**VBER ≤ 2×10^{-4} and CBER ratio between 10 and 100**	**VBER ≤ 2×10^{-4} and CBER ratio > 100**
E < E70	Q1	Q2	Q2	Q2
E70 ≤ E < E95	Q2	Q3	Q3	Q4
≥ E95	Q2	Q3	Q4	Q5

CBER: Channel BER or BER before Viterbi

VBER: BER after Viterbi

CBER ratio = $CBER_{min}/CBER$

where:

$\mathbf{E_{70}}$ or $\mathbf{E_{95}}$ [2] represents the minimum median field strength needed for location probability of 70% or 95% (DTTB Handbook, Chapter 5 (edition 2002) and Recommendation ITU-R BT.1368). The $\mathbf{E_{70}}$ or $\mathbf{E_{95}}$ value depends on the adopted configuration.

$CBER_{min}$ is the value presented when VBER is equal to 2×10^{-4} (QEF condition) and it depends on the adopted code rate. $CBER_{min}$ values for the most used configurations are listed below in Table 2. It should be noted that these values do not change with frequency and modulation scheme. Further studies are required for determination of values for other code rates.

TABLE 2

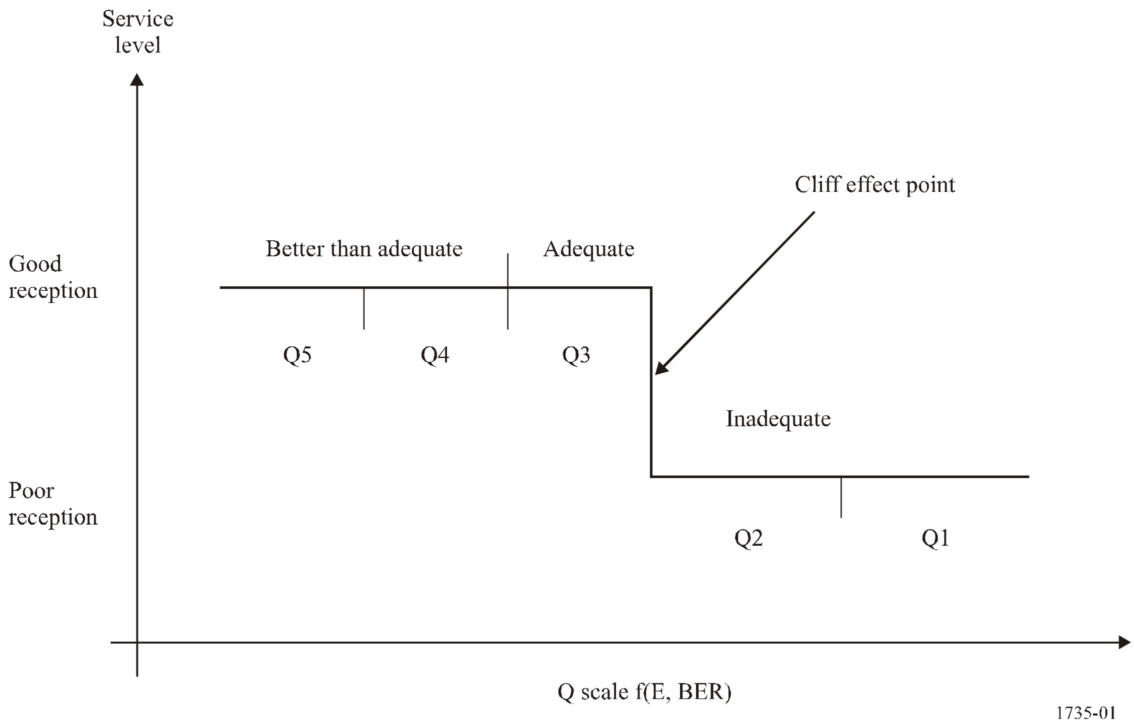
Values of $CBER_{min}$ for different code rates

Code rate	$CBER_{min}$
2/3	4×10^{-2}
3/4	2×10^{-2}

[2] $\mathbf{E_{70}}$ or $\mathbf{E_{95}}$ may also represent the planning values chosen by administrations.

4 Table 1 scale interpretation

FIGURE 1



The quality scale represents the distance from transition point, also called the "cliff effect" point. Each Q value is a function of E and BER. Q2 read on the horizontal line of the table means that field strength is lower than the minimum value assigned in the planning procedure. In such cases no protection against interference can be guaranteed. Q2 read in vertical line means that the "cliff effect" appears. In the first case it is possible to move to Q3 by increasing transmitted power or by modification of the antenna pattern. In the second case it is possible to move to Q3 by reducing interference or the level of multipath interference.

5 Measurements at fixed height

In this kind of measurement the receiving antenna is placed on the mast and raised to approximately 10 m height above the ground level such that the antenna is above local clutter or obstruction. The measurement results can be reproduced at any time just adopting a fixed reception system, usually found at monitoring stations. Fixed height measurements can be useful only for formal evaluation, conventionally made at 10 m high above the ground level (the height is the same used in propagation prediction method adopted for planning purposes).

In real situations the measured field strength depends on phase composition of the several received paths. Therefore, the final result depends on both: receiving antenna location and vertical variation of field strength. Using half wavelength receiving antennas, three specific situations can be identified where:

– the difference between the maxima of the vertical variation in field strength is less than half the wavelength: measured field strength is equivalent to the direct path field;

– the difference between the maxima of the vertical variation in field strength is greater than half the wavelength: measured field strength could be higher or lower than the direct path field;

– the first maximum value is higher than 10 m: measured field strength increases with height.

The fixed height measurement can be used to characterize the service area only if the result falls in evaluation class Q4 and Q5: it means field strength higher than E_{min} and absence of perturbation in the transmission channel. In such cases, it is possible to associate the measured value to an "area of validity". The extent of the area of validity must be determined on the basis of the environment, distance from transmitter, vertical variation of the field strength and height of the first field strength maxima. Experience in analogue signal evaluation indicates the radius of the area of validity is up to a maximum of 10 km.

If objective quality results are less than Q4 it is necessary to evaluate the vertical variation of field strength and then eventually the horizontal variation of field strength.

The objective quality results Q5 and Q4 indicate that "better than adequate" coverage has been achieved by the service being evaluated.

6 Vertical variation of field strength

The field strength and BER change continuously during the antenna positioning process up to 10 m above ground level. Values depend on the different path combinations and eventually on the obstruction at the low height. If the evaluated objective quality is less than Q4 at an antenna position of approximately 10 m, it is necessary to verify if the objective quality grade Q3 has been exceeded during the antenna positioning process. An antenna position suitable for reception should be identified. The objective quality grade evaluated in such cases is reported as significant and the recorded VV (Vertical Variation) is included in the measurement results. It has been found that the radius of the area of validity is up to a maximum of 2 km.

The objective quality result Q3 is similar to coverage level grade adopted in the planning system.

7 Horizontal variation of field strength

When using a vertical variation of field strength method the objective quality evaluation remains always lower than Q3, it is necessary to verify if that result depends on a bad choice of the measurement point or if it is related to the area under investigation.

In such cases it is necessary to select other measurement points near to the first one selected. If the results related to the new points give objective quality evaluation again lower than Q3, it should be reported as most significant the best result obtained and the relative range of validity. The range of validity should be as wider as greater is the distance between measurement points.

Annex 2

Simplified method for objective quality assessment of a digital signal at user receiver for System B

1 Background

Annex 1 contains a method for objective quality scales for digital television services. This is based on field (in-service) measurement of both field strength at specific height and BER (before CBER and after VBER Viterbi decoding). It could require expensively equipped vehicles and measurement instruments.

In the early stages of a digital service roll-out it is expected that there will be a widespread need for signal quality assessments to be undertaken using a wide variety of low-cost measuring instruments, especially those likely to be used by consumer electronics equipment installers. To meet this need, a simplified digital quality assessment method that is comparable to the established analogue television approach (of measurement of signal level together with a subjective assessment of signal quality) is proposed.

The measurement work indicated that a combined measurement involving measurement of both unattenuated channel signal power and the *C*/*N* margin to failure provided an assessment of signal quality that was comparable in reliability to that obtained using a more sophisticated method. That is, if an appropriate signal level and an appropriate *C*/*N* margin value were obtained then it could be assumed that a viewer would be able to receive the digital signals. Comparison with measured margins of *C*/*N* and BER suggested that a similar margin value was obtained for either parameter at any specific test location so it was taken that the simpler "level margin" method would be sufficient for the purpose.

2 Simplified digital signal quality scale

The data that has been collected during the survey work has allowed the development of a proposed signal quality scale based on the measurement of level and level margin. This scale has the form of the scales proposed in Annex 1 and is outlined below.

This digital signal quality scale requires the measurement of both received signal level and signal level margin to failure (headroom). Three ranges of signal level and three ranges of margin are combined to give a 5-step quality scale in which grades 1 and 2 constitute unacceptable quality, grade 3 is acceptable and grades 4 and 5 are good quality.

The measurement quality scale is as follows:

TABLE 3

Signal quality scale

Receiver input voltage to the receiver (dBµV)	**Margin above failure point *M* (dB)**		
	$M \leq 5$	**$5 < M < 10$**	**$10 \leq M$**
$V \leq V_{min}$	1	2	3
$V_{min} < V < V_{min} + 6$ dB	2	3	4
$V_{min} + 6$ dB $\leq V$	3	4	5

NOTE 1 – V_{min} is greater than the minimum useable signal level (failure point) by an amount determined by the individual administration's planning procedure (perhaps 5 dB).

NOTE 2 – In the absence of other impairments, the signal level and margin categories match (that is: for a noise-only environment, the case $V \leq V_{min}$ paired with 5 dB < M < 10 dB provides the same quality rating as the case $V_{min} < V < V_{min}$ + 6 dB paired with $M \leq 5$ dB, and so on).

NOTE 3 – The 6 dB steps are a somewhat arbitrary choice but are rounded figures related to observations of differences between minimum useable, E50/50, E50/70, E50/95, etc., field strength values.

NOTE 4 – Initial information suggests failure point signal levels of between 20 dBµV and 30 dBµV at the receiver terminals.

NOTE 5 – Grade 3 (or better) is taken as indicative that acceptable reception is available.

NOTE 6 – "Margin" is determined by inserting attenuation while watching the received image for onset of impairments.

NOTE 7 – The combination of signal level and margin increments will provide protection for location variability together with some protection against time variability (fading).

This simplified method requires the availability of a digital signal level meter, a digital television receiver and an attenuator and thus provides a test system that is familiar to an experienced analogue system installer in terms of equipment cost and complexity, method of use and obtained results. The assessment method is to determine digital signal level and then monitor the received signal while attenuating the incoming wanted signal until the onset of impairments is detected in the displayed picture. The amount of inserted attenuation then constitutes the margin value to be used in the assessment of signal quality.

While the actual failure point at any receiving location will depend on the combination of signal level and the extent of other impairments (such as multipath propagation and electrical impulse noise) it is supposed that there will, nonetheless, remain a direct relationship between the various measurements of signal quality such that any one measure of margin will be as good as any other for the purpose of determination of digital signal quality or receivability.

Cautionary Note: The simplified method (as with any method involving attenuation of the signal to determine available margin to failure) may give misleading results if the relationship between the wanted signal level and the interference signal is not constant. Such a situation can be expected to occur, for example, where coverage is "interference limited" and path lengths are such that significant fading of wanted or interfering signals occurs. It may be inappropriate to use the simplified method in such situations.

3 Remarks

The simplified quality assessment scale contains similar values for both wanted signal level and margin categories and thus gives some confidence in the method outlined in Annex 1.

Since the simple method was formulated, it is apparent that new field survey receivers are coming onto the market which appear to provide capabilities more closely compliant with the Annex 1 method. These new receivers are of the type that might be expected to be used by domestic equipment installers and claim to be able to undertake measurement of BER. If this is indeed the case, then the simplified method will not be required and the methods outlined in Annex 1 will become practical for both coverage survey tasks and as an aid in the correct installation of domestic System B receiving systems.

A useful task at the present time would be that of gathering information about the performance capabilities of the emerging generation of test receivers so that it can be shown that the method of Annex 1 is practical and useful.