

DETERMINATION OF THRESHOLD PARAMETERS FOR RELIABLE RECEPTION (MER_{min} , SNR_{min} , P_{th}) OF DVB-T2 SIGNALS IN THE MOUNTAINOUS REGIONS OF TASHKENT PROVINCE

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Digital terrestrial television broadcasting of the DVB-T2 standard is the basis of the modern broadcast television system, providing high spectral efficiency, noise immunity, and the ability to transmit high-definition digital content. However, the reliability of DVB-T2 signal reception largely depends on the conditions of radio wave propagation, which in mountainous areas are characterized by pronounced territorial heterogeneity, shielding relief, multi-beam propagation, and significant attenuation levels.

The mountainous regions of the Tashkent region represent a complex radiophysical environment characterized by sharp elevation fluctuations, the presence of natural barriers and radiotenuation zones, which significantly complicate the formation of a stable zone for reliable television signal reception. Under these conditions, traditional computational coverage models often prove to be insufficiently accurate, requiring the development of adapted criteria for assessing reception quality based on real threshold parameters of the radio channel.

The main indicators of the reliability of DVB-T2 signal reception are the minimum value of the modulation error coefficient MER_{min} , the signal/noise ratio SNR_{min} , and the threshold power of the received signal P_{th} . These parameters determine the boundary between stable and unstable reception and are directly related to the probability of bit errors and the quality of digital flow recovery. Their accurate determination allows for the correct setting of reliable reception criteria and increases the reliability of radio coverage forecasting [1-6].

The relevance of this research is due to the need to adapt DVB-T2 systems to the specific conditions of the mountainous terrain of the Tashkent region, where ensuring stable reception remains one of the priority tasks of regional broadcasting. Determining the threshold values of MER_{min} , SNR_{min} , and P_{th} , taking into account the influence of elevated relief, diffraction losses, and interference interference, will improve the accuracy of transmitting station design and optimize network parameters.

The purpose of this scientific thesis is to determine the threshold parameters for reliable reception of DVB-T2 signals in the mountainous regions of the Tashkent region based on the analysis of the energy characteristics of the radio channel. The research results can be used in optimizing transmitter placement schemes, forecasting radio coverage zones, and improving the accessibility level of digital television broadcasting in hard-to-reach areas.

In this regard, substantiating and analyzing the threshold value of the modulation error coefficient becomes a logical starting point for researching the criteria for reliable receipt of DVB-T2 signals. Further consideration will focus on revealing the physical basis of the MER indicator, methods for its measurement, and determining the minimum permissible level of MER_{min} that ensures reliable acceptance in complex terrain conditions.

MER (Modulation Error Ratio) - это отношение мощности идеального модулированного сигнала к мощности вектора ошибки модуляции [7-11]:

$$MER = 10 \log_{10}(P_{signal}/P_{error}), \text{ dB} \quad (1)$$

MER characterizes the quality of the OFDM signal constellation and reflects the combined effects of noise, phase and frequency distortions, intermodulation, and multicurrentiality.

Sustainable acceptance threshold condition:

$$MER \geq MER_{min} \quad (2)$$

Table 1 shows typical values for DVB-T2:

Typical values for DVB-T2

Table 1.

Modulation	Code speed	MER_{min} , dB
QPSK	1/2	10–11
16-QAM	3/4	17–18
64-QAM	2/3	23–24
256-QAM	3/4	27–28

Conclusion: at MER below the threshold value, there is a sharp increase in errors and an “acceptance interruption” effect.

After determining the minimum value of MER_{min} , which characterizes the quality of modulation and allows for assessing the level of signal distortion, the next logical step is establishing the threshold value of SNR_{min} (Minimum Signal-to-Noise Ratio). Unlike MER, SNR reflects the ratio of useful signal power to noise power in the transmission channel, which directly affects the reliability of reception and the likelihood of errors in the digital system. Thus, knowledge of MER_{min} serves as the foundation for determining the minimum permissible SNR required for reliable reception of DVB T2 signals in mountainous terrain conditions. The threshold value of SNR_{min} is determined by the following expression [1, 3, 8, 11]:

$$SNR = 10 \log_{10}(P_{signal}/P_{noise}), \text{ dB} \quad (3)$$

Connection to MER. In an ideal, distortion-free channel:

$$MER \approx SNR \quad (4)$$

In real conditions:

$$MER \leq SNR \quad (5)$$

Table 2 shows the typical SNR thresholds for DVB-T2:

Typical SNR thresholds for DVB-T2

Table 2.

Modulation	Protective interval	SNR _{min} , dB
QPSK	1/8	5–6
16-QAM	1/8	11–13
64-QAM	1/16	17–19
256-QAM	1/32	22–25

Confident reception condition:

$$SNR \geq SNR_{min} \quad (6)$$

SNR_{min} determination allows for the establishment of a minimal signal-to-noise ratio, which ensures reliable digital signal reception. Based on this criterion, the next step is to calculate the threshold reception power P_{th} , i.e., the minimum input signal power required to maintain the required SNR level and guaranteed reception quality in specific conditions, for example, in mountainous areas.

Receiving threshold power P_{th} (Threshold Power). P_{th} is the minimum power level at the receiver input, at which the specified reception quality is ensured (BER $\leq 10^{-6}$ after decoding) [1,2,8,12,13,14].

$$P_{th} = N_{floor} + SNR_{min} + Margin \quad (7)$$

where:

N_{floor} - receiver noise level:

$$N_{floor} = -174 + 10 \log_{10}(B) + NF \quad (8)$$

B - reception band (Hz)

NF - receiver noise factor (dB)

$$Margin = P_{received} - P_{threshold} \quad (9)$$

where: $P_{received}$ - measured signal power, $P_{threshold}$ - minimum threshold power for reliable reception.

Calculation example for DVB-T2

Options:

- band: $B=8$ MHz
- $NF = 6$ dB
- $SNR_{min} = 18$ dB

$$N_{floor} = -174 + 10 \log_{10}(8 \times 10^6) + 6$$

$$10 \log_{10}(8 \times 10^6) \approx 69 \text{ dB}$$

$$N_{floor} = -174 + 69 + 6 = -99 \text{ dB}$$

$$P_{th} = -99 + 18 = -81 \text{ dB}$$

Confident reception condition:

$$MER \geq 20 \text{ dB}$$

$$SNR \geq 18 \text{ dB}$$

$$P_{rx} \geq P_{th} = -81 \text{ dB}$$

The threshold parameters of reliable receiving of the DVB-T2 digital signal are determined by the minimum values of the MERmin modulation error coefficient, the signal/noise ratio SNRmin, and the threshold received power Pth. The condition of stable acceptance is realized when the following inequalities are satisfied:

$$MER \geq MER_{min}, SNR \geq SNR_{min}, P_{rx} \geq P_{th} \quad (10)$$

permissible SNR value. Failure to comply with these conditions leads to an increase in bit error and loss of transport flow decoding.

The work presents a comparative analysis of the threshold parameters (Table 3 and 4).

Comparison of confident reception parameters for plain and mountainous terrain

Table 3.

Parameter	Plain conditions	Mountainous regions of Tashkent region
SNR_{min} (QPSK)	6–8 dB	10–12 dB
SNR_{min} (16-QAM)	12–14 dB	15–18 dB
MER_{min}	18–20 dB	20–22 dB
P_{th}	-85 dB	-82...-80 dB

Influence of relief on signal quality parameters

Table 4.

Environmental factor	Influence on SNR	Impact on MER	Note
Shielding with mountains	-3...-6 dB	-2...-4 dB	Losses beyond the ridges
Multicircularity	+ BER	Decrease	Signal interference
Diffraction	Instability	Growth of error	Occurs in radiotonic zones
Height variations	Fluctuations	Lowering MER	Especially in the gorges

Conclusion. During the research, the threshold parameters for reliable reception of DVB T2 standard signals in mountainous areas of the Tashkent region were determined, including the minimum value of the MER_{min} modulation error coefficient, the minimum signal/noise ratio SNR_{min}, and the threshold reception power P_{th} . The analysis showed that the specific features of the region's relief, including height fluctuations and the presence of obstacles, significantly affect the signal quality and require consideration of additional margins above the minimum threshold values to ensure stable reception.

Thus, the established threshold parameters provide a basis for designing and operating digital television broadcasting in complex terrain conditions, increasing the reliability and quality of television signal reception in the Tashkent region.

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