Quality Estimation Algorithm for Wireless Telecommunications

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***Abstract*— The article considers the algorithm for assessing the quality of wireless telecommunications. The algorithm allows to determine the quality in the process of production, design and operation of telecommunication systems. The algorithm for assessing the quality of telecommunications takes into account factors (the quality of the telecommunication transmitter, the quality of the telecommunication receiver and the quality of the telecommunication channel), the criteria (power, frequency, sensitivity, noise immunity, bandwidth, security, transmission coefficient, amplitude-frequency and phase-frequency characteristics, selectivity, overlap frequency range, non-linear distortion, dynamic range, transient response, receiver stability) and relations between them. The number of factors and criteria depends on the conditions of a specific task.**

Keywords*— *expert evaluation methods; quality control; algorithm; wireless telecommunications

I. INTRODUCTION

Usually when assessing the quality of wireless telecommunications and services, quantitative and technical indicators of the performance of the telecommunications network are taken into account, as well as the degree of customer satisfaction with telecommunications services [1], [2], [3]. The most effective and relevant methods of quality control of telecommunications are expert assessment methods. However, these methods are expensive and require a lot of time and technical means for implementation. The algorithm of operative and effective preliminary estimation of quality is proposed in terms of time and resources. The algorithm allows to determine the quality of telecommunications in the process of its design, production and operation [4], [5].

II. DESCRIPTION OF THE ALGORITHM

The algorithm for assessing the quality of telecommunications considers the numerical values of the factors: the quality of the transmitter (TP), the quality of the receiver (TR), and the quality of the telecommunications channel (TC).

The quality assessment algorithm considers the following criteria based on relevant quality indicators:

1. Power,
2. Frequency,
3. Sensitivity,
4. Noise immunity,
5. Throughput,
6. Security,
7. Transmission factor (gain),
8. Amplitude-frequency and phase-frequency characteristics,
9. Selectivity,
10. Frequency range overlapping,
11. Nonlinear distortion,
12. Dynamic range,
13. Transient response,
14. Stability of the receiver operation.

The number of criteria can vary depending on the specific task.

The TP quality is determined by the group of following criteria: 1) power, 2) frequency, 3) security.

The TR quality is determined by the group of criteria: 1) power, 2) frequency, 3) sensitivity, 4) immunity, 9) selectivity, 10) frequency range overlapping, 14) stability of the receiver operation.

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The TC quality is determined by the group of criteria: 4) immunity, 5) throughput, 6) security, 7) transmission factor (gain) criteria.

Then the TS quality factor is determined by the {1, 2, 3} criteria combination. The quality factor of the TR is determined by the {1, 2, 3, 4, 9, 10, 14} criteria. The quality factor of the TC is determined by the {4, 5, 6, 7} criteria.

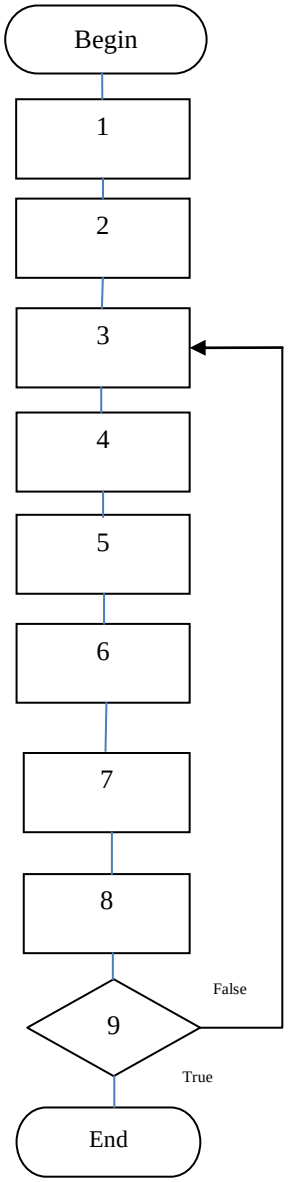

Fig. 1. Algorithm

The algorithm flowchart contains 9 modules and shown in Figure 1, where:

1. Names of factors and indicators formation.

2. Indicators numbers formation.

3. Giving names for indicators, their numerical values and order relations between them.

4. Formation of factors determined by selected indicators.

5. Formation of order relations between the indicators that determine factors.

6. Determination of factors numerical values, their mean values, variances and root mean square deviations.

7. Determination of the telecommunication system quality.

8. Results output.

9. Condition module. If the result is satisfied, then "Finish", else “Module 3”.

The user is offered to choose indicators taken into account when analyzing specific telecommunications from 14 indicators named above. Telecommunication properties are characterized by the following indicators:

1. “Power” – output power of the transmitter signal or output power of the receiver (power supplied to the terminal device).

2. “Frequency”, i.e. frequency of the transmitter signal.

3. “Sensitivity”, i.e. the minimum level of the input signal, at which the standard output power is provided for a given ratio of the voltage of the input signal to the noise voltage.

4. “Immunity”, i.e. resistance to external influences.

5. “Bandwidth”, i.e. a characteristic showing the maximum achievable information amount transmitted through the communication channel per time unit.

6. “Security”, i.e. the security of the communication channel from external interference (noise), which is determined by the ratio of the levels between the useful signal and noise.

7. “Transmission factor” (gain), i.e. the gain of the receiver, which is determined by the ratio of the output voltage amplitude to the amplitude of the information parameter of the receiver input signal.

8. “Amplitude-frequency and phase-frequency characteristics”, i.e. the amplitude characteristic of the signal receiver is determined by the dependence the first harmonic output voltage amplitude of the envelope of the input signal when it is harmonic modulated.

9. “Selectivity”, which is determined by the ability of the receiver to divide the received signal and the interference at the output of the receiving antenna.

10. “Frequency range overlapping”, i.e. overlapping of the frequency range, which is determined by the ability to receive radio signals, with carrier frequencies within a limited range of boundary frequencies.

11. “Nonlinear distortions”, i.e. distortions introduced by the receiver into the received signals.

12. “Dynamic range”, i.e. a range which is determined by the nonlinearity of devices for signals receiving and processing, that limits the maximum allowable amplitudes of input signals.

13. “Transition characteristic”, which is determined by the dependence of its response on the input signal.

14. “The stability of the receiver”, i.e. feature provides the received signal without distortions depending on stability of the tuning frequency, transmission coefficient, the constancy of the phase characteristic of the receiver / transmitter, and from other destabilizing factors.

At the discretion of the expert, the chosen K<=14 indicators should be arranged in order of decreasing importance. Then to determined relations of order (> = - greater than or equal,> - greater, >> - significantly greater) between each two neighboring indicators. Each of three quality factors (TP, TR, TC) is determined by indicators with serial numbers from 1 to 14. So, the quality factor TP is determined by the indices with the numbers 1, 2, 3; the quality factor TR - 1, 2, 3, 4, 9, 10, 14; the quality factor TC is determined by the indices with the numbers 4, 5, 6, 7.

Selecting K indicators ($K \le 14$), we obtain F ($F \le 14$) factors that characterize the telecommunications system. The numerical value of each of the factors is determined as follows.

Let N be a sufficiently large number. According [4], [5], [6] we can take $N = 20$.

Then $P_1 = 0$, $P_2 = 1/N$, $P_3 = 2/N$, ... $P = 1$ - weight coefficients in the formula for calculating the value of the i-th factor

$$f_i = \sum_{j=1}^{S_i} P_j K_j ,$$

where K_j ($j = 1, ..., S_i$) are the numerical values of the exponents. which determine the i-th factor, and S_i is the number of indices defining f_i. The quantities f_i. are determined for all $i = 1, ..., F$, taking into account the introduced order relations between the criteria (≥,> or >>) and conditions

$$\sum_{j=1}^{S_i} P_j = 1.$$

Since S_j. <N + 1, then for each i the quantity is greater than 1, i.e. for each factor we obtain several f values. According to [6], the average f value, the variance D and the standard deviation $\sigma = \sqrt{D}$. can be determined.

As a result, we get F values of factors. The numerical value of the telecommunication system quality is defined as the arithmetic mean of the factors obtained. If the quality does not satisfy the user's requirements, then criteria or relations between the selected criteria should be changed. After several changes, the algorithm gives the variant that corresponds to the maximum value of the telecommunication system quality. The algorithm is implemented by VBA programming language. The program allows to change the number of indicators and factors. Thus, an expert evaluation of the quality of the telecommunications system is implemented in the first approximation.

III. Conclusion

The considered approaches to the assessment of the quality of telecommunication systems show that their application is likely to be fruitful in the existing implementation and allows their further dissemination not only to the wireless telecommunications system, but also to a much wider extent.

Practice demonstrates that an expert method of assessing the quality of wireless telecommunications can be extended to other types of systems. It is only needed to change the names of factors, indicators, and the relationship between them. It is planned to develop a software component for automated calculation of indicators for assessing the quality of telecommunications using the VBA programming language.

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