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Method of frequency-territorial planning of digital sound broadcasting network on the basis of universal model of homogeneous network

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Abstract:

The paper proposes a method of frequency-territorial planning of digital sound broadcasting network. The method is based on the Universal Homogeneous Network Model (UMNM) as a tool for frequency planning in digital broadcasting. The main aspects of the model, including the principles of transmitter placement, coverage calculations and interference minimization are considered. The efficiency of UMOS under conditions of limited frequency and energy resources is analyzed, and recommendations for its practical application are offered.

Keywords: Digital radio broadcasting is a key technology for mass transmission of audio information. Under conditions of limited frequency resource, optimization of spectrum utilization is especially important.

Introduction

Digital radio broadcasting is a key technology for mass transmission of audio information. Under conditions of limited frequency resource, optimization of spectrum utilization is especially important. This requires the development of efficient frequency planning methods. It is frequency planning that maximizes the use of the allocated frequency spectrum and provides high-quality coverage of the broadcasting territory [1].

Frequency planning methods. In practice, there are various methods of planning broadcasting networks, including audio [2, 3]:

- linear, including methods of triads, relative distances, Heade;

- universal model of a homogeneous network.

Linear methods include approaches such as [2, 3]:

Triad method: based on calculating the minimum distance between transmitters to prevent mutual interference.

Relative Distances Method: involves optimizing the location of transmitters based on geographical conditions.

Heade method: uses empirical formulas to minimize interference in complex networks.

These methods are effective for localized broadcasting networks, but become less applicable as they become larger in scale.

UMOS is a model of a broadcast network in which transmitters are placed in nodes of a hexagonal structure. This model allows coverage areas to be estimated and frequency reuse to be determined.

Description and calculations. The hexagonal structure is based on the placement of transmitters at the vertices of equilateral triangles forming a hexagonal grid. This allows to cover the territory with mosaic coverage and to determine the minimum distance between transmitters operating in combined frequency channels.

Calculation of the coordination distance. Coordination distance. Consider two transmitters that may cause mutual interference. The minimum distance between them, at which their mutual influence does not reduce the radius of the broadcasting area of the transmitters compared to the maximum, let us call the coordination distance and denote D_k (Fig. 1). The coordination distance is calculated by the formula [4]:

$$D_k = R_{Max} + d, \qquad (1)$$

where R_{max} is the radius of the transmitter broadcasting area without taking into account the interference;

d - distance from the boundary of the useful transmitter zone to the interference.

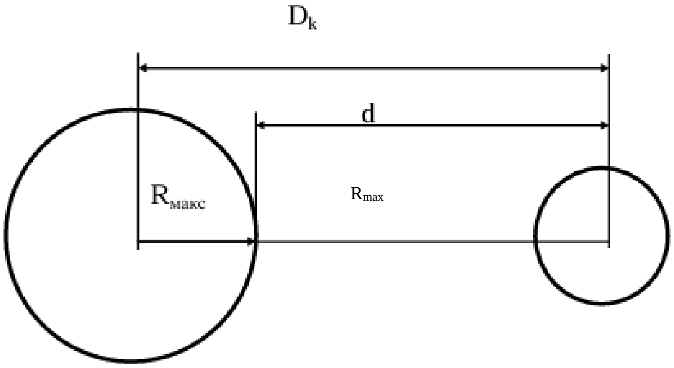

Fig.1.Determination of the coordination distance

In the network under consideration, the distance between all neighboring stations is the same - let us denote it by R_0 and call it the network module. If the broadcasting area of a transmitting station is a circle with a hexagon inscribed in it, its radius R_Z is related to the network modulus R_0 by the relation [5]:

$$R_3 = \frac{R_0}{\sqrt{3}}. \qquad (2)$$

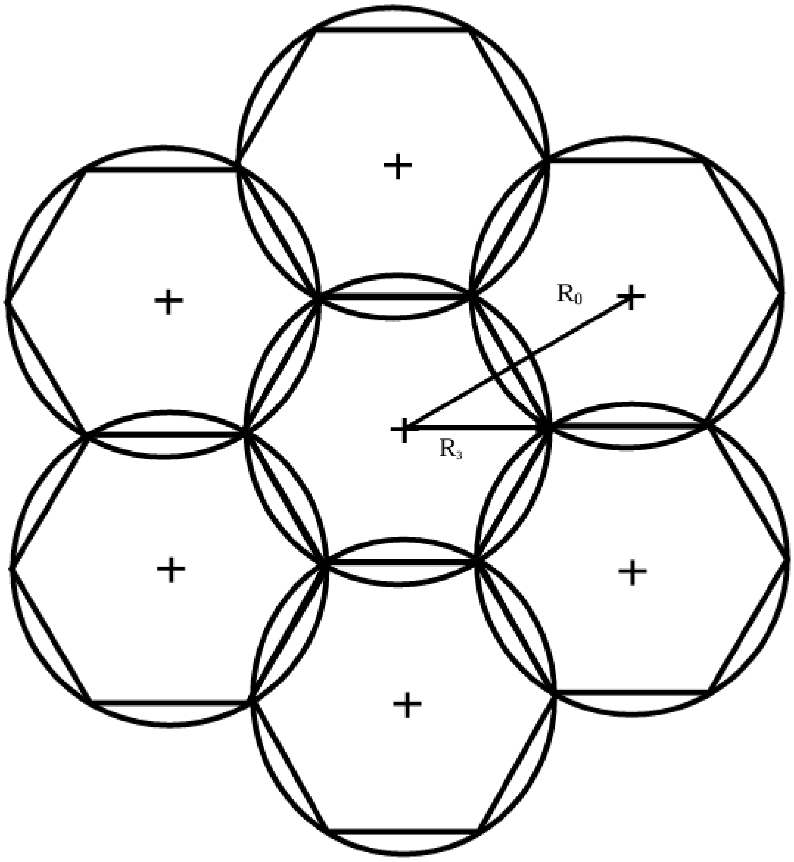

Figure 2. Cellular structure of a homogeneous network

When developing a model of a homogeneous broadcasting network, it is necessary to determine the location of transmitters operating in combined channels. For this purpose, it is recommended to use the universal model of homogeneous network (Fig. 2). If such transmitters are placed in the centers of hexagons designated by numbers “1” (Fig. 3), then the distance between them is defined as the network modulus $D = R_0$ or expressed in relative network moduli [5]:

$$r_0 = \frac{D}{R_0} = 1 \quad . \qquad (3)$$

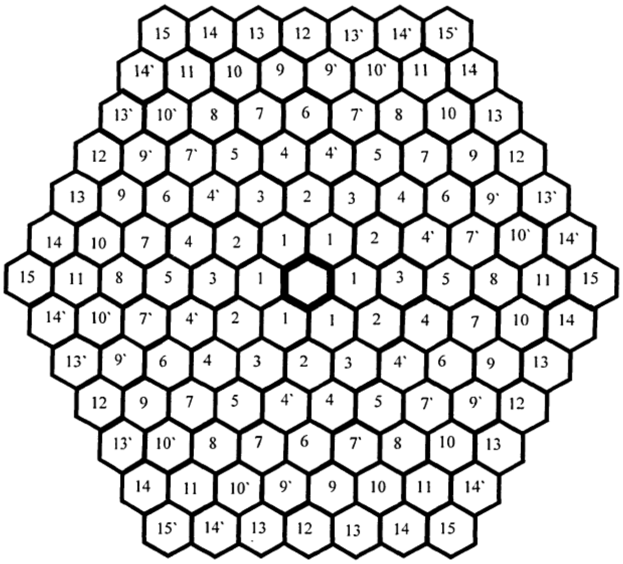

Figure 3. Transmitter placement in the universal

homogeneous network model

Definition of network modulus. The radius R of the transmitter's broadcast area is related to the network module as follows [5]:

$R\frac{R_0}{\sqrt{3}}$ (4)

One of the key stages in the design of digital audio broadcasting networks is the determination of transmitter coverage areas. For this purpose, a universal model of a homogeneous network is often used, which assumes uniform placement of transmitters on the territory with a pre-calculated theoretical radius of their coverage.

The distance between transmitters is calculated using the following formula [5]:

$\mathrm{D} = 2R_0$ (5)

where R_0 is the theoretical radius of the coverage area of one transmitter.

The transmitter utilization factor (Q) is a very accurate measure of efficiency because it takes into account the effect of interference on the entire broadcasting area of the transmitter. The proposed transmitter utilization factor is the ratio of the service area of a given station in the network S_{real} to the service area in the absence of interference S_{ideal}:

where S_{real} is the actual signal strength in the coverage area,

S_{ideal} - theoretically calculated signal strength under ideal conditions, allows to determine the coverage efficiency for a given distance between transmitters.

Calculation of the real coverage area taking into account the Q factor.

The real coverage area radius R_{real} is calculated as:

$R_{real} = Q \cdot R_0.$ (7)

The distance between transmitters is corrected as follows:

$D_{real} = 2 \cdot R_{real}.$ (8)

If the value of D exceeds 1 (real signal exceeds theoretical signal), the distance between transmitters can be increased. In case Q<1, it indicates the presence of areas with weak signal, which requires reducing the distance D to improve the coverage. Let R0 denote the theoretical radius of the coverage area of one transmitter. The distance between transmitters is initially set as D=2R_0 to ensure the required level of coverage quality. Then the signal quality is checked in the area of intersection of neighboring transmitter zones using the Q factor. If the Q value in these zones is below the acceptable level, the distance D is adjusted. Thus, formula (6) serves as a tool to assess the quality of coverage and further optimize the distance between transmitters.

$D = 2R_0 \cdot \mathrm{Q}.$ (9)

Table1.

Results of calculations of broadcasting parameters without and with Q.

Parameter	Excluding Q	Taking into account Q
Radius of coverage area (R) km	15	12,5
Distance between transmitters (D), km	30	25
Transmitter power ($P_{tx,}$). dBm	20	18,4

Taking into account the proposed extension of the range of Q coefficient variation, it can be applied as a system criterion of optimal frequency allocation for transmitters located at any distance from each other in any transmission networks. This is particularly effective when high estimation accuracy is required and significant computational resources are available.

The proposed method, frequency-territory planning aims at efficient frequency allocation in digital radio broadcasting networks and allows:

1) reduce mutual interference between channels. At dense packing of frequency channels there is a probability of overlapping of signals on each other. Allocation optimization can minimize such overlaps, improving the quality of data transmission.

2) Increase spectral efficiency. Every hertz of the radio spectrum is utilized as efficiently as possible. This is especially important in conditions of limited available frequency resources, especially in large cities with a high density of broadcast stations.

3) Ensure stable and high-quality coverage. Optimal distribution of frequencies taking into account the characteristics of transmitters, the landscape of the territory and models of radio wave propagation allows to achieve uniform coverage without significant "dead zones".

The introduction of DAB+ in combination with a homogeneous network model represents a promising direction for the development of radio broadcasting in Uzbekistan [6]. These technologies provide significant economic benefits, increase access to high quality radio broadcasts and open new commercial opportunities. Successful implementation of the project requires a strategic approach, including financial support and training of specialists. The use of DAB+ and SFN is a step towards the digital future of the country [7].

Literatures:

1. Khamidov H.A. Territorial frequency planning for digital sound broadcasting: modern approaches and technologies // "Ta'lim va innovatsion tadqiqotlar" ilmiy va ilmiy texnik onlayn konferensiya. Vol. 20, 2024.- O'zbekiston.- P.113-116.
2. V.I. Nosov. Optimization of parameters of terrestrial television and sound broadcasting networks. Novosibirsk 2005. C. 250.
3. Hale W.K. Frequency Assignment: Theory and Applications // TIIER, 1980 Vol.68, No.12, P.55-76.
4. Nosov, V.I. Efficiency of sector antennas and modulation methods in radio communication networks: Monograph / V.I. Nosov. - Novosibirsk: SibGUTI, 2008. - 235 c.
5. Radio frequency spectrum management and electromagnetic compatibility of radio systems Edited by Dr. M.A. Bykhovsky, Prof. M.A. Ecotrends. Moscow 2006 c.187.
6. Khamidov H.A. Technical characteristics of T-DAB/T-DAB+ standard // "Muhammad al-Xorazmiy avlodlari" ilmiy-amaliy va axborot tahliliy jurnal. - №4(14), 2020. - C.101-106
7. Khamidov Kh.A., Mukhamedaminov A.O., Qayumova A.M. Calculation of the Coverage Area of Digital Audio Broadcasting Dab+ Standard // American Journal of Social and Humanitarian Research. - Vol.2, № 4, 2021. - P.127-134