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Calculation of the Coverage Area of Digital Audio Broadcasting Dab+Standard

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ABSTRACT: This article discusses the coverage area calculation of digital audio broadcasting using DAB + technology

KEYWORD: DAB+, Geneva-06, RRC, ITU, ICS Telecom

INTRODUCTION

Over the past 20 years, the broadcasting service has been transferring television and audio broadcasting from analog to digital technologies for generating and distributing signals. Several systems have been developed for digital audio broadcasting in the world [1]. Today, many of them are successfully developing in the countries of the world. The economy of the digital transition also depends on the chosen state standards for digital broadcasting.

Based on the analysis of international experience in the implementation of digital audio broadcasting of the DAB+ standard, including a comparison of existing digital audio broadcasting standards, an analysis of the world experience in the implementation of digital audio broadcasting of the T-DAB+ standard (hereinafter - DAB+), in the report on the 1st stage of this research:

- it has been established that the DAB+standard is the most acceptable standard for the technical characteristics of the ground-based CVN network;
- international experience shows that the largest number of countries in the world are implementing and planning to implement the DAB+NCZV standard;
- it is determined what is optimal for the organization of the NTSV standard

DAB+ is a radio frequency range of 174-230 MHz.

In this case, the agreement "Geneva 06" noted that the international legal terms of use bandwidth

174-230 MHz sound broadcasting reflected in the Final acts of the Regional Radiocommunication conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3 in the frequency bands 174-230 MHz and 470-862 MHz (RRC-06), ITU, Geneva, 2006 (hereinafter-the Agreement "Geneva 06").

The Geneva-06 Agreement defines the broadcast radio frequency bands considered in the document, namely:

Band III: 174-230 MHz;

Band IV: 470-582 MHz;

V band : 582-862 MHz.

In accordance with the Geneva-06 Agreement, the frequency range of

174-230 MHz is allocated for use by T-DAB and DVB-T systems.

The Geneva-06 Agreement contains three frequency plans:

- Plan of frequency assignments and allocations of terrestrial digital audio broadcasting of the T-DAB standard (the Plan of the Geneva-06 CLC»);
- Plan for frequency assignments and allocations of terrestrial digital television broadcasting of the DVB-T standard (Geneva-06 DTV Plan);
- Plan for frequency assignments of analog television radio broadcasting in the frequency bands 174-230 MHz (for Morocco 170-230 MHz) and 470-862 MHz in the transition period.

Uzbekistan, as many other countries, plans to switch to a digital audio broadcasting standard in the future. The transition should be carried out based on the DSB Plan of the “Geneva-06” agreement [2].

The "Geneva-06" plans cover the frequency band 174-230 MHz (band III, divided into 7 or 8 channels with a band of 8 or 7 MHz, respectively, depending on the country) and the frequency band 470-862 MHz (bands IV/V, divided into 49 channels, each with a band of 8 MHz).

Before proceeding to the full-scale implementation of DAB+ in their country, the national AU must provide this implementation with a digital radio frequency resource and provide for its international legal protection. If this AU has frequency allocations in any digital Plan "Geneva 06", then they are already protected by the agreement itself. If these allocations are not enough, or they are not in the plan at all, it is necessary to declare an additional frequency resource.

Reference Networks (ES) for T-DAB

For the T-DAB, two reference planning configurations (ECP) were defined – ECP 4 for the mobile reception case and ECP 5 for the indoor portable equipment reception case. The corresponding ES have been developed, they are identical except for their power budgets, and they are directly related to the two ECPs.

For ECP 4 (the case of mobile reception), the ES consists of seven transmitters located in the center and at the vertices of the hexagon, and is a closed-type network. The power of the central transmitter is reduced by 10 dB relative to the peripheral transmitters, which have a power of 1 kVt. The antenna patterns of the peripheral transmitters reduce the level of the outgoing field strength by 12 dB for angles above 240°. It is assumed that in these directions there will be a sharp transition in the decrease from 0 to 12 dB.

The equivalent radiated power (e. i. m.) is given for 200 MHz; for other frequencies (/in MHz), the added frequency correction factor is: 30 logi0 (/7200) for ECP 4 and ECP 5.

For ECP 5 (indoor portable equipment reception), the same reference network characteristics are used as for ECP 4, and the transmitter power is increased by 9 dB, which corresponds to the higher minimum field strength levels required for this reception mode.

For ES 5 related to ECP 4 and ES 6 related to ECP 5, the parameters and power budget levels given in Table 5 should be used; Figure 1 shows the geometry of the ES.

Table 1 - Parameters of reference networks ES 5 for ECP 4 and IC 6 for ECP 5

ECP	ECP 4	ECP 5
Type of reception	Mobile	For portable indoor equipment
Network Type	Private	Private
Service area geometry	Hexagon	Hexagon
Number of transmitters	7	7
Geometry of the transmitter array	Hexagon	Hexagon
Distance between transmitters, d (km)	60	60
Diameter of the service area, D (km)	120	120
Antenna height Tx (m)	150	150
Radiation pattern of the peripheral Tx	Directional Reduction of 12 dB for a 240°angle	Directional Reduction of 12 dB for a 240°angle
Radiation pattern of the central Tx	Undirected	Undirected
Peripheral Tx EIIM (dBW)	30,0	39,0
EIIM of the central Tx (dBW)	20,0	29,0

At this time, T-DAB networks are deployed in a number of European countries. The advent of the DAB+ system, which has improved technical and consumer characteristics, contributed to the further spread of digital audio broadcasting.

Currently, many countries are in the process of reconstructing the existing T-DAB networks and converting them to the DAB+standard. The EBU has adopted a regulatory document prohibiting European automakers from equipping cars with receivers that do not provide DAB+reception.

In the frequency band 174-230 MHz (band III), along with digital television broadcasting, both digital audio and multimedia broadcasting can work. In this range, terrestrial digital audio broadcasting systems of the DAB family of standards (T-DAB and DAB+) are used.

There are several developers of specialized programs on radio frequency spectrum management with their packages of various software products, such as the LS Telcom (Germany), ATDI (France) etc.

For today, специалисты EMCAS SUE «UNICON.UZ» specialists use a software product ATDI ICS Telecom for frequency-territorial planning of radio communication networks of various standards, for calculating EMC using digital cards[3].

Discussion

ICS Telecom functions are based on the coverage area calculation of transceiver devices taking into account the area relief and morphology. Uses digital terrain models to simulate radio wave propagation in frequency ranges from 10kHz to 450 GHz in dynamic 2D or 3D display.

For example, ICS Telecom allows you to design and account for any modern wireless communication networks type, in particular:

- mobile radio networks: 2G, 3G, W-CDMA, CDMA 2000, LTE;
- fixed and mobile access networks WiMAX,
- point-to-multipoint networks: LMDS, WLL, BWA, DECT;
- radio relay networks;
- broadcasting networks: analog and digital TB broadcasting DVB-T, DVB-H, digital radiobroadcasting T-DAB;
- professional communication networks: analog, digital, TETRA;
- radar and direction finding networks.

The techniques and functions implemented in HTZ Communications offer the following features::

- forward planning to identify the best locations for new sites for scenarios from scratch and to seal existing networks;
- analysis of the transition from analog to digital communication;
- analysis of indoor coverage by calculating signal penetration losses;
- analyze the population by points, areas, import vector polygons or raster files;
- in-depth study of network coverage, composite coverage, overlap, best server, and network compaction;
- tuning the signal propagation model by correlation analysis between prediction and measurement of parameters;
- automated frequency assignment and optimization;
- traffic analysis by territory, target areas, or grid blocks for coverage
- point-to-point network analysis, including path profile, reliability, automatic optimization, frequency and spatial diversity, frequency analysis;
- planning and analysis of simultaneous transmission of sishnals;
- calculations of electromagnetic fields;
- field strength prediction;
- simulation of radio wave propagation based on the physical features of the terrain, including the diffraction effect;
- interference calculations and determination of the coordination zone;
- graphical display of the station service area on background maps;
- analysis of the covered population;

- analysis of the possibility of joint operation of analog and digital networks;- frequency planning of multi-frequency networks T-DAB MFN with the ability to assign frequencies to avoid intrasystem and intersystem interference;
- frequency planning of single-frequency T-DAB and DAB+networks (delay time configuration to avoid SFN/COFDM interference. Preliminary calculation of the SFN coverage area, unserved areas designation on the map);
- interference analysis for single frequency SFN T-DAB и DAB+.

ICS Telecom software product is managing multiple transmitters capable and their coverage within one project. It is based on a graphical interface for both single user and teams performing network planning work [4].

These and other advantages of this software make it an indispensable tool for solving complex problems of calculating the service areas of digital SFN and MFN. At the same time, it is possible to take into account the systems specifics with many carriers, in particular, OFDM technologies, intra- and inter-network interference calculation, as well as time delays setting for SFN.

RF channels in a frequency band (174 - 230) MHz, allocated in accordance with the Geneva-06 Plan for the allotment zone of the Republic of Uzbekistan, and their values are given in table 2« Radio frequency channels in the frequency band (174 - 230) MHz for the allotment zone of the Republic of Uzbekistan».

Table 2 - Radio frequency channels in the frequency band (174-30) MHz for the allotment zone of the Republic of Uzbekistan [5].

Frequency range	Radio channel number	Radio channel frequency band, MHz	Center frequency of the radio channel frequency band, MHz
III	6	174 - 182	178
	7	182 - 190	186
	8	190 - 198	194
	9	198 - 206	202
	10	206 - 214	210
	11	214 - 222	218
	12	222 - 230	226

The T-DAB digital sound broadcasting system is designed to organize multiservice sound broadcasting for reception on mobile, portable and stationary receivers in rough terrain. It is designed to operate in terrestrial, satellite and cable broadcasting networks (Table 3).

Table 3 - DAB+ operating modes

Mode	Mode I	Mode II	Mode III	Mode IV
Typical use	Terrestrial broadcasting, VHF range	Terrestrial broadcasting, L range	Спутниковое broadcasting, L range	Terrestrial broadcasting in the city, L range
Number of carriers, n	1536	384	192	768
Carrier spacing, Df,kHz	1	4	8	2
Symbol duration, T_U, µs	1000	250	125	500
Duration of the guard interval, T_G,	246	62	31	123

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μs				
Total symbol duration, T_S, μs	1246	312	156	623

DAB - the system is designed as a flexible multipurpose digital broadcasting system that can support a wide sources range with bit rates from 8 to 320 kbit/s, several levels of additional channel coding [6].

One of the ways to ensure high-quality reception in the conditions under consideration is to use a multi-frequency COFDM signal, in which:

- uses time and frequency interleaving and error correction codes (the letter "C" in the abbreviation COFDM);
- orthogonality of carriers is provided by mathematical arrangement of carrier separation and use of symbol duration;
- an additional guard interval is used to reduce intersymbol interference;
- QPSK modulation of each carrier frequencies is used, followed by differential demodulation at the receiver.

To correct errors in the DAB system, convolutional coding of each source is used. In the ETSI EN 300 401[7] standard provides five levels of protection for audio signals with coding rates from 1/3 to 3/4 and eight levels of protection for the overhead using a decimation procedure in a convolutional encoder.

DAB system parameters for different audio protection levels are shown in Table 4. The table shows the values of the signal-to-noise ratio at the input of the receiver by radio frequency, if the error rate is provided at the output of the convolutional code decoder (Viterbi decoder). It should be noted that the total transmission rate of the DAB signal, taking into account the correction code for all protection levels, is 2,4 Mbit/s. When planning a DAB network, the third level of protection is usually used.

Table 4. Protection levels in DAB

Protection level	Code speed	signal-to-noise ratio (dB) at $\kappa_{ош}=10^{-4}$ for channel			Transmission speed, Mbit/s
		Gaussian	Raisovsky	Releevsky	
1	0,34	5,9	7,1	12,1	0,78
2	0,43	6,7	8,0	12,6	0,99
3	0,5	7,4	8,8	13,3	1,15
4	0,6	8,4	10,0	14,9	1,38
5	0,75	10,2	12,0	18,6	1,73

When planning a digital broadcasting network, it should be ensured that the minimum signal power at the receiver input, at which the output of the Viterbi decoder provides the error rate $P_{ош} = 10^{-4}$. The minimum signal power at the receiver input is determined by the receiver bandwidth and its noise figure:

$$P_n = F + 10logkT_0B \quad (1)$$

$$P_{Smin} = P_n + \frac{C}{N} \quad (2)$$

where: B - receiver noise bandwidth, MHz;

C/N – signal/noise ratio at radio frequency, dB;

f - radio frequency, MHz;

F - receiver noise figure, dB;

P_n- receiver input noise power, dBW;

$P_{S\min}$ - minimum signal power at the receiver input, dBW;

K = 1,38· 10^{-23}W/Hz·grad - Boltzmann constant;

T_0 = 290° K - absolute temperature[8].

Terrestrial digital broadcasting systems based on COFDM modulation with the introduction of a guard interval mechanism, have the ability to receive, along with the main (useful) signal, also delayed signals (for example, reflected from obstacles on the ground) in the event that the delay value does not exceed the guard interval value. With a sufficiently large value of the guard interval, this also makes it possible to receive signals from other useful stations operating in the same frequency channel. In this case, all useful signals received at the omnidirectional antenna are added up in the receiver, which can significantly improve the reception quality. The summing signals effect from different transmitters is called "network amplification". A transmitting stations network synchronously operating on the same frequency and transmitting the same program is called a single-frequency network - SFN. However, the construction of single frequency digital broadcasting transmission networks requires careful design. Therefore, MFNs are more commonly used in TDSB networks[9].

The minimum required field strength used for planning in the III VHF band for mobile reception of digital broadcasting, taking into account the above correction factors is given in table 5.

Table 5 - Minimum required field strength for frequency range III (174-230 MHz)

Parameter	Value
Minimum equivalent field strength, dB/μV/m	35
Correction factor when going from 50% to 99% of seats, dB	+13
Correction factor when going from antenna height 10 m to 1.5 m, dB	+10
The minimum equivalent field strength of scheduling mobile reception of digital broadcasting, dB/μV/m	58

Propagation curves used to calculate field strength built for receiving antenna at 10 m heights above ground level. Digital broadcasting will be planned mainly for mobile reception, where the receiving antenna height is 1,5 m. Therefore, it is necessary to make 10 dB correction to the obtained from the propagation field curves strength, to take into account the reception on the 1.5 m antenna, instead of 10 m [10].

Conclusions. The introduction of digital broadcasting is only the first step towards the latest digital information technologies of tomorrow.

In DSB T-DAB, signals are transmitted in frequency blocks. The frequency block width is 1.536 MHz, the guard frequency interval between adjacent blocks is 176 kHz.

The protection ratio value for co-located T-DAB frequency blocks is 10 dB, and for adjacent blocks - minus 30 dB.

When calculating the maximum allowable field strength of the interfering signal the protective attitude given above must be taken into account. In addition, useful signal protection from interfering is required in 99% places, and not in 50%, determined from the propagation curves. Therefore, to take protection into account, a correction factor of 18 dB is introduced 99% of the time.

The introduction of digital radio for Uzbekistan is especially important since it should provide not only a significant increase in the quality and quantity of programs and additional services to the population, but also more efficient use of the radio frequency spectrum, energy consumption reduction by radio transmitting means, loading the industry and creating new jobs for the mass production of digital radio equipment.

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