COEXISTENCE OF TELEVISION BROADCASTING, FM BROADCASTING, DIGITAL BROADCASTING IN DAB AND DRM+ STANDARDS CALCULATION METHODOLOGY

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ABSTRACT

The model parameters of analogue and digital radio and TV broadcasting networks are determined on the basis of data on frequency assignments to radio broadcasting stations using information on issued permits for the use of radio frequency channels of existing and planned radio broadcasting stations. The parameters of the network model are also determined on the basis of data contained in the database on frequency assignments of a radio frequency service organization or radio frequency application materials for obtaining an EMC examination conclusion submitted to a radio frequency service organization to obtain permission to use frequency blocks / radio frequency channels for the declared radio broadcasting stations. The problem of sharing the spectrum in the VHF band by terrestrial digital television broadcasting services (DVB-T standard, etc.), analogue television broadcasting, analogue FM audio broadcasting, digital audio broadcasting DAB/DAB+, DRM+ and RAVIS and the conditions for them coexistence are considered. Compatibility criteria and calculation algorithm are considered. Compatibility criteria and calculation algorithm are considered. Directions for further research are presented.

KEYWORDS: *calculation methodology, coexistence, digital broadcasting, DAB, DRM+, FM broadcasting, television broadcasting.*

DOI: 10.36724/2664-066X-2024-10-1-18-23

Received: 16.12.2023
Accepted: 18.01.2024

Citation: Albert Waal, "Coexistence of television broadcasting, fm broadcasting, digital broadcasting in DAB and DRM+ standards calculation methodology," *Synchroinfo Journal* **2024**, vol. 10, no. 1, pp. 18-23

1 Introduction

Despite the widespread introduction of terrestrial digital television broadcasting (DVB-T standard and others) around the world [1-3], analogue television broadcasting [4,5] continues in a number of countries. In some cases, it is carried out in the VHF range. In the same range, analogue FM audio broadcasting [6-8] continues to be carried out, and various types of digital audio broadcasting [9-11], such as DAB/DAB+, DRM+ [12-14] and RAVIS, are being introduced. For this reason, it is necessary to consider the conditions for sharing the spectrum to ensure the coexistence of these types of broadcasting [15-17], which is especially important for the border areas of countries with different rates of digitalization.

This article examines various scenarios for how all of these broadcast services can work together and defines the criteria for ensuring electromagnetic compatibility (EMC). Compatibility criteria and calculation algorithm are considered.

2 Sharing Scenarios

Scenarios for the joint use of analogue television broadcasting of the D/SECAM standard, FM broadcasting, digital broadcasting in the DRM+ and RAVIS standards in the radio frequency range 48.5-108 MHz are presented in Table 1.

Table 1

List of scenarios for sharing radio frequency range 48.5-108 MHz

Interference receptor	Interference source	Note
Analog TV D/SECAM standard 48.5-56,5 MHz (1 TVCh) 58-66 MHz (2 TVCh) 76-84 MHz (3 TVCh) 84-100 MHz (4 and 5 TVCh)	Analog TV D/SECAM standard 48,5-56,5 MHz (1 TVCh) 58-66 MHz (2 TVCh) 76-84 MHz (3 TVCh) 84-100 MHz (4 and 5 TVCh)	EMC assessment in a combined channel EMC assessment in the lower and upper adjacent channels
	Analog FM radio broadcasting 66-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	DRM+ Digital radio broadcasting 65.9-74 MHz, 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	RAVIS Digital radio broadcasting 65,8-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
Analog FM radio broadcasting 66-74 MHz and 87.5-108 MHz	Analog FM radio broadcasting 66-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	Analog TV D/SECAM standard 58-66 MHz (2 TVCh) 84-100 MHz (4 and 5 TVCh)	Estimation of EMC for different carrier frequencies of the radio channel shifts
	DRM+ Digital radio broadcasting 65,9-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	RAVIS Digital radio broadcasting 65,8-74 MHz 87,5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
DRM+ Digital radio broadcasting 65.9-74 MHz 87.5-108 MHz	DRM+ Digital radio broadcasting 65,9-74 MHz 87,5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	RAVIS Digital radio broadcasting 65,8-74 MHz 87,5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	Analog FM radio broadcasting 66-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	Analog TV D/SECAM standard 58-66 MHz (2 TVCh) 84-100 MHz (4 и 5 TVCh)	Estimation of EMC for different carrier frequencies of the radio channel shifts

RAVIS Digital radio broadcasting 65.8-74 MHz 87.5-108 MHz	RAVIS Digital radio broadcasting 65,8-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	DRM+ Digital radio broadcasting 65,9-74 MHz 87,5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	Analog FM radio broadcasting 66-74 MHz 87.5-108 MHz	Estimation of EMC for different carrier frequencies of the radio channel shifts
	Analog TV D/SECAM standard 58-66 MHz (2 TVCh) 84-100 MHz (4 and 5 TVCh)	Estimation of EMC for different carrier frequencies of the radio channel shifts

Scenarios for the joint use of analog television broadcasting of the D/SECAM standard, digital television broadcasting of the DVB-T2 standard and digital broadcasting of the DAB/DAB+ standard in the radio frequency range 174-230 MHz are presented in Table 2.

Table 2

List of scenarios for sharing radio frequency range 174-230 MHz

Interference receptor	Interference source	Note
Analog TV D/SECAM standard 174-230 MHz	DAB/DAB+ Digital radio broadcasting 174-230 MHz	EMC assessment for different carrier frequency offsets of a radio channel/frequency block
Digital TV standard DVB-T2 174-230 MHz	DAB/DAB+ Digital radio broadcasting 174-230 MHz	EMC assessment for different carrier frequency offsets of a radio channel/frequency block
DAB/DAB+ Digital radio broadcasting 174-230 MHz	DAB/DAB+ Digital radio broadcasting 174-230 MHz	EMC assessment in a combined frequency block; EMC assessment in the lower and upper adjacent frequency blocks
	Digital TV standard DVB-T2 174-230 MHz	EMC assessment for different carrier frequency offsets of a radio channel/frequency block
	Analogue TV standard D/SECAM 174-230 MHz	EMC assessment for different carrier frequency offsets of a radio channel/frequency block

To determine sharing conditions in these frequency bands, it is necessary to consider all presented scenarios. Based on the results of the analysis, it is necessary to determine the frequency-territorial separations at which EMC is ensured between various broadcast services.

3 Compatibility criteria and calculation algorithm

The main requirement when carrying out EMC calculations is the protection of existing or planned for use services in an already established EMC in a given territory.

For existing or planned services, the service area (area of reliable reception) is calculated using the appropriate values of the minimum usable field strength and taking into account interference from all potential sources of interference, with the exception of declared services.

The service area calculated in this way (area of reliable reception) of the services and the values of the reference used field strength calculated for its control points are fixed and used in further calculations as the reference service area of protected services in existing network.

The following criteria are used for EMC calculation:

1) the indicator “exceeding the used field strength”, based on calculating the value of the usable field strength (E_{fs}) at the border of the reference service area of the protected services and comparing the calculated value with the value of the reference usable field strength (E_r);

2) the indicator “excess of usable field strength”, based on the calculation of the useful station strength (E_{us}) within the reference service area of the protected services and comparison of the calculated value with the value of the usable field strength (E_{fs}).

The calculation of Eu is carried out taking into account the inclusion of the proposed services (or a group of services that form the SFN) into an already formed existing or planned network.

The indicator “exceeding the used field strength” (ΔE) is calculated for each services of the existing network (both existing and planned) using the formula:

$$\Delta E \geq E_{fs} - E_r, \text{ dB}, \quad (1)$$

where

ΔE – excess of the usable field strength, dB;

E_{fs} – usable field strength at the reference point of the reference coverage area of the protected services of the existing network, taking into account the declared services, dB(μV/m);

E_r – reference value of the usable field strength, dB(μV/m). The permissible value of exceeding the reference usable field strength ΔE at control points for digital TV and radio broadcasting is not should exceed 0.3 dB, for analog FM broadcasting – 0.5 dB.

The indicator “excess of usable field strength” is checked for each distribution zone of the existing network (both existing and planned) using the formula:

$$E_{us} \geq E_{fs}, \quad (2)$$

where

E_{us} – useful field strength for terrestrial television and radio broadcasting, dB(μV/m);

E_{fs} – the usable field strength at the reference point of the reference coverage area of the protected services of the existing network, taking into account the declared services, dB(μV/m).

The declared services (or a group of services forming the SFN) is compatible with the existing television and radio broadcasting network if two conditions are met:

1) the permissible value of the indicator ΔE is not exceeded at all control points on the border of the reference coverage area of each protected services of the existing network;

2) the useful field strength exceeds the used field strength at all control points located within the reference coverage area of each protected services of the existing network.

To determine the used field strength at the reference point of the reference coverage area of the protected services of the existing network, the value of the interfering field strength from the declared services (or a group of services forming the SFN) – sources of interference is calculated. Then all the obtained values are added using the power addition method according to the formula:

$$E_{fs} = 10\lg\left(\sum_{i=1}^{I} 10^{\frac{E_{fi}}{10}} + 10^{\frac{E_r}{10}}\right). \quad (2)$$

where

E_{fi} – strength of the interfering field from the i-th proposed services, dB(μV/m);

E_r – reference value of the usable field strength, dB(μV/m);

I – the number of declared services that form the SFN.

To determine the reference value of the used field strength at the control point of the coverage area of the protected services of the existing network, the values of the interfering field strength from all services in the formed existing or planned network are calculated. Then all the obtained values are added using the power addition method according to the formula:

$$E_r = 10\lg\left(\sum_{n=1}^{N} 10^{\frac{E_{fi}}{10}} + 10^{\frac{E_{\min}}{10}}\right). \quad (3)$$

where

E_r – reference value of the usable field strength, dB(μV/m);

E_{fn} – interfering field strength from the n-th services, dB(μV/m);

$E_{\min}$ – minimum usable field strength of the protected services, dB(μV/m);

N – number of services (interference sources) in the existing or planned network.

When determining the reference value of the field strength E_r used, the number of services (interference sources) in an existing or planned network can be limited. In this case, several services (no more than 20) with the highest E_f values are taken into account.

If the result of the EMC assessment is positive for the proposed services (or a group of services forming the SFN), the following is carried out:

– calculation of the service area (area of reliable reception), which during the subsequent protection of the declared services will be considered as a reference;

– sel ction of reference control points;

– ca culation of the reference field strength used.

A negative result of the EMC assessment, depending on the degree to which the permissible value ΔE is exceeded, means the need to adjust the parameters of the proposed services (or a group of services that form the SFN) or, in some cases, the need to carry out additional calculations that take into account in more detail the nature of the route, the characteristics of propagation and etc.

The method for assessing EMC based on the ΔE indicator is applicable when protecting services of both analogue and digital television and radio broadcasting systems. The use of this criterion when assessing EMC allows us to provide the necessary protection for existing and planned services.

When using this method, the effectiveness of EMC assessment depends, first of all, on the accuracy of taking into account the state of EMC when calculating the reference field strength used.

When protecting the proposed services, you should be guided by the requirements for the planned coverage or size of the service area.

To determine the used field strength at the control point of the coverage area of the proposed services, the values of the interfering field strength from all services in the formed existing or planned network are calculated. Then all the obtained values are added using the power addition method according to the formula:

$$E_{up} = 10\lg\left(\sum_{l=1}^{L} 10^{\frac{E_{fl}}{10}} + 10^{\frac{E_{\min}}{10}}\right). \quad (5)$$

where

E_{up} – used field strength for the proposed services, dB(μV/m);

E_{fl} – interfering field strength from the l-th services, dB(μV/m);

E_{min} – minimum usable field strength of the proposed services, dB(μV/m);

L – number of services (interference sources) in the existing or planned network.

When determining the field strength to be used for the proposed services E_{up}, the number of services (interference sources) in the existing or planned network may be limited. In this case, several services (no more than 20) with the highest E_f values are taken into account.

4 Conclusion

This article discusses various scenarios for the joint operation of terrestrial digital television broadcasting DVB-T, analogue television broadcasting, analogue FM audio broadcasting, digital audio broadcasting DAB/DAB+, DRM+ and RAVIS. Compatibility criteria and calculation algorithm are considered.

In the future, it is planned to develop algorithms for calculating the reference service area of an existing or planned distribution network; to calculate EMC between existing and planned services and declared services; and to calculate the service area of the proposed television and radio broadcasting services.

REFERENCES

[1] The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T). Chester, 25 July 1997.

[2] ETSI EN 302 755 V1.4.1 (2015-07) EUROPEAN STANDARD "Digital Vidideo Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)"

[3] Rep. ITU-R BT.2254-5 (11/2021) "Frequency and network planning aspects of DVB-T2", 2021

[4] Rec. ITU-R BT.1368-13 "Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands", 2017.

[5] Rec. ITU-R BT.417-5 "Minimum field strengths for which protection may be sought in planning an analogue terrestrial television service", 2002.

[6] Final Acts of the Regional Administrative Conference for the Planning of VHF Sound Broadcasting (Region 1 and Part of Region 3); Geneva 1984.

[7] Rec. ITU-R BS.412-9 "Planning standards for terrestrial FM sound broadcasting at VHF", 1998.

[8] Rec. ITU-R BS.704 "Characteristics of FM sound broadcasting reference receivers for planning purposes", 1990.

[9] Rec. ITU-R BS.1114-12 "Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3 000 MHz", 2022.

[10] Rec. ITU-R BS. BS.1660-9 "Technical basis for planning of terrestrial digital sound broadcasting in the VHF band", 2022.

[11] Rep. ITU-R BS.2214-5 (10/2020) "Planning parameters for terrestrial digital sound broadcasting systems in VHF bands", 2020.

[12] Final draft ETSI ES 201 980 V4.3.0 "Digital Radio Mondiale (DRM); System Specification", 2023.

[13] F. Maier, A. Tissen and A. Waal, "Evaluation of the Channel Properties for a DRM+ System and Field Tests in the VHF-Band III (174-230 Mhz)," *2010 6th International Conference on Wireless and Mobile Communications*, Valencia, Spain, 2010, pp. 160-163, doi: 10.1109/ICWMC.2010.41.

[14] F. Maier, A. Tissen and A. Waal, "Evaluations and measurements of a single frequency network with DRM+," *European Wireless 2012; 18th European Wireless Conference 2012*, Poznan, Poland, 2012, pp. 1-5.

[15] Rec. ITU-R P.2001-5 "A general purpose wide-range terrestrial propagation model in the frequency range 30 MHz to 50 GHz", 2023.

[16] K. Ulovec Analysis of Coexistence of DRM Plus and FM Broadcasting Systems. *Radioengineering*. Vol. 24, No. 4. December 2015. DOI: 10.13164/re.2015.1060.

[17] A. V. Dolgopyatova and O. V. Varlamov, "Analysis of Long-Range VHF Radio Waves Propagation to Specify Protection Ratios Between Coexisting DRM+, RAVIS and IBOC Systems," *2021 Systems of Signal Synchronization, Generating and Processing in Telecommunications (SYNCHROINFO*, 2021, pp. 1-4, doi: 10.1109/SYNCHROINFO51390.2021.9488392