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ALGORITHM AND INSTRUCTIONS FOR PRACTICAL USE IN THE METHODOLOGY OF COEXISTENCE OF TELEVISION, FM AND DIGITAL BROADCASTING IN DAB AND DRM+ STANDARDS

Albert Waal [1]

[1] RF Mondial GmBH, Hannover, Germany

ABSTRACT

The parameters of the network model are 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. The most common cases of the developed methodology application can be the following options for calculating EMC and conditions for using electronic distribution systems for television and radio broadcasting: Calculation of reference service area of the protected service; Calculation of EMC between existing and planned for use service and declared service; Calculation of service area of the proposed distribution zone.

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

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.

Article [18] 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.

The most common cases of the developed methodology application can be the following options for calculating EMC and conditions for using electronic distribution systems for television and radio broadcasting:

1. Calculation of reference service area of the protected service.
2. Calculation of EMC between existing and planned for use service and declared service.
3. Calculation of service area of the proposed distribution zone.

2 Algorithm for calculating the reference service area of an existing or planned distribution network

The algorithm for calculating reference service area of an existing or planned distribution network contains the following steps:

1. Selecting an existing or planned radio electronics system from the database – Interference receptor.
2. Formation of an array of existing or planned for use services – sources of interference (n = 1…N). The selection is carried out from the database using frequency-territorial criteria.
3. Formation of control points (j = 1…J). Control points correspond to the locations where radio distribution zones receive television and radio broadcasts and are located within the coverage area of the current or planned distribution zone.

Calculations are carried out within the coverage area (ideal zone) of the protected service, determined in accordance with the minimum used field strength of the service for television and radio broadcasting.

4. Calculation of the useful field strength (E_{us}) of current or planned radio electronics – interference receptor at the j-th control point (1).

$$E_{us} = E\,(50, 50) + \Delta P,\ \text{dB}(\mu\text{V/m}) \tag{1}$$

where E (50, 50) – field strength determined for a reference transmitter with Equivalent Isotropically Radiated Power EIRP =30 dBW, 50% of locations and 50% of reception time, for a representative height, dB(μV/m); ΔP – correction factor for the effective radiated power relative to the reference transmitter with EIRP =30 dBW.

The effective radiated power is defined as:

$$P = 10\ \lg(\text{PTx\_Tv}) + \text{GTx\_Tv},\ \text{dB(kW)} \tag{2}$$

where PTx_Tv – transmitter power, kW; GTx_Tv – gain of the transmitting antenna (corrected in accordance with the azimuthal direction to a given design point), dBd.

To more accurately predict the level of field strength, it is desirable to have information about the ground cover (obstacles, building density, terrain) along the route. It is convenient to store obstacle categories in an additional data array for consistency with profile height data.

5. Calculation of the interfering field strength of the *n*-th operating or planned for use source of interference at the *j*-th control point (3-5).

$$E_{fiT} = E\,(50, t) + \Delta P + \mathrm{PRT} + \Delta A,\ \mathrm{dB(\mu V/m)} \quad (3)$$

$$E_{fiC} = E\,(50, 50) + \Delta P + \mathrm{PRC} + \Delta A,\ \mathrm{dB(\mu V/m)} \quad (4)$$

where $E(50, t)$ – field strength determined for a reference transmitter with EIRP=30 dBW, 50% of locations and t% of reception time, dB(μV/m); ΔP – correction factor for the effective radiated power relative to the reference transmitter with EIRP=30 dBW, dB; PRT – protection ratio for tropospheric interference, dB; PRC – protection ratio for constant interference, dB; ΔA – correction taking into account the spatial and polarization noise immunity of the receiving antenna (applies only to fixed reception), dB.

$$E_{fi} = E\,(50, 1) + \Delta P + \mathrm{PR} + \Delta A + \mathrm{OLC},\ \mathrm{dB(\mu V/m)} \quad (5)$$

where $E\,(50, 1)$ – field strength determined for a reference transmitter with EIRP=30 dBW, 50% of locations and 1% of reception time, dB(μV/m); ΔP – correction factor for the effective radiated power relative to the reference transmitter with EIRP=30 dBW, dB; PR – protection ratio, dB; ΔA – correction taking into account the spatial and polarization noise immunity of the receiving antenna (applies only to fixed reception), dB;
OLC – combined location correction factor (used when protecting digital TV and radio broadcasting receivers), dB.

6. Repeating the actions of paragraph 5 for all sources of interference selected in paragraph 2 that are active or planned for use.

7. Calculation of the reference value of the used field strength (E_{fs}) at the *j*-th control point (6).

$$E_{fs} = 10\lg\left(\sum_{n=1}^{N} 10^{\frac{E_{fi_n}}{10}} + 10^{\frac{E_{\min}}{10}}\right), \quad (6)$$

where E_{fs} – reference value of the field strength used, dB(μV/m), dB(μV/m); E_{fin} – interfering field strength from the n-th service, dB(μV/m); E_{min} – minimum used field strength of the protected electronic zone, dB(μV/m); N – number of interference sources in the existing or planned network.

8. Checking the condition: $E_{us} \geqslant E_{fs}$.

If the condition is met, then a useful signal with a given quality is received at the control point, thereby forming a reference service area.

If the condition is not met, there is no reception of the useful signal, and reference service area is reduced.

9. The next control point is set within the service area of the existing or planned distribution network and steps 4-8 are carried out sequentially.

As a result, an array of control points is determined, located within the service area of the existing or planned for use service, corresponding to the boundaries of the reference service area.

10. Calculating results of the used field strength reference value at the control points of the reference service area are saved and are subsequently used when calculating EMC between existing and planned for use service and declared service.

Block diagram of the described algorithm for calculating the reference service area of the distribution network for television and radio broadcasting is shown in Figure 1.

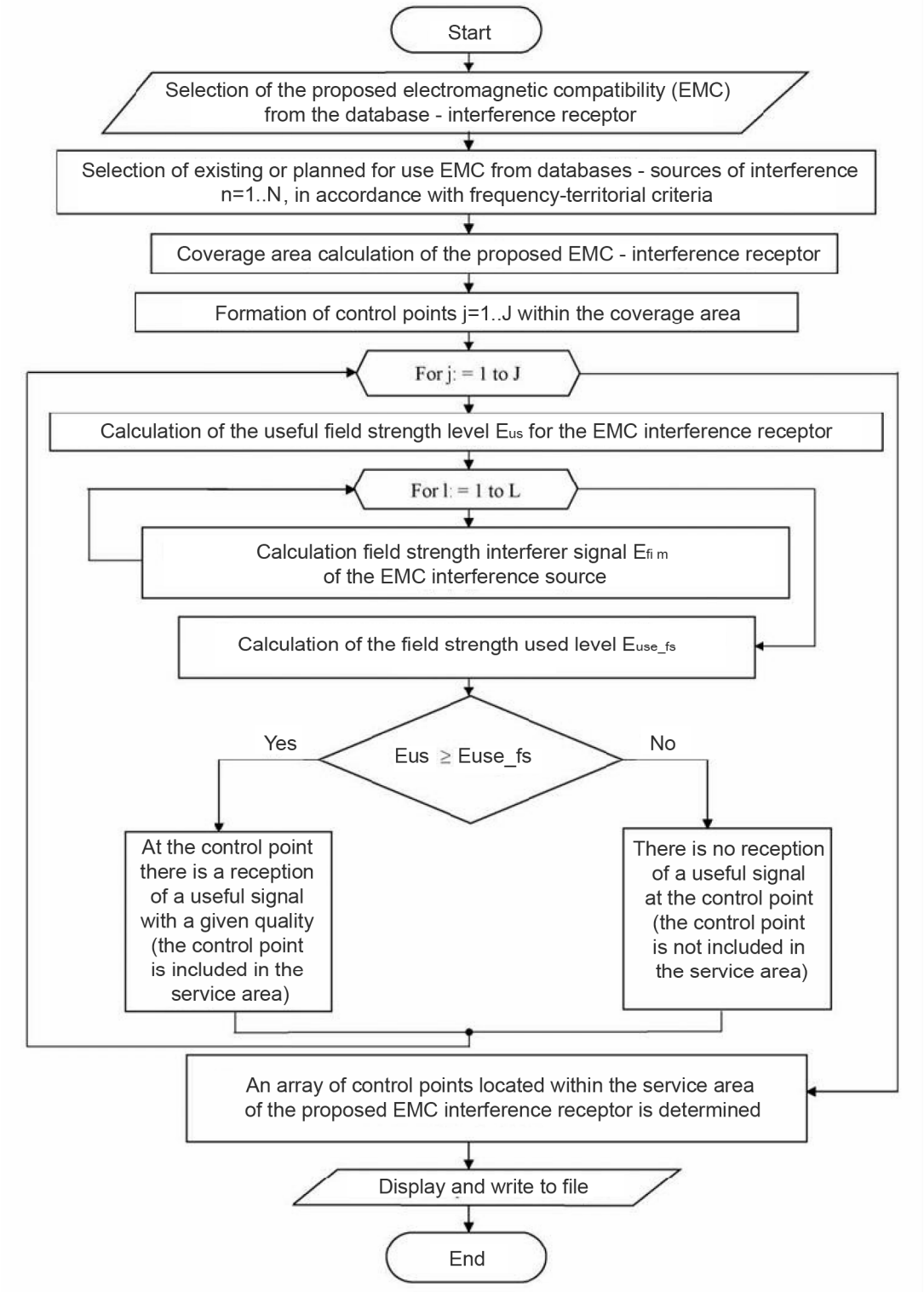

Fig. 1. Block diagram of the algorithm for calculating regional distribution network reference service area for television and radio broadcasting

3 Algorithm for calculating EMC between existing and planned for use service and declared service

The algorithm for calculating EMC between existing and planned for use service and declared service contains following stages:

1. Selecting the proposed service or a group of services forming SFN from the database and entering main initial data.

2. Formation of an ar y of existing or planned for use service interference receptors (i=1...I). Selection is carried out from the database using frequency-territorial criteria.

3. Formation of control points (j=1...J). Control points correspond to the places where radio distribution stations receive television and radio broadcasting and are located within the reference service area of the i-th operating or planned distribution zone and are determined in accordance with the algorithm for calculating the reference service area.

4. Calculation of the useful field strength at the j-th control point of the calculated reference service area of the i-th operating or planned for use service (1).

5. Calculation of the interfering field strength of the proposed service at the j-th control point of calculated reference service area of the i-th operating or planned service (3-5).

6. For the case of a group of claimed service forming an SFN, the value of the total interfering field from the specified service at the j-th control point is calculated (6).

$$E_{fi\ sum} = 10\lg\left(\sum_{m=1}^{M} 10^{\frac{E_{fi\ m}}{10}}\right), \quad (6)$$

where $E_{fi\ sum}$ – the total strength of the interfering field from the services, forming SFN; $E_{fi\ m}$ is the strength of the interfering field from the m-th service included in the SFN; M is the number of services forming the SFN.

7. Determination of the reference value of the used field strength at the j-th control point in accordance with the algorithm for calculating the reference service area of the existing or planned distribution network.

8. Calculati of the reference field strength used at the j-th control point (7).

$$E_{use\_fs} = 10\lg\left(\sum_{i=1}^{I} 10^{\frac{E_{fi_i}}{10}} + 10^{\frac{E_{fs}}{10}}\right), \quad (7)$$

where E_{use_fs} – used field strength, dB(μV/m); E_{fii} – interfering field strength from the i-th proposed service, dB(μV/m); E_{fs} – reference value of the used field strength, dB(μV/m); I – the number of declared services that form the SFN.

9. Calculation of the indicator “exceeding the used field strength” (8). Comparison with the permissible value of the indicator ΔE. The declared service (or a group of services that form the SFN) is compatible with the existing television and radio broadcasting network if the permissible value of the ΔE indicator is not exceeded at all control points on the border of the reference service areas of each protected service of the existing network.

$$\Delta E \geqslant E_{use\_fs} - E_{fs}, \text{ dB}, \quad (8)$$

where ΔE – excess of the used field strength, dB; E_{use_fs} – used field strength at the reference point of the reference coverage area of the protected service of the existing network, taking into account the declared service, dB(μV/m); E_{fs} – reference value of the field strength used, dB(μV/m).

10. Checking the condition that the value of the used field strength does not exceed the value of the field strength of the useful station (9). The declared service (or a group of services forming the SFN) is compatible with the existing television and radio broadcasting network if this condition is met at all control points within the reference service areas of each protected service of the existing network.

If the EMC criteria are met (positive check of the conditions in paragraphs 9 and 10), the actions of paragraphs 4–10 are repeated at the next control point of the reference service area of the *i*-th operating or planned for use service.

$$E_{us} \geqslant E_{use\_fs} \quad (9)$$

where E_{us} useful field strength for terrestrial television and radio broadcasting, dB(μV/m); E_{use_fs} – used field strength at the reference point of the reference coverage area of the protected service of the existing network, taking into account the declared service, dB(μV/m).

11. Repeat steps 3–10 for the remaining selected service – interference receptors.

12. The declared service (or a group of servicesforming the SFN) is compatible with the existing television and radio broadcasting network if the permissible value of the indicator ΔE is not exceeded at all control points on the border of the reference service areas, and the condition is met that the value of the used field strength does not exceed the value of the useful field strength stations at all control points within the reference service areas of each protected service of the existing network.

13. The calculation results are displayed on the screen and written to a special file.

If EMC conditions are not met, necessary measures are taken to limit the level of interference. Reducing the transmitter power, reducing the gain and introducing sectors in the antenna system, as well as changing the rating of the television or radio channel are considered as restrictive measures.

The block diagram of the described algorithm for calculating the EMC between the existing and planned for use service and the declared service is shown in Figure 2.

4 Algorithm for calculating service area of the proposed regional distribution network for television and radio broadcasting

The algorithm for calculating the service area of the proposed television and radio broadcasting distribution network contains the following steps:

1. Selecting the proposed service from the database and entering the main initial data.

2. Formation of an array of existing or planned for use service – sources of interference (*l*=1…*L*). The selection is carried out from the database using frequency-territorial criteria.

3. Formation of control points (*j*=1...*J*). The control points correspond to the places where radio electronic zones receive television and radio broadcasts and are located within the coverage area of the proposed radio electronic zone.

Calculations are carried out within the coverage area (ideal zone) of the proposed service, determined in accordance with the minimum used field strength of the service for television and radio broadcasting.

4. Calculation of the useful field strength ($E_{us}$of the proposed service at the *j*-th control point (1).

5. Calculation of the interfering field strength (E_{fi}) from the *l*-th operating or planned for use service at the *j*-th control point (3-5).

6. Repeating the actions of p.5 for all sources of interference selected in p.2 that are active or planned for use.

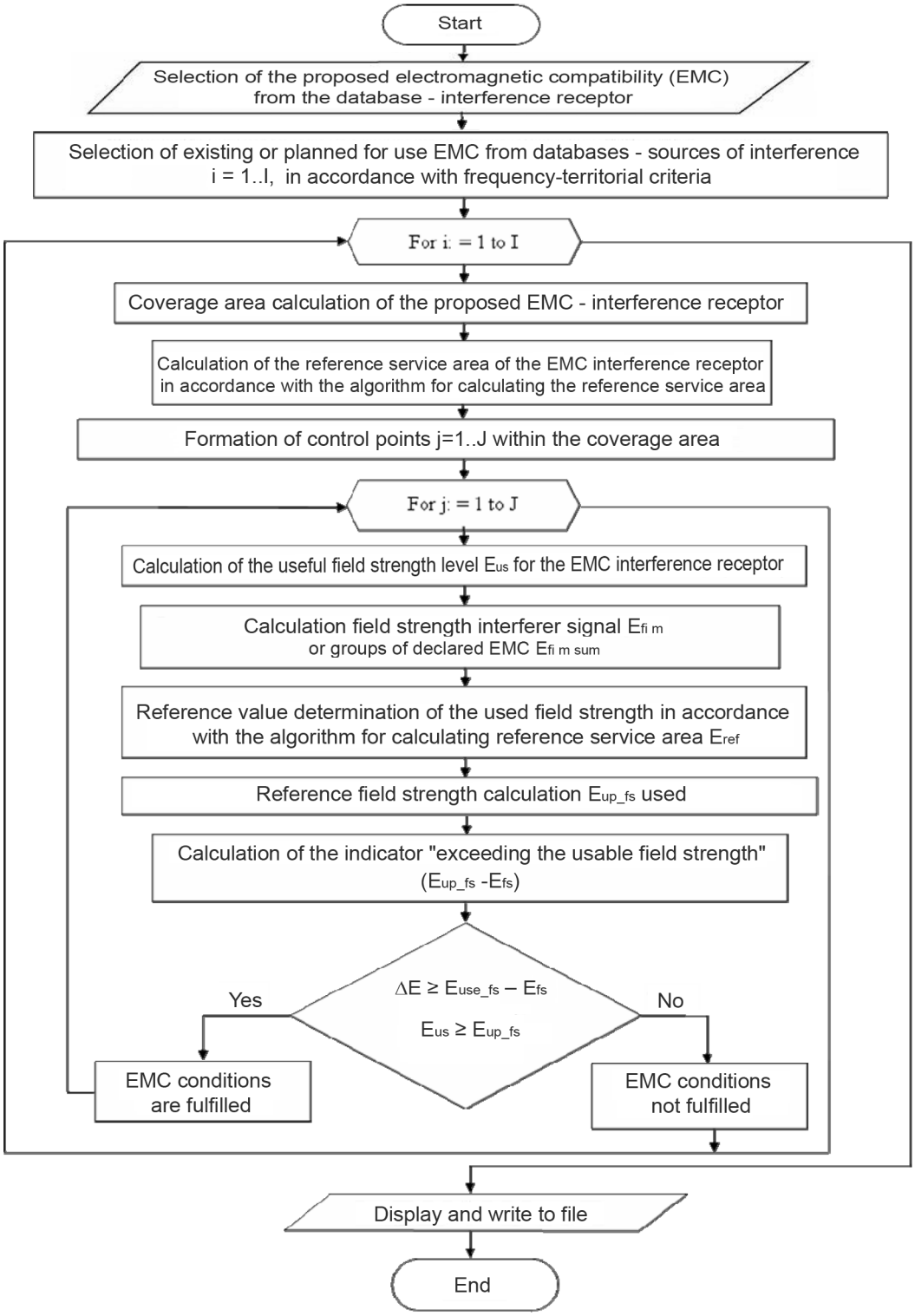

Fig. 2. Block diagram of the calculating EMC algorithm between existing and planned for use service and declared service

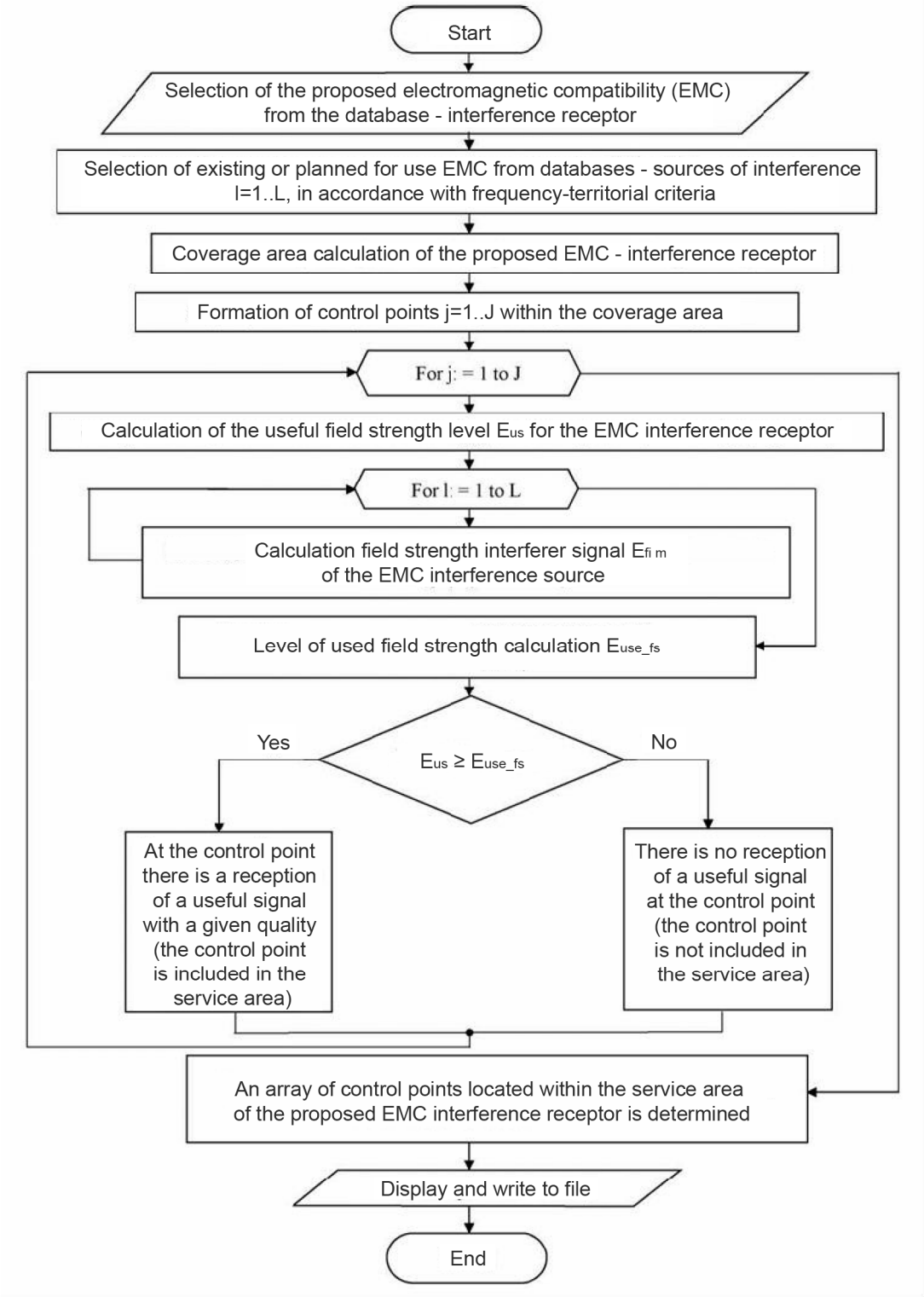

Fig. 3. Block diagram of the algorithm for calculating proposed service area

7. Calculation of the used field strength (E_{up}) at the *j*-th control point (10).

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

were E_{up} – used field strength for the declared service, dB(μV/m); $E_{fi\,l}$ – interfering field strength from the l-th service, dB(μV/m); E_{min} – minimum used field strength of the proposed service, dB(μV/m); L – number of services (interference sources) in the existing or planned network.

8. Checking the condition*:* $E_{us} \geq E_{up}$.

If the condition is met, then at the control point the useful signal is received with a given quality, thereby forming a service area (area of reliable reception) of the proposed service.

If the condition is not met, there is no reception of the useful signal and the service area of the proposed service is reduced.

9. The next control point is set within the coverage area of the proposed service and steps 4-8 are carried out sequentially.

10. The calculation results are displayed on the screen and written to a special file, and the resulting service area is displayed on the screen.

For a group of declared service that form a SFN, the service area is determined sequentially for each services.

The block diagram of the described algorithm for calculating the service area of the proposed television and radio broadcasting distribution network is shown in Figure 3.

5 Conclusion

This article 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. When protecting analogue and digital terrestrial television signals from simultaneous interference from several DAB+ blocks, it is advisable to carry out electromagnetic compatibility calculations and determine the conditions for using radio electronics separately for each DAB+ frequency block.

To determine the total interference impact from several DAB+ frequency blocks, the power addition method is used. A comparative analysis of the characteristics of digital radio broadcasting standards DAB and DAB+ (operating radio frequency bands, spectral masks, modulation methods, etc.) indicates their identity, with the exception of the applied audio signal coding method.

The procedures for processing the main digital streams, the structure of the transmission frame, the type of modulation, and the signal spectrum have not changed in the new version of the DAB+ digital broadcasting standard. Therefore, the values of the protective ratios considered as objects of influence from the DAB+ standard will also not change.

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