THE CURRENT STATE AND TRENDS OF THE DEVELOPMENT OF DIGITAL TELE-RADIO BROADCASTING SYSTEMS IN THE WORLD

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ABSTRACT

The object of the research is to make an analysis of the current state of the digital tele-broadcasting systems in the world and the transition trends from analogue to digital systems recommended by the International Telecommunication Union (ITU-R) for use in this area are considered. Therefore, the current trend of global transition to digital tele-broadcasting is due not only to the lack of a frequency resource, but also to society's growing demands for up-to-date information, the need to introduce common global standards and systems for broadcasting systems. expansion of digital tele-broadcasting in the context of globalization, as well as the presence of this transmission technology. In this work, he is dedicated to considering the sustainable development trends of digital satellite broadcasting in the world in the phase of migration from analog to digital technologies in this area. In the final part, the results obtained based on the research and analysis made in recommendations and in the ITU-R database are presented.

KEYWORDS: *tele-radio, terrestrial, broadcasting, digital, systems, frequencies, transmitters, transition, satellite, broadcasting, International Telecommunication Union*

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The Radiodifusion and digital television use the internet and 4G technology through cable, satellite, and mobile communications systems to keep the population informed. Despite the rapid development of 5G technology. In addition, there is a transition to active digital broadcasting systems and recommended by the International Telecommunication Union ITU-R for application in this area. This is mainly due to the additional benefits offered by digital television technologies and their expansion in the world. These benefits include [1, 13]:

– the ability to create single frequency networks, which significantly saves the radio frequency resource, and increases the efficiency of the use of the radio spectrum;

– improve image and sound quality, the ability to switch to surround, stereo and multichannel broadcasting;

– guarantee the protection of broadcast programs and other information against unauthorized access, which makes it possible to create paid broadcast programs;

– creation of interactive systems of tele-broadcasting, using which, the viewer and/or listener has the opportunity to work on the broadcast program, to request programs of interest to him at a time convenient for him;

– improve the quality and number of programs broadcast in the long wave (LF), medium (MF) short (HF) bands, with significant energy savings by radio devices and transmitters;

– the possibility of receiving high-quality mobile digital radio broadcasting programs, both in megacities and in places with compact populations, and in remote and inaccessible territories with low population density;

– the possibility of transmitting alerts to the population, governmental organizations, special services, state-owned companies, and in emergency situations.

Therefore, the current trend of global transition to digital tele-broadcasting is due not only to the lack of a frequency resource, but also to society's growing demands for up to date information, the need to introduce common global standards and systems for broadcast systems. expansion of digital tele-broadcasting in the context of globalization, as well as the presence of this transmission technology. This work is dedicated to considering the sustainable development trends of digital satellite broadcasting in the world in the phase of migration from analog to digital technologies in this area.

The development of an analog television program eventually led to the spread of three main standards in the world for color television: **NTSC, SECAM, PAL** [1]. Television in these formats is still watched in many countries, almost half a century after its creation.

The **NTSC** system (National Television System Committee) is used in North and Central America, in several countries in the eastern part of South America, as well as in Japan, South Korea and in several countries in the Southeast Asian [1]. The **SECAM** system (Séquentiel Couleur á Mémore – Sequential Color With Memory) is used in Russia, the countries of Eastern Europe and the Commonwealth of Independent States (CIS), France, most countries in North Africa and Southeast Asia [1, 2].

The PAL (Phase Alternate Line) system is used in most western and northern European countries, India, China, Australia, Brazil, Argentina, Angola, and other countries [1].

Among the digital terrestrial television transmission systems recommended by ITU-R for application in this area, two from the DVB (Digital Video Transmission) family are particularly noteworthy: DVB-T, DVB-T2 (where T is Terrestrial), and for the satellite system two are also worth noting: DVB-S (Digital Video Transmission via Satellite), DVB-S2. The DVB-T2 system (figure 1) is perhaps one of the most common Digital TV systems recommended by ITU-R for use in the VHF (Very high frequencies, 30 ... 300 MHz) and UHF (Ultra-High Frequency) bands 300 ... 3000 MHz). The European Telecommunications Standards Institute DVB-T standard emerged in 1996 [1, 3, 4]. Figure 1. We show the number of countries and their respective digital broadcasting systems.

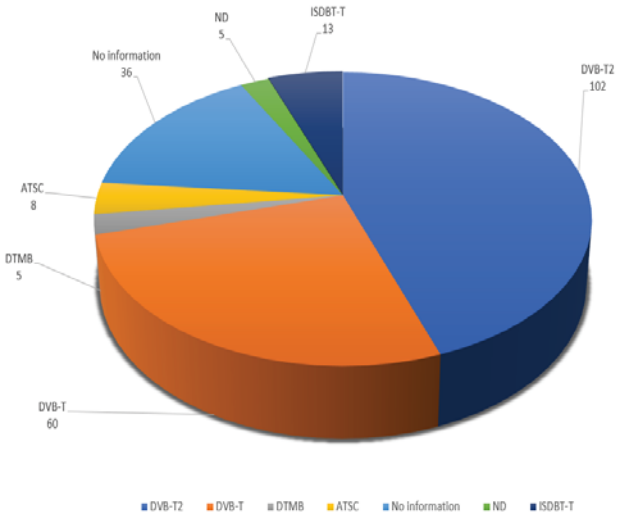

Figure 1. Number of countries and respective digital broadcasting systems

In February 2006 (within the scope of the DVB consortium), the creation of a study committee for this mission was established. This committee had to assess the potential of various digital television technologies and start to develop an improved standard, called DVB-T2, which also implements several business requirements:

– the bility to receive programs on existing simple home antennas;

– the transition to a new standard should not require a change in the transmission network infrastructure;

– an increase of at least 30 to 50% in productivity compared to the **DVB-T** system under identical transmission conditions;

– increase the flexibility of using the radio band's frequency band, and the possibility of diversification;

– the presence of a mechanism to reduce the peak power of the transmitted signal to the average value and several other less important requirements.

The above recommendations were implemented in the development of the DVB-T2 standard in 2010. The decision to implement the DVB-T2 standard was taken by the administrations of Austria, Great Britain, Germany, Denmark, India, Spain, Italy, Kazakhstan, Slovakia, Ukraine, Finland, Czech Republic, Sweden, South Africa, Russia, and many other countries in transition. In addition, in several countries in the world, the transition to digital TV has already been completed [1, 25]. In some countries, it did not even begin as (Bangladesh, Belize, Central African Republic, Eritrea, Jamaica) as shown in Figure 2.

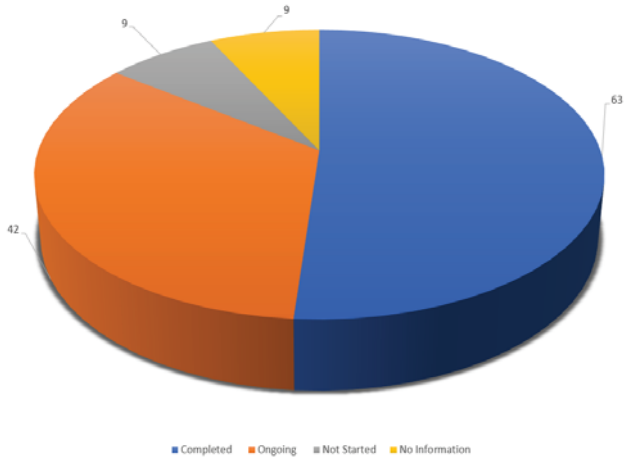

Figure. 2. Number of countries and their status for transition from the Digital TV system

We emphasize once again (figures 1 and 2) that the DVB-T2 system, which currently has the best characteristics, is the most used among the countries that have already opted for the digital television system (figure 1). The transition from analogue to digital television systems, established by the ITU-R Regional Radiocommunication Conference in Geneva in 2006 (RRC-06), was due to be completed in June 2015 [4]. However, due to several reasons (organizational, economic, and technical), this period was later postponed to 2020 [4].

The observed decrease in the cost of equipment for digital television networks of the DVB-T2 standard will allow that by the year 2030, highly efficient systems will be created for the delivery of digital content to users. At the same time, the limited volume spectrum is released due to the migration from analog to digital television for other types of use, mainly for mobile communication systems. We can say that in the world there is a process of transition to digital TV, which has not yet been fully concluded.

As for digital broadcasting systems, the situation is much more complicated: in many countries there is a clear delay in terms of switching to the "digit" in the very high frequency range (VHF 30 ... 300 MHz), intended (according to with the ITU-R recommendations) mainly for the use of high quality stereo broadcasting systems. Recommendations ITU-R.BS.1114-6 [22] and ITU-R.BS1660-6 (08/2012) [23] ITU-R present the construction resources, technical characteristics, and network planning of the following terrestrial digital broadcasting systems:

– **T-DAB** (Digital Audio Broadcasting), digital radio system in a 174…240 MHz frequency band, VHF III [10];

– **ISDB-T** (Integrated Services Digital Broadcasting Terrestrial), is a system recommended for television channels with a width of 6, 7 or 8 MHz for the transmission of sound programs, a segment is allocated as a fourteenth of the frequency range of the television channel, the frequency range of that segment is 429 kHz (6/14), 500 kHz (7/14), 571 kHz (8/14) [29];

– **DRM +** (Digital Radio Mondiale), recommended by ITU-R for use in the LF (30… 300 kHz), MF (300… 3000 kHz), HF (3… 30MHz) and VHF (30… 300 MHz) bands where bands of specific frequencies are allocated for other transmission purposes [8];

– **IBOC HD Radio FM** (In Band On Channel), recommended by the ITU-R for use in the VHF band [9];

– **RAVIS** [1, 24], is a Russian audiovisual information system in real time, recommended by the ITU-R for use in the VHF band. Note that the IBOC HD Radio FM and IBOC HD Radio AM technologies are combined under one standard. The same observation applies to DRM and DRM + systems. Of the above-mentioned systems, Digital broadcasting, only two are the most universal, recommended by ITU-R for use in all frequency bands allocated for transmission (LF, MF, HF, VHF bands). These are the DRM and IBOC HD radio systems.

From the data in table 2, it follows that the DAB system is currently the most widely used [6].

Initially, the Digital Audio Broadcasting (DAB) system was positioned by the developers only as a digital broadcasting system, designed to transmit quality sound programs, different information related only to digital data.

The **DAB** (Digital Sound Broadcasting) system is a system for use in megacities, as well as in areas with high population density, where the construction of a single frequency network is beneficial. However, this does not exclude its use either at the regional level, or simply at radio stations operating separately, which is also provided by the standard. Later, more efficient digital audio data compression algorithms were developed and standardized [5,16,17,18,19]. They were added to the new second version of the standard, called DAB +, which appeared in 2006 [5]. In particular, compression algorithms were added in the HE-AAC v.2 (High Efficiency- Advanced Audio Coding) encoder of the MPEG-4 standard (Moving Picture Experts Group). Moving Images) ISO/IEC 14496-3 [18] (International Organization for Standardization-International Organization for Standardization and International Electrotechnical Commission-International Electrotechnical Commission) and MPEG D (Group of Experts in Moving Images) Surround [19]. The ability to use the MPEG-1 ISO/IEC 11172-3 Layer II compression algorithm remained in this version of the standard for the DAB + system.

The DAB + (Digital Sound Radio) system is a much more flexible technology when used in small towns, it is possible to receive mobile data in a simple whip antenna

from a wide variety of multimedia information, including mobile television. Note that the subsequent processing of the digital data of the subchannels in the DAB + system has not changed compared to the DAB system. In 2009, there was an addition to the DAB + system, dedicated to the transmission of video information (video services), which transforms it into a complete multimedia system focused on mobile reception and television transmission [6,14,20].

According to the ITU-R recommendations, regular transmission of DAB / DMB family systems is carried out in 41 countries, and experimental transmission in 18 other countries. Since 2005, the T-DMB system started broadcasting in Seoul (South Korea). At the beginning of 2006, there were already 18 projects in the world to introduce DMB technology based on the terrestrial transmission infrastructure of the existing T-DAB system. In Europe, the main projects were launched in Germany, France, Norway, the Netherlands, Finland, England and Italy [14, 15]. The leader in this process is Germany, where in June 2006 there were already 39 T-DMB transmitters operating in 12 cities based on the use of transport mechanisms in the DAB + system.

In 2016, the most recent version of the standard for the DAB system appeared [10]. The specification [19] transforms the DAB / DAB + system in terms of its characteristics into multimedia A systems (also known as T-DMB), [20,12,21]. On a 1.54 MHz radio channel using transport mechanisms, DAB systems can be transmitted simultaneously:

– sev ral sound programs with different levels of quality;

– several television programs with monophonic or stereo accompaniment;

– v rious data, relevant information for entrepreneurs, fixed and mobile images, text and graphic information, etc.

Table 1

Technical characteristics	DVB-S2 System ETSI EN 302 307-2 V1.2.1 (2020-08) [30,31]	DVB-S System ETSI EN 302 307 V1.4.1 (2014-07)
1. D a input	Multiple transport flow and generic encapsulation (GSE)	A single transport streams (MPEG-TS)
2. Mod	Variable encoding. Coding adapted to modulation	Constant and modulated coding
3. Er r correction (FEC)	LDPC + BCH ¼, 1/3, 2/5, ¾, 4/5, 5/6, 6/7, 8/9, 9/10	Reed – Solomon (RS) ½, 2/3, ¾, 5/6, 7/8
4. Modulati	QPSK, 8PSK, 16APSK, 32APSK	Single carrier QPSK
7. Satéllite EI (dBW)	53.7	51
9. Modulati and coding	QPSK 7/8	QPSK 2/3
10. en speed	30,9(a=0,35)	27,5(a=0,35)
11. C (27,5 MHz)	7,8	7,8
12. ansfer fee per (Mbit/s)	58,8 (+32%)	33,8
13. № de channels SBTV	13 MPEG – 2 AVC 26 MPEG – 4 AVC	10 MPEG – 2 AVC 20 MPEG – 4 AVC
14. № de channels HDTV	3 MPEG – 2 AVC 6 MPEG – 4 AVC	2 MPEG – 2 AVC 5 MPEG – 4 AVC

Table 2

	System name	Tele-broadcasting		Starting year
Europe	DVB-S		Satellite	1998
	DVB-S2x	TV	Satellite	2006
	DAB	Audio	Terrestrial/satellite	
	DRM	Au	Satellite	2003
USA	IBOC	A	Terrestrial	2003
	Sirius	Audio	Satellite	2001
	XM	Aud	Satellite	2001
Japan	ISDB-S		satellite	2000
	MSB	Audio	Satellite	2003

Table 3

Condition (Status)	Digital Broadcasting System Name [32]			
	DAB/DAB+	DRM/DRM+	IBOC HD RADIO FM	ISDB-T
Regular Transmission	Australia	Tunisia	United States of America	Argentina
	Belgium	Malaysia	Argentina	Brazil
	Czech republic	Hungary	Mexico	Bolivia
	Denmark	India	Canada	Botswana
	France	Canada	Czech Rep.	Venezuela
	Germany	Ecuador	Colombia	Costa Rica
	Hong Kong	Mongolia	Jamaica	Peru
	Ireland	Finland	-	Paraguay
	Italy	Japan	-	Japan
	Kuwait	New Zealand	-	
	Malta	Corea	-	-
	Monaco	Rússian	-	-
	Netherlands	México	-	-
	Norway	-	-	-
	Poland	-	-	-
	Slovenia	-	-	-
	South Korea	-	-	-
	Spain	-	-	-
	Sweden	-	-	-
	Switzerland	-	-	-
	United Kingdom	-	-	-
	-	-	-	-
Experimental Radio	Austria	Brasilia	China	Uruguay
	Bahrain	France	Poland	Chile
	Brunei Darussalam	Croatia	savior	Nicaragua
	China	Germania	France	Honduras
	Taipei	Pakistan	Germany	savior
	Italy (Rome)	Italy	Indonesia	Guatemala
	Hungary	Romania	Philippines	Philippines
	Indonesia	Nigeria	Puerto Rico	Sri Lanka
	Israel	Beautiful Russia	Panama	Moldova
	Latvia	-	Dominican Rep.	Ecuador
	Malaysia	-	-	Angola
	Mongolia	-	-	-
	Myanika	-	-	-
	New Zealand	-	-	-
	Slovakia	-	-	-
	South Africa	-	-	-
	Thailand	-	-	-
	Tunisia	-	-	-
	Turkey	-	-	-
	Ukraine	-	-	-
	United Arab Emirates	-	-	-
	Estonia	-	-	-
Undecided Countries	Lithuania	Mozambique	-	-
	Russian Federation	Tanzania	-	-
	Serbia	Zambia	-	-
	Singapore		-	-
	Sri Lanka	-	-	-
	Vietnam	-	-	-

The DRM (Radio Digital Mondiale) system is a multifunctional digital transmission system, which was first standardized by the European Telecommunications Standards Institute (ESTI) in 2001 [8]. Originally, he intended to operate in the long wave (LF), medium (MF) and short (HF) transmission bands, that is, in the frequency sections of up to 30 MHz allocated by the ITU-R for audio transmission.

In 2009, a new version of this standard was published, in which the operating frequency range was expanded to a frequency of 240 MHz [14].

In this version of the standard, operation mode E, version of the system itself, is added, when operating in this mode, in a series of publications that received the name of DRM +. The latest version of this standard was published in January 2014 [1,14, 27, 28, 29].

Unfortunately, although there is no mass production of receivers of this format, the distribution of this system in the world is much slower, but still the number of countries focusing on its use is quite large (Table 3). For this reason, this system is recommended for countries with large territory and low population density.

Table 3. Distribution of digital transmission systems via satellite recommended by the ITU for application in this area [30,31].

As for the countries of North and South America, the American IBOC HD Radio system is spreading in some countries (Table 2).

Conclusion

1. In almost all documents and recommendations of the International Telecommunications Union for application in television and satellite broadcasting, digital systems have some transversal characteristics common in the processing and transmission of digital image and sound data, among which must be attributed: the compression of digital data, the permissible noise, the encoding of the audio and video-frame level, randomness of the digital data, which is necessary for a more balanced distribution of the signal energy in a frequency range of the radio channel, channels coding with different levels of protection of individual parts of digital streams, temporarily alternating digital data, alternating a cell modulation frequency during OFDM-character formation; multiple frequencies with OFDM or COFDM modulation, but with different configurations. It is the difference of these small details that ultimately determine their efficiency, quality, and the choice of countries for application in their respective territories.

2. Different publications by individual authors have been analyzed, reports and ITU-R recommendations show that the world is currently in constant transition from digital tele-broadcasting systems under the responsibility of two digital technology platforms for these systems, with emphasis on Europe (the DVB-T, DVB-T2, DVB-S, DVB-S2 system). Currently 102 countries in the world have adopted the European DVB-T2 standard.

3. The promotion of DRM and ISDB-T systems, despite their high efficiency, quality is slow enough, which apparently is the lack of mass production, the high cost of receivers of a given format. With the pandemic moment we are experiencing, the technological industries stop producing equipment on a large scale, so the process has become slower.

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