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Digitalization of Radio through DRM Standard on Mediumwave and Shortwave

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Abstract*— this paper work offers an overview of DRM standards used in digitization of radio on medium and short waves in the world. Firstly, it provides the raw characteristics of DRM technology and its working principle, with a special focus on audio coding. After that, the state of DRM transmissions in February 2014 is given. Also it gives an summary of radio stations which broadcast the program using DRM technology (country and language transmission). Broadcasting areas of radio stations are also provided, as well as the number of active DRM frequencies by regions of the world, for each radio station separately. Then, a map of DRM transmitters in the world is shown, with their main characteristics.

***Index Terms*—DRM, frequencie, radio channel, transmitters.**

I. INTRODUCTION

Shortwave radio is radio communication using the upper MF (medium frequency) and the entire HF (high frequency) portion of the radio spectrum, between 1,800–30,000 kHz.

Shortwave radio got its name because the wavelengths in this band are shorter than 200 m (1500 kHz) which marked the original upper limit of the medium frequency band first used for radio communications. The broadcast medium wave band now extends above the 200 m/1500 kHz limit, and the amateur radio 1.8 MHz – 2.0 MHz band (known as the "top band") is the lowest-frequency band considered to be 'shortwave' [1]. Initially thought to be useless, shortwave radio is used for long distance communication by means of sky wave or skip propagation, in which the radio waves are reflected back to Earth from the ionosphere, allowing communication around the curve of the Earth. Shortwave radio is used for broadcasting of voice and music, and long-distance communication to ships and aircraft, or to remote areas out of reach of wired communication or other radio services. Additionally, it is used for two-way international communication by amateur radio enthusiasts for hobby, educational and emergency purposes [2]. DRM (Digital Radio Mondiale) technology is intended for digital sound broadcasting in the frequency bands below 174 MHz. If it used in areas that are below 30 MHz (the bands LF, MF, HF) then it is called DRM30, and if it transmits in the VHF range I / II then it's called DRM+. Fig. 1 shows frequency bands applying the DRM standard [2]-[5]. DRM technology was originally developed for digital sound broadcasting in the areas where analog technology AM (amplitude modulation) was used. It is planned that AM should be replaced with digital technology which is similar to technologies DAB and DVB-T (all of these listed technologies use OFDM modulation) [3]. The primary purpose of DRM technology is for transfer of the audio content. With this basic purpose, DRM also supports the transfer of some multimedia content with lower transmission capacity:

- DRM text messages;
- EPG (Electronic Program Guide);
- Information text services (Journaline text based information service);
- Transmission frames (Slideshow);
- Channel with messages about traffic of TMC (Traffic Message Channel).

In order to promote DRM technologies, DRM Consortium was founded in 1998. The DRM Consortium (Digital Radio Mondiale) is an international not-for-profit organization consisting of broadcasters, network providers, transmitter and receiver manufacturers, universities, broadcasting unions and research Institutes. Its aim is to support and spread a digital broadcasting system suitable for use in all the frequency bands up to and including VHF Band III. There are currently 93 members and 90 supporters from 39 countries active within the Consortium. DRM was formed in Guangzhou, China in 1997, initially with the objective of digitalization the AM broadcast bands up to 30 MHz (long, medium and short-wave). The DRM System Specification for broadcasting below 30 MHz (DRM30) was first published by ETSI in 2001. Subsequently, a number of ancillary supporting standards were issued, including a Distribution and Communication Protocol. In 2005 a decision was taken to extend the DRM system to incorporate modes designed to operate in the VHF broadcasting bands. This required the addition of high-frequency modes, which, following refinement through laboratory testing and field-trials, resulted in the publication of the current (extended) DRM specification ES 201 980 v3.1.1 [3]. New DRM technology specification, ETSI ES 201 980 (v3.1.1), which has been published in august 2009. Gave novelties in terms of modes of transmission (new mod E), and also surround effect in audio coding.

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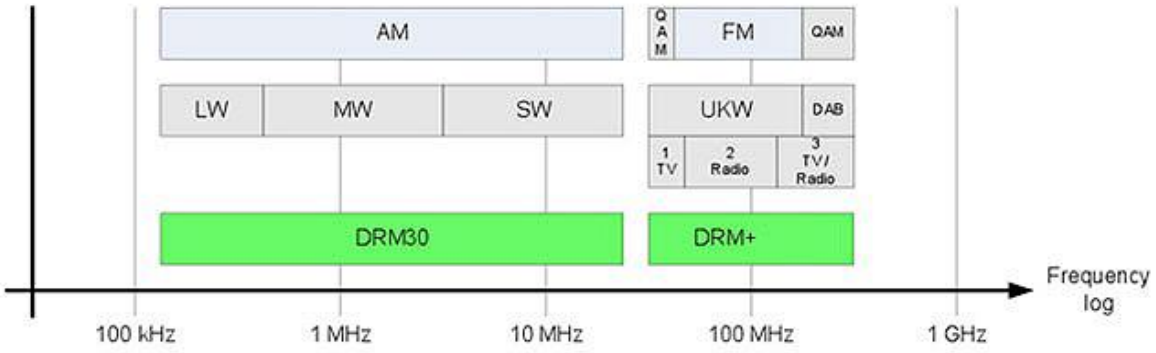

Fig. 1 - Frequency bands in DRM technology

Since the DRM+ is upgraded so that it can operate in the VHF band, it becomes the digital alternative for FM broadcasting (ITU -R BS.1114, Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3000 MHz, Proposal add to Digital System G - DRM +) [4], [6]-[8].

II. DRM TECHNOLOGY

This technology enables reliable process under different propagation conditions, or in channels of various potentials. In order to achieve it, the technology of DRM has defined different transmit modes of operation. The transmission mode is defined by transmitting parameters which can be classified into two groups:

- Parameters that are related to bandwidth frequency channels and
- Parameters associated with the efficiency of the transmission.

Width of the frequency bands can be: 4.5 kHz, 5 kHz, 9 kHz, 10 kHz, 18 kHz or 20 kHz (LF, MF, HF range) or 100 kHz (VHF range). The nominal width of the frequency band in the LF, MF and HF area is usually 9 or 10 kHz, and the other widths are less used (e.g. doubly wider channels if we want to achieve higher capacity) [3], [4].

The parameters related with the efficiency of the transmission provide ability to choose between the capacity (data rate speed) and resistance (robustness) of the noise, expansion of multipath and Doppler Effect. They include:

- The ratio of the code size and sizes related with parameters amplitude modulation (4-QAM, 16-QAM, 64-QAM hierarchical modulation method),
- Parameters related to the definition of the OFDM symbol.

As already noted, sound is a basic element of information that is transmitted through DRM technology. The analog audio signal, firstly is leaded to the unit for analog - digital conversion after which comes the compression and audio coding with adding protection form errors. Reducing of the amount of data that should be transferred is achieved by the compression process and audio coding. Besides the audio information, it is necessary to bring the data into digital information form, which is also coded into a format suitable for transmission. Two data streams obtained in that way are brought to a multiplexer in order to form a joint data stream on which is also applied a method of protecting from errors. Thus obtained common data stream is a base for forming a MSC channel (Main Service Channel). DRM signal is basically composed of data within the MSC, FCA (Fast Access Channel) and SDC (Service Description Channel) channels [9]-[11]. Data within the MSC channels presents all kinds of program content that is provided to users by DRM (can be up to 4 different types). FAC channel contains information related to the bandwidth DRM signal as well as the information regarding the selection of program content for the purposes of a fast search. SDC channel contains the information needed to decode the MSC channel, information about alternative sources of program content. Over all of these streams of data, a procedure of dispersion is applied in order to remove unwanted emissions in the range of DRM signal, and by the process of channel coding redundant bits are added in the form of codes for protection from errors. Digital information is modulated by QAM modulation method (producing QAM cells) [3], [11]. OFDM positioning combines QAM cells, MSC, FAC and SDC channels in time frequency domain. OFDM signal generator transformes cells in the DRM signal to the time domain.

III. AUDIO CODING

Due to restrictions imposed on radio channels below 30 MHz, the parameters of the coding and modulation schemes of broadcast signals, available speed for encoding sources ranges from 8 Kbit/s (half the width of the channel, i.e. 4 or 5 kHz) ≈ 20 Kbit/s (the standard width of the channel, i.e. 9 or 10 kHz) until ≈ 72 Kbit / s (for twice the width of the channel, i.e. of 18 or 20 kHz). The radio channels in the area between 30 and 174 MHz, speed for coding source are in the range of 35-185 Kbit/s. In that area, the channel width is 100 kHz [4], [12]. In order to ensure the optimal sound quality for a given rate of stream of bits, the technology offers a ability to choose from different coding schemes. Basically, they are:

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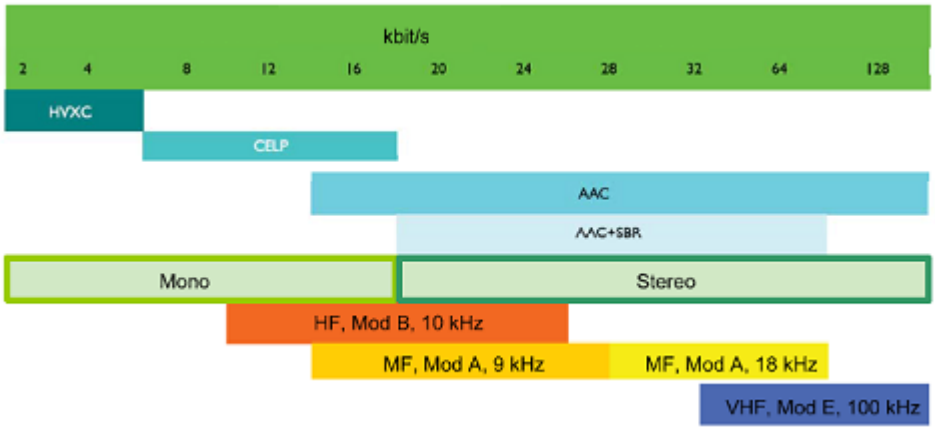

Fig. 2 - Options of audio coding for certain transmitting modes of DRM technology.

- Coding system of AAC (Advanced Audio Coding) which enables transmission of generic mono or stereo audio program. This encoding is a subset of the MPEG-4 standard. AAC can be used for any bit rate. Sampling frequency is 12 kHz, and 24 in the modes A, B, C, D, but 24 to 48 kHz for audio mode E. One frame lasts for 80 or 40 ms (Modes A, B, C, D), while in the mode E that duration is from 40 or 20 ms. The frame contains a variable number of bits [13].

- Coding system CELP (Code Excited Linear Prediction) is used in speech coding and mono transmitting. Small stream of data is generated, and such transmission is used when we want to achieve particularly strong transfer robustness. This coding is also subset of the MPEG- 4 standard. It is intended only for the encoding and decoding of speech. For the frequency band of speech (0.1 to 3.8 kHz) sampling frequency is 8 kHz, and 16 kHz for the frequency band of speech from 0.05 to 7 kHz. Speed of data stream is between 4 Kbit/s and 24 Kbit/s [13].

- Coding system HVXC (Harmonic Vector Excitation Coding) also generates a small stream of data, providing high robustness and is used at mono transmitting. It is also a subset of the MPEG-4 standard, and particularly is suited for coding of speech. Sampling frequency is 8 kHz for the frequency range of speech from 0.1 to 3.8 kHz. Speed of data stream is between 2 Kbit/s and 4 Kbit/s [13]. CELP and HVXC coding systems are used only in technology DRM30 [4], [10], [13]. With listed coding systems, the following methods to improve the sound quality are used:

- Reconstruction of high-frequency SBR (Spectral Band Replication) which can be applied to AAC, CELP or HVXC coding. It represents a tool that allows the total bandwidth of the audio signal can be transmitted by the slow stream of bits.

- Method PS (Parametric Stereo) that with the mono encoded signal adds the data stream to achieve the stereo effect sound.

- MPS (MPEG Surround) method which provides an opportunity for multi-channel coding with a small stream of bits.

Fig. 2 shows approximate stream data rate and the matching methods in the technology of DRM audio coding [5].

IV. DRM RADIO CHANNELS IN THE WORLD

DRM technology has been tested for the past ten years around the world by number of radio stations. In February, 2014, DRM transmission was used by 18 radio stations in world. Table 1 offers an overview of radio stations with the country in which the production of program is taking place. It is mostly the national radio stations that perform transmission outside of their home country.

Table I - Overview of DRM radio stations

RADIO CHANNEL	COUNTRY
BBC World Service	United Kingdom
RFI - Radio France Internationale	France
REE - Radio Exterior de Espana	Spain
RRI - Radio Romania International	Romania
VoR - Voice of Russia	Russia
KBS World Radio	South Korea
NHK Radio	Japan
AIR – All India Radio	India
RTM Malaysia	Malaysia
Radio Australia	Australia
RNZI - Radio New Zeland Internat.	New Zeland
VoN - Voice of Nigeria	Nigeria
The Disco Palace	USA
Brother Stair	USA
Radio Maria	Italy
Raiway Roma	Vatican
Vatican Radio	Vatican
Bit eXpress	Germany

Table 2 provides an overview of the languages in which DRM radio stations are broadcasting. In Table 2, the symbol "X" denotes existence of transmission radio channel in a particular language. AIR - All India Radio and VoR - Voice of Russia have the largest number of languages used. Most radio stations are available in English.

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Table II - Overview of the languages in which DRM radio stations are broadcasting

DRM station	English	Russian	German	Italian	Spanish	French	Chinese	Hindi	Urdu	Gujarati	Nepali	Sinhala	Indonesian
BBC World	X												
RFI						X							
REE					X								
RRI	X	X	X		X	X		X	X				
VoR													
KBS World	X		X										
NHK	X	X											
AIR	X	X					X	X	X	X	X	X	X
RTM	X												
Radio Australia	X												
RNZI	X												
VoN	X												
The Disco Palace	X												
Brother Stair	X												
Radio Maria				X									
Raiway Roma				X									
Vatican Radio	X												
Bit eXpress			X										

V. DRM FREQUENCIES, TRANSMITTERS AND COVERAGE ZONES

Shortwave radio stations mostly broadcast their program at regular time intervals, and a 24-hour broadcasting rarely occurs (mainly for transmitters with less power and less coverage). One radio station broadcasts to several radio frequencies. Fig. 3 shows the number of currently active DRM frequencies for a particular geographic area. Certainly, the most active of DRM frequency are for Europe.

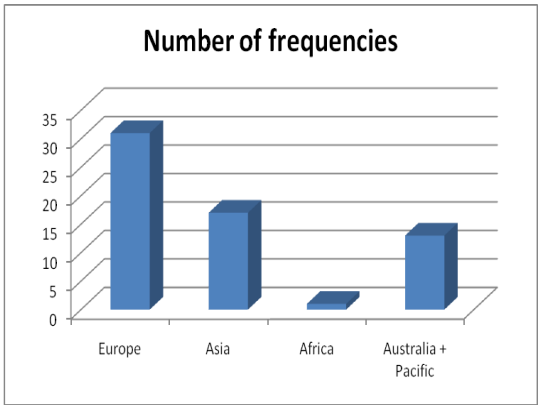

Fig. 3 - Number of active DRM frequencies for a particular geographic area

Table 3 gives the number of active DRM frequencies for each radio station dedicated for admission in different geographic regions [14]. Due to the nature of short-waves, radio station is also present outside of the region which is the target area. Most of active DRM frequencies has AIR - All India Radio, it's frequencies are provided on four continents.

Table III - Number of active DRM frequencies for each radio station

DRM Station	Europe	Asia	Africa	Australia + Pacific
BBC World	3	1	-	-
RFI	1	-	-	-
REE	3	-	-	-
RRI	4	2	-	-
VoR	7	2	-	-
KBS World	1	-	-	-
NHK	1	-	-	-
AIR	3	6	1	2
RTM	-	2	-	-
Radio Australia	-	2	-	6
RNZI	-	-	-	5
VoN	1	-	-	-
The Disco Palace	-	1	-	-
Brother Stair	1	-	-	-
Radio Maria	1	-	-	-
Raiway Roma	1	-	-	-
Vatican Radio	-	1	-	-
biteXpress	2	-	-	-

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Table IV - DRM transmitters in the world and their characteristics

	TRANSMITTER	COUNTRY	POWER [kW]	FREQUENCIES [kHz]	DRM RADIO STATIONS
1	Rajkot	India	25	1080	AIR
2	Khampur (Delphi)	India	50	9950,	AIR
			250	11645, 11715, 15050, 15140, 17715	
3	Bengaluru	India	250	11620, 13605,	AIR
			500	15795, 17875, 17895	
4	Nakhon Sawan	Thailand	250	5845	BBC
5	Kajang	Malaysia	90	6175, 11885	RTM
6	Shepparton	Australia	100	5940, 6080, 7410, 9475, 9890, 19000	Radio Australia
7	Rangitaiki	New Zealand	25	9630, 9870, 11690, 13730, 15720, 17675	RNZI
8	Abuja Lugbe	Nigeria	250	15120	VoN
9	Irkutsk	Russia	15	7400, 12035	VoR
10	Taldom (Moskva)	Russia	40	6000, 6110, 9680, 11635	VoR
11	Bolshakovo (Kalingrad)	Russia	15	6100, 6125, 9625	VoR
12	Galbeni	Romaina	300	7370, 9600,	RRI
13	Tiganesti (Saftica)	Romaina	300	5910, 5940, 7390, 9535, 15340, 21540	RRI
14	Kostinbrod (Sofia)	Bulgaria	20	5895	Brother Stair
			20	5875	KBS
15	Moosbrunn	Austria	40	7355	BBC
16	Dillberg	Germany	0.1	909	Bit eXpress
17	Erlangen	Germany	0.1	15896	Bit eXpress
18	Woofferton	UK	100	3955, 5875 9760	BBC KBS, NHK
19	Andrate	Italy	0.1	26010	Radio Maria
20	Vatican City	Vatican	0.2	26060	Raiway Roma
21	Santa Maria	Vatican	125	15775	Vatican Radio
22	Noblejas	Spain	50	15585	REE
			100	9780, 13720	
23	Issoudun	France	1	3965	RFI
			100	12115	The Disco Palace

Table 4 provides an overview of DRM transmitters with basic characteristics. As it shown all of the current DRM transmissions are made via short waves, except for Bit eXpress which has, besides one active frequency in HF, one in the MF range. The transmitter of maximum power is used by AIR broadcasters - All India Radio and RRI - Radio Romania International. All radio stations broadcast at specific time intervals, except radio stations with power of 0.1 kW, which broadcast 24 hours, but in the same time they have less coverage. Based on the information available at [14] and Table 4, a map of DRM transmitter in the world in February of 2014 is made. Fig. 4 gives a map of active DRM transmitter in the world, and in Fig. 5 is a map of active DRM transmitters in Europe. Numbers of transmitters on the map matches the numbers in Table 4 in which the more precise characteristics of DRM transmitters are given. Transmitters marked in red are functioning with a power of 0.1 to 1 kW, those in blue from 10 to 100 kW, and transmitters marked in yellow are with power higher than 100 kW.

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Fig. 4 - Overview of DRM transmitters in the world

Fig. 5 - Overview of DRM transmitters in Europe

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VI. CONCLUSION

For the past ten years we have witnessed a rapid digitization of all types of radio communications, all in order to increase the quality and quantity of content that can be transferred wirelessly, thus saving and optimizing the use of radio frequency spectrum. DRM technology has been developed for digital sound broadcasting in the frequency bands below 174 MHz (medium and short waves). Signal transmission on these bands, especially on short waves, provides signal coverage of large geographic areas. Given that the transmission of radio signals on medium and short wave transmitters require high power, it takes a few years after the introduction of standards for development of quality enough receivers that are able to deliver to the antenna DRM a signal of satisfactory quality. The process is still not finished as it is yet to happen a higher commercialization of DRM, and it will certainly require a better performance of the transmitter so that its structure can be further simplified thus became cheaper. According our research results All India Radio in February have the most of active frequencies. AIR - All India Radio and RRI - Radio Romania International emitters have transmitters of maximum power.

VII. ACKNOWLEDGMENT

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REFERENCES

[1] R. L. Freeman, "Telecommunications transmission Handbook", Fourth Edition, Wiley, April 1998.

[2] ETSI Standard: ETSI ES 201 980 V3.2.1, "Digital Radio Mondiale (DRM). System Specification", European Telecommunications Standards Institute, European Broadcasting Union, 2012.

[3] C ETSI Standard: ETSI ES 201 980 V3.1.1, "Digital Radio Mondiale (DRM). System Specification", European Telecommunications Standards Institute, European Broadcasting Union, 2012.

[4] ETSI Standard: ES 201 980 V2.2.1, "Digital Radio Mondiale (DRM). System specification", European Telecommunications Standards Institute, European Broadcasting Union, 2005.

[5] ETSI. TS 102 349, "Digital Radio Mondiale (DRM), Receiver Status and Control Interface (RSCI)", European Telecommunications Standards Institute, European Broadcasting Union 2009.

[6] F. H. Raab, "Drive Modulation in Khan-technique transmitters", IEEE MTT-S Int. Microwave Symposium Digest, Vol. 2, June 1999.

[7] R. Dietmar, "Out-of-Band Emission of Digital Transmissions Using Kahn EER Technique", IEEE Transactions on Microwave Theory and Techniques, Vol. 50, August 2002.

[8] "The DRM Digital Broadcasting System - DRM Introduction and Implementation Guide", DRM Consortium, August 2012, Geneva, Switzerland.

[9] Recommendation ITU - R BS.1615, "Planning parameters for digital sound broadcasting at frequencies below 30 MHz", International Telecommunication Union, 2003, Geneva, Switzerland.

[10] Recommendation ITU - R P.368-8, "Ground-wave propagation curves for frequencies between10 kHz and 30 MHz", International Telecommunication Union. 2006, Geneva, Switzerland.

[11] Recommendation ITU - R BS.1284, "General methods for the subjective assessment of sound quality", International Telecommunication Union 2003. Geneva, Switzerland.

[12] Document 6E/274 "Digital Radio Mondiale. DRM local coverage using the 26 MHz broadcasting band", International Telecommunication Union. 2005, Geneva, Switzerland.

[13] I. Pena, A. Arrinda, J. M. Matias, U. Gil, P. Angueira, D. Guerra, "Analysis of the ITU - R P.1546-2 prediction method accuracy for DRM local coverage using the 26 MHz band", 57th Annual Broadcast Symposium IEEE Broadcast Technology Society, Washington D.C., USA, October 2007.

[14] DRM - Digital Radio Mondiale: www.drm.org.

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