DIGITAL RADIO MONDIALE: THE GLOBAL DIGITAL RADIO

Purshottam Singh Rathore
Engineering Department
Doordarshan Kendra Shyamla Hills Bhopal, India

ABSTRACT
Digital radio Mondiale (DRM) is the universally standardized digital audio broadcasting system for broadcasting in the Medium Frequency (MF), High Frequency (HF) as well as Very High Frequency (VHF) band I, II (FM band) and III frequencies. It provides digital alternative to replace analog AM broadcasting being used for radio transmission. DRM uses existing frequency bands and infrastructure with little modifications in the transmitters being used for Medium and short wave transmission. It is compatible to various modes operating on 5 kHz and 10 kHz bandwidth being used in the current AM broadcasting, and modes requiring larger bandwidth. SSB communication requiring lower bandwidth for two way communication is also possible to replace by DRM. As DRM is requiring less bandwidth can accommodate more number of channels or higher data transmission rate for existing bandwidth of a channel being used for AM broadcasting. DRM can use range of audio content and is capable to integrate text and data along with audio. Display of these additional contents on DRM receiver enhances the listening experience. DRM receivers are equipped with attractive features like electronic programme guide (EPG), programmed reception & recording and display of programmes. DRM offers enhancement of the audio quality comparable to Frequency Modulated (FM) broadcasting. The backward compatibility and cost of the receiver are the hurdles to popular DRM globally. Efforts are being made to overcome these issues. This paper reviews the key features, the technology, benefits of technology to different constituent of society and implementation issues relating to technology.

KEYWORDS: *Amplitude Modulation (AM), HF Radio propagation, urban areas, Reception, Reliability*

I. INTRODUCTION

The digital sound broadcasting DRM system is a non-proprietary standard that operates in the MF, HF as well as VHF band I, II (FM band) and III frequency bands [1, 2, 3]. The transmission at these frequency bands can propagate by means of ground wave, ionospheric propagation or a combination of both mechanisms [4]. The coverage area of an AM transmission ranges from local areas in MW to regional areas up to large and far away areas in SW. MW transmission uses ground wave propagation requiring higher amount of power to cover designated geographical area. Additionally sound quality is also not good. The HF bands are usually utilized to broadcast programs to targets far away from the transmitter using ionospheric propagation. Ideally the ionosphere must refract the electromagnetic signal to the earth which is not the case in reality. Propagation through ionosphere has limitations to offer a successful transmission due to ionization of different layers in the daytime and night, additionally problem of multipath propagation fading.

DRM offers digital alternative to existing analog radio broadcasting. The key benefit of DRM is its capability to fit into existing plan of AM broadcasting. It offers FM like sound quality in the all frequency bands used for radio broadcasting. The DRM Consortium proposed alternative use of the 26 MHz band for local broadcasting [8]. Trials have been done to validate the same [7, 9, 10].

The tropospheric component is the main propagation mechanism when using the 26 MHz band for local coverage. The consideration of diffraction and the multipath parameters are of great importance in DRM. The 430 kHz bandwidth available in the 26 MHz band could be used for 43 DRM transmissions with 10 kHz bandwidth modes, or 21 DRM transmissions using 20 kHz modes. The

frequency planning of this band is coordinated by international coordination groups, ASBU, HFCC, as it is regulated by Article 12 of Radio Regulations [11]. This band offers the benefits of digital audio broadcasting for local broadcasting. Authorities in the each country would be in charge of frequency assignments although the coordinating committees should be informed about the same.
This paper is organized as follows: In the section II the key features of DRM are mentioned, section III describes the benefits of DRM to listeners, manufacturers and broadcasters of radio, section IV provides details of technology being used in DRM, section V conveys status of DRM in India and section VI covers benefit of DRM to Prasar Bharti (The public service broadcaster of India), section VII concludes the paper and VIII conveys future scope of work.

II. KEY FEATURES OF DRM

- DRM can deliver FM-comparable sound quality on frequencies below 30 MHz and beyond up to VHF band that enables very-long-distance signal propagation.
- DRM uses in-band on-channel (IBOC) technology and can operate in a hybrid mode called Single Channel Simulcast.
- DRM has been designed especially to use portions of older AM transmitter facilities such as antennas, avoiding major new investment.
- DRM is robust against the fading and interference.
- The encoding and decoding is performed using digital signal processing, so that a cheap embedded computer with a conventional transmitter and receiver can perform.
- DRM can transmit other data besides the audio channels.

III. BENEFITS OF DRM

3.1 Digital AM for broadcasters

DRM allows direct access to millions of listeners in excellent sound quality. DRM on Medium Wave is perfect for broadcasters aiming for a national audience, especially in countries covering a sizeable geographical area. In most of the countries regulatory authorities have already approved DRM as the digital successor to Medium Wave. In large countries, like Russia or India, DRM may be the only means to achieve seamless national coverage in the digital era and it will certainly be the most cost efficient. DRM is also the ideal solution for regional Medium Wave coverage, DRM is simply perfect for broadcasters planning to roll out new, additional digital services. For smaller broadcasters targeting urban niches, DRM+ is the answer. It will allow community radios or specialized commercial broadcasters to reach their intended audiences bypassing the congestion and high costs of the analogue FM band.

3. 2 DRM is cost efficient solution to migrate into the digital universe

Analogue Short and Medium Wave transmitters can be converted to DRM mode at low cost and the useful life of the equipment significantly prolonged, both from a technical and a financial point of view. The scope of the capital investment required is also manageable because just a few transmitters can achieve excellent coverage over very extensive territories. DRM does not require a large network of transmitters or a complicated lattice of repeaters to do the job. Transmission costs are not higher to those of analogue Short and Medium Wave broadcasts and offer excellent value for money given the wide area coverage and the superior sound quality. DRM has been developed to operate alongside other digital radio technologies and in the field of receivers. The integration of DRM capability into these hybrid chipsets receivers can be achieved at marginal cost, adding very little to the cost of the radio to the consumer using other digital technology receivers.
While television is forging ahead with digital conversion and many countries have already set analogue switchover, radio is entering the digital era. The iPod and the expanding capacities of mobile phones, handhelds and laptops are leading people expecting radio digital format. For radio to move into the digital world in step with other platforms, sound needs to be in a format that these platforms can understand. DRM standard provides that. DRM radio will be talking to your mpeg-liayer- 3 player

and your iPod. DRM also provides enhanced digital features such as on-screen EPGs, data streams and pause live radio and rewind functionality and it greatly facilitates interactivity with the audience.

3.3 DRM offers variety of programmes, better sound quality to the radio listeners

The average radio today can receive some 35-40 local FM stations and a handful of medium wave broadcasts. DRM has the potential to bring to every radio a vast selection of new content. New programmes are possible to incorporate from leading international broadcasters. Other benefit to the listener includes quality speech radio on medium wave, focusing on national and regional programmes. DRM brings is that short wave and medium wave broadcasts can now be heard in FM-like sound quality. Reception of DRM is excellent anywhere in cities as well as in dense forests, indoors in a block of flats and outdoors and even while mobile.
DRM receiver is portable and mobile. One can take a DRM radio anyplace and listen. DRM is ideally suited to long range broadcasting where one can stay tuned to the same. DRM receiver delivers all the benefits associated with modern digital radios. It offers access to an Electronic Programme Guide (EPG) and ability to tune in easily by frequency, station name or type of programme. In addition, the programmes come with associated text information the name of the station, the title of the programme or record playing etc. DRM radios can also tune in to both the analogue FM and MW bands and digital audio broadcasting, where available, this single device will fulfill the need to listen to all favorite radio content.

3.4 DRM provides a vast new market to the manufacturers of receiver, transmitter and semiconductor

There are an estimated 2.5 billion analogue AM receivers currently in the world. As radio moves into the digital era, these devices will be replaced and, potentially, the market as a whole will expand further. It is also worth noting that DRM is particularly to wide area coverage, hence, it is likely that it will be adopted in countries stretching over large territories, such as Russia, China and India which also have large populations and large markets.

3.5 An open standard technology and versatile technology

From a technological point of view, DRM is a mature, proven standard and free of shortcomings and no hidden surprises. DRM is an open, non-proprietary standard. The DRM Consortium holds the IP rights and licenses the technology to those organizations who want to use it and develop it further. DRM is fully compatible with the standard on which the DAB and DMB technologies are based. It complements that standard as DRM is currently best suited to the AM bands while DAB has been promoted as an alternative to FM. More importantly, perhaps, in the short term, it is relatively straightforward and cost effective to integrate DRM capabilities into a wide variety of devices from hybrid radio sets with multi-band functionality to handhelds and, soon, to mobile phones.

IV. THE DRM TECHNOLOGY

4.1 Audio source coding

It is demonstrated that DRM operates in different modes to cater the need of different broadcasting requirements. It offers the possibility to use different audio coding system (source coding) depending on the bit rate. Audio coding used in digital broadcasting are discussed in [12]. Bit rate depends also on other parameters includes desired robustness to errors power needed and robustness in regard to propagation conditions. Bit rates range from 6 kbit/s to 35 kbit/s for DRM application. The bit rates up to 72 kbit/s (Mode A) can be achieved for a standard 20 kHz (±10 kHz) wide channel.
Various source coding methods used in DRM includes:

- MPEG-4 High Efficiency Advanced Audio Coding. AAC is a perceptual coder suited for voice and music and the High Efficiency is an optional extension.
- MPEG-4 CELP which is a parametric coder suited for voice only (vocoder) but that is robust to errors and needs a small bit rate.
- MPEG-4 HVXC which is also a parametric coder for speech programs that uses an even smaller bit rate than CELP.

- MPEG-4 HE-AAC which is an implementation of MPEG. USAC is designed to combine the properties of a speech or a general audio codec according to bandwidth constraints. These changes were subsequently incorporated into the current System Specification.

Broadcasters have some freedom of choice depending on the material they send. The most commonly used mode is HE-AAC (also called AAC+) that offers an acceptable audio quality somewhat comparable to FM broadcast. Aside from perceived technical advantages over the MPEG family such as low latency (delay between coding and decoding), this codec provides hobbyists with an open source alternative to the MPEG family whose use is liable to royalties.

4.2 Bandwidth

DRM broadcasting can be done using a choice of different bandwidths

- 4.5 kHz. Band provides the broadcaster to do a simulcast and use the lower-sideband area of a full 9 kHz channel for single sideband AM. With a 4.5 kHz DRM signal occupying the area traditionally taken by the upper- sideband. It offers moderate bit rate and audio quality suits the requirement to the region–1 (European) medium wave and short wave bands, or to the region–3 (Asian) medium wave band.
- 5 kHz. Band widely used by the broadcaster for simulcasting and uses the lower-sideband area of a full 10 kHz channel for single sideband AM. DRM with a 5 kHz signal occupying the area traditionally taken by the upper-sideband. The bit rate 7.1–16.7 kbit/s and audio quality is marginal for 5 kHz. This regime would apply to the AM band in region–2 and to the short wave bands to the world.
- 9 kHz. occupies all the standard bandwidth of a region–1 long wave or medium wave broadcast channel so that the existing frequency plan can be reused. Also used for the region–3 medium wave band.
- 10 kHz. occupies all the standard bandwidth of a region–2 AM or worldwide short wave broadcast channel giving 14.8–34.8 kbit/s so that existing frequency plan can be reused.
- 18 kHz. offers better audio quality. This bandwidth occupies an adjacent pair of region–1 long wave or medium wave channels or an adjacent pair of region–3 medium wave channels according to the existing frequency plan.
- 20 kHz. offers better audio quality at the bit rate ranging from 30.6 to 72 kbit/s. These bandwidths occupy adjacent pair of region–2 AM or worldwide short wave channels according to the existing frequency plan.
- 100 kHz is used for VHF band I, II, and III. DRM+ can transmit four different programs in this bandwidth.

4.3 Modulation

The modulation used for DRM is coded orthogonal frequency division multiplexing, where every carrier is modulated with quadrature amplitude modulation with a selectable error coding. OFDM has been widely accepted as a multicarrier modulation technique over wireless channels [13]. OFDM uses large number of closely spaced carriers for transmission of the digitally encoded audio and associated data signals. The allotted transmission channel contains all these carriers within its allotted bandwidth. In order to mitigate against fading time interleaving is employed. Various parameters of the OFDM and coding can be varied to allow DRM to operate successfully in many different propagation environments – the selection of the parameters allows transmissions to be planned that find the best combination of transmit power, robustness and data capacity. It is possible to choose among several modulation patterns: 64-QAM, 16-QAM and 4-QAM. OFDM modulation has some parameters that must be adjusted depending on propagation conditions. The problem faced by digital broadcasters is the Doppler's effect and multipath fading. These problems are resolved in OFDM by changing modulation parameters. The carrier spacing determines the robustness against Doppler Effect and the guard interval ensures robustness against multipath propagation. The ITU provides minimum field strength and signal-to-noise ratio levels for different DRM modes and different estimated propagation channels [14]. The choice of transmission parameters depends on signal robustness and propagation conditions. Transmission signal is affected by noise, interference, multipath wave propagation and Doppler Effect. The resulting low- bit rate digital information is modulated using COFDEM. It can run in simulcast mode by switching between DRM and AM, and it is also prepared for linking to other

alternatives like DAB or FM services. DRM has been tested successfully on short and medium wave with 9 and 10 kHz

- The DRM system has four OFDM modes Theoretical calculation show that the robustness of first two modes is strong enough to cope with delay spread and Doppler spread due to multipath. Therefore, several combinations of parameters were used with those OFDM modes. The DRM standard allows up to four audio channels in the DRM signal, the four DRM modes were used with different audio channel configurations. These different combinations do not affect the minimum SNR and minimum field strength calculated for each DRM mode.
- The DRM consortium has configured four different propagations based on channel profiles:
- Gaussian channel profile with very little multipath propagation and Doppler effect is suitable for local or regional broadcasting.
- Multipath propagation channel mode is suitable for medium range transmission. It is preferred mode nowadays.
- Multipath propagation channel mode with better robustness to Doppler is suitable for long distance transmission.
- Multipath propagation channel mode with a resistance to large delay spread and Doppler spread is the case of adverse propagation conditions of very long distance transmissions. The useful bit rate for this mode is decreased.
- The more the carrier spacing is the more the system is resistant to Doppler Effect. The more the guard interval is the more the system is resistant to long multipath propagation. The trade-off between these profiles and requirement of broadcasting is made to maintain quality. The table [1] presents parameters for different Modes of DRM.

Table [1]: Parameters for different Modes of DRM

OFDM carrier spacing (Hz)	**Number of carriers**				**Symbol length (ms)**	**Guard interval length (ms)**	**Symbols per frame Nb**
	9 kHz	10 kHz	18 kHz	20 kHz			
41.66	204	228	412	460	26.66	2.66	15
46.88	182	206	366	410	26.66	5.33	15
68.18	-	138	-	280	20.00	5.33	20
107.14	-	88	-	178	16.66	7.33	24

I. **DRM in India** A study group called "sub- group ongoing digital "was set up by planning commission to study the digitization of broadcast industry. The sub-group headed by the Member Secretary of Planning Commission. The sub-group has laid down the migration path from analog transmission to digital domain. The target for complete switch over to digital mode is 2017 has been given the. State broadcaster All India Radio (AIR) decided that DRM is the best technology for converting its vast public service broadcasting network to digital. AIR is converting 4 shortwave transmitters (250 kW) to DRM mode and there are plans to introduce DRM transmissions in 42 new medium wave, 36 existing medium wave and 5 new short wave transmitters. During BES 2010-11 in New Delhi, the purchase of 2 Megawatt MW DRM transmitters was announced, covering very large areas in the Indian sub-continent as well West, North, East and Southeast Asia. All India Radio launched its first DRM Service on 16 January 2009. Short wave high Power Transmitter radiating at freq. 6100 kHz from 14.30 to 17.30 located at Khampur, Delhi. The coverage of transmitter is 800 km. The quality of DRM signal found comparable to FM quality. For Digital Radio transmission All India Radio has adopted (DRM) as the digital successor to Medium Wave transmission DRM is also the name of the international non-profit consortium of 75 broadcasting associated organizations designing and implementing the platform to develop a digital transmission system for the current AM broadcast band. Table [2] shows current scenario of DRM transmitters installed in India and population coverage as on December 2013.

II. **Benefits of DRM for Prasar Bharati (The public broadcaster of India)**

For broadcasters, DRM is great advantage. It offers benefits of digital broadcasting over the traditional medium and Short Wave transmitters operating in AM analog mode. DRM can be implemented to the existing transmitter systems with little modifications, additionally because of its in band, additionally; it can operate in hybrid mode simulating both analog signal and digital signal. The additional investment to migrate to the digital broadcasting technology only 10 to 20 % that will reduce transmitter power consumption will go down by 20 –40 %.

Table [2]

Serial number	Name of location of transmitter	Area covered km^2	Population Covered
1	Chinsurah (Kolkata, West Bangal)	987,525.19	233,493,738
2	Rajkot (Gujrat)	572,821.13	75,380,080
3	Delhi	80,745.88	74,317,210
4	Chennai (Tamilnadu)	121,985.87	26,525,240
5	Guwahati (Assam)	46,382.44	15,622,043
6	Barmer (Rajsthan)	30,405.48	2,954,976
7	Bikaner (Rajsthan)	23,944.95	2,265,271
8	Tawang (ArunachalPradesh)	26,409.16	80463

V. CONCLUSIONS

DRM is digital radio standard currently being implemented in emerging markets such as India, providing FM-comparable or better audio quality on the AM radio band. AM covers over 98% of the population in India, while only 37% of listeners can currently receive the FM signal. DRM significantly improves audio quality at a low cost, while providing additional data services such as traffic updates, natural disaster warnings and news. DRM is digital audio broadcasting technology designed to work over the bands currently used for AM and shortwave broadcasting. DRM can offer more channels at higher audio quality, into a given amount of bandwidth, using various MPEG-4 codecs. It offers benefit to broadcasters, manufacturers, listeners and solution to mitigate digital universe. Digital broadcasting offers benefit of reduction in power requirement, more channels per transmitter and better listening experience. Fading, the serious problem in short wave broadcasting is possible to eliminate and reception like FM channels are the added benefit of using DRM without changing existing infrastructure of MW and SW broadcasting . Also, the minimum field strength level needed for a DRM transmission at those frequencies is far lower than the field strength needed for an AM transmission in the MW band.

VI. FUTURE SCOPE OF WORK

The limitation of DRM is that there is no backward integration of receivers. Due to that existing receivers are of no use. Another limitation is the cost of DRM compatible receivers which is roughly around Rs.10000 make difficult to purchase by the public. Efforts are made to decrease the cost of receivers so as to make it affordable to majority in the society globally. It may be possible future time for the 4.5 kHz bandwidth DRM version used by the Amateur Radio community to be merged with the existing DRM specification. Several automobile and car radio manufacturers have shown interest in using DRM solution for future deployment.

REFERENCES

[1] ETSI, "ES 201980 V2.2.1, Digital Radio Mondiale (DRM) system specification," ETSI, October 2005.
[2] System for digital sound broadcasting in the broadcasting bands below 30 MHz, recommendation, BS.1514-1, Oct. 2002.

[3] Digital Radio Mondiale (DRM) Part 1: system specification, International Electro Technical Commission, IEC 62272-1, Mar. 2003.
[4] J. Stott. "Digital Radio Mondiale: key technical features," IEE Electronics & Communication Engineering Journal, vol. 14, no 1, Feb 2002, pp. 4-14.
[5] ITU-R, Recommendation P.534-4, method for calculating sporadic-E field strength, ITU, Oct. 1999.
[6] ITU-R, "Recommendation P.533-8, HF Propagation Prediction Method," International Telecommunication Union, March 2005.
[7] T. Lauterbach , "Local Radio in the 26 MHz band using DRM – results of the Nuremberg field trial and general considerations,"Sonderdruc hriftenreihe der Georg-Simon-Ohm-Fachhochschule Nürnberg Nr. 31.
[8] Broadcasters' User Manual, A Digital Radio Mondiale (DRM) Publication. 1st edition, March 2004. Pp. 47.
[9] T. Lauterbach, B. Kreuzer, R. Zitzmann, K. Blomeier, "Is DRM on 26 MHz an Option for Local Digital Broadcasting? Results from a field trial in Nuremberg, Germany," in Proc. 5th Workshop Digital Broadcasting, Erlangen, Germany, 23-24 Sep. 2004.
[10] ITU, Radio Communication Study Groups, Document 6E/54-E, "Digital broadcasting at frequencies below 30 MHz MF and HF field-tests report summary final system performance report for IST-Radiate 1999-20113 for ITU," Feb. 4, 2004.
[11] Pham Nhu Hai, "The Planning Procedure for HF Broadcasting –Article Of The Radio Regulations," Radio communication Bureau, ITU. Radio Communication Seminar. Geneva 11-15 Nov. 2002.
[12] S. Meltzer, G. Moser. "MPEG-4 HE-AAC v2 – Audio coding for today's digital media world," EBU Technical Review, Jan. 2006.
[13] Illsami B. Oluwafemi and Stanley H. Mneney, "Review of Space- time coded frequency division multiplexing Systems for Wireless Communication" IETE Technical Review vol.30, no.5, pp. 417-426, Sep-Oct 2013.
[14] ITU-R, "Recommendation BS. 1615-1, "Planning Parameter" for Digital Sound Broadcasting at Frequencies Below 30 MHz," International Telecommunication Union, June 2003.

AUTHORS

P. S. Rathore obtained B.Tech. degree in Electronics and Telecommunication Engineering from IETE, New Delhi, and M.E. degree in Digital Communication, from Rajiv Gandhi Technological University, Bhopal, India. He received MBA Degree from Devi Ahilya University, Indore. He has 22 years of experience in the field of Telecommunication and Broadcasting. In addition, he is teaching and guiding UG and PG students of Engineering and management. Currently He is associated with Indian Institute of Technology Indore, India. His research interests include Speech Processing, Digital Communication, Digital Signal Processing and Broadcasting. He has been visiting faculty at Military College of Telecommunication Engineering Mhow Indore. He is visiting faculty at Electronic Multimedia Research Center (EMRC) and Institute of Management Studies(IMS) of Devi Ahilya University Indore. He worked with HFCL, New Delhi From 1989 to 1993, first as an Engineer and later as a Senior Engineer. Since 1993, he is with the min. of I & B, Akashvani and Doordarshan, Govt. of India and looking after installation, operation and maintenance of centers at Akashvani and Doordarshan. He has published sizable number of research papers in international conferences and delivered expert lecture on various topics of signal processing and broadcasting. He is member of professional societies of engineering and management. He has been reviewer of research papers for International conferences of IEEE as technical committee member. He has organized national conferences of IEEE and chaired the sessions of IEEE conferences.