Radiocommunication Study Groups

Received: 9 April 2013

Document 6A/DRM-E
9 April 2013
English only

Digital Radio Mondiale (DRM)

PROGRESS ON IMPLEMENTING THE DRM SYSTEM FOR THE TRANSITION TO DIGITAL SOUND BROADCASTING

Introduction

With the transition to digital television broadcasting now well advanced it is appropriate to consider once again why there has been little impetus on the part of administrations or demand from listeners to make a complete transition to digital sound broadcasting.

This contribution from the DRM Consortium addresses the technical and economic factors involved in bringing the advantages of digital sound broadcasting to all listeners around the world and considers how the Digital Radio Mondiale (DRM) family of transmission standards can serve to bring these to the public as the only truly open and global standard for digital sound broadcasting. The DRM30 standard covers digital sound broadcasting the LF, MF and HF bands and the DRM+ standard covers the VHF broadcasting bands I, II and III.

Sound broadcasting has developed over the past 90 years as essential part of daily life for providing the public with a rich, advanced and diversified information and entertainment and is set to play a continuing role in shaping and participating in the global knowledge and information based economy.

Rather than being in decline, audience monitoring figures from advanced media markets, such as the United Kingdom (see RAJAR[1] listening figures) reveal that sound broadcasting has undergone a resurgence of interest in recent years and is now increasing in popularity – the key factors being the universality, mobility, intimacy of the listening experience, and all without any access charges. Moreover, terrestrial broadcast delivery offers truly mobile reception, particularly in cars, that is both cost effective and reliable for content providers.

The technical and propagation characteristics of sound broadcasting combine so that it remains the best medium for relaying of live news and information. The propagation characteristics of the broadcasting bands below 30 MHz are ideal for wide area/long distance coverage free from the constraints that can be imposed on other methods of delivering electronic communication services by economic factors or political gatekeepers.

[1] RAJAR stands for Radio Joint Audience Research and is the official body in charge of measuring radio audiences in the UK. It is jointly owned by the BBC and the RadioCentre on behalf of the commercial sector.

Why replace analogue sound broadcasting?

The traditional model of sound broadcasting faces challenges that make it essential to pursue the goal of moving to digital modulation techniques. For administrations and broadcasters, the analogue modulation techniques of amplitude modulation (AM) and frequency modulation (FM) used around the world for sound broadcasting do not provide the optimum use of spectrum. For listeners, audio quality is often compromised by adverse propagation conditions or interference, from a combination of man-made noise sources and over-use of the available frequency bands. However, in order to command the interest and support of listeners in making the transition from analogue to digital transmission, the technologies used must present the audience with very clear advantages.

For AM broadcasting in the LF, MF and HF broadcasting bands, there is no doubt that the levels of noise and interference from competing broadcasting stations in crowded frequency bands do not make for a satisfactory listening experience. The first DRM standard (DRM30) was developed in order to provide a way of re-engineering sound broadcasting in the LF, MF and HF bands so as to provide far superior audibility and reliability. Audio quality with DRM30 is perceived as coming close to FM quality for most in-home, portable and in-car use.

Although AM broadcasting in the LF, MF and HF bands has provided considerable advantages in terms of wide area coverage for regional, national and international sound broadcasting since the 1930s, it has suffered a decline in recent years, as high electricity costs and poor audio quality, relative to FM and DAB, have combined to make it less attractive to broadcasters. But replacement of wide area AM transmissions by FM or DAB networks needs careful planning and, in all likelihood, will require investment in an extensive infrastructure. (This may be problematic or impractical for serving some needs, particularly for external broadcasting operations.)

The transition to the DRM30 standard would lead to major savings in transmission power and electricity costs – down to between half or a quarter of conventional AM transmitter requirements – coupled with audio quality close to FM. DRM therefore offers broadcasters providing international, national and regional services an excellent opportunity to cut costs, simplify their operations and attract new audiences to high quality programming. The advantages of economy and quality are particularly attractive when considering upgrading national AM networks. DRM has the potential to revitalise the bands previously used for AM broadcasting.

The planning aspects and the implications on spectrum use of making a complete transition to the DRM30 transmission standard in the LF, MF and HF bands are examined in Annex 1.

The issues are not so clear though when it comes to replacing FM broadcasting. The reason for introducing FM broadcasting at VHF frequencies in the 1950s was mainly to overcome the noise and interference evident with AM broadcasting, particularly from ever more prevalent noise from unsuppressed car ignition systems. Later, of course, the advantages of higher audio quality and stereo programming became the main drivers of audience acceptance and demand. Likewise, digital systems must be seen to provide not just additional features, but features whose advantages are very obvious to the general public – not hidden deep within the system specification.

By providing high quality stereo broadcasting to receivers in the home environment, FM has become the world standard for sound broadcasting, and can be considered as meeting the pragmatic engineering objective, valid in all fields of technology, of being “as good as it needs to be”. Nevertheless, there are deficiencies: FM broadcasting does not make the best use of the available spectrum, which in turn places limitations on coverage and listener choice. FM planning is still based on the original expectation that domestic reception would be on a main radio set connected to an external antenna at rooftop level. The available signal level is therefore not always sufficient for the usual situation nowadays that most listening is indoors on portable receivers or in cars. Multi-path reception of additional time-delayed signals, reflected from natural and man-made structures adds to the problems so that annoying drop-outs and interference are often experienced, especially in built-up areas or in terrain with no clear line of sight path to the transmitter, resulting in noisy, squawky reception.

The digital sound broadcasting systems developed for use at VHF, including DRM+, have therefore focussed on using modulation and audio coding schemes that can overcome the effect of multiple radio signal reflections and thus provide dependable quality of service in cars or with portable receivers. However, the DRM+ system offers further technical advantages over FM in being able to use the available bandwidth for additional service offerings.

Each DRM+ signal only takes up half the bandwidth of an FM emission yet delivers the same audio quality and has the flexibility to organize the available data throughput in a variety of ways for additional programme content or other data purposes. For example, broadcasters have the option to combine locally to provide mini local multiplexes of 2, 3 or 4 programme streams, depending on quality and coverage requirements within the bandwidth of a single FM transmission. However, it remains the case that switching off FM broadcasting, which carries a wide range of programming genres, with coverage ranging from national networks to very localized community stations, would prove a major disruption to established patterns of listening. In order to command public acceptance and support, the complete transition to digital sound broadcasting should at least preserve and, ideally, expand on the range and diversity of content currently available with FM.

The planning aspects and the implications on spectrum use of making a complete transition to the DRM+ transmission standard in the VHF bands are examined in Annex 2.

Mixed signals in making the transition to digital sound broadcasting.

The transition from analogue to digital television broadcasting is now well advanced, mainly through regional and sub-regional agreements on re-planning the use of Bands I, III and IV/V. Digital modulation techniques have allowed current television broadcasting requirements to be delivered in considerably less spectrum than previously, opening the way for the spectrum savings to be used for delivering an extended range of broadcasting and other multi-media content.

With sound broadcasting, however, there has been no concerted move to make a coordinated transition to digital sound broadcasting from AM in the LF, MF and HF bands and FM in Band II. The DAB (digital audio broadcasting) system has been widely implemented in Band III for delivering groups of multiplexed programming where the band is no longer needed for television broadcasting or other purposes (e.g., trunked mobile applications), but may not be technically or cost effective for all sound broadcasting needs.

The DAB system started development some 25 years ago as the Eureka 147 project under the technical direction of the European Broadcasting Union and with the active support of the major European broadcasters. There were two main objectives:

1) to save on radio frequency spectrum by moving to single frequency networking using DAB multiplexes;
2) to overcome various degradations of FM broadcasting experienced in dense urban environments and for in-car reception.

DAB technology did indeed meet these requirements, with significant spectrum savings over comparable FM networks achievable for the country-wide networks of large scale broadcasters, which reflects how the technology was developed. The optimization of DAB for large scale multiplexes in 1.744 MHz channels does however pose problems when considering how to make digital alternatives available for all purposes, particularly for smaller scale FM broadcasters or substituting for narrow-bandwidth/wide-area AM broadcasting in the LF, MF and HF bands. For example, the Radio in Digital Britain report, noted at section 5.5.1:

> "*Small-scale commercial services and community services cannot generally afford carriage on DAB and in any case the size of the DAB footprint and technical characteristics of DAB do not make it suitable for small stations. For this reason, they are likely to remain on FM for the medium-term, although many are also available online."*

Such doubts have led some countries to re-consider whether DAB is the optimum solution to their sound broadcasting needs. Portugal ceased DAB transmissions on 1 June 2011 after 13 years of operation citing poor acceptance by public and commercial broadcasters. Concerns have also been emerged during consultations in some Nordic countries about the viability of DAB as regards infrastructure costs, receiver cost, duplication of digital sound broadcasting services already available over digital television multiplexes, suitability for localized and community services, and the present situation that FM has become the worldwide standard for most radio listening. Norway (a commercial network) has got some government support to test DRM+ in May and June 2013.Views have also been expressed that Band III may have to be devoted instead for digital television broadcasting, maybe because of expectations that the spectrum available in Bands IV/V for digital television broadcasting may be radically reduced under WRC agenda items 1.1 and 1.2.

Can DRM provide a renewed impetus for completing the transition?

The DRM family of standards can provide a comprehensive solution to all digital sound broadcasting needs. DRM technology can be tailored to suit the requirements of any type of sound broadcasting from wide-coverage, national and international stations to community stations, in all the commonly used wavebands through the DRM30 (LF. MF and HF bands) and DRM+ (VHF Bands I, II and III) standards.

The range options available with DRM technology will allow for:

- retention of the single transmitter per service area model to be retained where appropriate,
- operation over single frequency networks where appropriate; and
- provision of mini-multiplexes in the VHF bands where the multiplexed broadcasting model is preferred.

Moreover, various added value audio and data services are available. This is particularly useful when implementing DRM30 in the LF, MF and HF bands, where transmission characteristics can been chosen so as to emphasise robustness or quality, or in order to provide stereo of dual language programming, as well as a variety of data services.

DRM, therefore, has the potential to bring every listener a vast selection of additional content, either related to the programme content or for completely different purposes. The supplementary digital data streams available within the DRM standards can be used to provide a variety of added value services, accessible through a link to a personal computer or a self-contained display device.

Several types of additional content are possible, singly or in combination:

a) Additional visual/text based programme related features possible with DRM include:
   - electronic programme guides;
   - full speech text or commentary on the programme;
   - web pages and links to the programme content;
   - Journaline text based information service (Unicode), supporting all classes of receivers, triggers interactivity and geo-awareness access

- additional content for advertisers, such as text or web-based material for supplementing the voice advert with more details on the products, local suppliers, pricing, ordering etc.;
- integrated text, graphics, web-pages, videos & slide shows with audio commentary;
- screen based control over interactivity and functionality.

b) Additional audio based programme related features possible with DRM include:

- Stereo/surround sound/surround sound 5.1
- Dual or multi language programme streams translating the main programme feed or for providing an alternative programme feed
- extended commentary on particular programme or advertising features.

c) Additional audio/visual/text content provided under a public service remit or on revenue producing basis, which could include:

- government or public sector announcements or service information;
- dedicated news streams or emergency broadcasts in time of crisis, natural disasters, extreme weather;
- customer specific information services (e.g., stock/commodity/currency market information).

One of the simpler additional data service features to implement is a continuous feed of a selection of web pages, together with links to further web based content, which can then be displayed via a connection to a personal computer. This service was tested extensively by BBC World Service and Vosper-Thorneycroft Communications (now Babcock Communications Limited) during 2005 by adding maritime safety information web pages from the United Kingdom's Coastguard service, providing weather forecasts and warnings, to the subsidiary data stream during DRM30 test transmissions at HF. This was demonstrated to the International Maritime Organization on the occasion of the 10th session of the Sub-Committee on Radiocommunications and Search & Rescue in September 2005.

Another possibility for providing visual content within the DRM data stream is "Caption Radio", in which text data stream are displayed on a small LCD or LED display. This can provide real time information on programme content, even the complete text of a speech programme in order to help those with hearing difficulties.

In September 2010, the DRM Consortium gave the first demonstration of a more extensive range of data based audio-visual possibilities through the Small Scale Video Application "Diveemo". This DRM based application for broadcasting "live" small-scale video and audio services could provide cost efficient, large area distribution of information and education programs in the AM broadcasting bands.

Moreover, reception is independent of gatekeepers and third party providers like satellites, cable networks or the internet.

Examples of DRM implementations.

On the 8th April 2010, the government of India announced the approval of its core digitalization programme for All India Radio (AIR), its public broadcasting organization. AIR has chosen DRM as the technology for converting or replacing its vast analogue, mainly MF, transmitter network for digital operation.

In an effort to improve the quality of MF transmissions, AIR has planned to convert and/or replace its MF transmitters by digital transmitters. In this process, 72 of the 148 MF transmitters are either being replaced or converted to digital transmitters. AIR has already replaced one of its 1000 kW transmitters at Rajkot (Gujarat) and it is already carrying regular digital transmissions. In addition to value added text services, the Rajkot digital transmitter has provision to work in simulcast mode wherein one radio programme can be broadcast in analogue mode (for reception on conventional AM radio sets) and another programme in digital mode, which can be received only on digital receivers. The Urdu service of AIR, which was being provided from the old transmitter at Rajkot, is still being broadcast in analogue mode from the new transmitter for reception on AM receivers, with the popular commercial service, known as *Vividh Bharati*, now being broadcast in digital mode from this transmitter.

The switch to DRM services is proceeding rapidly, with another 1000 kW MF digital transmitter at Kolkata and six 20 kW digital transmitters at an advanced stage of installation. For the next phase of the MF switchover, orders for the replacement of six 300 kW, ten 200 kW and eleven 100 kW digital transmitters have recently been issued. Orders for the conversion of another 36 transmitters to digital are in progress.

In Ukraine, the National Radio Company of Ukraine (NRCU) has recently announced that it plans to switch broadcasting of two Ukrainian medium-wave networks to DRM. It is expected that 85-90% coverage will be achieved with around 15 new transmitters capable of digital or analogue operation. In DRM mode electricity consumption is estimated to be one third that of the current analogue medium-wave networks.

In Denmark, the Danish public broadcaster (Denmark Radio) has purchased a high efficiency 300 kW solid-state LF transmitter in order to provide a DRM service from the 243 kHz station at Kalundborg.

Conclusions

Digital sound broadcasting is opening the door for improved or completely new broadcasting applications, including multichannel operation, bilingual educational programs and preventive warning or emergency services. This is not the radio of old but one that sits right at the heart of the connected new media space of the information society. However, given the huge base of analogue receivers in operation, the crucial question now is how to make transition to digital sound broadcasting and realise the benefits of improved audio quality and access to the wide range of service offerings now available in the audio-visual sector.

In the VHF bands, the DRM+ standard can provide the same coverage, more economically than an FM broadcasting station, by using much lower power levels. DRM+ provides other advantages over FM, with the flexibility of being able to offer a wide range of subsidiary data services, multiplexed programming or single frequency networks. DRM+ is also capable of operating in a compatibility mode in which the huge existing base of FM receivers in the home and cars can continue to be used until the audience and broadcasters can complete the changeover on the basis of mutual convenience and needs. Moreover, DRM+ has the flexibility to satisfy any coverage need in Band II ranging from national and regional networks to community stations. DRM+ can also provide high quality broadcasting services in Band I and III, where these are not already used for TV or DAB.

In the LF, MF and HF bands, the DRM30 standard has the potential to revitalise the bands previously used for AM broadcasting. Although there are no spectrum savings *per se*, the spectrum will be used to better effect by bringing listeners reception with greater reliability and of much higher quality for all in-home, portable and in-car uses. For broadcasters, the advantages of economy and quality are particularly attractive when considering upgrading national and international AM networks. The main reason given against continuing with MF broadcasting has been the lower quality of AM. However, because most listening at MF takes place in cars, with relatively high ambient noise levels, or on portable radios with small loudspeakers, the quality issue may have been overstated. Nonetheless, a transition to DRM30, which can provide a subjective listening quality close to FM, would solve the quality issue and allowed the same coverage with a much reduced power output, thus saving energy and costs.

Moreover, both DRM30 and DRM+ can operate in a single frequency network mode in those cases where a uniform programme stream over a wide area is indeed the objective. In short, the change to DRM30 and DRM+ would make for more effective and efficient use of spectrum on several levels.

Digital sound broadcasting combines excellent audio quality with new features, such as additional data services with electronic newspapers, images and low bit video streams. All these features have already been demonstrated by DRM technology which offers the only comprehensive solution for digital sound broadcasting in all the terrestrial broadcasting bands from LF to VHF.

Proposals for further action

Although some administrations have implemented DAB/DAB+ services in Band III and some are taking steps towards making a transition to digital sound broadcasting in the bands currently used for AM and FM broadcasting, there seems to be a lack of impetus worldwide compared with how the switchover to digital broadcasting has progressed with television. Indeed, as noted above, reservations have been expressed during public consultations on whether or not the transition is actually in the interests of consumers, considering the immense number of analogue receivers in use and, seemingly, no widespread evidence of audience dissatisfaction with current levels of service (see also the Consumer Experts Group report on the digital switchover).

An appropriate question for consideration within ITU-R then is if a switchover to digital sound broadcasting will bring benefits to the public (as envisaged by the purposes of the Union, No. CS5) and, if so, how ITU-R can assist administrations and broadcasters in promoting and managing the transition?

The DRM Consortium is convinced that a transition to the DRM system in the broadcasting bands currently used for AM and FM broadcasting will bring tangible benefits to listeners; moreover, that the transition using DRM can be managed in a way that avoids disruption or loss service to the public. However, the DRM Consortium also recognizes that there are other digital sound broadcasting systems recommended by ITU-R who may wish to contribute to this debate.

The DRM Consortium would therefore propose that WP6A develops a new ITU-R Report informing administrations and broadcasters of progress on implementation of the various recommended digital sound broadcasting systems, and advising on the technical and regulatory considerations involved in making a rolling replacement of AM and FM broadcasting services. To this end, WP6A should start work on developing a working document towards a new Report, to be carried forwards on the Chairman's report. It is further proposed the work be organized initially as a compendium of alternative/parallel approaches, with separate sections on how the various recommended systems are being deployed, before compiling the separate summaries of progress into the final version.

The DRM Consortium has also noted the important work of the Study Group 6 Rapporteur Group on *Spectrum requirements for broadcasting* and has included in Annexes 1 and 2 to this submission some considerations of how a transition to DRM could affect spectrum use that the group may wish to take into account.

Annexes: 2

ANNEX 1

Spectrum management and service planning considerations in the broadcasting bands below 30 MHz

DRM system characteristics

DRM provides a single common digital sound broadcasting system for national and international coverage in in the LF, MF and HF bands. The system characteristics are given in Annex 1 to Recommendation ITU–R BS.1514-2, with more extensive details referenced in Appendix 1. These meet the service requirements for digital sound broadcasting at frequencies below 30 MHz as set out in Recommendation ITU–R BS.1348-2, and satisfy the objectives for digital sound broadcasting in the broadcasting bands below 30 MHz set by Question ITU-R 60/6.

Spectrum management considerations

In spectrum management terms, the transition from analogue to digital broadcasting using the DRM system in the broadcasting bands would be neutral and would not of itself require additional spectrum resources or release spectrum suitable for re-engineering for other purposes.

However, there would be important benefits in being able to make more effective use of the LF, MF and HF broadcasting bands generally. This would, in principle, would allow more scope for re-using frequencies for broadcasting. The adaptability built into the DRM technology allows power levels to be matched more precisely to the service requirement than with AM. An important feature of OFDM systems, and DRM in particular, is that transmissions can co-exist with lower protection ratios than with analogue modulation. Also the power requirement for a DRM30 emission carrying the same equivalent data throughput as an AM emission is lower by a factor equating to the removal of the carrier and lower side-band – basically only the upper analogue side-band power has to be transmitted when replacing an AM emission by DRM30. A DRM30 transmission can therefore be configured so as to replicate AM coverage with an average power requirement 4 to 6 dB lower than the analogue case.

A complete transition to DRM30 in the bands allocated to the broadcasting service below 30 MHz would therefore lead to better utilization of the spectrum in terms of lower transmitter powers. Further benefits in spectrum utilization can also be realized through delivering improved audio quality and a range of added value service operations such as joint stereo and dissemination of textual and graphical data streams. However, during the transition phased of mixed analogue and digital operation, some compromises on digital coverage versus analogue audio quality may be necessary when the various protection requirements are taken into account.

Planning considerations

The planning parameters for digital sound broadcasting at frequencies below 30 MHz given in Annex 1 to Recommendation ITU–R BS.1615-1 shows that, in an all DRM30 environment, the protection requirements are considerably lower than for conventional AM broadcasting. The absolute co-channel protection ratio for DRM to DRM emissions are of the order of 16 dB for a bit error rate of 10^{-4}. This compares with the absolute value for the AM to AM co-channel protection ratio of 30 dB for a stable wanted AM signal (27 dB for a fluctuating wanted signal) in the GE75 Plan[2].

The ITU-R Circular Letter CCRR/20 condenses the comprehensive guidance provided in Annex 1 to Recommendation ITU–R BS.1615-1 on the planning parameters applicable to the complete range of DRM30 modulation schemes, spectrum occupancy and robustness modes, into a practical assessment of how DRM30 should be introduced into the broadcasting bands below 30 MHz. For DRM interference into wanted AM emissions, CCRR/20 explains that the required absolute co-channel protection ratio should be 36.5 dB, meaning that that the interference potential of a DRM emission is about equal to the interference from an AM transmitter with a power 7 dB greater than the DRM transmitter.

The main consideration in re-engineering the broadcasting bands below 30 MHz is that a DRM30 transmitting station can achieve roughly equal coverage operating at powers 4 to 6 dB below the AM transmitter to be replaced, but that a power reduction of 7 dB is indicated in order to equalize the interference environment. This implies that some reduction in coverage will have to be accepted during the during the transition phase from AM to DRM. In practice, this may not prove to be a severe limitation. Because the spectrum occupancy of a DRM30 emission is virtually rectangular, with energy dispersed evenly across the entire occupied bandwidth, the 7 dB power back-off requirement can be considered as deriving from the energy throughput considerations across the channel bandwidth. However, this approach does not make use of the established methods for evaluating subjective responses to audio degradation. The interference generated by a noise-like co-channel DRM30 signal is of a very different character to the highly intrusive nature of a second (intelligible) AM service audible in the background (a technique that is recognised to be the most effective form of deliberate jamming). Nevertheless, this value of power back-off (7dB) is currently built into the Recommendation ITU-R BS.1615.

For AM interfering with DRM30, the situation is significantly better than with any other permutation, because a well-designed COFDM receiver is able to ignore interfering AM carriers. Depending on the desired quality of service, a typical co-channel protection ratio from a co-channel AM emission into a wanted DRM30 service, delivering around 20kb/s, is +7dB, which is at least 20 dB less stringent than the AM into AM case. Therefore, interference from existing AM stations should not disadvantage incoming DRM30 services, irrespective of whether the interference or coverage equalizing power back-off is applied.

Conclusions

A complete transition to DRM would allow for more effective and intensive use the broadcasting bands below 30 MHz compared to AM. This would certainly be the case in the LF and MF bands.

Unfortunately, matters are not so straightforward in the HF bands where seasonal planning for analogue HF broadcasting now has to be carried out on the basis of only17 dB (instead of 30 dB) absolute co-channel protection because of the excessive level of congestion in many of the HF broadcasting bands. Thus, any potential benefits in terms of better spectrum occupancy through a transition to digital modulation in the HF broadcasting bands have already been absorbed by the present level of congestion. If spectrum demand in the HF broadcasting bands then increases as a result of the higher quality of service possible with DRM30, then a choice will again have to be made on whether to sacrifice quality for quantity.

[2] NB: in the HF bands, planning for analogue broadcasting now has to be carried out on the basis of only17 dB absolute co-channel protection because of the excessive level of congestion.

Overall, the combination of OFDM/QAM techniques used in DRM offers close to the maximum theoretical spectral efficiency. Moreover, DRM offers important benefits in spectrum utilization through being able to replicate analogue coverage at average power levels at least half of that required by conventional AM broadcasts, as well as being able to provide a wide range of added value services.

ANNEX 2

Spectrum management and service planning considerations in the VHF broadcasting bands

DRM system characteristics

DRM technology was originally developed for use in the broadcasting bands below 30 MHz. The DRM Consortium has since developed a version of the DRM technology at higher frequencies in order to provide a single common digital sound broadcasting system for use Bands I, II and III. The DRM system characteristics applicable for use in the VHF bands are set out in Annex 5 (System G) to Recommendation ITU–R BS.1114-7 – *"Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3 000 MHz"*. Also termed DRM+ for commercial purposes, System G is registered as ETSI standard ES 201 980V3.1.1 (2009.08).

The system offers audio quality comparable to that obtained from consumer digital recorded media. In addition, DRM offers data services, including images and electronic programme guides, and the capability of dynamically rearranging the various services contained in the multiplex without loss of audio.

Spectrum management considerations

Band I

Band I was used by countries around the world at the commencement of TV broadcasting form the 1940s. Subsequently, many countries moved their TV broadcasting to higher frequencies in Bands III, IV and V, with some discontinuing use for broadcasting altogether. At present, the band is used for many different purposes, including legacy analogue TV and various business and military applications in the land mobile service.

Nonetheless, many countries still retain the possibility to re-engineer the whole or parts of the band for digital TV or sound broadcasting. The band could also be used more extensively for services ancillary to broadcasting, such as wireless microphones. As regards digital sound broadcasting, Band I could in principle support deployment of any of the technologies recommended in Recommendation ITU–R BS.1114-7. The limited amount of spectrum available in Band I contributed to previous decisions by many countries to cease analogue TV broadcasting, and this could again be a consideration when examining future options for making optimum use of Band I. However, DRM+ would provide greater flexibility for re-engineering Band I for broadcasting purposes on account of its compact spectrum mask.

Other considerations on introducing any form of digital broadcasting technology in Band I would be the impact of long distance, high level interference by sporadic-E propagation events. Previous UK studies, dating back to the days of 405 line analogue TV (1946-1985) showed nearly daily sporadic-E events during the summer months, sometimes strong enough for reception of TV and mobile service signals in the 40 – 60 MHz range from the USA over the Atlantic Ocean. The amateur service in the United Kingdom is allowed access to the bands 50 – 52 MHz, which matches with the Region 2 and 3 allocation to the amateur service in the band 50 – 54 MHz.

Given the wide variations in current usage, planning for the introduction of DRM+ in Band I would have to be undertaken on a national basis following decisions on how much spectrum could be released for uses that are no longer required.

Band III

As with Band I, there are considerable variations in national use of Band III. Several countries abandoned use of Band III for analogue TV broadcasting in favour other applications, notably for trunked land mobile networks. Also, as with Band I, the band is well suited for services ancillary to broadcasting.

Many countries have maintained the use of Band III for analogue TV and plan to use the band for digital TV broadcasting, for example, according to the planned transition to digital TV broadcasting contained in the RRC-06 Agreement. In addition, the band is now widely used around the world for DAB and DAB+ sound broadcasting networks, including several countries that previously discontinued use of Band III for analogue TV services. In some cases, Band III was designated for use as a parking band for DAB, pending a future move to replace FM broadcasting in Band II with DAB multiplexed services – a consideration that shows uncertainty on how to make the transition to digital sound broadcasting has persisted for over 25 years.

Band III would certainly be well-suited to supporting DRM+ services but, again, given the wide variations in current usage, planning for the introduction of DRM+ in Band III would have to be undertaken on a national basis following decisions on how much spectrum could be released for uses that are no longer required. The situation is further complicated at present by suggestions that Band III might be needed to support digital TV broadcasting services displaced from Bands IV/V as a result of changes introduced at WRC-15 under its agenda items 1.1 and 1.2. In such a situation, the narrower bandwidth characteristics of DRM+ would be an advantage in giving more flexibility in re-planning the use for Band III for a mixture of digital sound and TV broadcasting.

Band II

With a few exceptions Band II is used extensively for FM sound broadcasting around the world, often with spectrum being re-used up to the maximum extent theoretically possible – the situation in Western Europe. The major outstanding question involved in making the transition from analogue to digital sound broadcasting is therefore the feasibility and practicality of re-engineering Band II for use with digital broadcasting technology.

The factors relevant to introducing DRM+ services into Band II while maintaining compatibility with legacy FM services and the aeronautical services operating in the adjacent bands above 108 MHz were summarized in Document 5B/487. As some points relate to material contained in ETSI standards, the relevant information is repeated here for ease of reference.

DRM+ employs Orthogonal Frequency Division Multiplexing (OFDM) with Quadrature Amplitude Modulation (QAM). Details of the sub-carrier structure and modulation are given in Table 1.

TABLE 1

DRM+ Modulation scheme

Modulation	COFDM
Number of sub-carriers	213
Sub-carrier spacing	444 Hz
Modulation (data carriers)	4-QAM or 16-QAM
Bandwidth	96 kHz

The spectrum emission and transmitter masks for DRM+ are shown in Figure 1 and Table 2 below.

FIGURE 1

Spectrum mask for DRM+ and FM

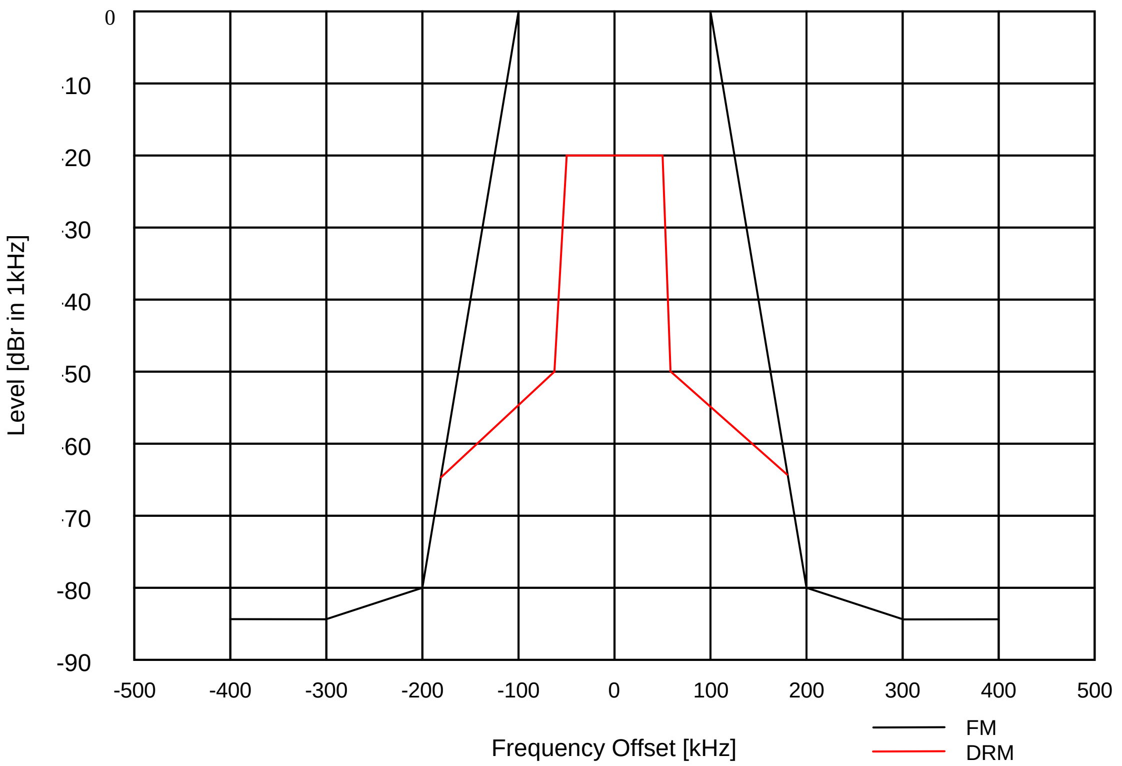

TABLE 2

Spectrum masks for FM and DRM+

ETSI mask for FM	
Offset	**Rel. level (1 kHz)**
-400 kHz	-85,0 dB
-300 kHz	-85,0 dB
-200 kHz	-80,0 dB
-100 kHz	0,0 dB
100 kHz	0,0 dB
200 kHz	-80,0 dB
300 kHz	-85,0 dB
400 kHz	-85,0 dB

DRM+ mask		
Offset	**Rel. Level (1 kHz)**	**Attenuation**
-400,00 kHz	-85,0 dB	-65,0 dB
-300,00 kHz	-85,0 dB	-65,0 dB
-200,00 kHz	-80,0 dB	-60,0 dB
-181,00 kHz	-65,0 dB	-45,0 dB
-60,00 kHz	-50,0 dB	-30,0 dB
-50,00 kHz	-20,0 dB	0,0 dB
50,00 kHz	-20,0 dB	0,0 dB
60,00 kHz	-50,0 dB	-30,0 dB
181,00 kHz	-65,0 dB	-45,0 dB
200,00 kHz	-80,0 dB	-60,0 dB
300,00 kHz	-85,0 dB	-65,0 dB
400,00 kHz	-85,0 dB	-65,0 dB

The DRM+ signal can be offsets of multiples of 10 kHz from the nominal centre frequency. This feature can be further exploited by placing two DRM+ signals side by side, offset by –50 kHz and +50 kHz from the classical FM carrier frequency, so as to fill the nominal ±200 kHz ETSI FM mask bandwidth. This “double DRM+” mask is shown in Figure 2 and Table 3 below.

FIGURE 2

Spectrum mask for double DRM+ and FM

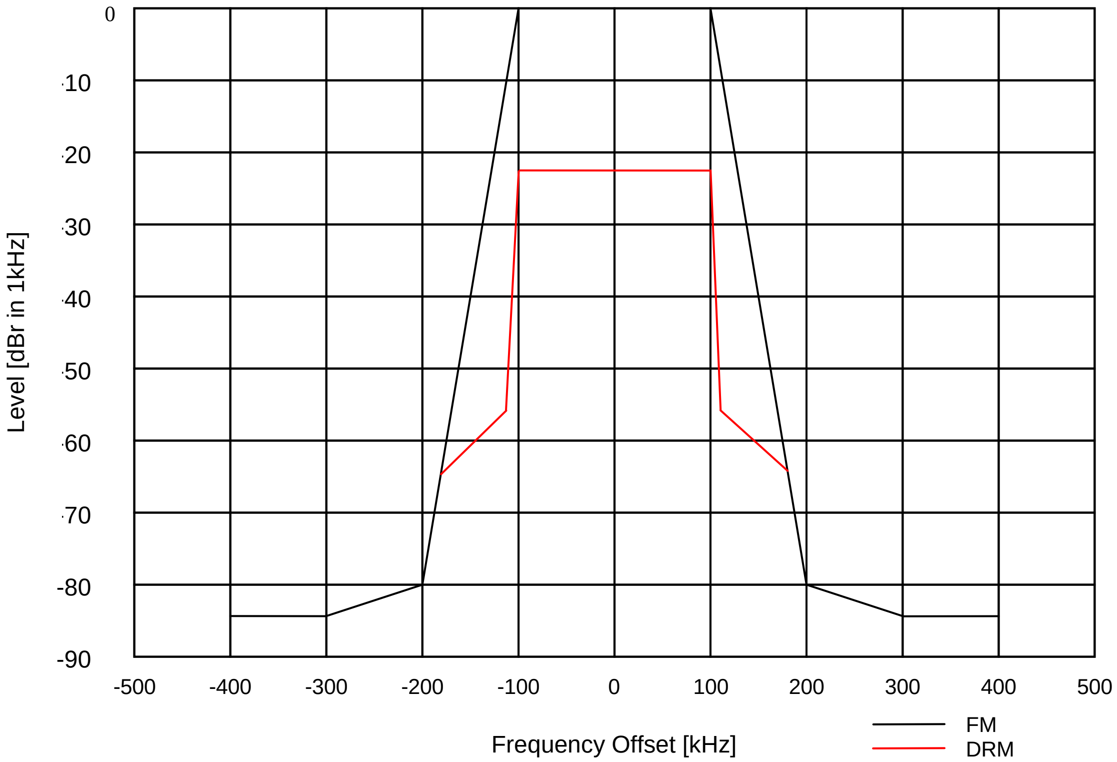

TABLE 3

Spectrum masks for FM and double DRM+

ETSI mask for FM	
Offset	**Rel. level (1 kHz)**
-400 kHz	-85,0 dB
-300 kHz	-85,0 dB
-200 kHz	-80,0 dB
-100 kHz	0,0 dB
100 kHz	0,0 dB
200 kHz	-80,0 dB
300 kHz	-85,0 dB

Double DRM+ mask		
Offset	**Rel. Level (1 kHz)**	**Attenuation**
-400 kHz	-85,0 dB	-62,0 dB
-300 kHz	-85,0 dB	-62,0 dB
-200 kHz	-80,0 dB	-57,0 dB
-181 kHz	-65,0 dB	-42,0 dB
-111 kHz	-57,0 dB	-34,0 dB
-100 kHz	-23,0 dB	0,0 dB
100 kHz	-23,0 dB	0,0 dB

400 kHz	-85,0 dB

111 kHz	-57,0 dB	-34,0 dB
181 kHz	-65,0 dB	-42,0 dB
200 kHz	-80,0 dB	-57,0 dB
300 kHz	-85,0 dB	-62,0 dB
400 kHz	-85,0 dB	-62,0 dB

The two DRM+ signals sit side by side and the upper signal can operate up to 107.95 MHz without exceeding the existing ETSI FM mask. Note that, in this configuration, the DRM+ signals operate 3dB down from the single DRM+ signal in order to maintain the overall power spectral density relative to the planned analogue FM service.

Band II planning considerations

A number of receiving scenarios can be envisaged for planning purposes, including fixed reception using an external antenna, in-car mobile reception and reception on a handheld PDA type terminal.

For the fixed reception case, the C/N values for the average white Gaussian noise (AWGN) channel from ETSI ES 201 980 may be used. For the various portable reception scenarios the values for the rural channel (i.e., channel 9) from ETSI ES 201 980 may be used, and in the case of mobile reception the C/N values of the terrain obstructed channel (i.e., channel 10) may be used from ETSI ES 201 980.

Table 4 provides the C/N values for the various receiving scenarios and two modulation modes: 4 QAM corresponds to a robust transmission mode, optimised for difficult propagation conditions or a noisy environment, and 16-QAM corresponds to a high quality transmission mode.

TABLE 4

C/N values (dB) for the different receiving scenarios and modulations

Scenario	Fixed reception	Portable indoor	Portable outdoor	Mobile vehicles	Indoor handheld	Outdoor handheld
4-QAM	1.3	5.6	5.6	5.4	5.6	5.6
16-QAM	7.9	13.1	13.1	12.6	13.1	13.1

By taking account of the applicable parameters for the various combinations of antenna gain, antenna height, building shielding and entry loss, the planning values for the minimum median equivalent field can be derived, as given in Table 5.

TABLE 5

Planning values for minimum median equivalent field strength levels, E_{med} (dBμV/m), for the different receiving scenarios and modulations

Scenario	Fixed reception	Portable indoor	Portable outdoor	Mobile vehicles	Indoor handheld	Outdoor handheld
4-QAM	7.5	37.2	34.2	38.9	58.1	55.0
16-QAM	14.1	44.7	41.7	46.0	65.6	62.5

These figures use an allowance for the man-made noise component of 4 dB, which was derived from ETSI TR 101 190[3]. Any additional interference from other sources such as signals in the aeronautical mobile (R) or aeronautical radionavigation services operating close to the 108 MHz band edge will reduce coverage accordingly.

The standard way of planning FM broadcasting, as exemplified in the GE84 Plan, is to use planning criteria based on achieving a minimum field strength of 54 dB(μV/m) for a fixed receiver fed by an external antenna at 10m height. This assumption was more suited to the situation expected soon after the introduction of FM broadcasting in the 1950s, but now most listening is on a portable radio with a small/poor aerial a metre or so above floor level. This practical situation has now long been recognized for planning mobile services and digital broadcasting, notably for the Eureka 147 DAB system where the objective now is to ensure good reception indoors or in cars. These more demanding conditions need considerably more power (by at least 20 dB) in order to achieve the same quality and reliability of service as with a fixed rooftop antennal. Fortunately FM interference immunity and receiver performance characteristics turned out to be considerably better than expected. For the future though, the introduction of a new digital sound broadcasting service demands that the planning scenario is accurate and consistent. The problem then is that, as shown in Table 5, the power savings possible by going to digital broadcasting look rather small once all the additional factors needed to go from a 10m high external aerial to reception in cars or indoors are included.

Another important aspect of Band II planning is the impact on the aeronautical radionavigation and aeronautical mobile (R) services operating in the adjacent bands above 108 MHz. This was a major consideration in extending FM broadcasting from 104 to 107.9 MHz for the GE84 Plan. As noted in Recommendation ITU-R SM.1009, incompatibilities caused by FM broadcasting stations are power related, resulting either from combining several high power FM transmitters into a common antenna or through driving aircraft receivers into non-linear operation, or both. Although detailed consideration is still needed on all the factors involved with maintaining compatibility with the aeronautical service operating above 108 MHz when introducing DRM+ stations into Band II, the lower transmitting powers needed can only be beneficial.

Results of Band II case studies

In addition to the theoretical considerations above, recent case studies on the implementation of DRM+ in Band II (see EBU Report TECH 3357) have assessed how the DRM+ standard could be introduced into Band II either to replace existing FM transmissions or to provide new services. These studies confirm that DRM+ can provide the same coverage, more economically than an FM broadcasting station, by using much lower power levels. Some technical compatibility problems with low level digital artefacts remain to be resolved where FM and DRM+ transmissions would continue to serve overlapping areas. The mechanism involved is not entirely clear at present; and the disturbance is not consistently observed, becoming less apparent where the band is heavily occupied. In any event, the problem would disappear after a complete transition to DRM+ in Band II.

Conclusions

Planning of DRM+ services in Band II would generally tend to start from the same 100 kHz grid as conventional FM service in Europe or the 200 kHz grid commonly used in Regions 2 and 3. This

[3] At the upper edge of Band II, additional interference from other sources such as the aeronautical mobile (route) or aeronautical radionavigation services close to the 108 MHz band edge will reduce coverage accordingly.

would certainly provide for more efficient use of the available spectrum, especially as the analogue services are switched off. However, there is scope for further flexibility in planning DRM+ services in that the specification allows for DRM+ signals to be located at any frequency which is a multiple of 10 kHz. This would allow a DRM+ service to be placed close to an FM emission as part of a transitional arrangement (see Figures 43 and 44 of Recommendation ITU–R BS.1114-7) or use of the double DRM+ configuration shown in Figure 2.

The analysis above shows that DRM+ can provide broadcast coverage comparable to FM broadcasting at much lower power levels – some 40 dB lower if retaining the fixed receive/external antenna configuration. But more practically, a power reduction of 10 to 15 dB on the required minimum field strength for FM reception would, without other interference constraints, ensure satisfactory coverage for portable/mobile reception. The lower transmission powers possible with DRM+ should also prove advantageous when considering compatibility with aeronautical services operating in the adjacent bands above 108 MHz.

DRM+ can also provide high quality broadcasting services in Band I and III, where these are not already used for TV or DAB.