Minimum C/N Requirements for DRM Reception based on Field Trials

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Abstract—This paper presents field measurements results of minimum signal to noise ratio required to achieve a threshold BER based on the first medium wave Digital Radio Mondiale (DRM) measurement campaign in Spain. The main goal of these measurements has been to compare the laboratory simulated values recommended by the ITU with field measurements using real transmission and reception systems and real propagation and reception environments.

Index Terms—Digital broadcasting, measurement systems, C/N measurements, DRM.

I. INTRODUCTION

DRM (Digital Radio Mondiale) is the standard adopted in Europe for digital sound broadcasting in the frequency bands below 30 MHz [1]–[3]. The work of developing all the technical, promotional and standardization tasks has been mainly carried out by the members of the DRM consortium [4]. The result of this collaborative effort is a successful launch of commercial emissions in June 2003 by the 16 leading international broadcasters.

Despite this successful launch of services, there is still a need for network planning parameter values measured on the field [5], [6]. One parameter of special interest is the minimum carrier to noise ratio (C/N) requirement for achieving a threshold bit error rate (BER). Laboratory simulations of this minimum C/N ratio have been done [7] for different DRM signal configurations contained in the standard, but these values must be contrasted with real ones measured under real environments and with real transmission and reception systems.

This paper presents the results of a C/N measurement campaign carried out in Spain for DRM ground wave propagation using the 1359 KHz medium wave frequency. Resulting minimum C/N values will be presented for different signal configurations and compared to the ones obtained from laboratory simulations.

II. MEASUREMENT CAMPAIGN

A. Introduction

This section presents a summary on the measurement system and the measurement campaign that have been carried out to achieve C/N and BER measurements for DRM.

UPV/EHU is a member of the System Evaluation (TC-SE) and Monitoring Network (TC-MN) groups of the DRM Consortium.

B. Measurement System

A van was equipped with a specifically designed measurement system in order to make measurements in different environments and under different reception conditions. The measurement system is composed of three different sections: signal acquisition, measurement and the control section.

The key element of the signal acquisition section is a short monopole active antenna with a 40 MHz low-pass filter modification. The antenna is placed at the top of the van with a specifically prepared ground plane. The filter modification turned to be necessary in order to avoid antenna saturation noise under noisy urban environments [6].

The measurement section consists of a DRM demodulation system and additional equipment for RF signal analysis. The demodulation system is one of the three professional receivers used for system evaluation purposes within the DRM consortium [8]. A spectrum analyzer has been used for providing spectrum traces and a field strength meter has been used for accurate measuring of the signal power.

The control section is in charge of configuration and control of all the equipment and also of providing a GUI to a human user. The control section is based on a laptop, running a specifically designed software on a GNU/Linux platform and which controls the equipment via TCP/IP.

C. Methodology

The BER measurement has been done using the rbp0 tag provided by the professional receiver via RSCI [9]. This tag only contains data when a PRBS sequence is used at the transmitter and returns the number of both the errored bits and the total bits for each 400 ms frame.

The field strength and the external noise have been measured every 400 ms during 3 min at each measurement location. The 400 ms integration period has been chosen since it is the DRM frame duration and, consequently, long enough to include more than one OFDM symbol. The 3 min interval has been chosen to include stochastic environmental effects like cars or motorbikes passing near the measurement unit.

The measurement system has been configured in such a way that the external noise was always 10 dB above the internal noise of the system (including the field strength meter).

D. Locations

Measurements have been taken in locations with C/N and BER values near the theoretical threshold. The measurements
have been carried out in fixed locations with the mobile unit stopped, so additional effects due to mobile reception were avoided. Moreover, different reception environments were selected ranging from open rural environments to dense noisy urban environments.

E. Signal Configurations

The DRM standard allows many kind of parameters to be adjusted at different levels [3]. In this measurement campaign two opposite and usable cases for ground wave propagation have been used. For the sake of briefness these signal configuration modes have been named mode1 and mode5e. Table I summarizes the parameter values in each configuration.

<table>
<thead>
<tr>
<th>DRM SIGNAL CONFIGURATIONS</th>
<th>mode1</th>
<th>mode5e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robustness Mode</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Protection Ratio</td>
<td>PL1-0.6</td>
<td>PL0-0.5</td>
</tr>
<tr>
<td>Interleaver</td>
<td>short</td>
<td>short</td>
</tr>
<tr>
<td>MSC Constellation</td>
<td>64-QAM</td>
<td>16-QAM</td>
</tr>
<tr>
<td>SDC Constellation</td>
<td>16-QAM</td>
<td>4-QAM</td>
</tr>
<tr>
<td>Audio Codification</td>
<td>AAC+ 24 kHz</td>
<td>AAC+ 12 kHz</td>
</tr>
<tr>
<td>Resulting Bitrate</td>
<td>23.5 Kbps</td>
<td>13 Kbps</td>
</tr>
</tbody>
</table>

Mode1 offers good quality for music broadcasting but has a smaller coverage while mode5e is more suitable for voice broadcasting and allows reception at longer distances since it requires a smaller minimum C/N.

III. DATA PROCESSING

A. Introduction

This section presents the processing applied to the data collected during the measurement campaign to obtain the final results. A series of BER versus C/N points will be obtained and fitted to a curve in order to obtain an interpolated minimum C/N value for achieving a given threshold BER.

B. Measured Values

As previously stated, measurements have been taken in 400 ms intervals during 3 min approximately. The resulting RF carrier and noise power is obtained as the mean value of this set of measurements, while the BER value is the result of dividing the number of bits with errors by the total bit count in that 3 min interval. Fig. 1(a) and Fig. 1(b) plot the obtained BER values versus the corresponding measured C/N values for total locations of mode1 and mode5e respectively.

For a measurement time of 3 min the minimum BER that can be measured for mode1 (23.5 Kbps) and mode5e (13 Kbps) is $2 \cdot 10^{-7}$ and $4 \cdot 10^{-7}$ respectively. Thus, for measurements without errors (BER=0) a special approach has to be taken. Since the threshold BER recommended by the ITU [7] is $10^{-4}$, a first impression could led to ignore these low values. But this would not be correct because, as Fig. 1(a) and Fig. 1(b) show, these values also appear at C/N levels where greater error rates have been detected, and thus they will do affect to the final interpolation curve. The solution adopted has been to assign $BER = 10^{-9}$ to these points. This is because, as they are in the proximity of measurements with errors, its BER it is not likely to be $10^{-20}$ for example. The error obtained when substituting this value in a margin of $10^{-8}$ to $10^{-10}$ can be considered small.

C. Interpolation Curve

The next step is to fit an interpolation curve to the results. This would give a resulting BER vs C/N curve from which a minimum required C/N value for achieving a threshold $BER = 10^{-4}$ can be obtained.

Theoretical simulations for different front-ends [10] show that BER versus C/N values approximately follow a lineal variation in a BER range from $10^{-1}$ to $10^{-5}$ when displaying both parameters in logarithmic magnitude. Fig. 2(a) and Fig. 2(b) show the result of interpolation to a Z-shaped curve applying the minimum mean square error (MMSE) criterium. This curve shape has been chosen in order to take into account the non-linear effects that appear at low and high BER values.
IV. RESULTS

The minimum C/N values recommended by the ITU for achieving a $BER = 10^{-4}$ using ground wave propagation and a 9 kHz spectrum occupancy are 15.3 dB and 8.6 dB for mode1 and mode5e respectively [7]. As Table II shows, the minimum C/N value that has been obtained from field measurements is quite similar to the one recommended by the ITU for mode1, but it is more than 1.5 dB higher for mode5e. This difference in the more protected mode could be due to the fact that real channels are not as Gaussian as theoretical ones and the robustness techniques applied improve the protection less than what simulations show.

Table II also shows that the effect of substituting the BER0 value in a range from $10^{-8}$ to $10^{-10}$ does not affect significantly the resulting minimum C/N requirement, so the $10^{-9}$ value previously chosen can be considered suitable.

<table>
<thead>
<tr>
<th>Mode</th>
<th>ITU lab. value C/N (dB)</th>
<th>Measured value C/N (dB) vs BER0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$10^{-8}$</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>mode1</td>
<td>15.3</td>
<td>15.0</td>
</tr>
<tr>
<td>mode5e</td>
<td>8.6</td>
<td>10.3</td>
</tr>
</tbody>
</table>

V. CONCLUSION

This paper has presented the results of the first medium wave DRM measurement campaign in Spain for minimum required C/N values. The main goal of these measurements has been to compare laboratory values recommended by the ITU with field measurements using real transmission and reception systems under real propagation and reception environments.

Measurements have been done for two opposite DRM signal configurations for the case of ground wave propagation. Results show that the measured value is very close to the one recommended by the ITU for the least protected mode, but that the ITU value for the most protected mode is a bit optimistic.

ACKNOWLEDGMENT

The authors would like to thank RNE and Telefunken-VIMESA for the transmission infrastructure they have provided for this measurement campaign, and to the colleagues within the DRM consortium for their suggestions and help.

This work has been economically supported by public funding under the projects MCYT TIC2002-01340 and UPV/EHU-UE2003.

REFERENCES


All Authors are members of the TSR (Signal Processing and Radiocommunications) Research Group. This group belongs to the Department of Electronics and Telecommunications at the Bilbao Engineering College (University of the Basque Country) and focuses its main interest on digital broadcasting systems.