CNR Requirements for DVB-T2 Fixed Reception
Based on Field Trial Results

Iñaki Eizmendi, Gorka Berjon-Eriz, Manuel Vélez, Gorka Prieto, Amaia Arrinda

This letter presents the C/N requirements for DVB-T2 fixed reception. Results have been obtained from field trials carried out to test DVB-T2 performance, considering outdoor rooftop antenna scenario. Two commercial receivers have been used to obtain C/N threshold values for image error-free condition. The tested configuration modes are the ones recommended for this scenario: 32K FFT and 64 and 256 QAM constellations. DVB-T has also been measured in order to obtain direct comparison between both systems.

Introduction: In 2009 a new standard for Digital Terrestrial Television (DTT), named DVB-T2, was published by the ETSI [1]. The use of DVB-T2 to carry out HDTV services for rooftop reception is suggested in DVB-T2 Implementation Guidelines [2], so this scenario was chosen to be tested during the field trials.

The aim of this study is to provide broadcasters with real C/N threshold values that can be used for the first network developments and to help choosing the correct system configuration options that provide the required data rate with the lowest C/N requirement. This study could be very useful, as no field trial results have been published until now and at this moment some countries have just adopted this new standard and many others are deciding what DTT standard they adopt, so having values for real reception conditions could be a key factor when taking the decision.

At the time of the measurement campaign (June and July, 2010) no professional receivers with BER measurement capabilities were available. Two commercial DVB-T2 receivers were used instead; a TV Set and a Set-Top Box (STB).
Transmitter Equipment and Measurement Locations: The measurements analyzed in this study were carried out during June and July 2010, in the city of Vitoria-Gasteiz in the north of Spain. The transmitter centre was located on a mountain, 450 m higher than the average altitude of the city and 9 km far from the city centre. This centre is used to broadcast the main DTT commercial channels to the city. The radiating system consisted on two array panels. The frequency was 706 MHz (C50). The Effective Isotropic Radiated Power (EIRP) was 4.8 kW, similar to the EIRP used at this transmission centre to broadcast the DVB-T commercial channels.

The DVB-T2 signal was configured with the common main settings described in table 1. 256 and 64 QAM constellations were tested in combination with all defined code rates. The DVB-T signal was configured with the following parameters: 8K FFT, 8 MHz Bandwidth, 1/4 Guard Interval Fraction (GIF). Code rates 2/3 and 3/4 were tested. Two HD MPEG4 services were broadcasted for the tests. In total 14 different configurations were measured. The bit rates (Mbps) are summarized in Table 2.

The measurements were taken at 18 different locations. Fig. 1 shows the locations where the measurements were taken and the transmitter location. These locations were selected to have clear view of the transmitter, providing Ricean channel with low multipath. The distance from the transmitter ranged from 6.6 km to 30.3 km. All the configurations were measured with both receivers at 9 of the points. Some DVB-T2 configurations were measured at extra 9 locations using only one receiver. Two of the measured locations are not represented at the picture as they are outside of the showed area and two locations are superimposed. The number of measurements for each configuration is listed in table 3. For example, mode DVB-T2 64 QAM 3/4 was measured 27 times, 18 with one receiver and 9 with the other.

Measurement System and Methodology: The reception equipment was mounted in a mobile unit with telescopic mast that rises up to 8 meters, where the reception
antenna was mounted (15.5 dBi Yagi-Uda). The measurement equipment and set-up is sketched in Fig. 2. The objective of the measurements was to obtain the minimum C/N (C/N_{min}) at which the video services were received correctly. The procedure was:

1. The modulator was configured with the corresponding settings.
2. The output of the combiner was connected to the receiver A. The level of the noise generator was adjusted in 0.5 dB steps to reach the maximum level at which the image was received correctly for at least 30 seconds.
3. The output of the combiner was connected to the Signal Analyzer. The noise generator was muted to measure the signal level (C).
4. The modulator was muted and the noise unmuted to measure the noise level (N).
5. C/N_{min} was obtained by subtracting C and N.
6. Steps 2 to 5 were repeated for the receiver B.

In order to classify the channel, the DVB-T impulse response (IR) and the spectrum of the signal was measured too.

Results: The measured C/N_{min} values are represented in Fig. 3 for both receivers, for all the locations, and for all tested configurations against the bit rate obtained for each configuration (table 2). The median values of the results are used to plot the curves for DVB-T, for DVB-T2 64 QAM, and for DVB-T2 256 QAM. The performance of both receivers was very similar, being the average difference 0.2 dB. The standard deviation for each mode is around 0.5 dB with a maximum value of 0.8 dB.

The signal levels, from -60 to -36 dBm, had no noticeable influence in the results.

The IR measurement results showed only one main path, with very low multipath (<25dB). The ripple of the spectrum, measured as the standard deviation (σ), showed the same results, being σ <1.9 dB for all the measurements. So the channel should be classified as Ricean at all the locations.

Table 3 provides more information about the measured values together with the results of simulations provided by the standards for DVB-T [3] and for DVB-T2 [2] and the NorDig requirements for TV receivers [4]. DVB standards provide simulation...
results for Gaussian, Ricean, Rayleigh and 0 dB echo channels. Ricean channel
describes the fixed outdoor rooftop antenna reception conditions [2], so these values
have been used for comparison. NorDig requirements do not provide values for
Ricean channel, so the requirements for Gaussian channel have been used.

Fig. 3 and table 3 show that DVB-T2 64 QAM behaves better than 256 QAM for
similar bit rate. For instance, 64 QAM 4/5 performs 0.8 dB better than 256 QAM 3/5,
and 64 QAM 2/3 performs 1.2 dB better than 256 QAM 1/2.

Regarding the comparison between DVB-T and DVB-T2 for similar bit rate, the C/N_{min}
is 4.6 dB lower when using DVB-T2. For similar C/N_{min} requirements, DVB-T2 64
QAM 3/4 increases the bit rate of DVB-T 2/3 by 56 percent, and DVB-T2 64 QAM 4/5
increases the bit rate of DVB-T 3/4 by 45 percent.

The median values in table 3 are lower than NorDig requirements [4] for all the tested
configurations. When comparing with the simulation results published in DVB
standards, the measured performance of DVB-T2 is worse than the simulation results
(more optimistic). It is not the case for DVB-T, as simulation results have been
outperformed by present receiver designs.

Conclusions: The aim of these field trials has been to provide threshold values and
guidelines for planning DVB-T2 networks. Although commercial receivers have been
used, the C/N_{min} obtained could be used as a reference point, because future
receiver developments could outperform the tested ones, but a worse performance
should not be expected.

The worse performance of 256 QAM modes could make this new constellation
useless for bit rates that can be provided by 64 QAM modes. This performance
differs from the theoretical models [2] but agrees with tests carried out with integrated
receiver decoders [4]. This effect could be increased when Single Frequency
Networks are present, because rotated constellations are supposed to be intended
for this situation, as they have better performance for lower constellation orders [5].
As final conclusion DVB-T2 reception has shown an important improvement over DVB-T, with noticeable lower C/N_{min} requirements or providing higher data rates.

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References
1 Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2), ETSI Std. EN 302 755 V1.2.1, Oct. 2010.
2 Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2), ETSI TS 102 831 V1.1.1, Oct. 2010.
3 Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for digital terrestrial television broadcasting system, ETSI Std. EN 300 744 V1.6.1, Jan. 2009.

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Figure captions:

Fig. 1 Transmitter centre and measurement locations.
Fig. 2 Measurement set-up used in the field trials
Fig. 3 C/N_{min} vs. bit rate for both receivers and for all locations

Table captions:

Table 1 Common main DVB-T2 settings
Table 2 Bit rate for each measured configuration (Mbps)
Table 3 C/N_{min} (dB)
Figure 1
Figure 2

[Diagram showing the connections between Reception Antenna, Channel 50 Filter, Noise Generator, Combiner, Receiver A, Signal Analyzer, and Receiver B.]
Figure 3

![Graph showing C/N min (dB) vs. bitrate (Mbps) for DVB-T 64 QAM, DVB-T2 64 QAM, and DVB-T2 256 QAM.]
Table 1

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\(^1\) peak-to-average power ratio, \(^2\) low-density parity-check, \(^3\) physical layer pipes, \(^4\) time interleaving
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\(^1\) Ricean Channel

\(^2\) Gaussian Channel