Measurements methodology for evaluation of Digital TV operation in VHF high-band

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Abstract: This paper describes the experimental setup of field measurements carried out for evaluating the operation of the ISDB-T_B (Integrated Services Digital Broadcasting, Terrestrial, Brazilian version) standard digital TV in the VHF-high band. Measurements were performed in urban and suburban areas in a medium-sized Brazilian city. Besides the direct measurements of received power and environmental noise, a measurement procedure involving the injection of Gaussian additive noise was employed to achieve the signal to noise ratio threshold at each measurement site. The analysis includes results of static reception measurements for evaluating the received field strength and the signal to noise ratio thresholds for correct signal decoding.

Keywords: Digital TV, ISDB-T_B, field measurements, UHF, VHF High-band

1. INTRODUCTION

The Brazilian regulator, the National Agency of Telecommunications (Anatel), approved the allocation of part of the UHF spectrum band (698 to 806 MHz, TV channels 52-69) to mobile cellular services of fourth generation (4G), known as the Long Term Evolution (LTE) system [1]. To clear this frequency band for this usage, the implementation of digital TV transmission of ISDB-T_B standard in the VHF-high band (174-216 MHz) in Brazil [2] became a priority in the Brazilian TV broadcasting scenario. Considering that the majority of ISDB-T_B transmission already operate in UHF band, an assessment of operation in VHF high-band was required.

This paper presents results of field measurements carried out for the evaluation of ISDB-T_B digital TV operation in the VHF-high band [3] [4]. A mobile unit fully prepared with measurement equipment and digital TV signal recording setup performed the trials in urban and suburban areas in a Brazilian city (Gama, near the country capital Brasília). The measurements of static reception were performed at 63 sites. The analysis includes results of field strength values and signal to noise ratio thresholds for correct signal decoding, and the coverage area with static reception.

1.1 Transmission Setup

The experimental setup was composed by two digital TV transmitters in VHF channels 12 (204-210 MHz) and 13 (210-216 MHz). The transmission of adjacent channels 12 and 13 aimed the interference analysis. The directive antennas with 10 dBi gain were installed at a 40-meter tower (15°59'42''S/48°03'08''W), at 32 m (channel 12) and 41.5 m (channel 13) from the ground. Table 1 presents the configuration of the transmission modes employed in this trial, usually employed in current digital TV broadcasting systems. Three transmission ERP levels were employed: 481 W, 48 W and 5 W.

Table 1. Modulation parameters.

Bandwidth	6 MHz	
Mode	3 (8K)	
Guard Interval	1/16	
Layer	A	B
Number of segments	1	12
Modulation	QPSK	64-QAM
Convolutional code	2/3	¾
Time interleaver (ms)	1000	500
Transm. rate (Mbps)	0,44056	17,8416

1.2 Reception Setup

The mobile unit contained the reception setup, which encompasses three distinct receive chains, as sketched in figure 1.

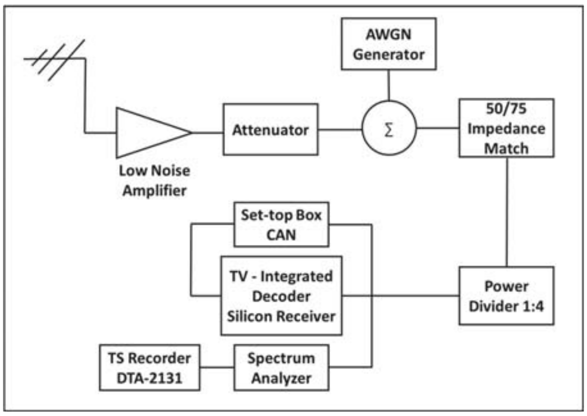

Figure 1. Reception setup.

The digital TV signal analyzer captured the received power level and noise level (in the spectrum analyzer mode), bit error rate (BER), modulation error rate (MER), power delay profile and the transport stream. The two DTV receivers (a can tuner receiver and an integrated silicon tuner receiver) allowed the subjective analysis of the image quality (Layer B).

2. PARAMETERS AND MEASUREMENT METHODOLOGY

2.1. Measurement parameters

The equipment and measurement system provided a set of parameters recorded during testing. Table 3 shows the parameters and the respective equipment and sampling. These parameters, together with the topographic map, aid the analysis of the behavior of the reception signal.

Table 3. Measurement parameters.

Parameter	Equipment	Sampling
Signal power	Spectrum analyzer	3 min
Noise power		3 min
Signal spectrum		1.2 s
BER	ISDB-T signal analyzer	3 min
MER		3 min
Channel impulse response		10 samples
TS, logs, mosaic	DTA-2131	2 min
Lat / Long	GPS	--
Image	TV set	--

Three important parameters were calculated for each measurement site. The field strength E (dBμV/m) employed the received signal power adding the coaxial cable losses and an antenna “K” factor. The signal to noise ratio C/N (dB) was achieved from signal and noise power, which was registered when the signal transmission was turned off. The signal to noise ratio for additive white Gaussian noise (AWGN) injection (C/N_{awgn}) was achieved when a Gaussian noise from an AWGN Generator was injected into the reception setup, forcing the image into the “threshold of visibility” (TOV), according to the guidelines of Report ITU BT.2035-2 [5]. In addition, photos, videos and description of measurement sites provided the environment characterization.

2.2. *Measurements methodology*

The Report ITU BT.2035 recommends practices for field tests evaluations. The 63 measurement sites were planned to be in a grid with site separation of approximately 2.5 km, aiming at allowing the signal reception in as many environments as possible within the city. They were located inside the service area of the transmitting station of channel 13, as indicated in figure 2.

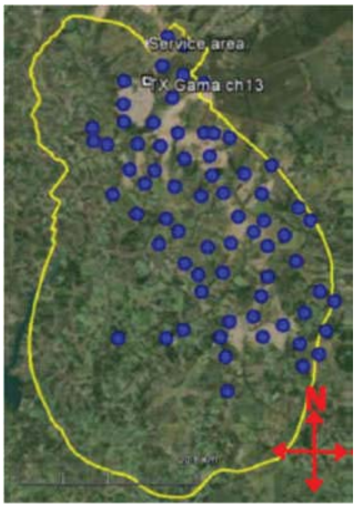

Figure 2. Measurement sites.

The coverage evaluation was performed with the observation of the image at the TV screen, which is the indication whether the digital signal decoding was successful or not. This information is correlated to the field strength values at each measurement site. The service receivability evaluation was done with parameters from the spectrum analyzer of signal power, noise power, error rate, BER and MER, which were registered simultaneously with the signal decoding status.

2.3. Measurement of C/N_{awgn} threshold

This procedure aims the identification of the threshold of C/N at each measurement site with successful signal decoding. Given an optimal received signal level in the range between -40 and -50 dBm, the additive Gaussian noise is injected in the setup until the image reaches the TOV, which means the beginning of image pixelization. The AWGN generator is parallel to the main branch, as depicted in figure 1.

3. RESULTS

The results from static measurements provided information about coverage area, electric field strength threshold, signal to noise ratio threshold (C/N) and signal to noise ration threshold with noise injection (C/N_{awgn}).

The field strength values at each measurement site and the corresponding digital signal decoding status provided the coverage area and the field strength threshold. The coverage area was given by the number of sites with digital decoding. From the set of 63 sites, the digital reception was successful at 56 sites (89%) with the silicon tuner receiver and at 53 sites (84%) with the can tuner receiver. The main reason for no digital decoding at the remaining sites was the attenuation due to obstacles of the terrain profile.

Figure 3 presents the field strength values as a function of the distance and reception condition (green or red). The field strength threshold for good reception is in the range 46 to 48 dBμV/m, depending on the tuner receiver type (silicon or can tuner). These values are 5 to 3 dB lower than the theoretical threshold required for UHF band (51 dBμV/m [6]), and 14 to 12 dB lower than UHF experimental value of 60 dBμV/m [7].

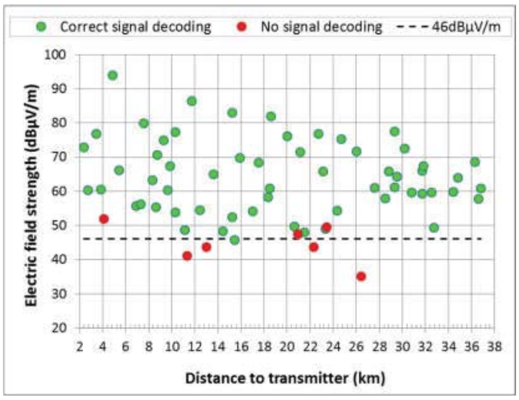

Figure 3. Field strength vs. distance (silicon tuner)

The signal to noise ratio achieved for each measurement site in correlation with the signal decoding status, is presented in figure 4. The results for the three station classes with different transmission levels (Class A, B and C) presented that the signal to noise ratio threshold is in the range from 15 to 18 dB. However, at one site with signal-to-noise ratio 19.7 dB the reception was not successful. In this case, the reception failed due to the influence of multipath, which caused great variability in the received signal.

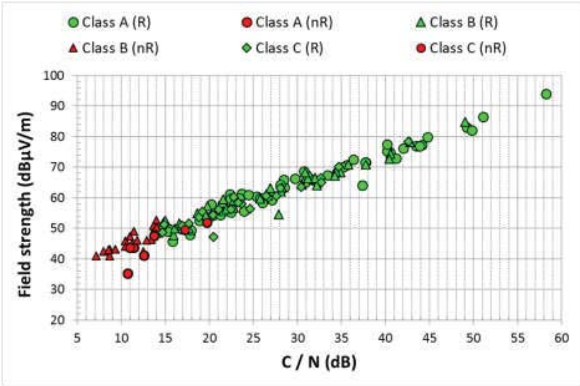

Figure 4. Field strength vs C/N (silicon tuner)

The evaluation of C/N_{awgn} resulted in values in a range of 15 to 19 dB, as shown in figure 5. These results are in accordance to the C/N threshold achieved from measured values, as presented in figure 4, which are in the range of from 15 to 18 dB.

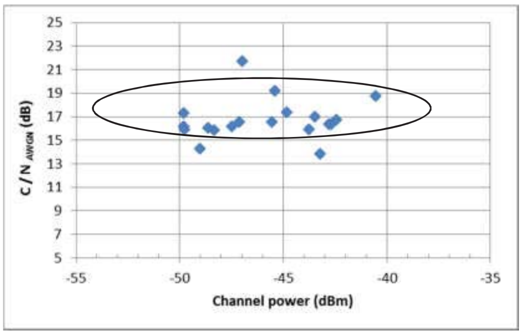

Figure 5. C/N_{awgn} achieved from field tests

4. CONCLUSIONS

This work focuses on the measurement methodology of the field measurements of VHF High-band tests at the city named Gama in the federal district (DF). The main aspects are the measurement procedure to register the environmental noise and the procedure of additive noise injection to the achievement of signal to noise ratio threshold in optimal reception conditions in field.

5. ACKNOWLEDGEMENT

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