Contribution to the Analysis of Coexistence between 5G Operating at 10.5 GHz and DTH Satellite System Operating in Ku band

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The main contribution of the research was to analyze whether the TV signal received by FSS (ES) can be affected by the adjacent channel operation of 5G base stations operating at 10.5 GHz. Therefore, for this assessment, a CW (Continuous wave) carrier at 10.5 GHz was used and radiated by a log-periodic antenna. The FSS (ES) antenna was pointed towards Star One C2 satellite, located at 70W orbital positions, to be able to obtain TV channels. Moreover, to measure the power level of the signal received by the LNBF, a horn antenna was coupled above the LNBF, and using the spectrum analyzer, we analyzed the interference level. As a result, a power threshold of -64 dBm, was obtained for the 5G interferer signal that blocks the TV channels received the Ku-band FSS system with the LNBF model used. Furthermore, the LNBF starts operating in a saturated region, so non-linear effects such as distortion and inter modulation start to appear. Therefore, from the experiment carried out, the results considering the proposed scenario and the LNBF model show that a 5G signal operating in an adjacent band to the DTH satellite system can cause interference depending on the 5G power level that reaches the LNBF. As future work, it is intended to evaluate other LNBF models and also a possible protection distance between the systems.

Keywords: 5G, 6G, Coexistence spectrum sharing, Ku-band, Satellite communications.

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1 Introduction

The Release 15 of the 3rd Generation Partnership Project (3GPP) specifies two frequency bands for the fifth generation of mobile systems (5G), namely: Frequency Range 1 (FR1) from 410 MHz to 7.125 GHz; Frequency range 2 (FR2) from 24.25 to 52.6 GHz [1]. Nevertheless, according to the World Radio communication Conference 2019 (WRC-19), the 10.5 GHz band is currently being studied for the implementation of IMT-2020 in ITU Region 2 (Americas) [2]. This frequency band is adjacent to the Ku-band for DTH systems, which operates from 11 to 14 GHz [3], so there is an adjacent channel analysis to be carried out to assess the possible interference between systems.

Satellites operating in Ku-band are commonly used for DTH systems, which provide television and radio channels for subscribers over the world through the direct transmission between satellite and terrestrial receiver systems [4]. The advantages of the satellite DTH system compared to the terrestrial broadcast can be summarized in benefits related to the line-of-sight path, high-definition image quality in all channels, and large footprint coverage, reaching customers in remote areas where terrestrial broadcast reception could not attend [5].

Regarding the coexistence analysis between terrestrial and satellite communication systems, there are works in the literature that covers this issue. In [6], the author investigates the possibility of coexistence between 5G NR and Television receiver only (TVRO) in the C-band. The authors performed the analysis of the TV image and also assessed the intermediate frequency spectrum after the Low Noise Block Feeder (LNBF) of the signal received from the satellite, in which the results present the 5G interference in TVRO depending on the distance between systems. Two mitigation methods were proposed, the use of a low-cost planar RF filter before the Low Noise Amplifier (LNA) stage of the LNBF and electronic enhancements to improve LNA's1 dB compression point (P1dB). Tan et al. [7] performed an analysis of coexistence between 5G and FSS in the C-band. The interference level from the 5G signal received by the FSS (ES) system was analyzed to propose a solution aiming at peaceful coexistence between systems. The results showed the protection distance of 1-2 Km from base stations to earth stations. In addition, the authors proposed a filter to provide 35 dB of isolation to be implemented in the LNBF, reducing the protection distance to 50 meters.

This work addresses the initial assessment of the possible harmful interference effect into satellite TV signal received by an FSS (ES) DTH system by future 5G base stations operating at 10.5GHz. Moreover, in Brazil, there will be a migration of the TVRO system from the C to the Ku-band, due to the interference generated by 5G operating in FR1 [6]. Therefore, the current work may also contribute with initial results to check the interference from 5G operating at 10.5 GHz in the FSS (ES), which would affect approximately 17.5 million households in Brazil [8]. The manuscript is structured in four sections. Section 2 summarizes the experimental setup and methodology, whereas results are presented in Section 3. Conclusions and remarks are addressed in Section 4.

2 Methods

Two systems were configured for the practical experiment, the DTH system and the simulated 5G interfering signal. Regarding the FSS (ES) DTH setup, it was installed at latitude 22° 15' 16'' south and longitude 45° 41' 28'' west. Furthermore, an offset dish antenna with 60 cm of diameter was used to receive the channels in the Ku-band and a DTH receiver, from the manufacturer Claro, for the demodulation and decoding channels to be presented on the TV screen. The parabolic antenna was pointed towards the Embratel Star One C2 satellite, located in the 70 W orbital positions, to receive the TV channels in the Ku band. Moreover, a satellite signal analyzer (Satlink model) was used to locate the satellite by means of varying azimuth and elevation. Regarding the simulated 5G interfering signal, a vector signal generator, model n5172b EXG, from Keysight, was used to generate a Continuous Wave (CW) signal at 10.5 GHz to simulate the interferer signal in the DTH System. The CW signal was radiated using a Hyperlog 6080 model log-periodic antenna at a distance of 1.5 meters, pointing directly to the FSS (ES) antenna pointed towards the satellite. The 1.5-meter distance was chosen to guarantee the minimum path-loss to maintain a dynamic range level of the interfering signal to cause a possible saturation in the LNA from the LNBF.

First, we vary the 5G Effective Isotropic Radiated Power (EIRP) level and assessed the interference level that reaches near satellite feeder, by means of using a horn antenna, coupled above the satellite LNBF. The spectrum analyzer, model FieldFox N9952A, from Keysight, was used to measure the level of the CW signal that could reach into the LNBF, interfering with the DTH system. The block diagram and experimental setup are presented in Figure 1. In order to analyze the coexistence between systems, the 5G EIRP was increased until the TV image was blocked. The receiver block effect can be explained by the LNBF saturation, which is working above its P1dB. In this context, saturation and distortion effects start to appear, and the receiver is no longer be able to demodulate the satellite amplified signal. The results will be discussed further in the next section.

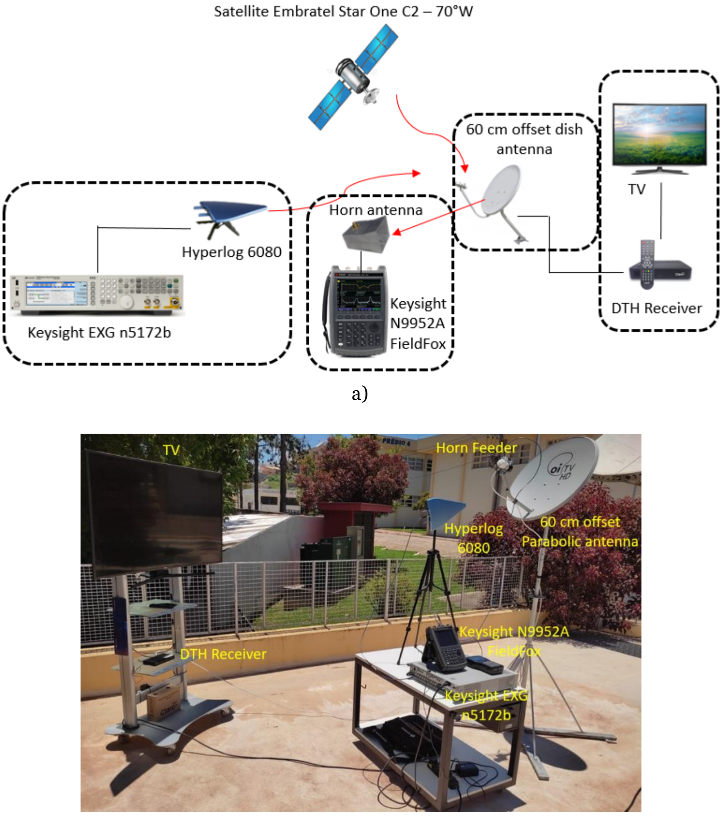

Fig. 1. Proposed setup: a) Block diagram; b) Experimental setup.

3 Results

The coexistence analysis between the FSS (ES) DTH system and the CW signal operating at 10.5 GHz was based on increasing the 5G EIRP until there was no TV channel demodulation.The TV quality image metric was used to find the 5G level, -64.39 dBm, that cause a failed satellite reception. Through this level and the receiver blocking effect, we can conclude that this LNBF was saturated, its first stage LNA starts working above the 1dB compression point. From this power level onwards, the gain curve no longer presents a linear behavior and the device becomes non-linear, and unwanted effects start to appear, such as distortions, harmonics, and intermodulation products. In this way, the receiver is no longer able to demodulate the channels, thus an error message occurs on the television, as shown in Figure 2.It´s important to highlight that coupling loss between the coupled horn and LNBF and misalignment focus of the horn antenna was not taken into account in our initial results.

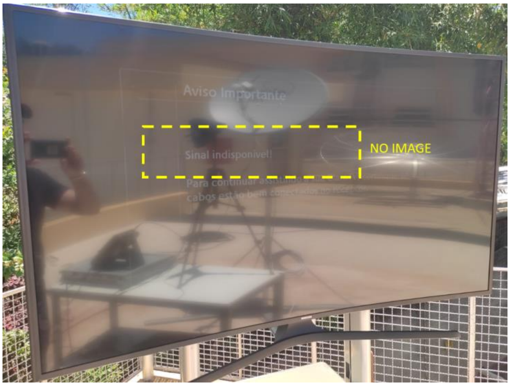

Fig. 2.TV image in the coexistence analysis

4 Conclusion

An analysis of the coexistence between the FSS (ES) DTH system and a CW signal operating at 10.5 GHz, simulating a possible 5G signal, was presented in this work. The main contribution of our work is regarding the practical experiment to assess the reception of the FSS (ES) DTH system in the presence of a 5G interfering signal operating in an adjacent channel. The initial results presented that increasing the EIRP of 5G considering our proposed scenario; the receiver block effect appears for a 5G interference level of -64 dBm for the LNBF model assessed. Therefore, to improve the coexistence between systems, there are mitigation measures such as protection distance and electronic enhancements as the use of improved LNBF with higher P1dB, and RF filters after the first LNA stage to protect the mixer against a high level of interference. As future work, we envisage assessing other LNBF models, computing all the losses of the experimental setup, and proposing the use of a modulated 5G signal.

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