



## The Effect of LTE Networks on DVB-T2 in Nigeria

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### ABSTRACT

*This paper presents the results of the field measurement to investigate the effect of 700MHz LTE network on DVB-T2 co-existence in Nigeria. The field measurements were to ascertain the level of interference the DVB-T2 receiver can condone from the interfering LTE transmission while confirming to the selected quality benchmark. The findings of the study reveal that the traffic loading on the base station has a significant impact on the protection ratio results; receivers become more susceptible to interference as the desired signal increases. Consequently, the protection ratio for DVB-T2 and LTE should be maintained for a seamless co-existence.*

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### INTRODUCTION

Most of the world today is transiting from terrestrial analogue television systems to digital television (Ashigwuoke, Umar, & Moses, 2020). Because of this paradigm shift, a large amount of frequency bandwidth used for television services would be given to wireless broadband communication systems (Ashigwuoke et al, 2020 and Gbenga-Ilori & Sanusi, 2020), this thought from monetary perspective is a cost-effective and efficient use of the spectrum, however, the resultant effect of the co-existence of the two networks need to be cautiously considered and appraised (Ashigwuoke et al, 2020). According to Ashigwuoke et al (2020), findings of such analyses could help to ensure that, within a shared frequency band; new systems can operate without performance degradation while existing services are protected and as well recommend realistic guiding principles for efficient spectrum usage and dependable services in Nigeria. For this coexistence circumstances, a Long Term

Evolution (LTE) transmitter operates as an interferer on the television receiver via the set-top box. The LTE transmitter could either be on LTE base station transmitting a downlink signal or an LTE terminal (User Equipment) transmitting an uplink signal. Digital Video Broadcasting -Second Generation Terrestrial (DVB-T2) is the victim system in the analyzed circumstances.

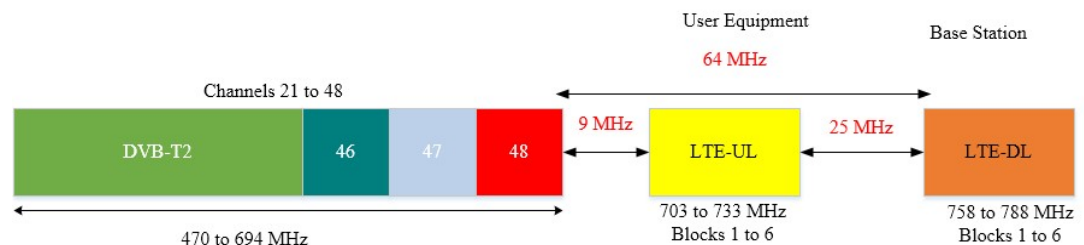
Numerous studies in the past were on ways of avoiding expected destructive interference effect between LTE and DVB-T2 systems, (Tekovic, Bonafacic, Sisul, & Nad, 2017; ITU, 2017; Okamoto, Mello, Almeida & Rodriguez, 2016; Polak, Kaller, Klozar, Sebesata & Kratochvil, 2016 and Polak, Kaller, Klozar, Sebesata & Kratochvil, 2015) failed to look at the Nigerian peculiarity. The foremost challenge facing the ITU is that spectrum sharing studies are complex to generalize internationally, as various nations have their spectrum planning design (ITU, 2018). Thus, each nation should conduct its spectrum sharing studies. In addition to the above, DVB-T2 receivers with low Adjacent Channel

Selectivity (ACS) performance could enter the Nigerian internal market, as there were no legally binding requirements for receiver performance. Ofcom(2020) asserted that the elevated the ACS worth is, the more enhanced the receiver can eliminate interference from a tough signal on an adjacent channel. Excellent ACS performance in a DVB-T2 receiver is valuable in spectrum sharing circumstances, as it tolerates other services on adjacent channels to use elevated power levels devoid of causing destructive interference to the DVB-T2 reception. The DVB-T2 receiver ACS is adequate to eliminate the interference from the transmission on the adjacent channel. If the interferer power level is higher, it would cause interference to the DVB-T2 reception. The technical process to advance ACS in the DVB-T2 receiver implementation was known (Ofcom, 2020), but there was no genuine encouragement for the equipment manufacturers to spend in receiver performance.

Both co-channel and adjacent channel interference may occur between the two services. If, for example, Nigeria completes the Analogue Switch Over (ASO) phase and deploys mobile services in the 694–862 MHz sub-band, while a neighbouring country like the Republic of Niger is in a transition period of switching from analogue to DVB-T2 and still using the 694–862 MHz sub-band for broadcasting services, then co-channel interference will

occur in radio communication between the Nigeria and Niger. Likewise, adjacent channel interference may occur in Nigeria between two services operating within the same geographical region. For instance, Nigeria deploys mobile service in the 694–862 MHz sub-band where DVB-T2 service is already operational in the 470–694 MHz band; the two systems will experience adjacent channels interference with each other even though they are separated in the frequency domain. Such interference will be more challenging when both services are active and cover the same area that is a co-cited situation (Ashigwuike et al, 2020).

Ashigwuike et al (2020) stress that Nigeria’s digital dividend is within the frequency range of 694 MHz to 862 MHz that is from channel 48 to channel 69. When LTE FDD services are deployed in the digital dividend, channel 48 will be the most affected television channel. Channel 48 lies within the frequency range of 687MHz to 694MHz. The implementation of mobile services in the 694 -790 MHz band can cause signal interference on the television receivers in home environments. The radio interference between various services is generally mitigated by employing guard bands or by ensuring satisfactory geographical separation (CEPT, 2016). For mobile LTE networks, deployed in the UHF band, the guard band was set to 9 MHz from the edge of Channel 48 for television broadcasting as illustrated in Figure 1.



**Figure 1:** Spectrum Plan for the 700MHz Band (CEPT,2016)



Ashigwuike et al (2020) postulated that the closeness of the transmission frequencies of the DVB-T2 and LTE base station transmitters can result in digital television service interference in some areas, but essentially on the coverage boundaries. Network topologies, transmitter power, antennas, base station location, and mobile services network infrastructure are completely different for DVB-T2 and cellular mobile networks. Due to these discrepancies, there are higher chances for interference to occur. Seven years ago antennas employed for the reception of television signals were configured to receive VHF Band III and UHF Bands IV and V up to 862 MHz, which exceeds Channel 48. With the deployment of LTE in the band from 694 MHz to 790 MHz, the television system is linked to interference, in particular, upper channels up to Channel 48. Ashigwuike et al (2020) reported that the LTE interference on the DVB-T2 consequences is the degradation of the sensitivity, which in turn results in loss of signal and reduction of coverage of the DVB-T2 system. This undoubtedly illustrates and confirmed the present predicament of Free Television reception in FCT Area Councils, in some locations like Abaji, Arozo, Karishi, Kwali, and New Nyanya.

#### RELATED WORK

In recent times, many studies focused on the influence of LTE Network on DVB-T2 reception presented in (Tekovic et al, 2017; ITU, 2017; Okamoto et al, 2016; Polak et al, 2016 and Polak et al, 2015). Protection ratios for DVB-T2, the characteristics of the LTE interfering signal, and the measurement of protection ratios overload thresholds for broadcast television receivers has been considered in (ITU, 2017 and Okamoto et al, 2016). In ITU (2017) and Okamoto et al (2016), field measurements were carried out to compute approximately the adjacent channel interfering effects of LTE Base

Station and User Equipment (UE) on DVB-T2 receiver systems. Okamoto et al (2016) presented the field measurement of the adjacent channel interference effects of the LTE FDD DL on DVB-T/T2 home receivers. It was shown that LTE-Downlink and Uplink (LTE-DL and LTE-UL) configurations diversely influence DVB-T/T2 performances. Furthermore, Renfors (2020) reveals that the nonlinearity in the signal processing at the receiver components and amplifiers can also create intermodulation distortions, which may negatively affect the DVB-T2 reception. Renfors (2020) highlights that silicon tuners are more prone to second-order intermodulation distortion while can tuners are linked to third-order intermodulation distortion.

#### MATERIALS AND METHOD

##### *Measurement Equipment*

Broadcast Test System is a measuring instrument that can process signals from several different systems. The instrument provides platforms that support all conventional TV and audio broadcasting standards in a frequency range from 100 KHz to 3GHz and it is used as a reference signal source. The instrument is used in the tests of interference between DVB-T2 and LTE (Rohde & Schwarz, 2020).

Test System (TS 8980) is an instrument used for RF test system for mobile devices and to carry out interference tests (Rohde & Schwarz, 2020). ETL TV Analyzer is an instrument that is an all-in-one solution. It contains generators that create analogue video signals, audio signals and MPEG-2 transport streams which make the Bit Error Rate measurements along with nearly all elements test in real-time (Rohde & Schwarz, 2020). Other devices are Set-Top Boxes, 52" LCD Samsung Television, splitter and antennas.

**Measurement Procedure of LTE interference on DVB-T2**

The proposed measurement setup and accepted measurement procedure are based on previously proposed laboratory solutions (ITU, 2019 and Okamoto et al, 2016). The test specifications from the individual standards define the maximum permissible influence on other frequency bands as their most important consideration. These output RF spectrum emissions for LTE and digital TV standards are described in (Okamoto et al, 2016). The propagation loss of the DVB-T2 signal was determined by employing the model in recommendation ITU-R P.1546 (ITU, 2019) while for the LTE eNodeB, the researcher

employed Extended Hata for propagation loss model (Okumura, 1968) and User Equipment used Extended Hata SRD (Hata, 1981) for propagation loss model. The desired DVB-T2 signal has been generated using the broadcast test system for channels 48 to 38. The DVB -T2 signal was received by a log-periodic antenna, then the signal was divided via a splitter that decouples the signal and feeds it to the ETL TV analyzer and the second path connected to the set-top box which converts the digital signal to analogue signal since the majority of the television set in Nigeria at the moment is analogue, then the output is fed to a 52" LCD Samsung Television set as illustrated in Figure 2.

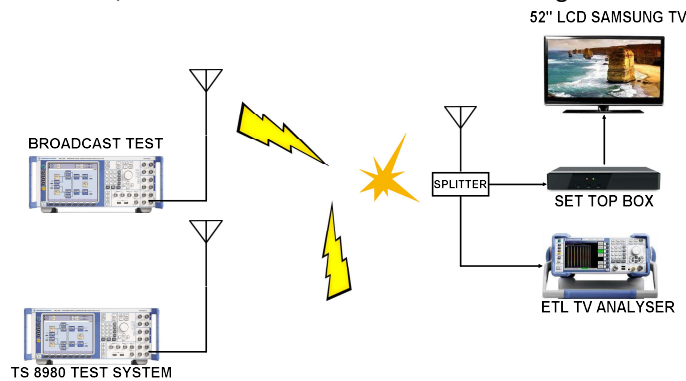


Figure 2: Field Measurement on Influence of LTE on DVB-T2.

The receiver under test was initially tuned to 690MHz (Channel 48) and the wanted signal at the input to the antenna was set to the required power level, then the desired signal channel power C was recorded in an 8 MHz channel bandwidth employing the spectrum analyzer in channel power mode with the analyzer set to RMS detection with a resolution bandwidth of 100KHz and a video bandwidth of 1 MHz. The interfering LTE signal power has been set to minimum (39dBm) while the LTE base station set to a centre frequency of 700MHz and the interfering signal (I) was enlarged in 1dB steps pending when the required failure

criterion was met which is considered as Picture Failure (PF) then the LTE signal power was reduced to the Subjective Picture Failure (SFP), which has been defined as the minimum Carrier-to-Noise Ratio value that guarantees a 60- the second period liberated from picture artefacts. The interfering signal channel power (I) was recorded in a 10 MHz channel bandwidth employing a spectrum analyzer in channel power mode. The analyzer was positioned to resolution bandwidth of 100 KHz and a video bandwidth of 1 MHz. Then the Carrier-to-Interference protection ratio was computed from records desired signal power and interfering signal power. The

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above procedures were repeated for desired signal level -70 dBm for channel 48,47,46, 45,43,42,41,40,39 and 38.

### Presentation of Data

The influence of LTE on DVB-T2 reception field measurement is as shown in Figure 2. The field measurements carried out summarized in table 1 Test 1 is the

reference test, in which only the DVB-T2 TV is active. In test 2, the LTE eNodeB is turned on to calculate the consequence of its interference on the DVB-T2 TV receiver threshold. In tests 3, 4 and 5, the LTE UE (user terminal) is also activated at dissimilar positions close to the TV receiver, with two dissimilar transmitting power levels.

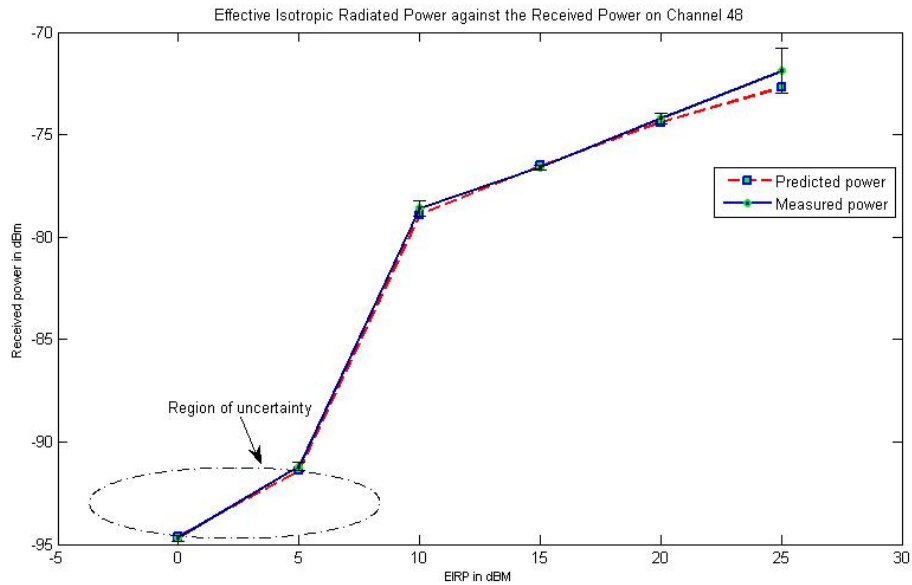
Table 1: Tests of LTE Interference of DVB-T2

Test	Measurement	Description	Predicted Value (dBm)	Measured Value (dBm)	Average Relative Error
Test 1	TV receiver threshold	Only the DVB-T2 transmitter operating	-91.4	-91.2	0.0022
Test 2	LTE downlink interference on the TV receiver	eNodeB transmitting 39dBm User Equipment turned off	-78.9	-78.6	0.0038
Test 3	LTE downlink and uplink interference on the TV receiver	eNodeB transmitting 39dBm and User Equipment operating inside the van	-76.5	-76.6	0.0013
Test 4	LTE downlink and uplink interference on the TV receiver	eNodeB transmitting 39dBm and User Equipment operating 1m from the receiver	-74.4	-74.2	0.0027
Test 5	Measurement of LTE downlink and uplink interference on the TV receiver	eNodeB transmitting 46 dBm and User Equipment operating 1m from the receiver	-72.7	-71.9	0.0110

In every of the field measurement trials, the power of the DVB -T2 TV transmitter was reduced to until the DVB-T2 TV receiver reached the threshold of high-quality reception, defined as the signal level for which there is picture freezing occurs at least once during 60 seconds surveillance

period.

Figure 3 shows the disparity of the TV signal reception level as a function of transmitter EIRP for test 1. For this, it was practicable to decode the signal without artefacts down to a threshold of -91.2 dBm.



**Figure 3:** Transmitter EIRP VS. Received power level at channel 48 (Test 1, no LTE interference)

## RESULTS AND DISCUSSION

The existence of the interference signal from the eNodeB, transmitting 39 dBm at a distance of 75 metres from TV receiver, results to an amplification of the reception threshold from  $-91.2$  dB, measured in test 1, to  $-78.6$  dBm, measured in test 2. In tests 3, 4 and 5, supplementary interference was caused by the LTE UE and the reception threshold diverse a function of the UE transmission power and location of the UE relative to the TV receiver. The most horrible case, with the eNodeB transmitting its optimal power of 46 dBm at one metre from the TV receiver, the joint interference of the eNodeB and the UE raised the channel 48 TV reception thresholds to  $-71.9$  dBm. Thus, high values in both interferers Adjacent Channel Leakage Channel (ACLR) and present ACS consequence in high Adjacent Channel Interference Ratio (ACIR) values, which means that the interfering transmissions can use higher power levels devoid of causing destructive interference

to DVB-T2 reception. No serious significant deterioration of the reception threshold was noticed in channels 46 and 47 in any of the tests.

It was observed that a critical look at figure 3 reveals that below about  $-91$  dBm the receiver loses linearity which means at that point TV signal reception is not guaranteed (region of uncertainty). The nonlinearity in the signal processing at the receiver components and amplifiers can also produce intermodulation distortions, which may negatively affect the DVB-T2 reception. From the measured results, silicon tuners are more prone to second-order intermodulation distortion and can tuners to third-order intermodulation distortion. This is similar to Renfors (2020) findings. Furthermore, it was noticed that the traffic loading on the base station has a foremost impact on the protection ratio results, so also the location of the base station about the DVB-T2 transmitter is an important factor.

The basic finding at this point is



that it is obligatory to limit the power of the User Equipment's to a range of 14dBm to 39dBm to achieve the desired seamless coexistence operations. The results were in accord with the results found in (Tekovic et al, 2017; ITU, 2017; Okamoto et al, 2016; Polak et al, 2016; Polak et al, 2015).

## CONCLUSION

Based on the researcher's findings, it is concluded that the protection ratio of DVB-T2 should be maintained for a seamless co-existence. The interference from a base station generally affects only the users located within a certain distance from the base station.

## RECOMMENDATIONS

From the findings of the field measurement, the paper recommends the following considerations in planning the digital network:

1. Nigerian Communication Commission (NCC) and National Broadcasting Commission (NBC) should ensure they protect ratios: the minimum separation distance, adequate guard band, transmission power are adhered to ensure spectrum sharing and co-existence between DVB-T2 and LTE systems in a seamless operation without harmful interference.
2. Standards Organisation of Nigeria (SON), Nigerian Custom, NCC and NBC should work together to ensure that substandard mobile and broadcast equipment that is not in conformity to Nigerian Frequency Plan is not in the Nigerian market.
3. Capacity building (workshops, seminars, and conferences) on practical guide on spectrum sharing and co-existence between DVB-T2 and LTE systems in a seamless operation without

harmful interference should be a regular task to be carried out Ministry of Communication and Digital Economy, NCC, NBC, Professional organizations like the Nigerian Society of Engineers (NSE), and Council for the Regulation of Engineering in Nigeria (COREN).

4. Nigerian Government should encourage genuine Set-Up manufacturers to invest in receiver performance for excellent ACS.

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