ORIGINAL ARTICLE

The Impact of DVB-T2 on LTE Networks in Nigeria

OKPANACHI-MOSES, S.O., [2]ASHIGWUIKE, E.C., [3]UMAR, S.A

[1]Nigerian Television Authority, Abuja.[2]Department of Electrical and Electronics EngineeringUniversity of Abuja.[3]National Space Research and Development Agency, Abuja.

Abstract

This paper presents the simulation result on investigation of the effect of 700MHz DVB-T2 on LTE network co-existence in Nigeria. The simulation was to ascertain the level of interference the LTE can condone from DVB-T2 transmission while confirming to the selected quality benchmark. The findings of the study revealed that the interference situation of LTE uplink is much more severe than LTE downlink which indicates attention should be paid more on uplink. In addition, this interference can be minimized by locating the broadcasting system transmitter at the LTE system's cell edge. The simulation results also lead to the conclusion that the protection ratio for DVB-T2 and LTE should be maintained for a seamless co-existence.

Keywords: Co-existence, DVB-T2, EIRP, Interference at 700MHz and LTE

Introduction

Most parts of the world today are transiting from terrestrial analogue television systems to digital television (Ashigwuike, Umar, & Moses, 2020). In view of this paradigm shift, a large amount of frequency bandwidth allocated for television services would be re-allocated to wireless broadband communication systems due to massive development in mobile communication technology (Ashigwuike et al., 2020; Gbenga-Ilori, & Sanusi, 2020). This thought from monetary perceptive is cost-effective and in larger view will lead to efficient use of the spectrum. However, the resultant effect of the co-existence of the two networks needs to be cautiously considered and appraised (Ashigwuike et al., 2020). According to Ashigwuike 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. Also, the findings can recommend realistic guiding principles for efficient spectrum usage and dependable services in Nigeria. For this coexistence circumstances, Digital Video Broadcasting -Second Generation Terrestrial (DVB-T2) transmitter operates as an interferer on the Long Term Evolution (LTE). LTE is the victim system in the analyzed circumstances.

Numerous studies in the past were on ways of avoiding the expected destructive interference effect between LTE and DVB-T2 systems (Tekovic, Bonefacic, Sisul, & Nad, 2017; ITU, 2017; Okamoto, Mello, Almeida, & Rodriguez, 2016; Polak, Kaller, Klozar, Sebesata, & Kratochvil, 2016; Polak, Kaller, Klozar, Sebesata, & Kratochvil, 2015; Mathe, Farias, & Costa, 2015; Li, Chen, Long, & W., 2012; Wang, Wang, Lv, Huang, & Zhang, 2010). Mathe, et al. (2015) analyzed the DTV interference impact in LTE system. The results show that interference from DVB-T2 would restrain the LTE channel capacity. However, the DTV interference could be significantly reduced if the separation distances between DTV tower and LTE base station are respected. Wang et al. (2010) examined the DVB-T2 interference influence on LTE system considering the Chinese Digital TV parameters. The findings show that the LTE uplink suffers greater influence of Digital TV interference. Tekovic et al. (2017) investigated the coexistence between Digital TV and 10MHz bandwidth LTE system operating in the Digital Divided spectrum. The results show the decrease on the mutual interference in function of Adjacent Channel Interference Ratio (ACIR) and separation distances. In Li et al. (2012), the authors studied the

interference that DVB-T2 may cause on LTE system and the results revealed that the interference situation of LTE uplink is harsher than LTE downlink and stress that it may perhaps be enhanced by locating the broadcasting system transmitter at the LTE systems cell boundary. Okamoto et al. (2016) evaluated the co-channel interference between DTV and LTE systems. The findings of this study brought to light that DTV transmit power and antenna heights are key factors for determining the distance to protect LTE system.

Among the cited works, none of them analyzed the interference between DVB-T2 and LTE systems in the Nigerian setting. In this study, we present a comprehensive analysis of the interference impact of DVB-T2 in LTE system operating within adjacent channels in Nigeria. In order to quantify the impact of the interference, analysis of the LTE channel capacity loss linked to bit rate with interference due to DVB-T2 interference.

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 within the UHF band, the guard band was programmed to 9 MHz from the edge of Channel 48 for television broadcasting as illustrated in figure 1.

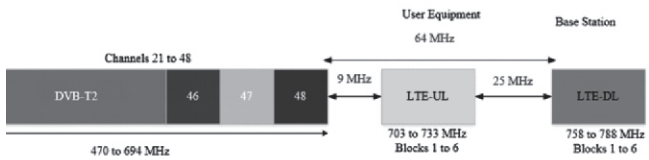


Figure 1: Spectrum plan for the 700MHz band (CEPT, 2016)

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. As highlighted by Ashigwuike et al. (2020) antennas, transmitter power, network topologies, base station location, and mobile services network infrastructure are entirely diverse for DVB-T2 and for cellular mobile networks. Taking cognizance of these differences, there are higher probabilities of existence of interference. In addition to the above, before the year 2013, antennas deployed for the reception of television signals were put together to receive VHF Band III and UHF Bands IV and V up to 862 MHz, which is higher than Channel 48. It then implies that with the deployment of LTE in the band from 694 MHz to 790 MHz, LTE network could be exposed to interference, in particular, upper channels up to Channel 48.

MATERIALS AND METHOD

Presentation of Data

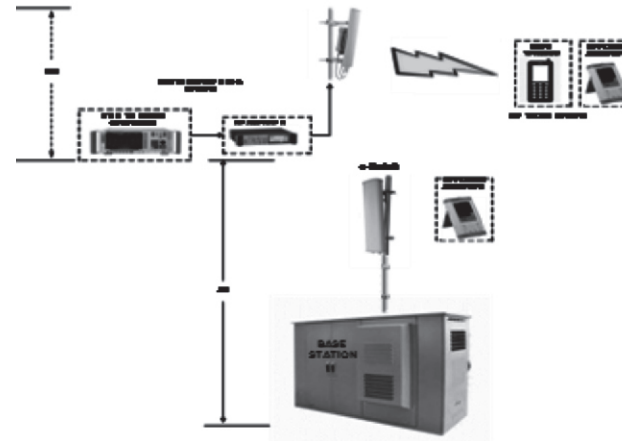


Figure 2: Influence of DVB-T2 on LTE

Monte Carlo Simulation

ECC Report 252 asserted that Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) is a statistical simulation model that uses a technique of analysis called Monte Carlo to evaluate the possible intrusion between different radio communication networks. SEAMCAT is an open source software tool.

As stated by Ashigwuike et al. (2020), the radio spectrum is an inadequate resource and can only be used optimally if compatibility is guaranteed between radio systems located in the same or adjacent frequency bands. For instance, a significant condition for radio compatibility is the difference between the desired (wanted) and interfering (unwanted) signal levels in the victim receiver input. SEAMCAT is used to derive a separation between the victim and interfering systems. The software has

the feature that permits the simulation of a huge number of trials with the arbitrary positions of the interfering and victim systems and the responses of the propagation channels described by probability distributions with known parameters.

The SEAMCAT simulation software for the case of Victim link (LTE eNodeB) and interfering links (DVB-T2) considers the effects of co-channel and adjacent channel interference, including unnecessary emissions, intermodulation products, and receiver blocking. The level of unnecessary emissions and out-of-band spurious emissions of the interfering transmitter that fall within the band of receiver-victim is determined by the employment of the victim receiver selectivity, transmission filter masks, frequency separation between victim and interferer, antenna gains and antenna gains propagation loss.

Results of DVB-T2 interference on LTE

The loss of capacity in the presence of interference is the resultant effect of DVB-T2 on the LTE system. The assessment is by the loss of capacity which is the bit rate loss. The outcomes of bit rate per user in the uplink (User Equipment to eNodeB) achieved from the simulations is illustrated in table 1, for a TV coverage radius of 10 km, with the DVB-T2 EIRP ranging between 60 and 85 dBm and LTE cell radius of 500m while table 2 provides results of TV coverage radius of 10 km, with the DVB-T2 EIRP ranging between 60 and 85 dBm and LTE cell radius of 2000 m. The eNodeB transmission power is 45.5 dBm and the User Equipment's transmission power is 22.5 dBm. The upper limit bit rate loss considered satisfactory is 30%.

Table 1: TV interference on LTE simulations with variable TV EIRP at cell radius 500m

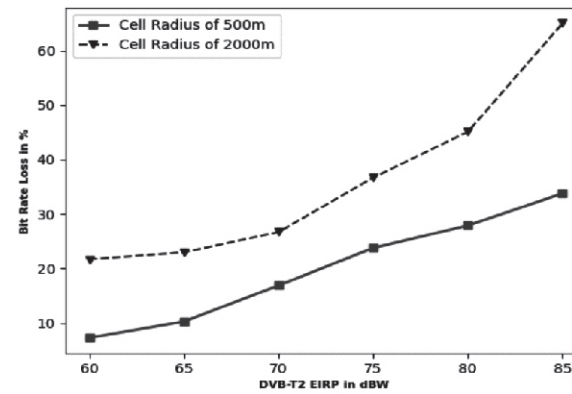
DVB-T2 EIRP	C/I (dB)	Bit rate devoid of interference (Mbps)	Bit rate with interference (Mbps)	Bit rate loss (%)
60	8.2	13.00	12.05	7.3
65	7.9	13.00	11.66	10.3
70	6.8	13.00	11.00	16.9
75	5.4	13.00	9.90	23.8
80	4.0	13.00	9.40	27.9
85	4.0	13.00	8.60	33.8

Table 2: TV interference on LTE simulations with variable TV EIRP at cell radius of 2000m

DVB-T2 EIRP	C/I (dB)	Bit rate devoid of interference (Mbps)	Bit rate with interference (Mbps)	Bit rate loss (%)
60	-3.5	3.0	2.35	21.7
65	-4.7	3.0	2.31	23
70	-5.8	3.0	2.2	26.7
75	-7.3	3.0	1.9	36.7
80	-9.5	3.0	1.7	45.1
85	-11	3.0	1.05	65

As illustrated in table 1 and table 2, under normal condition, even without interference, the bit rate per user is significantly reduced when the cell radius increases; this could be linked to the distance with respect to the eNodeB of the User Equipment's located on the cell border. However, it should be noted that with the existence of interference, the bit rate loss increases with the increase in power of the DVB-T2 transmitter and with the cell radius. On the other hand, a critical look at figure 3 reveals that the case with 85dBm DVB-T2 EIRP and LTE cell radius of 2000 m is that the loss (65%) surpassed the particular limit of 30 %. From the foregoing, it can therefore be deduced that simulations of interference of DVB-T2 on the downlink of the LTE system (eNodeB to User Equipment) did not demonstrate any significant loss in the bit rate. This could be adduced to the larger operation frequency separation (9MHz guard band) between the DVB-T2 transmitter and the eNodeB as illustrated in Figure 1.

Figure 4: TV interference on LTE bit rate loss



Conclusion

The LTE system performance dilapidation was measured by the decrease in the average bit rate transmission by the user, with a loss threshold of 30% considered acceptable. Cell radius of 500 m to 2000 m was simulated, with the other parameters maintained. In the LTE downlink, there was no significant loss in the transmission rate. In the uplink, the loss in the average rate of transmission of users was above 60% for cells with a 2000m radius. For cells with 500 m radius the transmission rate reduction is below the conventional edge of 30%. The results were also in agreement with the results found in Okamoto et al. (2016). The propagation loss of the television signal is in conformity with the model recommendation ITU-R P.1546 and the extended hata propagation model of Hata (1981) and Okumura (1968).

Based on the findings, it is concluded that the protection ratio of DVB-T2 should be maintained for a seamless co-existence.

Recommendations

In view of these findings and their implications, the following recommendations were made:

i. Nigerian frequency regulators (NCC and NBC) should ensure the protection 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.
ii. SON, Nigerian Custom, NCC and NBC should work together to ensure that substandard mobile and broadcast equipment that is not in conformity with Nigerian Frequency Plan is not in the Nigerian market.
iii. 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 by stakeholders such as 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).

References

Ashigwuike, E. C., Umar, A. S., & Moses, S. O. (2020). Analysis of DVB-T2 and LTE networks co-existence in the digital dividend band in Nigeria. *European Journal of Engineering Research and Science*, *5*(6), 698 - 701.

CEPT. (2016). *CEPT Report 60 : Report B from CEPT to the European Commission in response to the mandate to develop harmonised technical conditions for the 694-790MHz (700MHz) frequency band in the EU for the provision of wireless broadband.* Geneva: CEPT.

Gbenga-Ilori, A., & Sanusi, O. I. (2020). Assessment of the scope and usage of digital dividend in Nigeria. *ATBU Journal of Science, Technology and Education, 8* (2), 143-153.

Hata, M. (1981). Empirical formula for propagation loss in land mobile radio services. *IEEE Transactions on Vehicular Technology, 29* (4), 317-325.

International Telecommunication Union (ITU). (2018). *Digital dividend: In sights for spectrum decisions.* Geneva: ITU Publications.

International Telecommunication Union (ITU). (2019). *Recommendation ITU-R P.1546-5: Method for point-to-area predictions for terrestrial services in the frequency ranage 30 MHz to 4000MHz.* Geneva: ITU.

International Telecommunication Union (ITU). (2017). *Recommendation ITU-R BT 2337-1, Sharing and compatibility studies between digital terrestrial television broadcasting and terrestrial mobile broadband applications, including IMT, in the frequency band 470-694/698 MHz. Geneva:ITU Publication.*

Li, W., Chen, J., Long, H., & Wu, B. (2012, October). Performance and analysis on LTE system under adjacent channel interference of broadcasting system. *2012 IEEE 12th International Conference on Computer and Information Technology* (pp. 290-294). IEEE.

Mathe, D. M., Farias, F. S., & Costa, J. C. W. A. (2015). Digital television interference on the

LTE system in the 700 MHz band. *XXXIII Brasileiro De Telecommunication*, 1e4.

Okamoto, D., Mello, L., Almeida, M., & Rodriguez, C. (2016). Performance evalution of digital TV and LTE systems operating in the 700MHz band under the effect of mutual interfernce. *Journal of Microwaves, Optoelectronics and Electromagnetic Applications*, *15*(4), 441-456.

Okumura, Y. (1968). Field strength and its variability in VHF and UHF land mobile radio service. *Review Elect. Commun Laboratory*, 16(9), 2-10.

Polak, L., Kaller, O., Klozar, L., Sebesata, J., & Kratochvil, T. (2015). Exploring and measureing possible co-existences between DVB-T2 - lite and LTE systems in ideal and portable fading channels. *Journal of Applied Research and Technology*, *13*(1), 32-44.

Polak, L., Kaller, O., Klozar, L., Sebesata, J., & Kratochvil, T. (2016). Coexistence between DVB-T/T2 and LTE standards in common frequency bands. *Wireless Personal Communications*, *88*(3), 669-684.

Renfors, M. (2014). *ELT - 44006: Receiver architectures and signal processing.* http://www.cs.tut.fi/kurssit/TLT-5806/RecArch.pdf

Series, B. T. (2019). Use of Monte Carlo simulation to model interference to DTTB.

Tekovic, A., Bonefacic, D., Sisul, G., & Nad, R. (2017). Interference analysis between mobile radio and digital terrestrial television in the digital dividend spectrum. *Radioengineeing*, *26*(1), 211-220 .

Wang, W., Wang, B., Lv, Z., Huang, W., & Zhang, Y. (2010, September). Analysis of interference from digital terrestrial television broadcast to LTE TDD in digital dividend spectrum. *2010 2nd IEEE International Conference on Network Infrastructure and Digital Content* (pp. 692-697). IEEE.

APPENDIX A: PYTHON CODE

```
import matplotlib.pyplot as plt
import numpy as np
#first plot
EIRP = list(range(60,90,5))
#Allocating the bit rate loss at cell radius of 500m
Bit1 = [7.3,10.3,16.9,23.8,27.9,33.8]
#Allocating the bit rate loss at cell radius of 2000m
Bit2 = [21.7,23,26.7,36.7,45.1,65]
#Plotting the graph of interference on LTE Simulations with Variable TV EIRP for 500m and 2000m cell radius
plt.plot(EIRP,Bit1,'s-g', label = 'Cell Radius of 500m', linewidth = 2)
plt.plot(EIRP,Bit2,'v--b', label = 'Cell Radius of 2000m')
plt.xlabel("DVB-T2 EIRP in dBW ", fontsize = 8, fontweight = 'bold')
plt.ylabel("Bit Rate Loss in %", fontsize = 8, fontweight = 'bold')
plt.legend()
plt.show()
```