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Article

Variation of radiofrequency intensities from the DTTV-transmitter in Kampala Metropolitan; Uganda

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Abstract: This paper presents the variation of radiofrequencies intensities from the DTTV-transmitter in Kampala Metropolitan for the sub 700 MHz (470-694 MHz) and the 700 MHz (694-790 MHz) frequency bands. The results of this study showed that though all the measurement locations from the transmitter have a good reception of DTTV signals, their radiofrequency intensities varied at the different points on the same measurement location at a constant distance from the DTTV transmitter. The study further showed that there is a general decrease in the radiofrequency intensities for the sub 700 MHz frequency band and a slight general increase in the radiofrequency intensities for the 700 MHz frequency band. This research revealed that the measured Reference Signal Received Power (RSRP) values for all the measurement locations where within the IEEE and FCC recommended values for any DTTV signal reception.

Keywords: Frequency band, radiofrequency intensities, DTTV-transmitter, Reference Signal Received Power (RSRP).

1. Introduction

Transmission of television signals ever since the inception of television broadcast [1] has been on the Analogue Television (ATV) technology until a couple of years ago that Digital Terrestrial Television (DTTV) technology was proposed in a bid to maximize frequency spectrum and have good quality of television services [2]. With DTTV technology, television signals are transmitted by multiplex transmitters (transmission of many channels in a single frequency range) and are being radiated from the transmitting antenna whereas in ATV technology, the signals are transmitted through a single channel by an analogue transmitter [3]. Reception of DTTV signals is always influenced by a number of factors like; the height of transmitting and receiving antenna's, the output power of the transmitter [4], the terrain between the transmitter and the receiver, the effect of meteorological parameters [5] and foliage, amongst others.

All forms of radiation in free space are governed by the inverse square law. For this law, if the distance from the transmitter is doubled, the power density of the radiated wave is reduced to a quarter of its former value at the new location. Power density is the radiated power per unit area, hence a measure of radiofrequency intensity and received signal strength. In radiation, power density is directly proportional to the transmitted power and is inversely proportional to the square of the distance from the source [6–8]. Therefore;

$$p_d \propto \frac{p_t}{r^2}, \quad (1)$$

$$p_d = \frac{p_t}{4\pi r^2}, \quad (2)$$

where, p_d is the power density at a distance $r(m)$ from the transmitter and p_t is the transmitted power, all the powers measured in watts.

Globally, almost all countries have switched onto DTTV in accordance with the dates of 17 June 2015 (for Ultra High Frequency) and 17 June 2020 (for Very High Frequency) as set by ITU [9] for its member states, including Uganda.

Uganda being in ITU region 1, her DTTV broadcasting service has a primary allocation of 470-790 MHz frequency band and the Digital Switch Over (DSO) was done on June 2015, within 60 Km radius of Kampala Metropolitan [10].

The motivation for this research was because Kampala Metropolitan, Uganda, was the first region to undergo full DSO and as a result, there was need to know the quality of service, the propagation pattern and coverage of DTTV signals with distance from the transmitter at various climatic zones.

Radiofrequency intensity is a measure of the DTTV received signal (received power). The higher the value of RF intensity, the higher is the received power from the DTTV transmitter and the better is the quality of the received TV signal. The purpose of this work is to study the variation of radiofrequency intensity for different distances from the transmitter. Related studies by different researchers from different countries (Nigeria, Korea, India, and Spain) have been carried out as explained by [11–14]. In these studies, the quality of DTTV signals reception at different distances and locations have been analyzed.

In Uganda, since little is known about radiofrequency intensities from DTTV transmitter and their relation to TV signals reception, this study is important in order to give a clear sense about the DTTV situation. With this study, we will be able to know the signal attenuation in DTTV transmission. In ATV technology, signal attenuation may not lead into total loss of the signal, which is not the case with DTTV technology. In DTTV technology, TV reception levels below $-116dBm$, will lead to total loss of signals [13,15,16].

2. Materials and methods

In order to investigate the variation of radiofrequency intensities from the broadcasting transmitter in Kampala, measurements were done in an outdoor setting for a period of two months. The measurements first considered all the DTTV- UHF frequency band of 470 – 862MHz and there after a 470 – 790MHz frequency band as assigned to Uganda by the ITU [9] and as implemented by UCC [10] was selected.

2.1. Measurement location

The two month measurements were conducted during day hours at seven different locations which were marked on different eight concentric circles, that's, CC1, CC2, CC3, CC4, CC5, CC6, CC7 and CC8. The radius of these concentric circles determined the horizontal distances between the measured points, that's receiver antenna and the transmitter. The radii of CC1, CC2, CC3, CC4, CC5, CC6, CC7 and CC8 were; 1 Km, 2 Km, 3 Km, 4 Km, 5 Km, 6 Km, 7 Km and 8 Km respectively, from the transmitter. A Google map of one of the measurement location at Latitude: 0.348340, Longitude: 32.599286 is shown in Figure 1.



Figure 1. One of the measurement locations

Each measurement location chosen in this research had at least the minimum achievable Direct Line of-Sight (DLoS) with the DTTV-Transmitter and the minimum distance of the receiving antenna from the ground. The locations are in urban setting hence allowing signal measurements which have encountered less distortion in form of; absorption, diffraction, reflection, refraction, scattering and directional characteristics of both the transmitter and the receiver antennas [17].

2.2. Measurement setup

The Setup measurement at every measurement location was made up of a calibrated Aaronia Spectran HF-6065V4 spectrum analyzer, an Aaronia AG HyperLOG 4025 Antenna, a T430s Lenovo Laptop, connected to the spectrum analyzer via a USB cable, and the MCS software. The MSC software is specifically designed to run on Aaronia spectrum analyzers and can easily suit a given measurement since it is easy to configure. Points on each concentric circle as shown in Figure 2, where randomly selected and determined the Measurement Locations (MLOs).

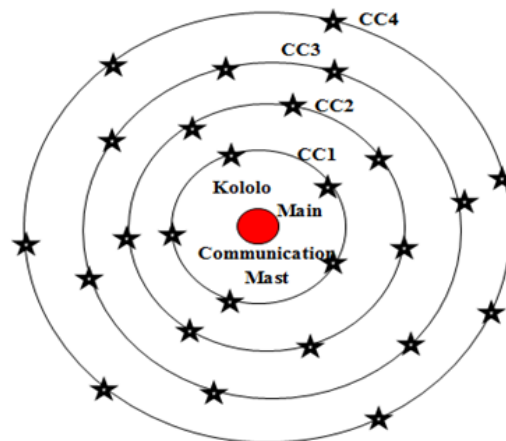


Figure 2. View of the Measurement Locations (MLOs) on the concentric circles

A full over view of the UHF frequency band of 470-862 MHz at different seven location measurements were taken. An average of two times measurements at every measurement location were taken for every 5 minutes for a period of 10 minutes before taking the actual average measurements of the frequency band variation of radiofrequency intensities. The radiofrequency intensity measurements were measured in form of Reference Signal Received Power (RSRP).

In Kampala Uganda, the DVB-Transmitter broadcasts all the television signals within the frequency range of 470 – 790MHz, with the (470 – 694)MHz as the sub 700MHz frequency band and (694 – 790)MHz as the 700MHz frequency band.

The configurations of the parameters for the spectrum analyzer on the MCS software during the measurements are as in Table 1.

Table 1. Parameter configuration for the spectrum analyzer

Parameter	Value
UHF Frequency range	470 MHz-862 MHz
DVB-T broadcasting band	Sub 700 MHz band 700 MHz band
Resolution Band Width	100 KHz
Video Band Width	100 KHz
Sweep time	5ms
Detection type	RMS
Sample points	100
Attenuation factor	Auto
Reference level	-10
Unit	dBm

3. Results and discussion

Measurements of all the UHF frequency range for DTTV has been made for the eight concentric circles whose GPS coordinates for every measurement locations on each circle are as seen in Table 2.

Table 2. GPS coordinates for the different measurements location on the different concentric circles

Measurement Location (M _{Lo})	GPS Coordinates	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8
1	Latitude	0.3332 06	0.32894 99999	0.3299 1	0.32592 16666	0.3482 4833	0.3294 266	0.3309 2667	0.2689 25
	Longitude	32.587 644	32.5830 11667	32.573 885	32.5654 5466	32.562 78166	32.552 29	32.545 64167	32.566 18
	Altitude	1203	1175	1201	1188	1173	1242	1271	1169
2	Latitude	03272 016	0.31827	0.3384 85	031893 1666	0.3355 267	0.3382 5	0.2948 15	00.2728
	Longitude	32.596 766	32.5903 04999	32.5741	32.57049833	32.561 0267	32.555 02	32.552 28	32.617 5
	Altitude	1212	1172	1187	1165	1194	1213	1192	1159
3	Latitude	03282 15	033480 0000	0.3281	0.32166 63333	0.3234	0.3654 63	0.3608 95	0.3634
	Longitude	32.593 256	32.6014 8	32.556 4	32.615865	32.556 4	32.603058	32.561 648	32.663 4
	Altitude	1215	1178	1206	1163	1206	1198	1195	1178
4	Latitude	0.3369 98	0.34070 16666	0.338033	0.34417333	0.3320 315	0.566 6	0.3672 95	0.3802
	Longitude	32.857303	32.5888 2333	32.6052317	32.61251	32.620 1275	32.61553	32.559543	32.557 1
	Altitude	1222	1220	1182	1196	1176	1226	1194	1221
5	Latitude	0.3378 1	0.33747 6666	0.3263 89	0.34834 0	0.3485 786	0.3123 45	0.3622 68	0.3653
	Longitude	32.672 39	32.5838 5	32.577 222	32.599286	32.619 7121	32.636113	32.62246	32.624 9
	Altitude	1167	1212	1236	1229	1195	1164	1198	1220
6	Latitude	0.3369 98	0.33641	0.3437 7333	0.36100 8333	0.3526 773	0.3608 95	0.3539	0.378564
	Longitude	32.587 303	32.5826 81666	32.585 6083	32.599863	32.608 873	32.56 648	32.636 8	32.845 64
	Altitude	1202	1207	1185	1200	1230	1195	1194	32.8451155
7	Latitude	0.33702833	0.32189 83333	0.32368	0.33491 6	0.3626862	0.3021 66	0.3043 56	0.2954
	longitude	32.589 6266	32.6043 3833	32.57712	32.5663 01	32.601 4431	32.552 638	32.643 552	32.542 4
	Altitude	1255	1162	1181	1249	1197	1261	1162	1164

In general, as seen in Figure 3, experimental results show that all Measurement Locations (MLO) on the different distances from the transmitter have a good reception of digital television signals.

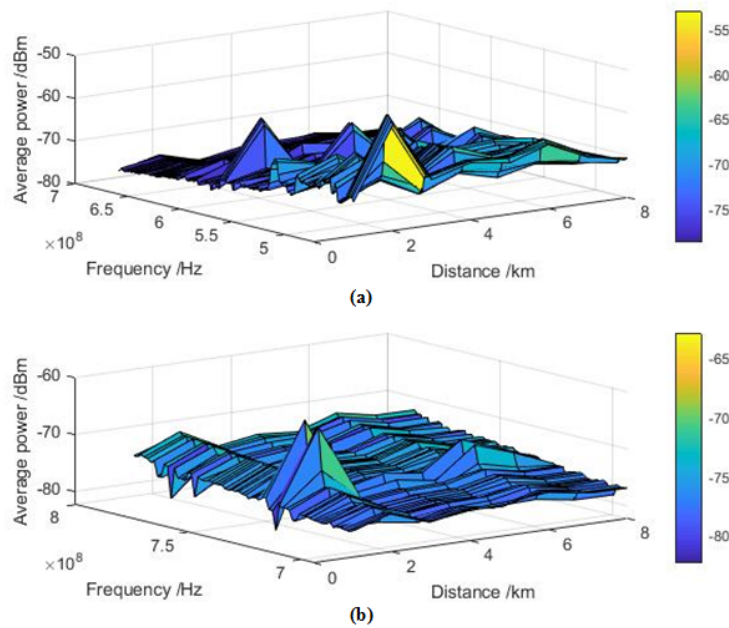


Figure 3. Radiofrequency intensity at different measurement locations for the different distances: The frequency ranges are 470 MHz-694 MHz for (a) and 694 MHz -790 MHz for (b)

Theoretically, radiofrequency intensities at a constant distance from the broadcasting transmitter must be constant. However, this is not the case as seen in Figures 3–7 since the graphs obtained show that radiofrequency intensities vary with location for the same distance though measurements were taken at the least possible DLoS with the transmitter at every measurement location. This means that in some locations there are more obstacles yielding to low radiofrequency intensities while in some there a few obstacles leading to high values of radiofrequency intensities. This cause may also be due to multipath effects giving graphs of varying radiofrequency intensities

This same trend was also observed on the different MLOs of the; 2 km, 4 km, 6 km and the 8 km distances. From Table 2, every concentric circle has different altitudes for the different Measurement locations indicating that some MLOs are in the valley while as others are on the hill; hence differences in RF Intensities for the same CC.

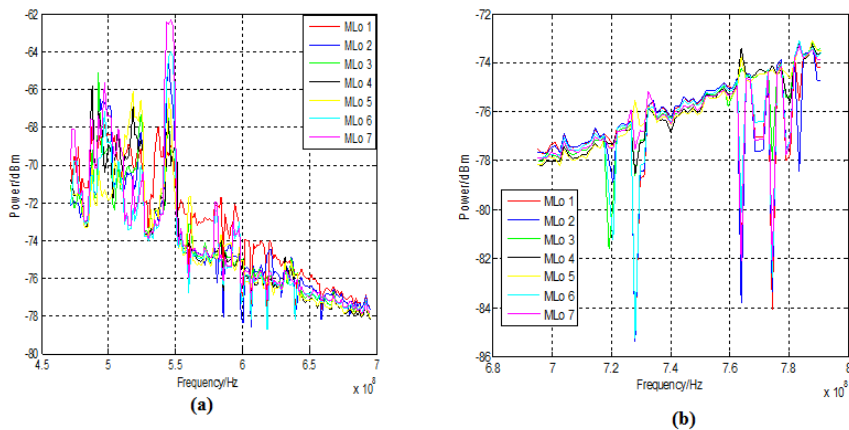


Figure 4. Radiofrequency intensities at various measurement locations for the 3 km distance from the transmitter. The frequency ranges are 470 MHz-694 MHz for (a) and 694 MHz -790 MHz for (b)

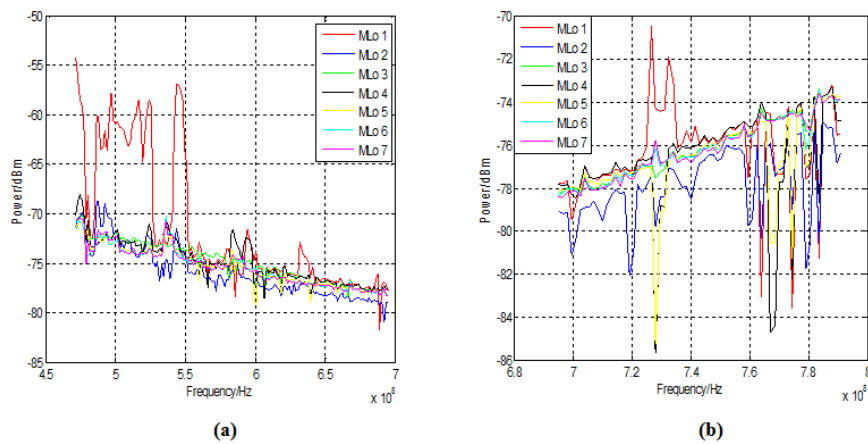


Figure 5. Radiofrequency intensities at various measurement locations for the 3 km distance from the transmitter. The frequency ranges are 470 MHz-694 MHz for (a) and 694 MHz -790 MHz for (b)

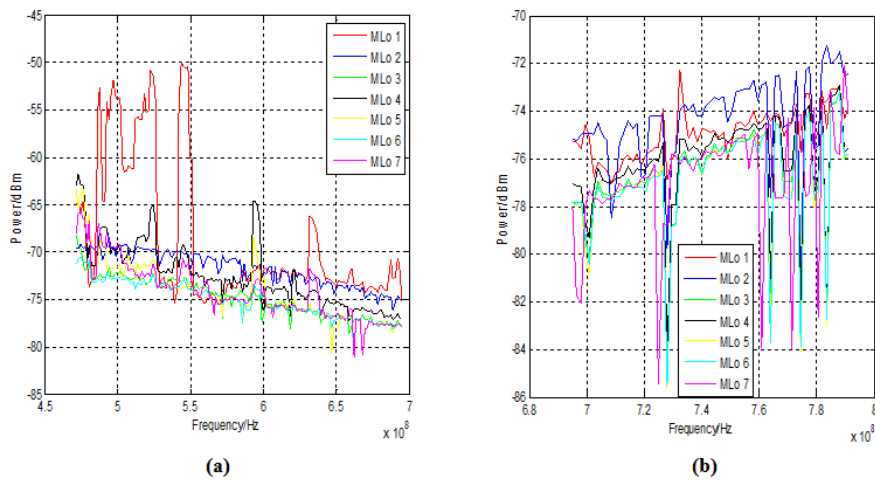


Figure 6. Radiofrequency intensities at various measurement locations for the 5 km distance from the transmitter. The frequency ranges are 470 MHz-694 MHz for (a) and 694 MHz -790 MHz for (b)

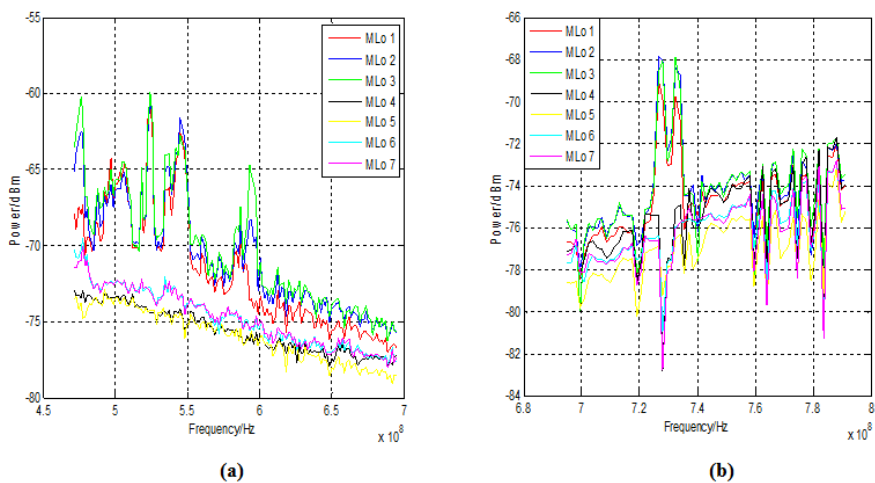


Figure 7. Radiofrequency intensities at various measurement locations for the 7 km distance from the transmitter. The frequency ranges are 470 MHz-694 MHz for (a) and 694 MHz -790 MHz for (b)

Another observation made here is that there is a general decrease in the radiofrequency intensities with increasing frequency for the 470 MHz -694 MHz frequency band while as for the 694 MHz -790 MHz frequency band, there is a slight general increase in the radiofrequency intensities as the frequency increases, for every measurement location of every frequency value. This also means that more TV stations are located within the sub 700 MHz frequency band than in the 700 MHz frequency band.

When a single frequency value of 542 MHz from the sub 700 MHz frequency band was considered, for each distance with its MLOs as seen in Figures 8 below, the RF intensity for every MLO for a particular concentric distance from the transmitter is not constant [18]. This is because different MLOs on the same concentric circle had different altitudes, hence giving different values of RF intensities on the same concentric circle. Specifically, MLOs on CC2, CC4 and CC6, recorded higher values than those ones on CC1, CC3 and CC5, yet CC1, CC3 and CC5 are closer to the transmitter than CC2, CC3 and CC6, respectively. This same difference was also observed on the 740 MHz frequency selected from the 700 MHz frequency band. These observations do not conform to the inverse square law and the mathematical expression as shown in Equation (1)

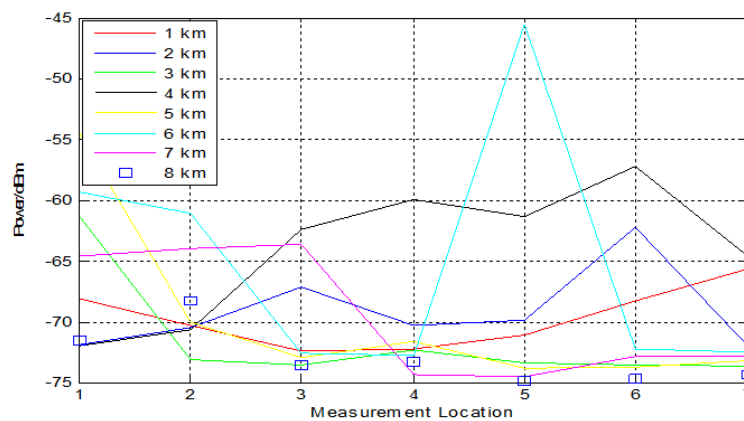


Figure 8. Radiofrequency intensities at various measurement locations of different distances from the transmitter for the 542 MHz frequency taken from the sub 700 MHz frequency band

From Figure 9, it is noted that there is total non-observance of the inverse square law. In (a), it is expected that RF intensities at all MLOs on the 1km distance would be greater than the rest of the RF intensities for all other distances, but it was not so. This also applies in (b) for the 2 km RF intensities at all the MLOs on the 2 km in comparison to other distances from the transmitter [4]. The same was observed for the 740 MHz frequency selected from the 700 MHz frequency band.

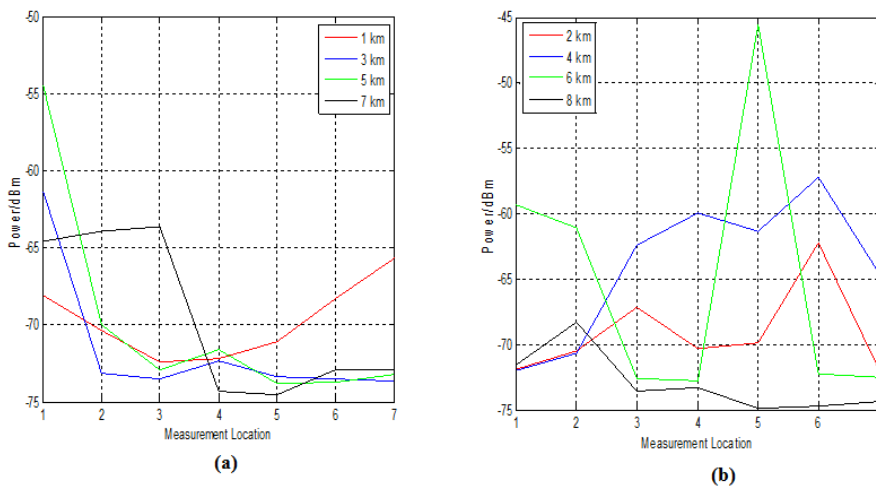


Figure 9. Radiofrequency intensities at various measurement locations of different distances from the transmitter for the 542 MHz frequency taken from the sub 700 MHz frequency band. The distances are odd for (a) and even for (b)

4. Conclusion

In this paper, radiofrequency intensities from the Digital Terrestrial Television (DTTV) Broadcasting Transmitter in Kampala Metropolitan have been measured and analyzed. The measurements generally show that there is a variation of radiofrequency intensities for a constant distance from the DVB-T Transmitter for any point around it. The measurements have shown that the sub 700 MHz frequency band of 470 MHz-694 MHz is more utilized than the 700 MHz frequency band of 694MHz-790 MHz; though both bands are still less utilized as being expected by ITU and UCC. The study has also revealed that in Kampala Metropolitan, there is good reception of DTTV signals at all the Measurement Locations where DTTV RF intensities measurements were carried from. The measurements do not obey the inverse square law which governs all forms of radiation in free space. This is evidenced on comparison of the RF Intensity measurements of CC1 with CC2, CC3 with CC4, CC5 with CC6 and CC7 with CC8. This is due to different Measurement Locations on the same CC having different altitude values. The study has come at the rightful time when there is an increase in the number of DVB-television stations in Kampala Metropolitan, Uganda.

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