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UHF (700 MHz) Spectrum Band Occupancy Measurements, Analysis and Considerations for Deployment of Long Term Evolution (LTE) Deployment in Kenya

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Abstract-This article covers spectrum occupancy measurements in 700 MHz frequency band. The data collected is presented in a plot and frequency band occupancy is calculated in percentage. Analysis of the measurement results indicate that 700 MHz band is hugely underutilized in Kenya. Further analysis in comparison with other developments across the world indicates that this band can be used for LTE deployment both as LTE on TVWS and as a UHF digital dividend. Some of the challenges that can be faced while using this band have been highlighted together with the benefits that will be realized. Further research areas on this subject have been suggested.

Index Term-700MHz band plan, digital dividend, LTE deployment, spectrum band occupancy measurement, spectrum utilization, whitespaces, world radio communication conference.

1.0 Introduction

A spectrum occupancy study is an experimental survey of electromagnetic energy occurring in a broad range of radio frequency (RF) bands over a given period of time. Because the spectrum management has been a politically as well as technically sensitive issue, it is usually very hard to access the open data of real spectrum usage. In this sense, grass-roots data collections are important. The emergence of new technologies and the phenomenal growth of wireless communication services have created an ever increasing demand for the radio frequency spectrum. The radio frequency spectrum is a scarce natural resource and to meet the growing demands of all these new bandwidth-hungry services, effective and efficient utilization of radio spectrum is essential [2]. In principle, international and regional regulatory bodies like ITU (International Telecommunication Union), the Federal Communications Commission (FCC) in the USA among others coordinate and properly regulate the usage of radio spectrum resources and the regulation of radio emissions [3]. In Kenya, based on the recommendations of the ITU, the Communications Commission of Kenya (CCK) assigns spectrum to licensed holders, also known as primary users, on a long-term basis. Such the policy partitions the overall radio spectrum into non-overlapping frequency bands corresponding to different purposes, i.e. government, public safety, national defense, approach ensures that competing wireless applications do not interfere with each other's, it is worth determining whether the approach allows maximum utilization of the available spectrum. This approach provides ultimate protection from harmful interference in an allocated radio band, but on the other hand, as many measurement studies reveal [4], the fixed radio frequency allocation may lead into significant underutilization of the radio spectrum due to very sporadic usage across different geographical regions as well as in different periods of time which results in whitespaces across several frequency bands. Whitespaces are frequencies allocated to a broadcasting service but not used locally at particular time in a particular location. There are two main kinds of whitespace; one is the free band (band-plan) rendered between the used frequency band to avoid the interference. This is also called a guard band. With advancement in modulation and demodulation technology, small bandwidth is needed to transmit the signal making required guard band to be small as well. Another whitespace is the really unused that exist because of lack of utilization. It makes a lot of band spectrum vacant while a large number of wireless services suffer because of spectrum scarcity. In addition, the current spectrum policy makes it difficult for the rapid television, radio, cellular, and unlicensed consumers. Although the fixed allocation deployment of new services. Till now, several measurement campaigns were conducted in USA, Spain, Singapore, Vietnam, Ireland, Qatar, and France among many others. A shared finding among these studies reveal that a large portion of the assigned spectrum remains underutilized.

Kenya sees the ICT sector as one of the economic spring boards to achieve vision 2030 and that makes the sector a key area for development. The wireless industry has rapidly grown through the development of multiple standards and technologies. Each wireless standard has evolved with its specialized service such as voice, video streaming, wireless internet access, or email services. Presently we are aiming for the 4th generation of mobile communication systems, the Long Term Evolution technology (LTE). LTE provides High-speed digital data transmission over a fully IP-based wireless system capable of greater than 80 Mbps in both the downlink and uplink. It also provides the most spectrally efficient standard currently developed using an Orthogonal Frequency Division Multiple Access (OFDMA) modulation scheme, which delivers efficient re-use of frequency. Any dead space in a call for example, is used to squeeze in information from another call.

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The World Radio communication Conference (WRC) 2000 and WRC-07 identified UHF spectrum for use by administrations wishing to deploy IMT systems. In the WRC-07, the band 698-806 MHz was identified by nine Region 3 Administrations for IMT attracting significant interest from both the Member States and mobile industry understanding the potential benefit that this frequency band would give to customers and the society as a whole when being used by mobile communications [9]. APT members have noted that the frequency 698-806 MHz band would allow cost efficient wide area coverage by Mobile systems and thereby promote wide spread availability of affordable mobile broadband, especially for rural areas. In the USA the condition for the mobile industry is more favorable and high data rate IMT networks are expected to be deployed in the range 698 – 806 MHz (the band 700 MHz) already by the end of year 2009 or early 2010 under a nationwide rollout scheme [9].

The US band plan is already defined. 3GPP has defined uplink and downlink arrangements along with band classes covering this plan. This paper will analyze the detailed results of 700MHz band spectrum occupancy measurements conducted in Kenya which will be extremely useful in determining the utilization of this frequency band and how it can be used for LTE deployment.

BANDWIDTH	698.0 – 704.0	704.0 – 710.0	710.0 – 716.0	716.0 – 722.0	722.0 – 728.0	728.0 – 734.0	734.0 – 740.0	740.0 – 746.0	746.0 – 752.0
CHANNEL NO.	52	53	54	55	56	57	58	59	60
BANDWIDTH	752.0 – 758.0	758.0 – 764.0	764.0 – 770.0	770.0 – 776.0	776.0 – 782.0	782.0 – 788.0	788.0 – 794.0	794.0 – 800.0	800.0 – 806.0
CHANNEL NO.	61	62	63	64	65	66	67	68	69

Figure 1.1: UHF TV Channels 52-69 vs. Frequency in MHz

1.1 Study Objective and Scope

The purpose of the study is to determine is to determine the usability of the 700MHz frequency spectrum band currently allocated for TV channels 52-69.

The scope involves measurement and analysis of the spectrum occupancy in the 700MHz spectral region using energy detection principle. This will provide information on which spectrum channels have low and high utilization in this spectral region. This information will be analyzed and compared with other measurements elsewhere to see the gains Kenya can make both in the short term and long term LTE deployments in this particular band.

3.0 Spectrum Occupancy Measurements

3.1 Measurement Equipment

Device	Description
Anristu 8221B BTS Master	Digital Spectrum Analyzer
Laptop Computer	Data Acquisition and Control System
Anristu antenna series	Antennas for the frequency range of600-3000 MHz

3.2 Equipment Settings

Spectrum Analyzer				
Start Frequency (MHz)	Stop Frequency (MHz)	RBW (kHz)	VBW (kHz)	Input Attenuation (dB)
698	806	10	100	0

3.3 Data Calibration

The recorded power levels measured by the spectrum analyzer are provided in dBm/m^2 relative to the analyzer input. Dynamic threshold was used for the measurement so as to detect as many emissions as possible. Regardless of their level, a dynamic threshold that adapts to the current noise level is preferred. The critical part is the reliable detection of the current noise level.

3.4 Collected Data

The data was collected on June 02, 2013 11:00 AM at Safaricom House located in Westland, Waiyaki Way, Nairobi. The equipment used was Anristu antenna series with a frequency range of 600 to 3000 MHz which fed the received signal to Anristu 8221B spectrum analyzer. The spectrum analyzer converted the received signal into power versus frequency traces using an internal mixer, sampler, and a computational Fast-Fourier Transform (FFT) engine. Measurements were saved to the external USB flash drive during measurement and then transferred to the computer for analysis.

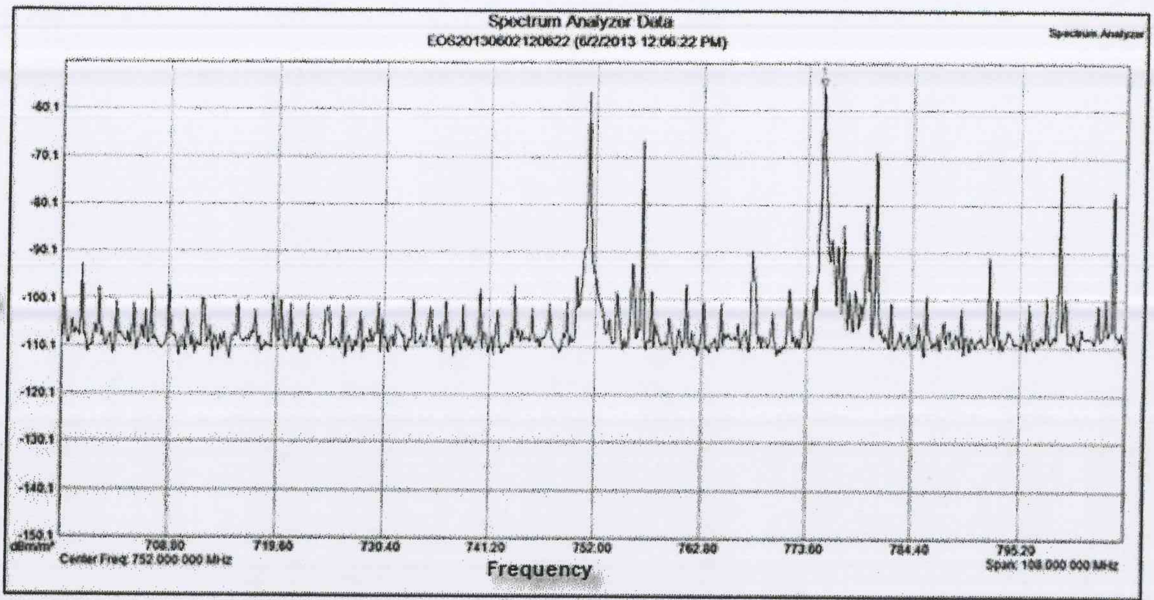

Fig 3.1: Measurements plot for 698-806 MHz Band

TRACE Data	Field Strength (dBm/m^2	Frequency	MHz
P_393	-55.068	775.17091	MHz
P_271	-56.404	751.214546	MHz
P_299	-66.528	756.712728	MHz
P_421	-68.72	780.669091	MHz
P_394	-68.96	775.367273	MHz
P_516	-73.244	799.323637	MHz
P_395	-75.788	775.563637	MHz
P_544	-77.252	804.821819	MHz
P_272	-78.132	751.41091	MHz
P_416	-79.872	779.687273	MHz
P_392	-81.384	774.974546	MHz
P_404	-84.376	777.33091	MHz
P_391	-85.888	774.778182	MHz
P_398	-87.24	776.152728	MHz
P_401	-88.728	776.741819	MHz
P_270	-88.844	751.018182	MHz
P_356	-89.604	767.905455	MHz
P_269	-89.612	750.821819	MHz
P_418	-90.492	780.08	MHz
P_396	-90.608	775.760001	MHz
P_479	-91.096	792.058182	MHz
P_273	-91.56	751.607273	MHz
P_397	-91.992	775.956364	MHz
P_294	-92.4	755.73091	MHz
P_10	-92.968	699.963637	MHz
P_399	-93.112	776.349091	MHz
P_274	-94.144	751.803637	MHz
P_357	-94.3	768.101819	MHz
P_402	-94.976	776.938182	MHz

Table 3.1: Measurements for 698-806MHz Band trace data above -95 dBm

4.0 Spectrum Measurements Analysis

The parameter used to evaluate the utilization of RF spectrum is frequency band occupancy. The occupancy of a whole frequency band counts every measured frequency and calculates a total figure in percent for the whole band, regardless of the usual channel spacing. The number of measured frequencies determined by the frequency resolution is usually higher than the number of usable channels in a band. If the measurement time of each sample is equal, the FBO is calculated as follows:

FBO=NO/N

Where:

NO: number of measurement samples with levels above the threshold

N: total number of measurement samples during the integration time

From the measurements carried out, NO=29 and N=551

FBO=0.0526x100=5.26%

From the measurement graph and calculated frequency band occupancy it is evident that this particular spectrum band is underutilized and has a huge opportunity for LTE deployment. Figure 4.1 below shows the US band plan for this particular band which has been approved by 3GPP. Comparing the band plan and the utilization graph measured in Kenya it shows that most of the frequencies identified in this plan are whitespaces and can actually be available for use as LTE on TVWS (TV Whitespace). Alternative the entire band can be available for LTE deployment after the digital migration.

In the scenario for LTE on TVWS, the US band plan will be the most ideal however a lot of interference analysis has to been done to address the challenges of mobile stations interfering with broadcasting transmitters.

For the case of using the entire band after digital migration, a simple and spectrum efficient FDD frequency arrangement in 698 – 806 MHz band based on –

- 2x50 MHz arrangement with a central gap of 8 MHz between UL and DL directions
- Duplex spacing of 58 MHz
- Reverse duplex transmission
- split dual-duplexer with current available filter technologies
- the size of the two duplexer blocks should be standardized

The FDD frequency arrangement in the band further provides maximum utilization of spectrum i.e. 100 MHz out of the 108 MHz available in the band. Figure 4.2 below shows a simple view on frequency arrangement for entire 700 MHz band

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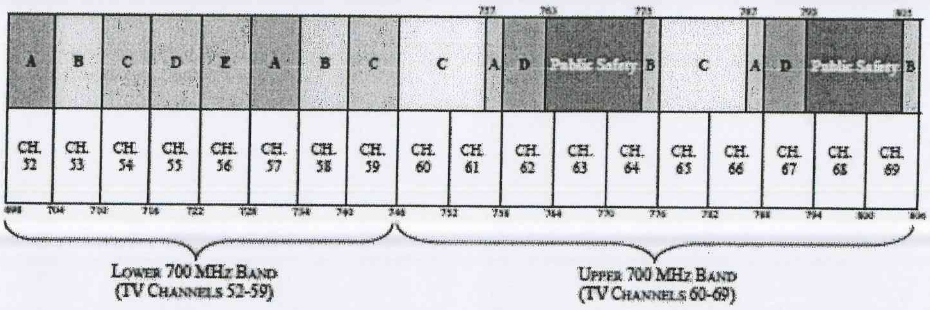
Revised 700 MHz Band Plan for Commercial Services



Block	Frequencies (MHz)	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734
D	716-722	6 MHz	unpaired	EAG	6
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1 *
B	775-776, 805-806	2 MHz	2 x 1 MHz	MEA	52

* Subject to conditions respecting a public/private partnership.

The blocks shaded above in gray (Lower 700 MHz Band C and D Blocks and Upper 700 MHz Band A and B Blocks) were auctioned prior to Auction 73.

Fig 4.1: US Band plan

Figure 4.2: A simple view on frequency arrangement for entire 700 MHz band

5.0 Conclusion

From the collected measurement data it is evident that Kenya has huge potential for commercial LTE deployment on 700 MHz band. This can be achieved through LTE on TVWS (TV Whitespace) or use the entire band for LTE after digital migration.

Challenges

- The UHF band has been and is still mainly used for analogue television in Kenya with broadcasting channels scattered across the UHF band as seen in the measurement plot. This makes it difficult to do proper band planning when using TVWS and more so when addressing the challenge of interference.
- Kenya have made plans for her analogue switch-offs, while this has kicked off the progress is very slow thus the digital dividend will not be fully available before complete analogue switch-off.

Advantages

- Mobile operators and manufactures will be able most efficiently to address a large market, through the achievement of economies of scale for equipment manufacture. The future mobile technology is to have single equipment for all technologies.
- The propagation characteristics of the spectrum below 1 GHz made this 700 MHz UHF digital dividend band very suitable for wide coverage provision. This UHF spectrum is also very suitable for in-building coverage provision, e.g. in urban areas.

With this development further research is suggested on interference challenges, frequency plan and technical considerations required for LTE deployment on this band in Kenya.

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