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SPECTRUM OCCUPANCY ANALYSIS OF ACTIVE FM BAND IN OSOGBO METROPOLIS

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Abstract An investigation was conducted to ascertain the FM band (88-108) MHz spectrum occupancy measurement within Osogbo, Nigeria over a period of 48 hours. The energy detection method was used to analyze the spectrum data, and a threshold of 5 dB/Hz above the noise level was put in place. The Fountain University Osogbo campus, the Atelewo Fire Station, the Uniosun Osogbo campus, and the National Control Centre Osogbo were the four venues for the campaign measurement of the spectrum occupancy. The fieldwork analysis led to the deduction that the Uniosun campus experienced a maximum duty cycle of 99.48% spectrum occupancy at band 9 of frequency 91.625 MHz and band 35 of frequency (104.375-104.5) MHz. Of the four locations, the Uniosun campus had the highest average duty cycle of 89.81% spectrum occupancy and the highest power spectral density of -67.50 dB/Hz. The maximum average power spectral density of -87.89 dB/Hz is recorded at the National Control Center. The Uniosun campus had the highest number of active channels, with 574 channels located at band 9 of frequency channel 91.625 MHz and band 35 of frequency channels (104.375-104.625) MHz. The university campus also had the highest average number of active channels, with 518 channels.

Keywords: Frequency modulation, duty cycle, spectrum occupancy, power spectral density ,number of active channels

I. INTRODUCTION

Determining the actual behavior of spectrum consumption in an environment is crucial for future channels wireless communication system development and deployment and for utilizing the underutilized and unused frequency spectrum. This paper aims to thoroughly analyze the active FM band (88–108 MHz) spectrum measurements made at the four different Osogbo city locations namely; Fountain University, Uniosun Osogbo campus, Firestation and National Control Centre Power Line. An adaptive energy detection threshold approach was used to determine the duty cycle and a modified duty cycle that considered the space factors was used. According to a hypothesis-based energy detection model [1], the transmitted signal x(k) and the received signal y(k) are as follows:

$$H_0 : y(k) = w(k) \quad (1)$$

$$H_1 : y(k) = h.x(k) + w(k) \quad (2)$$

H_1 and H_0 here, represents "signal presence" and "signal vacancy" respectively.
$w(k)$= white Gaussian noise with zero mean, h= the channel gain amplitude, and $r_n^{\ 2}$= variance.

The frequency spectrum is a finite resource with infinite demands; and man must find new and more ways state of the art to manage it so as to satisfy the desire for boundless services while practicing frequency spectrum

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frugality. Among the methods that investigated the measuring rate of frequency usage is frequency reuse to achieve greater efficiency and occupancy of the spectrum [2].

In [2], spectrum measurements were conducted in rural and urban areas, covering the 50 MHz to 6 GHz bands. The average spectral occupancy was 0.18% in rural areas and 5.08% in urban areas, with an average of 1.45% in urban areas on weekends. The duty cycle was significantly impacted by the selection of the detection threshold, with the TV band showing an abrupt exponential decay that becomes invariant at -85 dBm. The entire band was underutilized, with absolute spectral occupancy moderately populated in urban areas and nearly empty in rural areas. The CDMA band had the lowest occupancy and frequencies above 1 GHz were comparatively underutilized. The detection threshold affected the duty cycle, with GSM 1800 and 900 showing exponential decay.

In [3], the study assessed Samsung's radio spectrum usage using RF Explorer 6G Combo. Measurements were conducted at 115 locations in the GSM 900 band, revealing that Samsung's spectral occupancy is approximately 8.5% at 40 dBm and 82% at -75 dBm. The GSM 900 band is nearly fully occupied at -75 dBm. The energy detection measurement technique identified unused spectrum gaps. The occupancy percentages for the -40 dBm threshold were around 8% at 50% of the locations, and 39 out of the total locations were fully occupied at -75 dBm.

In [4], it was revealed that the duty cycle in Kwara State, Nigeria, varies significantly between rural and urban areas, with mean occupancies of 1.67 and 17.76 percent, respectively. The variability was due to the introduction of new technical devices and wireless connections, necessitating research into effectively using constrained radio spectrum. The study suggested that Nigeria's telecommunications' sector should implement practical strategies to maximize limited radio resources, especially for rural areas, to ensure better signal quality.

The study in [5], evaluated spectrum use in HILLAH and IQ, focusing on cognitive radio (CR) technology. It revealed that certain licensees use too little spectrum, presenting an opportunity for efficient CR network usage. The study found persistent underutilization of bands 49-500 MHz, with an average occupancy of 4.1%. Bands ranging from 50 to 900 MHz are potentially helpful for CR applications. Concurrent measurements at different heights and locations can provide a more thorough estimate of the spectrum occupied.

In Kwara State, spectrum occupancy was measured over a 24-hour, covering the frequency range of 48.5 MHz – 870 MHz in rural and urban areas. TV band 3 was the most inhabited band, with occupancy rates up 20.26% and 37.27%, respectively. The results suggested that TV bands are underutilized, making them ideal for software-defined radio implementation. Further experiments were conducted in different geopolitical zones to determine spectrum occupancy in the frequency range [6].

In Nigeria, a 24-hour outdoor spectrum occupancy test in rural and urban areas of Kwara State revealed that CDMA bands are less frequently used than TV bands. The data suggested that cognitive radio could be deployed to better utilize the radio frequency spectrum, as the mean average duty cycle for

TV bands 1-4 and CDMA bands were 2.58% and 12.02%, respectively.

Cognitive Radio, a concept that allows unlicensed users to use licensed spectrum, has been proposed as a potential solution to reduce spectrum scarcity in wireless communication systems. A study in [8], that utilized a spectrum analyzer in Pakistan found that 36% of the authorized spectrum for GSM 900 uplink and downlink is unused, and between 22.5% and 79.9% of bandwidth allotted to GSM service providers remains idle. It was suggested that Cognitive Radio Networks could be the most effective way to increase spectrum utilization in Pakistan's GSM 900 uplink and downlink assigned spectrum.

A 24-hour spectrum measuring experiment in Beijing revealed a low signal occupancy rate of 13.5% in the 450-2700 MHz frequency bandwidth. This suggests a promising future for cognitive radio and dynamic spectrum access. The results were part of a more extensive BUPT measurement program aiming to construct a whitespace database for cognitive applications. The data will facilitate the development of effective dynamic spectrum access technologies and applications [9].

In [10], the research work emphasized on the limitations of Nigeria's current fixed radio spectrum allocation policy, the artificial scarcity and underutilization of radio spectrum. The study used three locations within the South-West Geopolitical Zone to measure radio spectrum usage. The results showed that the use of radio spectrum varies concerning time, space, and frequency, with actual usage ranging from 0.08% to 64.4% in the 80–2200 MHz frequency band. The study suggested replacing the current fixed radio spectrum management policy with dynamic spectrum access (DSA) due to its economic benefits and rapid technological advancements. This will allow the current radio spectrum waste to be converted into wealth and ensure the performance of the existing radio governed by the fixed spectrum allocation policy is not jeopardized.

In [11], the research work focused on determining the detection threshold in the Cognitive Radio System using the Cooperative Sensing Spectrum (CSS) approach. It models the functional subsystems, including Primary User (PU) Generator, Transmission channel, Switching Subsystem (SS), Secondary User (SU) Generator, and Spectrum Management subsystem. The detection decisions are based on false alarms and detection decisions. The study enhances the detection threshold by fine-tuning it based on hypotheses H_0 and H_1.

Despite regulatory agencies granting licenses, many spectrum bands still need to be occupied. Cognitive Radio (CR)-based dynamic spectrum access (DSA) is a potential solution to increase spectrum utilization for wireless communications. In [12], global spectrum occupancy measurements, offering a unified methodological framework for future campaigns were introduced. Results showed little spectrum usage, but a substantial spectrum exists for cognitive radio deployment. The study discussed methodological issues, including frequency and time effects, antenna selection, spectrum analysis, and measurement, emphasizing the importance of careful assessment in cognitive radio.

The perception of spectrum scarcity often needs to be revised due to the rapid development of wireless communication. However, studies showed that most allocated spectrum needs to be more utilized. In [13], study was conducted for an indoor spectrum occupancy test in Abuja, Nigeria, between 700 MHz and 2.5 GHz. Results showed that there is room for cognitive radio implementation. The bands carrying 2G and 3G cellular standards had the highest usage levels (26% and 25.56%, respectively), while the 1000-1500 MHz and 2000-2200 MHz bands had the lowest usage. The findings could help create future spectrum management regulations].

The cognitive radio paradigm aims to transform spectrum management by addressing spectrum underutilization. However, current spectrum allocation methods could be more efficient, leading to a perception of spectrum scarcity. Measurements of spectrum occupancy in Nigeria show a sufficient amount of spectrum available, and correlation analyses show that spectrum occupancy is location and time dependent. In [14], the study conducted in two cities revealed that all bands have low occupancy rates, with 700-1000 MHz having the highest usage (26%) and 2000-2200 MHz having the lowest (0.45%). The study is crucial for Nigeria's adoption of cognitive radio technology and aids decision-makers in making informed choices regarding spectrum use.

In [15], study carried out in US found that regions with fewer than 100,000 residents underutilize FM radio spectrum. This is due to the lack of bandwidth between nearby FM radio channels and the potential for interference from low-power, short-range Internet of Things devices. A new algorithm was developed to identify protected FM radio stations in these areas to ensure reliable connections. The analysis showed that the areas with less than 100,000 residents and no major densely populated areas had the most potential for CIoT device secondary licensing. Frequency-reuse allows low-power, short-range devices to achieve bitrates of about 30 Mbps.

In [16], a week-long measuring experiment on spectrum use in London, UK, was carried out to understand the variability in spectrum use across various regions in a large metropolitan area. The experiment involved three spectrum analyzers, two for sampling around the fixed measurement site and one for long-term measurements at a specific location. The results provided more precise information about spectrum use than regular single-location campaigns. The study also examined the temporal, geographical, and frequency domain correlation structures and dynamics in spectrum utilization. The results showed hetero-elasticity, with site type significantly impacting observed power spectral density variance. The study suggested that statistical estimates for propagation models and spectrum sensing accuracy should be reevaluated, and cautious estimates for protection mechanisms should be employed. The data from the metropolitan area is complex and full of phenomena, making it helpful in studying nonmetropolitan locations.

In [17], Cognitive radio (CR) was described as a disruptive technology that could address spectrum scarcity and simplify flexible spectrum use. Measurements of spectrum occupancy reveal underutilized bands, offering the potential for CR. The study conducted in Mumbai, India, found a low occupation rate and significant opportunities for dynamic spectrum usage. However, a comprehensive analysis of CR bands is needed for long-term potential.

Cognitive Radio (CR) systems with spectrum awareness features are promising for efficient spectrum use. In [18], investigation carried out over three days found that the 700-3000 MHz frequency band is not widely used, with varying usage percentages at different locations. Time, frequency, and location significantly impact spectrum occupancy. The busiest spectrum occupancy was observed at one location, particularly during the afternoon. Bandwidth utilization varies with time, peaking in areas from afternoon to dusk. Multidimensional spectrum occupancy measurement and analysis are crucial for accurate spectrum utilization modeling and performance evaluation of CR systems.

In [19], the study explored the potential of using the Television White Spaces (TVWS) spectrum in Malaysian cities for cognitive radio. Data from eight cities revealed that channel bonding can increase bandwidth for TVWS channels. The findings suggest that TVWS initiatives could meet future wireless service demand through extended wireless fidelity networks.

In [20], investigation was carried out on the evaluation of uncertainty management in cognitive radio networks, which proposes a solution called DSA to improve access to restricted radio spectrum. The study examined various models and methods for managing uncertainty, including probabilistic theory, fuzzy set theory, possibility theory, and evidence theory. The aim is to reduce uncertainty in the cognitive cycle and improve the performance of cognitive radio systems and the objectives of these strategies are to reduce sensing error, enhance the fidelity of sensing decisions, and overcome mistakes caused by fading, shadowing, and uncertainty noises.

In [21], the state-of-the-art spectrum sensing methods for cognitive radio networks were analyzed, along with comparisons. A lot of metrics utilized for performance evaluation were described together with the spectrum sensing model and the currently available spectrum sensing approaches, such as energy, autocorrelation, Euclidian distance, wavelet, and matching filter-based sensing.

In [22], the outcome of the outdoor spectrum occupancy measurements analysis in three regions of Konya metropolis in Turkey namely; Seluklu, Karatay, and Meram over six months results showed that, the use of spectrum below 1 GHz is excessive, with minimal activity detected in the 230-470 MHz, 960-1700 MHz, and 2500-3000 MHz frequency bands. GSM communication applications require a lot of bandwidth in the downlink bands, making it challenging to detect uplink frequencies. Selçuklu has high occupancy rates for GSM 900, GSM 1800, and 3G downlink bands, while Karatay has low occupancy rates. Meram, situated near vineyards and gardens, has high spectrum consumption in these bands. The study highlights re the importance of effectively utilizing the available radio spectrum for new applications.

A research study conducted in [23], in Nigeria found that there is a need for more bandwidth for secondary rural broadband service providers due to high VHF band spectrum utilization in three villages. The UHF band usage was 33%, 41%, and 55% in Asong, Ikot

Akpabio, and Afaha-Offiong, respectively. These frequencies can easily accommodate a lightly licensed spectrum band to enhance broadband penetration in the state. By combining research efforts with TV whitespaces, Nigeria could improve data access capabilities for rural residents.

In [24], the investigation carried out explored frequency-agile cognitive radio as a solution to wasteful radio spectrum use in the 30-300 MHz (VHF) region, a survey in a major US city and rural 25-90 MHz band shows potential for this strategy. The urban survey predicts that 80% of the 30-60 MHz band is signal-free, with noise levels below ambient noise limits. However, temporal density, spectral resolution, and spatial sampling are constrained.

In [25], Dynamic spectrum access (DSA) in China was described as a promising solution to increasing frequency congestion. However, it requires a thorough analysis of spectrum utilization in various domains. The study measured concurrent spectrum occupancy in South China, evaluating practical spectrum occupancy using a digital wideband receiver. It was proposed that a systemic spectrum measurement methodology, matrix format data storage, duty cycle evaluation metric, and data mining process, demonstrating the potential for license-exemption use of released spectrum using CR technology.

In [26], study conducted in Aachen, Germany, compared indoor and outdoor spectrum occupancy measurements. The results showed high spectrum occupancy outside the 20 MHz to 3 GHz region, while indoor settings decreased due to less background noise. The study also demonstrated that the 3-6 GHz frequency band is seldom used. The data can streamline spectrum sensing procedures and identify potential research and secondary applications.

Another study conducted in [27], discussed the issue of spectrum bands remaining unoccupied despite regulatory bodies granting licenses. Dynamic spectrum access (DSA) was proposed to improve spectral utilization. The study presented a spectrum measurement setup, background noise processes, and a novel duty cycle distribution model for DSA research. The model explored the effects of duty cycle correlation in the frequency domain. The study also assesses the effectiveness of an adaptive spectrum sensing procedure and the model's application in assessing dynamic spectrum access systems. The model's output is remarkably close to measurement traces, validating the modeling strategy.

In [28], the research work showed that the primary goal of spectrum management is to maximize the utilization of available spectrum. Yaounde, the capital city of Cameroon, has demonstrated potential for dynamic spectrum access in its mobile networks. The 900 MHz band yielded an uplink spectral opportunity of 30%, while the 1800 MHz band provided a downlink spectral opportunity of 26.44% and an uplink spectral opportunity of 86.82%. This suggests that dynamic spectrum access techniques could be applied with significant economic benefits to Cameroon's mobile networks.

II. MATERIALS AND METHODS

A. Raw Materials

The four locations and their respective coordinates for the research work were highlighted in Table 1 while the Google map of the locations was shown in Figure 1a.

Table 1: Research work locations

LOCATION	NAME	COORDINATES
1	FOUNTAIN UNIVERSITY	7.7437 ^{0}N , 4.5460 ^{0}E
2	UNIOSUN CAMPUS	7.7616 ^{0}N , 4.6012 ^{0}E
3	FIRE-STATION	7.7845 ^{0}N , 4.5457 ^{0}E
4	NATIONAL CONTROL CENTRE	7.8026 ^{0}N , 4.5786 ^{0}E

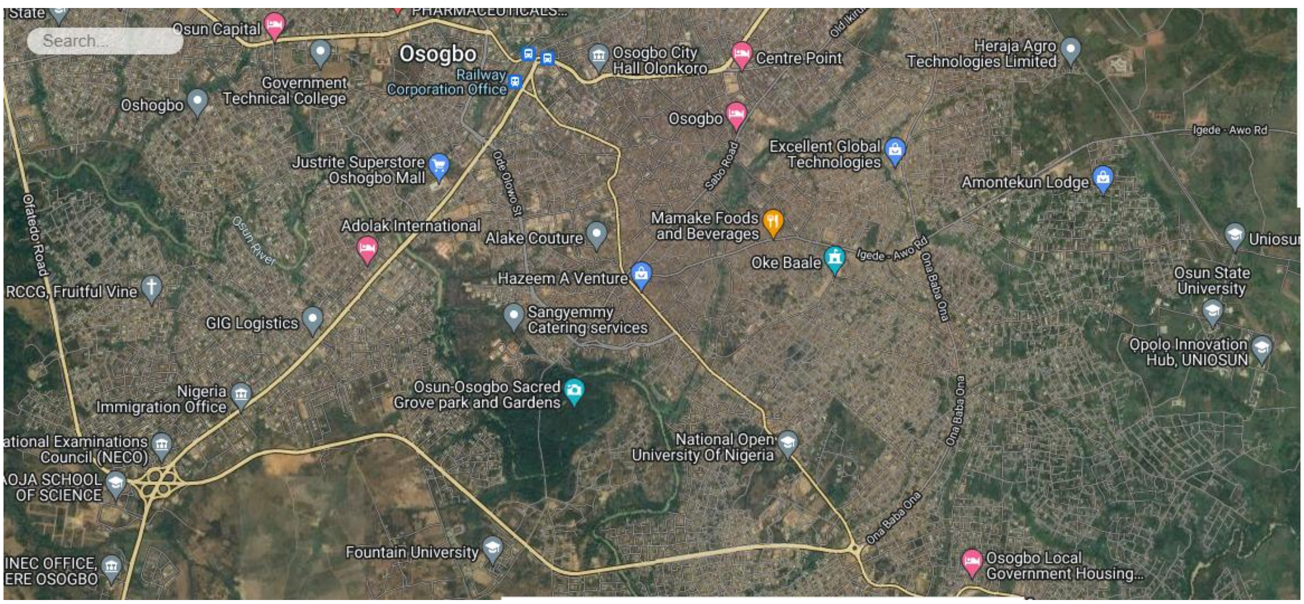


Figure 1a: Google map of the locations measurement within Osogbo Metropolis

Table 2: Parameters for (88-108) MHz Band

Radio Services	Band in (MHz)	Bandwidth in (MHz)
Frequency Modulation	88 - 108	20

B. Preparation of Material

Table 2 showed the band parameters for the considered Frequency Modulation in the research work

C. Measurement Equipment Set -Up

A more potent, more sensitive spectrum analyzer was used to measure the setup apparatus to detect all signals, strong or weak within the specified frequency range. A field strength analyzer (BK PRECISION 2640 with variable parameters, 500ms sweep-time, 50 input impedance, variable resolution bandwidth, 3.125Hz resolution, maximum accuracy of 3ppm and minimum accuracy of 1.5 ppm and frequency range of (0.1GHz -2.0 GHz) and a global positioning system (GPS) to record all coordinates of chosen locations within Osogbo metropolis are all part of the experimental setup.

D. Decision Threshold, Bandwidth of Resolution (BR) and Frequency Size Bin

A higher frequency size bin than the signal bandwidth could result in an overestimation of spectrum utilization. The accuracy of spectrum occupancy is governed by the frequency size bin that is just less than the signal bandwidth. In addition, the signal frequency system runs smoothly with a narrower BR, and the noise floor is decreased. To better balance the duty cycle-derived detection capabilities and the average spectrum analyzer's sweep time for measurement, a resolution bandwidth of 12.5 k20 Hz was used.

Equation (3) computes the duty cycle in accordance with [1],

$$Duty\ Cycle = \frac{Signal\ Occupation\ period}{Total\ Observation\ period} \times 100\ \% \qquad (3)$$

The duty cycle functions are determined by the decision threshold that is chosen. A low decision threshold leads to an overestimation of the occupancy rate due to noise samples that are above the threshold, while a high decision threshold results in an underestimation of the actual occupancy rate due to incorrect detection of the faded primary transmission.

The Variable p_i-dB criteria is the one that is utilized to set the decision threshold in accordance with [1]. Depending on the band, the matched load applied across the spectrum analyzer determines the noise level, and that is where the threshold p_i-dB is placed.

A constant p_i-dB threshold above the whole frequency range being measured is inaccurate since the noise variance σX(f) and the maximum noise level can vary from band to band depending on the measurement setup. This is why the variable mi-dB criteria was utilised.

Equation (4) according to [29], computes the decision threshold in dB as:

$$\lambda_{TH} = Z(f) + p_i \qquad (4)$$

$Z(f)$ = the average noise level

The pictorial diagram of Set-up on the field was shown in Figure 1b.

III. RESULTS AND DISCUSSION

A. Results of Duty Cycle for all Locations

Figure 2 indicates the FM (88-108) MHz of duty cycle in percentage versus FM band for Fountain University with frequency band (8-9) and of frequency channels (91.625-91.875) MHz having 98.44 % duty cycle and frequency band 35 of frequency channels (104.375-104.625)MHz having 98.44 % duty cycle. The average duty cycle for Fountain University was observed to be 8.36 % duty cycle.

Figure 3 indicates the FM (88-108) MHz of frequency channel 105.625 MHz having 78.68

% of duty cycle. The average duty cycle for the fire station was observed to be 19.77 % d

Figure 1b: Pictorial diagram of set-up on the field

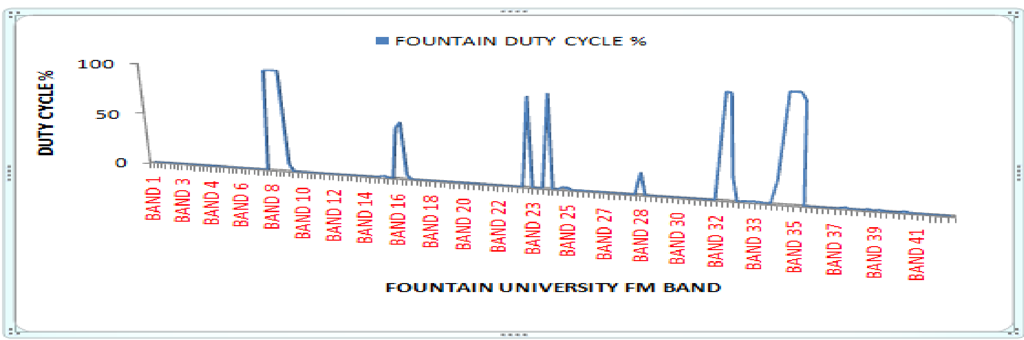


Figure 2: FM (88-108) MHz of duty cycle versus FM band for Fountain University

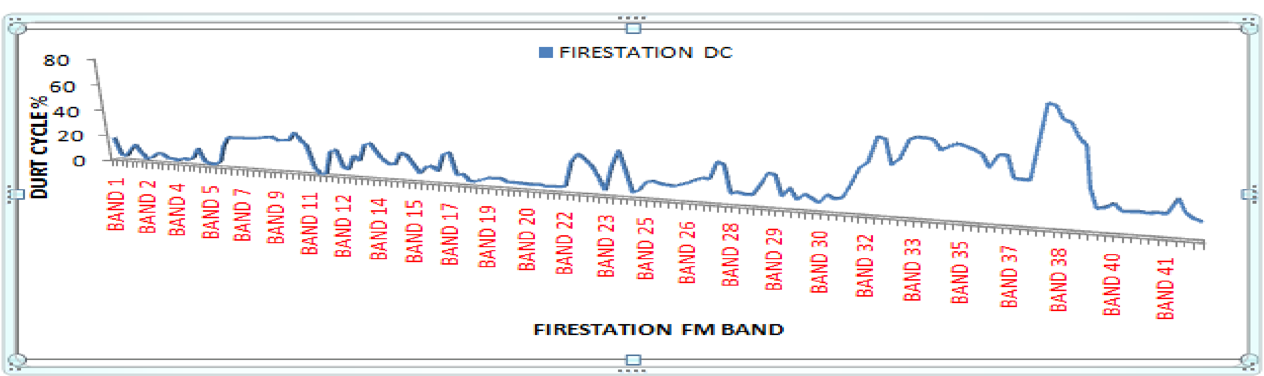


Figure 3: FM (88-108) MHz of Duty cycle versus FM Band for Fire-station

Figure 4 indicates the FM (88-108) MHz of duty cycle in percentage versus the FM band for Uniosun with frequency band 9 of frequency channels 91.625 MHz having a maximum duty cycle of 99.48 % and frequency band 35 of frequency channels 104.375 MHz having a maximum duty cycle of 99.48 %. The average duty cycle was observed to be 89.81 % duty cycle.

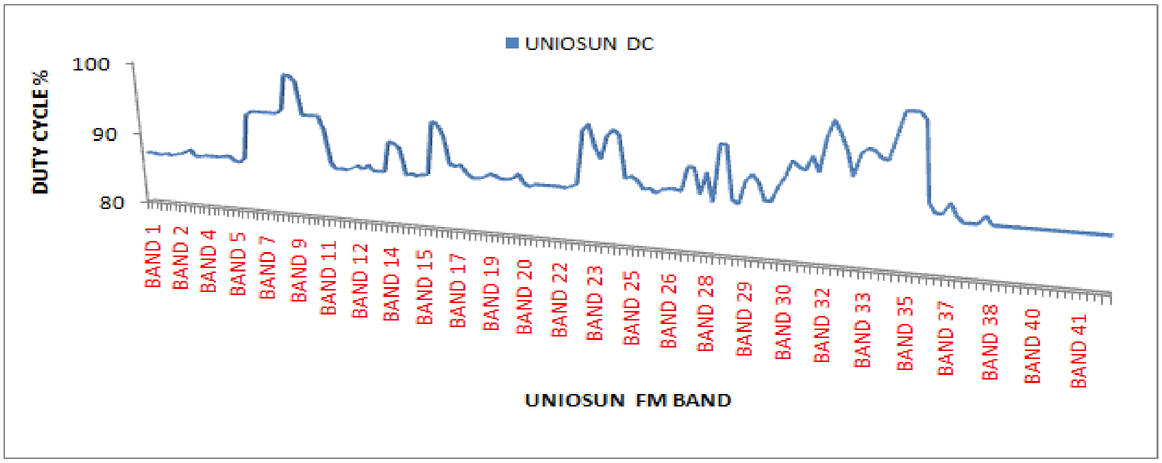


Figure 4: FM (88-108) MHz of Duty cycle versus FM Band for Uniosun

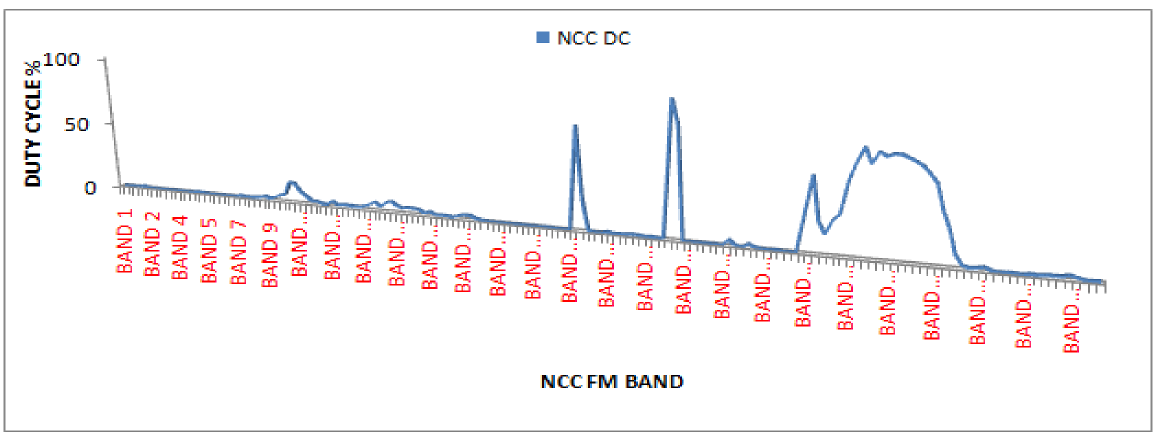


Figure 5: FM (88-108) MHz of duty cycle versus FM band for National Control Centre

Figure 5 indicates the FM (88-108) MHz duty cycle in percentage versus FM band for the National Control Centre with frequency band 27 of frequency channels 100.5 MHz having a maximum duty cycle of 95.32 %. The average duty cycle for the location was 9.53 %.

B. Results of Number of Active Channels for all Locations

Figure 6 indicates the FM (88-108) MHz number of active channels versus the FM band for Fountain University with frequency band 9 of frequency channels (91.625-91.875)

Figure 7 indicates the FM (88-108) MHz number of active channels versus the FM MHz having a maximum number of active channels of 568 channels, and band 35 of frequency channels (104.375-104.625) MHz having the same maximum number of active channels of 568 channel. The average number of active channels for the location was observed to be 48 channels.

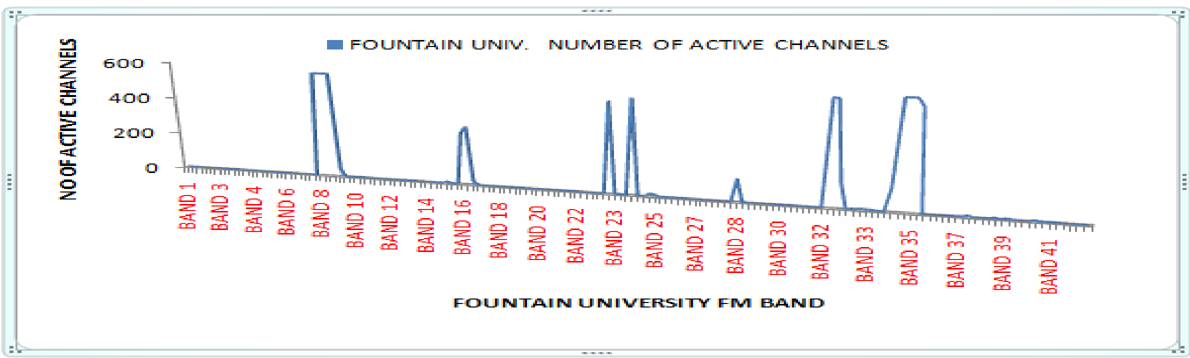


Figure 6: FM (88-108) MHz Number of active channels versus FM band for Fountain University

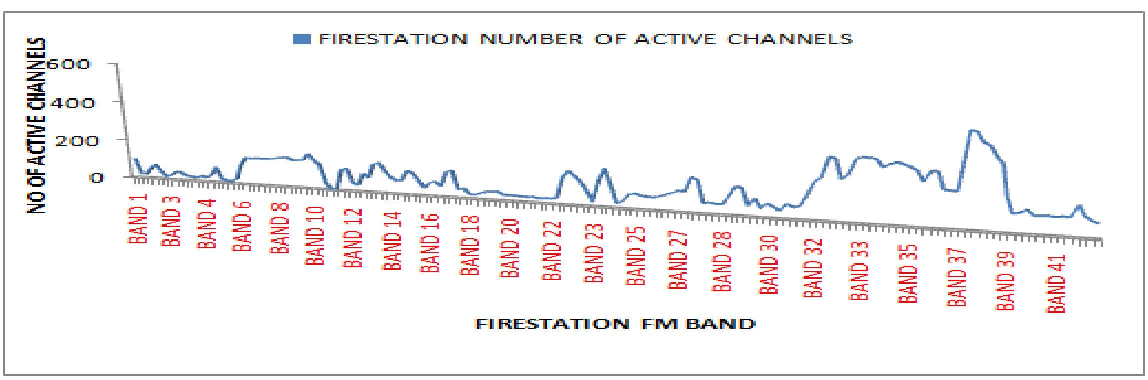


Figure 7: FM (88-108) MHz Number of active channels versus FM Band for Fire-station

band for a Fire station with frequency band 37. The frequency channel 105.625 MHz has a maximum number of active channels of 454; the average number for the location is 114.

Having a maximum

number of active channels of 574 channels, and band 35 of frequency channels (104.375-104.625) MHz having the same maximum

Figure 8 indicates the FM (88-108) MHz number of active channels versus the FM band for the Uniosun campus with frequency band 9 of frequency channel 91.625 MHz

number of active channels of 574 channels. The average number of active channels for the location was observed to be 518 channels

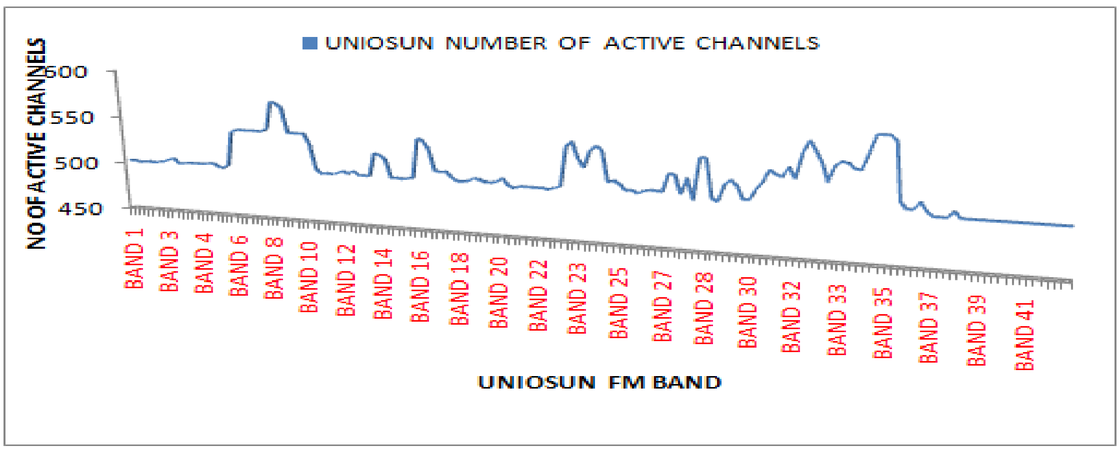


Figure 8: FM (88-108) MHz Number of active channels versus FM Band for Uniosun

Figure 9 indicates the FM (88-108) MHz number of active channels versus the FM band for the National Control Centre with frequency band 27 of frequency channel 100.5 MHz having a maximum number of active channels of 550 channels, the average number for the location was observed to be 55 channels.

C. Results of Number of Inactive Channels for all Locations

Figure 10 indicates the FM (88-108) MHz Power Spectral Density versus FM band for Fountain University with frequency band 35 of frequency channel 104.5 MHz having a maximum power spectral density of -81.04 dB; the average power spectral density for the location was observed to be -88.64 dB.

Figure 11 indicates the FM (88-108) MHz Power Spectral Density versus FM band for Fire-station with frequency band 34 of frequency channel 104.25 MHz having a maximum power spectral density of -73.10 dB/Hz; the average power spectral density for the location was observed to be -91.69 dB/Hz

Figure 12 indicates the FM (88-108) MHz Power Spectral Density versus FM band for the Uniosun campus with frequency band 35 spectral density of -67.50 dB, the average power spectral density for the location was observed to be -95.10 dB.

Figure 13 indicates the FM (88-108) MHz Power Spectral Density versus FM band for the National Control Centre with frequency band 27 of frequency channel 100.5 MHz having a maximum power spectral density of -78.63 dB/Hz, the average power spectral of frequency channel 104.5 MHz having a maximum power

density for the location was observed to be -87.89 dB/Hz.

Table 4 shows the summary of the estimation of the spectrum occupancy characteristics parameters for the four considered locations with the highlighted yellow values having the highest performance index of estimation for the correspondence of location of the occurrence.

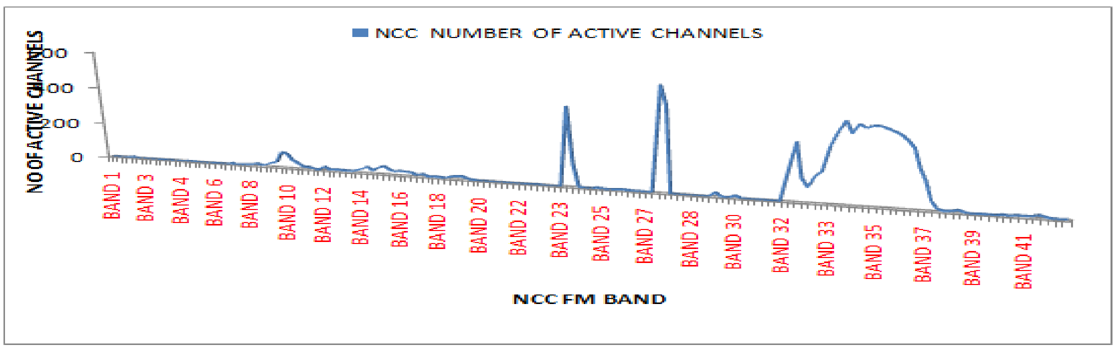
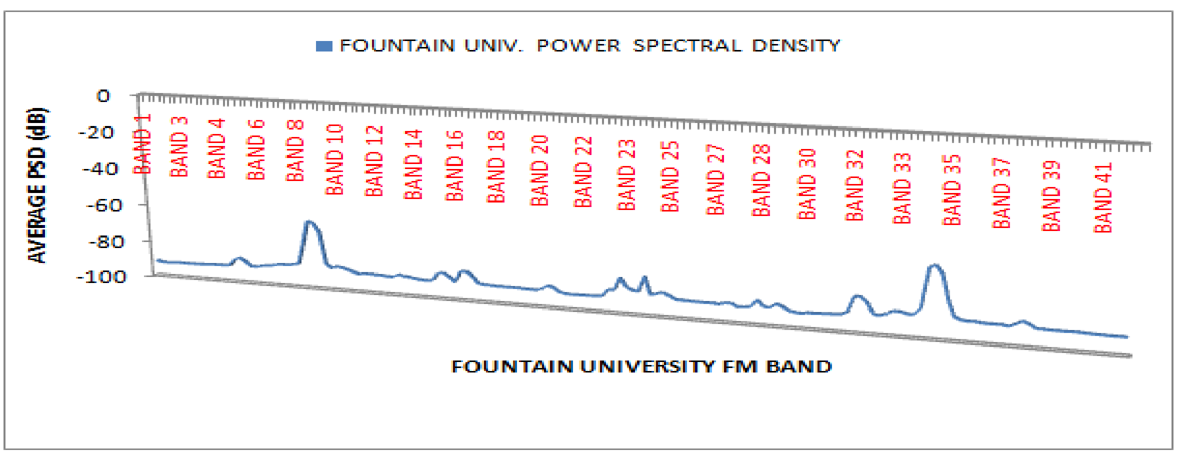


Figure 9: FM (88-108) MHz Number of active channels versus FM band for National Control Centre



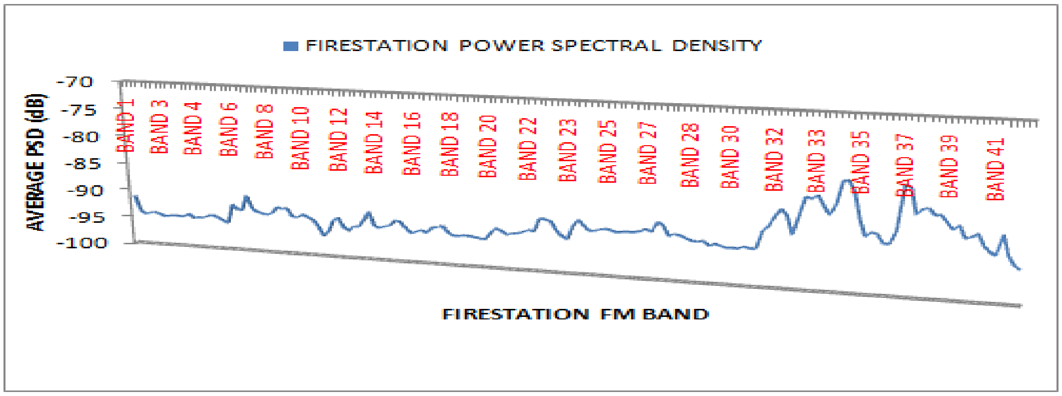


Figure 11: FM (88-108) MHz power spectral density versus FM band for fire-station

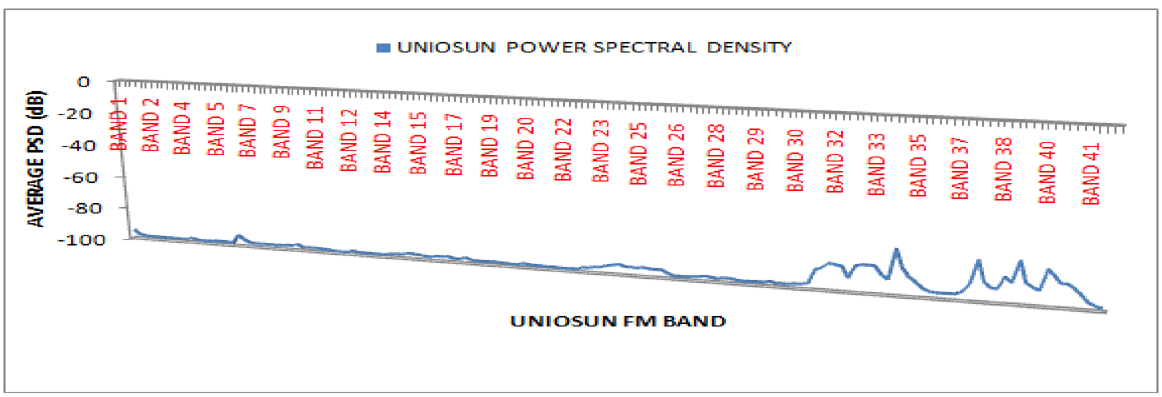
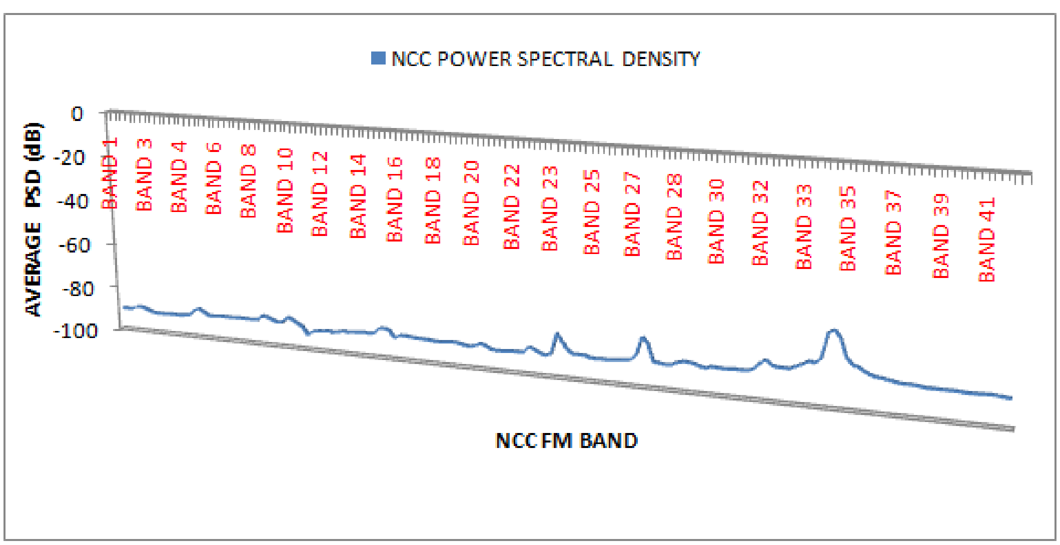


Figure 12: FM (88-108) MHz power spectral density versus FM Band for Uniosun campus



From the Table, Uniosun experienced the highest performance for the five characteristics parameters namely, maximum duty cycle, average duty cycle, maximum power spectral density, average number of active channels and average number of inactive channels, while National Control. Centre Power Line experienced highest performance in the average power spectral density. This implies that the highest signal quality was experienced at Uniosun campus than any other four locations within the 48 hours of spectrum occupancy campaign measurement.

Table 4: Summary of estimation of the spectrum occupancy characteristics parameters for the four chosen locations within Osogbo metropolis

LOCATION	Maximum duty cycle %	Average Duty cycle %	Maximum Power Spectral density dB/Hz	Average Power Spectral density dB/Hz	Maximum number of active channels	Average number of active channels
Fountain University	94.88	8.36	-81.04	-88.64	568	48
Fire-station	78.68	19.77	-73.10	-91.69	454	114
Uniosun campus	99.48	89.81	-67.50	-95.10	574	518
National Control Centre	95.32	9.53	-78.63	-87.89	550	55

IV. CONCLUSION

This research work investigated the spectrum occupancy of the Frequency Modulation within the four specified locations of Osogbo metropolis, Nigeria. The summary of the investigation is given in Table 4. From the table, the maximum duty cycle of 99.48 % spectrum occupancy was observed at the Uniosun campus at band 9 of frequency 91.625 MHz and band 35 of frequency (104.375-104.5) MHz. The maximum average duty cycle of 89.81 % spectrum occupancy, with a total power spectral density of -67.50 dB/Hz, was found at the Uniosun campus out of all four locations. The maximum average power spectral density of -87.89 dB/Hz occurs at the National Control Centre. The maximum number of active channels was found at the Uniosun campus, with 574 active channels found at band 9 of frequency channel 91.625 MHz and band 35 of frequency channels (104.375-104.625) MHz, while the maximum average number of active channels also occur at Uniosun campus with518 number of active channels. This implies that the signal quality level for Frequency Modulation (FM) favoured

Uniosun campus location than all other locations considered in this study.

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