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THE EFFECT OF NOISE FROM POWER GENERATING SOURCE ON MODULATION OF A GLOBAL SYSTEM OF MOBILE TELEPHONY: A CASE STUDY OF MTN COMMUNICATION LTD

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ABSTRACT
GSM operation in Nigeria has generated a lot of concern partly due to the huge economic support/development and partly due to the environmental implication of its operation, the impact of which is the noise emanating from generators supporting the vast number of base transceiver stations (BTS) sites scattered all over the nation. An assessment of the noise effects involved a survey of the six regions covering the entire nation. Noise measurement was taken from each of the base stations on two different occasions. Several noise readings were taken. The research sought to analyze the generator; factor considered in the noise level analysis were the year of installation of generators. The result was then compared with the baseline data of 68dB and the noise level limits specified by FEPA (Federal Environmental Protection Agency).MATLAB SIMULINK blocks were also used to simulate the BTS site to determine the effect of the measured generator noise on signal modulation. Finally recommendations were made to obtain a minimal level of noise at BTS sites.
Keywords: noise pollution, decibel, mobile telephony, GSM operators

INTRODUCTION
Various environmental concerns across the globe have necessitated the need for environmental impact assessment of any major projects that may affect the future sustainability of man on earth. The impact of mobile telephony on environment particularly the noise emanating from generators used to power the Base Transceiver Stations (BTS) is one of such related concerns, considering that Global system of mobile telephony (GSM) is a recent entry into the industry in Nigeria. This is occasioned by the unreliable power supply and thus total dependence on portable electricity generator, to support Mobile Telephone Network (MTN) operation in Nigeria.
MTN Nigeria was incorporated on 8th November 2000 as a private company. In February 2001 it secured a 15yrs license from Nigeria communications commission (NCC) to provide global system for mobile telephony services in Nigeria through a band spectrum of 900MHz and 1800MHz.
The use of generators was earlier envisaged by MTN during the planning stage. This necessitated the execution of environmental impact assessment for noise level of generators installed in all the MTN operations, both for the switch and base transceiver stations, (BTS), for which a baseline data of 68decibel was established.
The operation of MTN and other GSM operators have found a place in Nigeria because the first telecommunication facilities in Nigeria established in 1886 by the colonial administration were geared towards discharging administrative functions rather than the provision of socio-economic development of the country. Since independence in 1960, there has been a number of development plans for the expansion and modernization of the telecommunication facilities. However, most of these plans were not fully implemented. In January 1985, the Nigeria telecommunication limited (NITEL) was incorporated to harmonize the planning and co-ordination of the internal and external telecommunication services, rationalize investments in telecommunication development and provide accessible efficient and affordable services (NESG, 2001). Due to the need to embrace modern telecommunication systems, this created the room for mobile cellular operators to be licensed and one of these is MTN.

Aim and Objectives of the Study

The commencement of MTN operation in Nigeria witnessed the deployment of numerous base transceiver station (BTS) sites and switch centers in different locations. In 2003, there were 3000 BTS sites in Nigeria, and each of these has two generators to provide portable electricity to support their operations. The aim of the study is to assess the noise impact by comparing the measurements obtained from MTN generators with baseline data of 68decibel, considering the effects of generator age and maintenance profile. These measured noise level will be simulated using MATLAB Simulink Blocks to determine its effect on modulation signals on BTS sites within 900MHz and 1800MHz frequency band.

This study thus assesses the noise pollution arising from MTN operations based on the bench mark level of 68dB obtained from baseline studies and noise level rating by Suter (Suter.A.H, 2005).The following objectives will be pursued:

1) To determine the noise level in these areas and compare these with the permissible limits of 68 decibel.
2) To recommend possible noise control measures to bring the effects of the noise within tolerance limits.

Scope of Study

The study covered the six regions of MTN operations in Nigeria, namely Lagos, Abuja, Kano, Port Harcourt, Kaduna and Enugu. Only the environmental effect of noise from generating sets was considered and possibly identifying effective mitigation measures.

Basic Concept in Noise Pollution

Noise means unwanted or unpleasant sound that causes discomfort and irritations to human beings. Noise pollution thus means unpleasant sound in the atmosphere causing health hazards like sleeplessness, annoyance, stress and fright. The major sources of noise pollution are jet planes, traffic, loud music played during the marriage parties or other occasions and industries. It is a growing nuisance especially in the cities. However, noise pollution is subjective since a particular source of noise may be irritating for few while pleasing for others. It is a different type of pollution since its effects are transient (once the noise stops, the atmosphere is free from it). In other words, noise is a controllable pollutant (H.P.Singh, 2007).

In simple terms, noise is unwanted sound. Sound is a form of energy, which is emanated by a vibrating body and on reaching the ear, causes the sensation of hearing through nerves (Bruer and Kjaer, 2000). Noise may be continuous or intermittent. Noise may be of high frequency, which is undesired for a normal hearing, for example the typical cry of a child produces sound, which is mostly unfavorable to normal hearing. Since it is unwanted sound, it is called noise. During the process of transfer, air molecules oscillate and the small displacement of air molecules creates pressure waves. If the air molecule oscillates at a frequency f, and the noise (sound) travels at a velocity v, the wavelength of the sound λ Is given by

$$\lambda = v/f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where:

λ = wavelength, in meters

v = velocity of sound in a given medium in m/s

f = frequency in cycles/second or Hz.

Frequency and amplitude are two basic parameters that describe noise. Amplitude is expressed as noise level, NL, and if it is plotted against time for a pure noise (noise with only one frequency), the wave produces a sinusoidal trace. The amplitude of noise wave is measured in units of pressure, N/m^2. The range of pressure waves which the human ear can detect (audible sound) is $2x\ 10^{-5}$ to $2x10^{+5}\ N/m^2$, an obviously inconveniently large range. As a result, sound pressures are expressed in decibels (dB). Decibel is not a unit of anything but a logarithmic ratio of two pressures.

Noise level is thus defined by a ratio of two pressures one being a reference pressure (Vesilind and Pierce, 1983) that is

$$NL\ (dB) = 20\log_{10}(P/P_o) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where NL (dB) = Noise level in dB

P= Pressure of noise wave, N/m^2 and

P_o = some reference pressure, generally chosen as the threshold of hearing $2x10^{+5}\ N/m^2$

Noise Measurement Instruments

Noise measurement is an important diagnostic tool in noise control technology. The objective of noise measurement is to make accurate assessment, which gives a purposeful act of comparing noise under different conditions and the determination of noise impacts and suitable noise control/reduction techniques. The time constants used for the sound level meter standard are

S (slow) = 1seconds

F (fast) = 125 milli seconds.

Relatively steady sounds are easily measured using the 'fast' response and unsteady sounds using 'slow' responses. When measuring long term noise exposures, the noise level is not always steady and may vary considerably, in an irregular manner over the measurement period. Measuring the continuous equivalent level, which is defined as the constant sound pressure level, which would have produced the same total energy as the actual level over the given time, can solve this uncertainty?

International Standard on Noise

International standards are important in the assessment of environmental noise either because they are used directly or because they provide inspiration or reference for national standards. This section highlights some of the more important standards. There are two main international bodies concerned with standardization. This international organization for standardization (ISO) deals with methodology to ensure that procedures are defined to enable comparison of results. The international electro technical commission (IEC) deals with instrumentation to ensure that instruments are compatible and can be interchanged without major loss of accuracy or data (IS:3483,1965).

METHODOLOGY

This study spans the operation area of MTN Nigeria, which lies within the geographic co-ordinates of latitude 4^o to 14^oN; and longitude 3^o to 14^oE. It is bordered to the north by Niger Republic, to the south by Gulf of Guinea, to the northeast by Chad Republic, while United Republic of Cameroun and Benin Republic are to the east and west, respectively.

Nigeria is a republic comprising 36 states and a Federal capital Territory; Abuja. It has a presidential system of government with three tiers: local government authorities; state governments with state legislative house; and federal government with two legislative houses. The states have been grouped into six regions in line with MTN operations. The main MTN operations are in the cities of the six regions namely: Lagos, Abuja, Port Harcourt, Enugu and Kano.

Mode of Measurement

Readings for noise are first taken at a node a distance of 1.5m from the source and thereafter at nodes at progressive intervals of 1.5meters.For each successive node measured, time for noise measurement was increased by 10seconds to a maximum of 100seconds.This approach was adopted in other to maintain a uniform scale from each node.

The factors taken into consideration, in determining the noise effects for which data was obtained through desk research include year of installation of generating sets and maintenance frequency.

A total of two visits were made per location for data collection and data were collected by direct physical measurement. The readings recorded are the averages of the measurements. During each visit the measurements were taken two times.

A total of two times ten different measurements were obtained (twenty) for each location. Forty-five locations were covered for BTS site making a total of 900 readings, while nine switch sites were covered giving a total of 180 readings. The total numbers of readings were 1080.

Equipment for Data Collection

The noise levels from the various locations were measured using sound level meter (SLM) type 1. The sound level meter consists of a microphone, electronic circuit and a readout display. The microphone detects the small air pressure variation associated with sound and changes them into electrical signals. These signals are then processed by the electronic circuitry of the instrument. The readout displays the sound level in decibels. The sound level meter takes the sound pressure level at one instance in a particular location.

The procedure adopted to ensure the reliability and accuracy of the data was as follows:

- When taking measurements, the sound level meter was held at arm's length since from the manual it was stated that it does not matter whether the microphone is pointed at the noise source or not but the manual explains how to hold the microphone. The noise level meter was calibrated before and also after measurements, the sound level meter manual also gave the calibration procedure.
- The mode of measurement indicating the source and node intervals. The sound level meter can take readings on either slow or fast response. The response rate is the time period over which the instrument averages the sound level before displaying it on the readout. The measurements were carried out at fast response.
- When air blows across the microphone, the noise readings are altered. To avoid the effect of wind, the measurements were taken with the aid of a windscreen to cover the microphone in area with considerable air movement. The windscreen is attached to the sound level meter and it is detachable.
- The sound level meter was calibrated before and also after measurements.

Noise measurements were taken in the open fields and the average noise levels were determined by calculations. Data are as tabulated in the appendixes**.**

Data Analysis

Statistically, average mean noise level determination was carried out for all the locations. To add the dBs is to convert the individual dB values to linear values, add these together, and convert back to dB using the following equation (Bruer and Kjaer, 2000).

$$L = 10x\log_{10}([10^{L1} + 10^{L2} + \ldots\ldots\ldots + 10^{Ln}]/n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where L=Noise level at distance (m) in decibel

n = number of n^{th} distance from the source of the noise.

The sample of the calculation based on the raw data is shown in Table 2.1.The relevant equation for this is given by equation (2.5).Since basically the same calculations are involved for appendixes, the analysis procedure is the same for all.

Table 1. Calculation of Mean Noise Level for MTN Switch at Ikoyi Urban

Gen.Type: 15KVA Lister Perkin. Soundproof: Foreign made			Maintenance: Bi-monthly.	Date installed: 2003
Loc:Ikoyi (urban)			Average Noise Levels at this Location L (dB)	Initial Baseline Data (dB)
Time In sec	Dist from source in m	dB(A)		
10	1.5	86	83.55	68
20	3.0	84	83.55	68
30	4.5	84	83.55	68
40	6.0	83	83.55	68
50	7.5	83	83.55	68
60	9.0	83	83.55	68
70	10.5	82	83.55	68
80	12.0	82	83.55	68
90	13.5	81	83.55	68
100	15.0	81	83.55	68

The average noise levels at Switch operation Ikoyi 1

Based on the measurements from L_1 to L_{10}. Noise levels are to be logarithmically averaged. Average of L_1,L_2, to L_{10} =L.Convert the noise levels from Decibels to bels

i.e. L_1 =81dB or 8.1bels, $L=10x\log_{10}([10^{8.1} + 10^{8.2} + 10^{8.3} + 10^{8.4} + 10^{8.6}]/5)$

$= 10 \text{ x } \log_{10}[226464430.759] \quad = 10 \text{ x } 8.355 = 83.55\text{dB}$

Table 2 MTN Operation Areas in Nigeria Data Analysis

S/No	Generator Noise source (location)	Average Noise Level (dB)	Year Installed	Sound-Proof Make	Initial Baseline Data	Maintenance Frequency	FEPA RECOM dB(8hrs duration)	Remarks
1	Ikoyi Urban 1 (Switch)	83.55	2003	Foreign	68	2months	90	High
2	Enugu Urban (Switch)	85.23	2003	Foreign	68	2months	90	High
3	Benin Urban (Switch)	74.23	2004	Foreign	68	2months	90	Moderate
4	Kano Urban (Switch)	85.23	2003	Foreign	68	2months	90	High
5	Ikeja Urban (Switch)	72.98	2004	Foreign	68	2months	90	Moderate
6	Abuja Urban (Switch)	83.64	2003	Foreign	68	2months	90	High
7	Kaduna Urban (Switch)	77.23	2004	Foreign	68	2months	90	Moderate
8	PHC Urban (Switch)	82.23	2003	Foreign	68	2months	90	High
9	Ibadan Urban (Switch)	76.23	2004	Foreign	68	2months	90	Moderate
10	Kano Urban 1 (BTS)	84.64	2003	Local	68	Monthly	90	High
11	Kano Urban 2 (BTS)	82.64	2003	Local	68	Monthly	90	High
12	Kano Urban 3 (BTS)	81.16	2003	Local	68	Monthly	90	High
13	Kano Remote 1 (BTS)	94.23	2003	Foreign	68	2months	90	Very High
14	Kano Remote 2 (BTS)	94.64	2003	Foreign	68	2months	90	Very High
15	Kano Remote 3 (BTS)	93.23	2003	Foreign	68	2months	90	Very High
16	Abuja Remote 1 (BTS)	94.64	2003	Foreign	68	2months	90	Very High
17	Abuja Remote 2 (BTS)	93.23	2003	Foreign	68	2months	90	Very High
18	Abuja Remote 3 (BTS)	92.64	2003	Foreign	68	2months	90	Very High
19	Abuja Urban 1 (BTS)	83.16	2003	Local	68	Monthly	90	High
20	Abuja Urban 2 (BTS)	84.23	2003	Local	68	Monthly	90	High
21	Abuja Urban 3 (BTS)	82.64	2003	Local	68	Monthly	90	High
22	Ibadan Remote 1 (BTS)	96.64	2002	Foreign	68	2months	90	Very High
23	Ibadan Remote 2 (BTS)	94.64	2002	Foreign	68	2months	90	High
24	Ibadan Remote 3 (BTS)	97.23	2002	Foreign	68	2months	90	Very High
25	Ibandan Urban 1 (BTS)	85.64	2002	Local	68	Monthly	90	High
26	Ibadan Urban 2 (BTS)	83.64	2002	Local	68	Monthly	90	High
27	Ibadan Urban 3 (BTS)	84.64	2002	Local	68	Monthly	90	High
28	Lagos Remote 1 (BTS)	96.23	200	Foreign	68	2months	90	Very High
29	Lagos Remote 2 (BTS)	94.64	2002	Foreign	68	2months	90	Very High
30	Lagos Remote 3 (BTS)	93.64	2002	Foreign	68	2months	90	Very High
31	Lagos Urban 1 (BTS)	84.23	2002	Local	68	Monthly	90	High
32	Lagos Urban 2 (BTS)	83.64	2002	Local	68	Monthly	90	High
33	Lagos Urban 3 (BTS)	85.94	2002	Local	68	Monthly	90	High
34	PHC Remote 1 (BTS)	94.64	2003	Local	68	2monthly	90	High
35	PHC Remote 2 (BTS)	94.23	2003	Foreign	68	2months	90	Very High
36	PHC Remote 3 (BTS)	94.64	2003	Foreign	68	2months	90	Very High
37	PHC Urban 1 (BTS)	81.64	2003	Local	68	Monthly	90	High
38	PHC Urban 2 (BTS)	85.23	2003	Local	68	Monthly	90	High
39	PHC Urban 3 (BTS)	82.23	2003	Local	68	Monthly	90	High
40	Enugu Remote 1 (BTS)	94.23	2003	Foreign	68	2months	90	Very High
41	Enugu Remote 2 (BTS)	94.23	2003	Foreign	68	2months	90	Very High
42	Enugu Remote 3 (BTS)	94.23	2003	Foreign	68	2months	90	Very High
43	Enugu Urban 1 (BTS)	80.23	2003	Local	68	Monthly	90	High
44	Enugu Urban 2 (BTS)	80.98	2003	Local	68	Monthly	90	High
45	Enugu Urban 3 (BTS)	82.23	2003	Local	68	Monthly	90	High

DISCUSSION

Bar charts shown in Figures 2.6 and 2.7 are used to explain the relationship between noise level and the years of installation and maintenance frequency respectively.

90dB (A) is the maximum exposure limit recommended by Federal Environment Protection Agency, FEPA (1991). Any noise level, beyond this critical value of 90dB (A), which is the threshold limit for commencement of hearing damage is high or very high and objectionable.

For conversation noise level limit is at 85dB (A), thus any noise level beyond this limit is considered a nuisance, since it masks speech.

Any worker exposed to this noise level definitely needs an ear protection. FEPA statement is not very specific on sound pollution levels consequently the specifications of Suter (2005) are utilized, which is as follows:

i) 70dB (A) < NPL, noise level is low.

ii) For 70dB (A) < NPL< 80dB (A), noise level is Moderate.

iii) For 80dB (A) < NPL< 90dB (A), noise level is high.

iv) For NPL >90dB (A), noise level is Very high.

Factors Influencing Noise Level

Year of Installation

Table 2.3 and Fig 2.6 presented the relevant information with respect to year of installation from which it was noted that noise level increases with age of installation of the facility. The generators installed in the year 2004 had moderate noise levels below 77dB, while the noise level of generators installed in the year 2003 were all far above 80decibels (High noise levels). From the histogram, it was observed that noise level varies depending on locations. Port Harcourt and Abuja gave low noise level compared to Enugu and Kano. Using the noise level baseline/limit of 68dB, it can be said that these generators have depreciated and the noise level also increased with the passage of time. Most of the generators in the BTS sites were installed almost at the same time.

Table 3 ANALYSIS BASED ON YEAR OF INSTALLATION

S/N	LOCATION SOURCE	YEAROF INSTALLATION	AV.NOISE LEVEL dB(A)
1	IKOYI	2003	83.55
2	ENUGU	2003	85.23
3	KANO	2003	85.23
4	ABUJA	2003	83.64
5	PORT-HARCOURT	2003	82.23
6	BENIN	2004	74.23
7	KADUNA	2004	77.23
8	IBADAN	2004	76.23

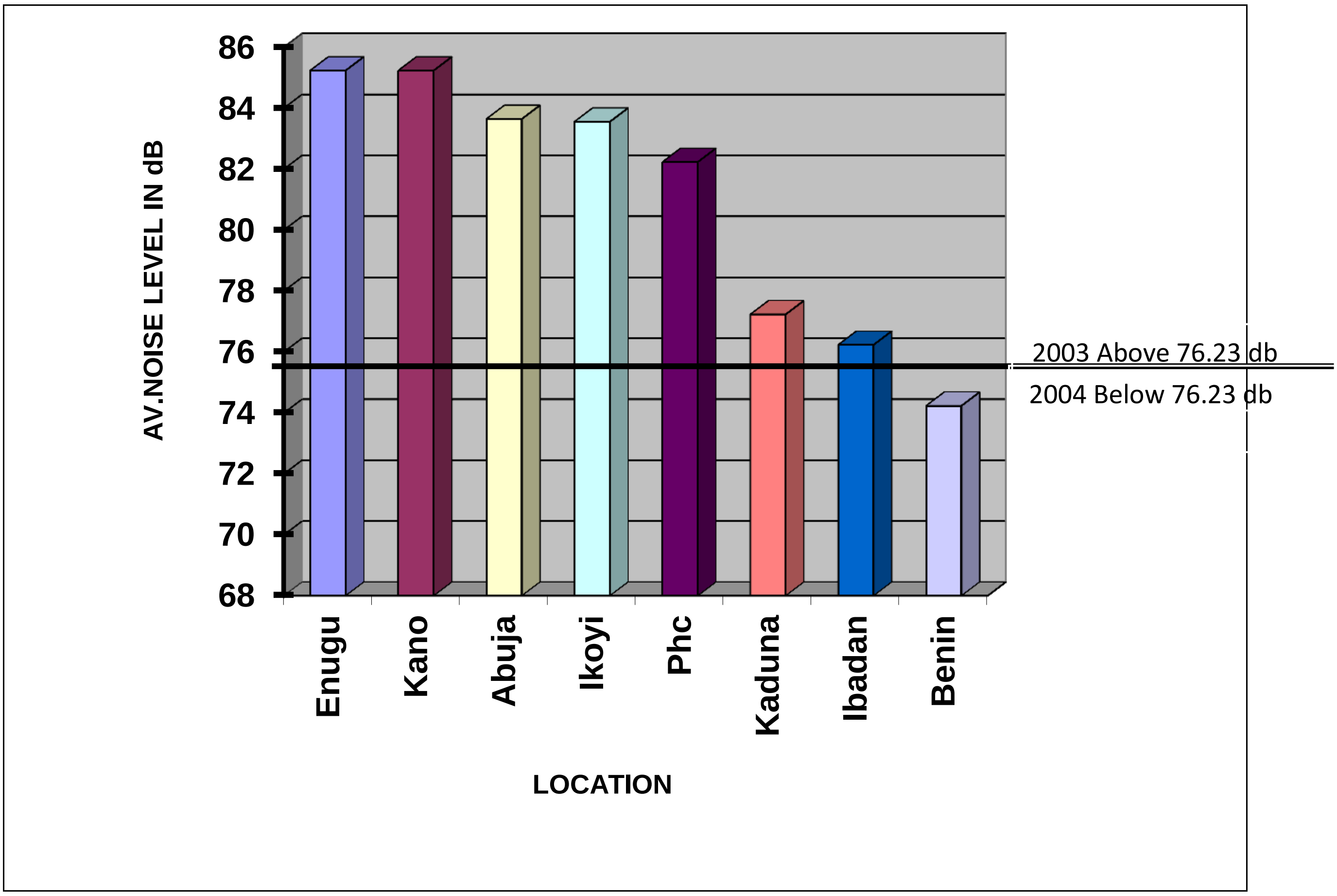

Fig 1: Year of installation Analysis

ANALYSIS OF FIELD DATA

It is observed from Fig 1 that the year of installation of generator has a considerable effect on the level of noise generated at BTS sites. Locations like Ikoyi, Enugu, Kano, Abuja and Port Harcourt whose generators are installed in 2003, have average noise level ranging from 82.23dB (A) to 85.23 dB(A). While locations like Benin, Kaduna, and Ibadan whose generators were installed in 2004 have average noise level ranging from 74.23 dB(A) to 76.23 dB(A). Conclusively it can be deduced that the year of installation of generators have a significant effect on the noise level generated at the BTS sites.

Also the noise level at the BTS sites increased from baseline limit of 68dB at the time of installation to 85dB after 7years for one-month maintenance and from 68db to 95db after 7years for two monthly-maintained MTN facilities. Over the period of seven years, the generators at the low noise level were already at the apex of the medium noise level for the monthly-maintained facility and at the very high level for the two monthly maintained one. In conclusion, there is a significant increase over seven years justifying replacement plan for the generators.

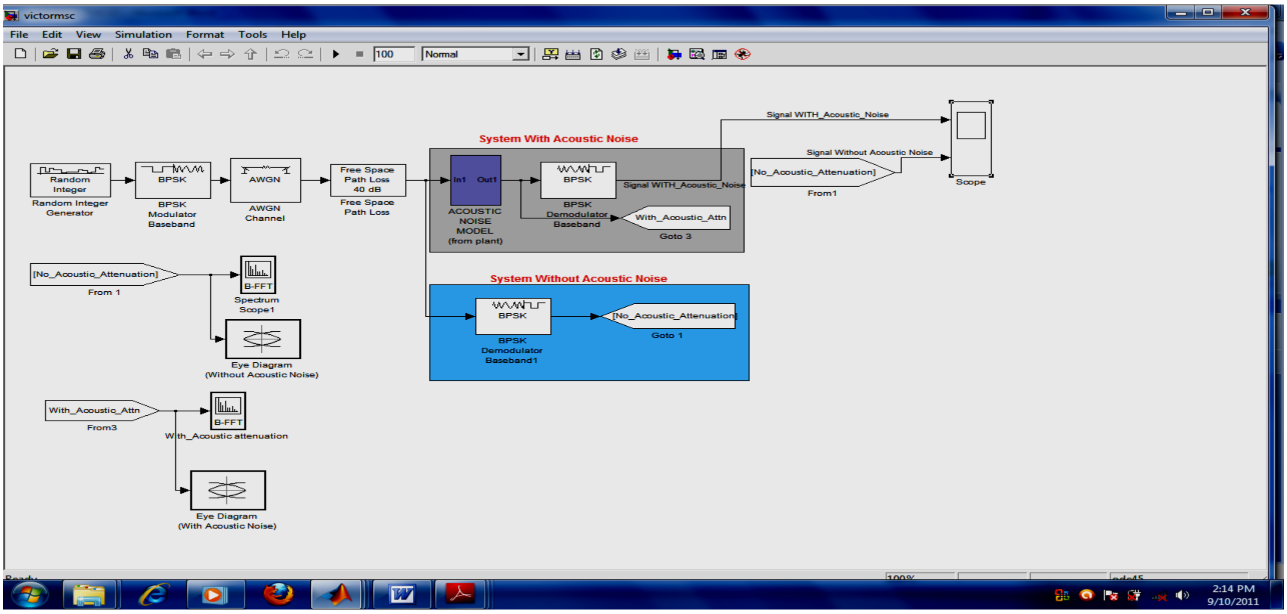

Fig 2: SIMULINK Model of the Base Transceiver Station (BTS)

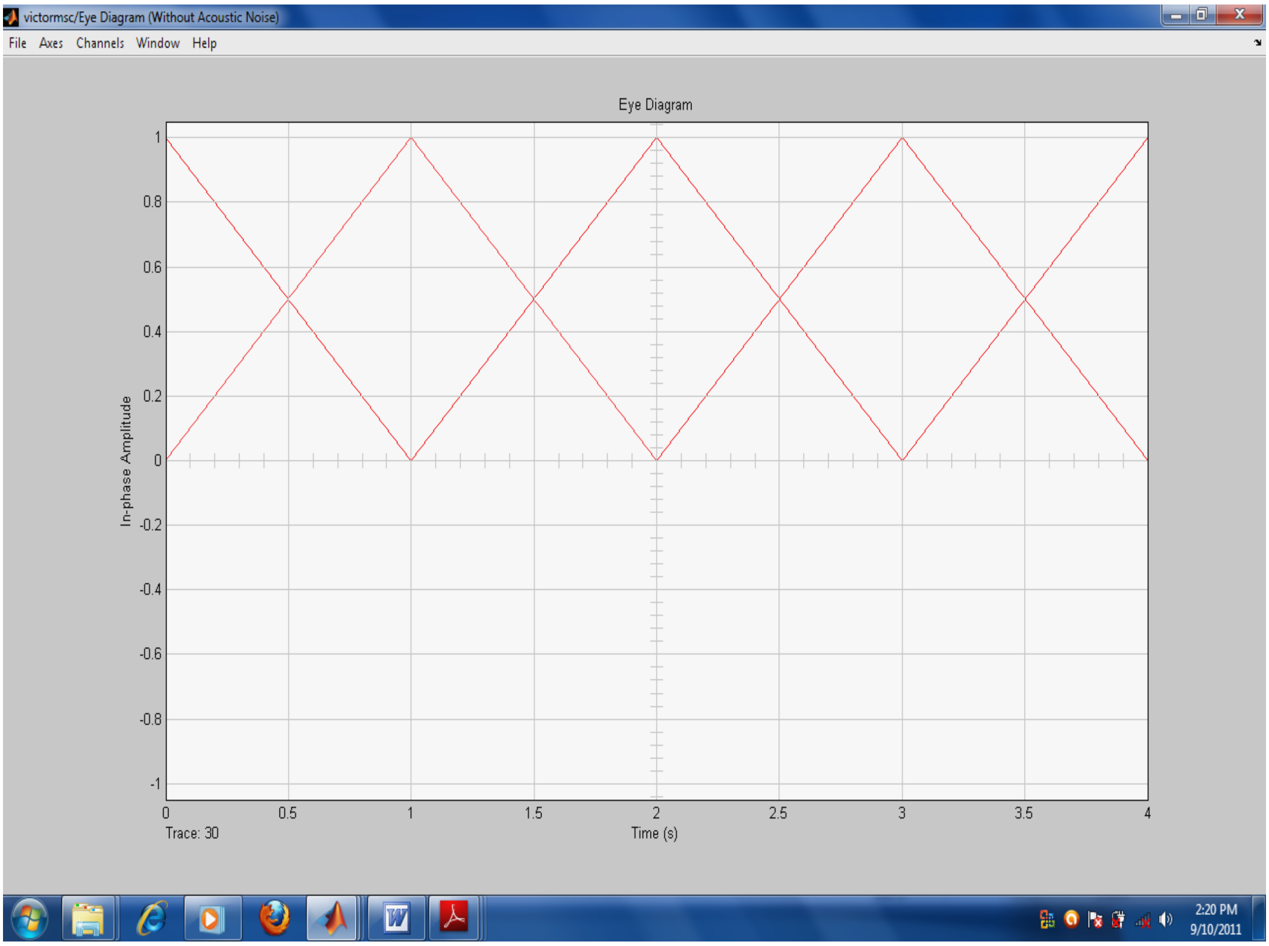

Fig 3: Eye diagram of modulated signal without generator (Acoustic) noise.

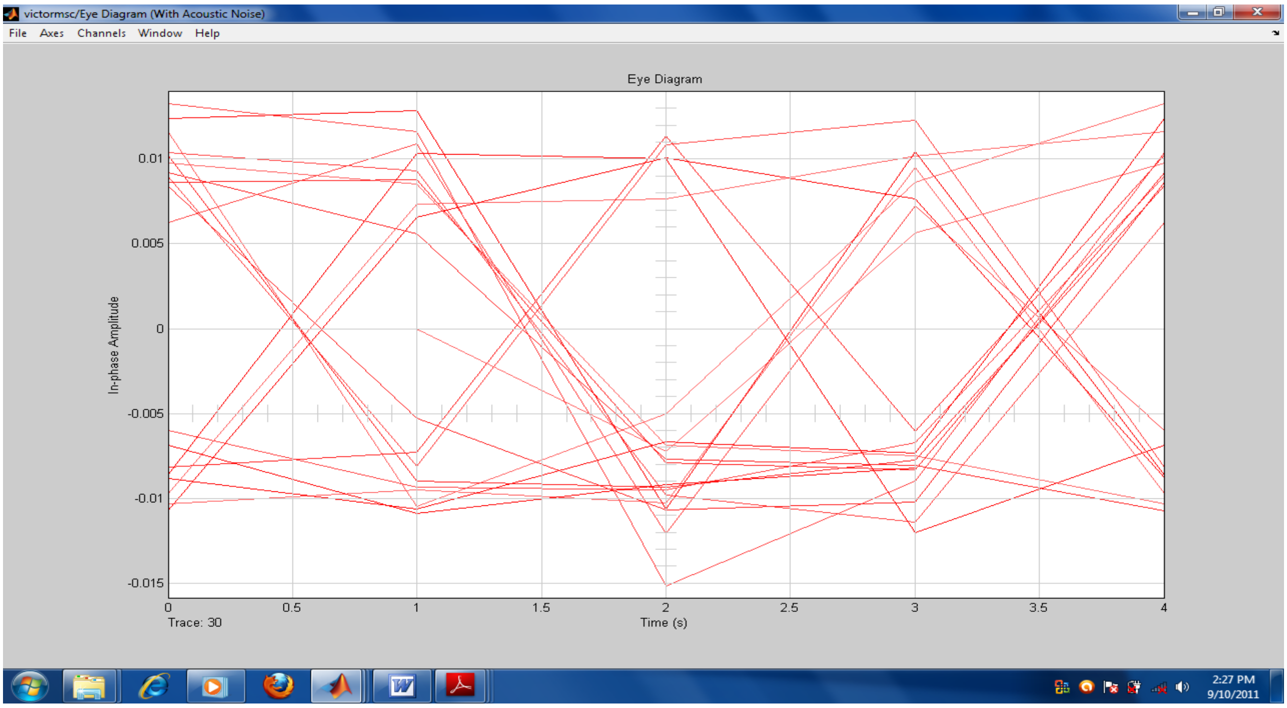

Fig 4: Eye diagram of modulated signals with generator (Acoustic) noise.

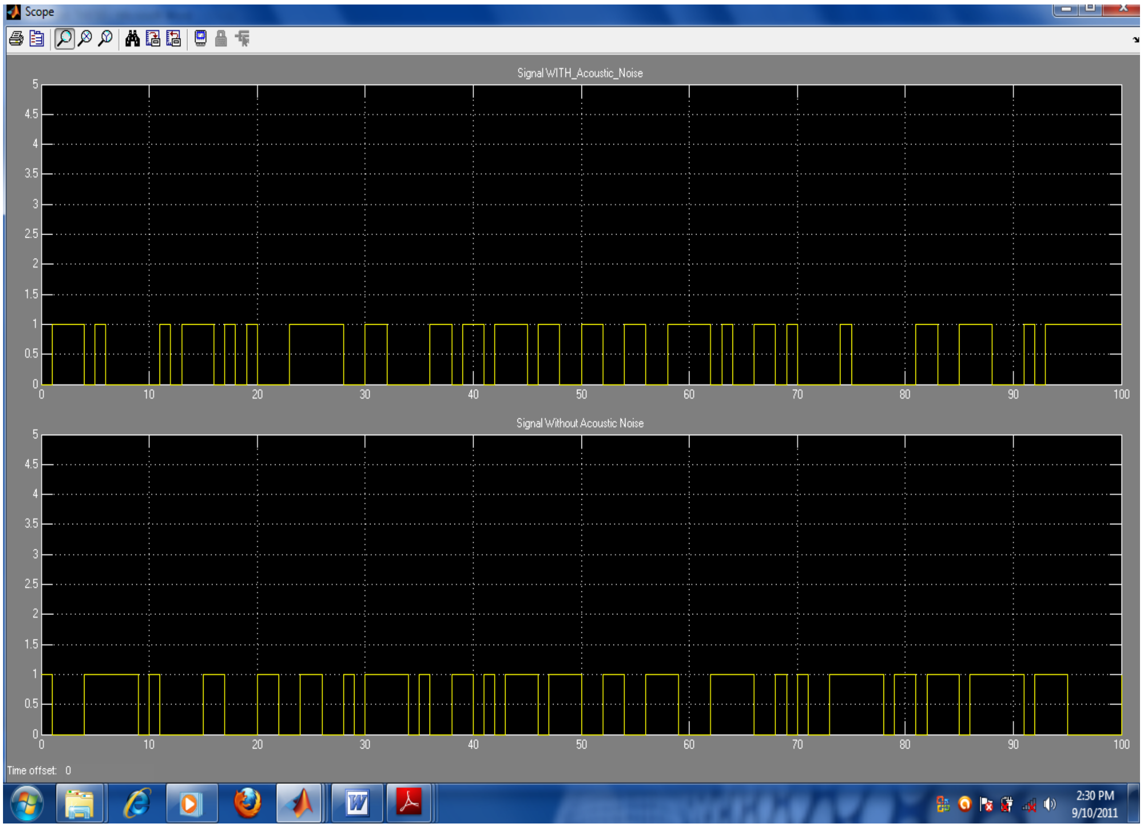

Fig 5: Distortion of Modulated Signal in a GSM Network.

SIMULINK Based Modelling of GSM BTS Site

The model in fig 2 represents a simulation of a typical GSM transmitter using MATLAB/SIMULINK block. When the transmitter was modeled considering a baseline noise level of 70dB (A) as the optimum noise level at BTS site, the eye diagram block produced a modulated signal as shown in fig 3. When the model was exposed to noise level above 70dB (A) as it is in case of generators situated in most BTS sites, the eye diagram produced a distorted modulated signals (fig 4). This conclusively show that generator noise have a significant effect on modulated signals.

DISCUSSION OF SIMULATION RESULT

A signal is an oscillating wave-form of electromagnetic representation of data as a function of time so that it can be reliably carried over the medium. Sinusoidal functions are single frequency functions with three attributes, namely, the amplitude, the frequency and the phase. The amplitude of the signal is the maximum value of the signal and is the voltage, the frequency of the signal is the number of cycles (or wavelengths) per seconds, and the phase of the signal is the angle of the sinusoid when t= 0.

Consequently, these are the attributes of the signal which are affected by the noise, not to mention if external noise is also involved as the case was when BTS sites were subjected to noise level of 70dB(A). The reasons may be many but the following three are the major contributing factors in making a source or information signal no longer suitable for direct transmission because:

- Its bandwidth is large compared to a central frequency that means there is significant frequency distortion which cannot be compensated.
- Its does not lie in frequency band that can be transmitted over the media.
- It does not fully utilize the capacity of the channel to facilitate signal transmission.

The waveforms of Fig 4 when the system was subjected to external noise is a clear prove of how noise can be damaging to information carrying signal as compared to that of Fig 3 with no external noise. The amplitude (voltage), frequency and phase of Fig 5 were completely changed and distorted beyond recognition. Such signals are difficult, if not, impossible to recover even with powerful detection techniques. Hence, the lesser the effect of external noise the better the modulated signals.

RECOMMENDATION FOR IMPROVEMENT OF NOISE LEVEL

FEPA needs to consider figures or range of 68dB as low, 70-78dB as medium and above 80dB as high noise level. The make of soundproofing type (local or foreign) has no impact on noise level control, so use of locally made models will be a benefit to the nation from economic point of view.

PHCN (Power Holding Company of Nigeria) needs to ensure steady supply of electric power to power BTS sites; this will consequently eliminate the use of generator on BTS sites thereby totally reducing the noise generated on BTS site.

CONCLUSION

Noise level measurements were taken at MTN BTS sites within the country; namely Lagos, Abuja, Kano, Port Harcourt, Kaduna and Enugu, only the environmental effect of noise from generator set was considered. The noise level measurements were analyzed based on the year of installation of generators, taking cognizance of FEPA noise level benchmark of 68dB (A). The research revealed that when the noise level was analyzed based on the year of installation, generator installed in the year 2004 had moderate noise level below 70dB (A), while the noise level of generators installed in 2003 were far above 80dB(A). These results obtained were above the 68dB (A) as specified by Federal Environmental Protection Agency (FEPA), therefore revealing non compliance to FEPA specification. From the plot of fig 4, it can be clearly seen that the modulated signal distortion as a result of influence of generator noise is evident when compared with the plot in fig 3 where the BTS site was exposed to optimum noise level 70dB(A) . This deductions verifies that noise have a significant effect on signal modulation and therefore should be minimized as much as possible to facilitate effective modulation processes on BTS sites.

Furthermore, when comparing the signal modulation plots (fig 5) with the oscilloscopic outcome of the model developed. It can be seen that the signal distortion as a result of generator noise is visible at the entire simulation time indicating significant effect of noise on BTS sites.

REFERENCES

Bruel,P.V and Kjaer, V (2000) "Environmental Noise Booklet".Published by Bruel and Kjaer Head

Federal Environmental Protection Agency, FEPA (2002) "Guidelines and standards for Environmental pollution control in Nigeria" (pp 28).

Ferreira, A.J.M,(2009) "MATLAB Codes For Finite Element Analysis",Springer .ISBN 978-1-4020-9199-5.

H.P.Singh (2007) "Noise and microbial pollution" Lecturer, Centre for Environment & Vocational Studies Panjab University, Chandigarh

Ibrahim, D. A. (2008). "Measurement of Radio Wave Propagation in Urban Environment (A Case Study of M-TEL Network, Kaduna)" Msc Thesis, Electrical Engineering Department Ahmadu Bello University Zaria, pp 17, 71-73.

IS: 3483 (1965) "Code of practice for noise reduction in industrial buildings, Bureau of Indian standards", New Delhi.

Joshi, G. G. (2005). "*Near Ground Channel Measurements over Line of Sight and Forested Paths*", IEEE Proceedings on Microwave, Antennas and Propagation. Pp 589 – 596.

Meng et al, Y.S. (2009). " Study of Propagation Loss Prediction in Forest Environment". Msc Thesis Progress report, School of Electrical and Electronics Engineering Nanyang Technological University Singapore, Vol 17, pp 122 - 123.

Mishra, A.R. (2004) "Fundamentals of Cellular Network Planning and Optimization" John Wiley & Sons Ltd, New York. pp 28.

NESG,(2001) Nigerian Communications Commission, "One Year of GSM Revolution,What Future for Telecommunications".Sept,2001.

OSHA (2005) "Occupational Safety and Health Admin,Occupational Noise Exposure"Hearing Conservation Amendment,46 Fed.Reg. 4078-4179.

SAGEM. (2003). "*SAGEM OT 200 Product Line*". SAGEM Engineering Mobile. Seybold, J. S. (2005). "*Introduction to RF Propagation*", John Wiley & Sons Inc, New York. Pp 134-143.

Suter, A.H (2005) "The Effects of Noise on Performance". Tech. Mem. 3-89, U.S. Army Human Engineering Lab,A berdeen Proving Ground,MD.

Vesilind, P.A and J.J Pierce (1983) "Environment Pollution and Control", 2nd edition, Published by Ann Arbor Science, Butterworth Ltd, England.

William, C. Y. L. (2005). "Mobile Cellular Telecommunications: Analogue and Digital Systems", McGraw-Hill, Inc, New York, Second Edition, pp 124- 125.