FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

THE ELECTRIC POWER TRANSMISSION LINE - A VIABLE LINK FOR INTELLIGENCE TRANSMISSION

By

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INAUGURAL LECTURE SERIES 41

17TH MARCH, 2016

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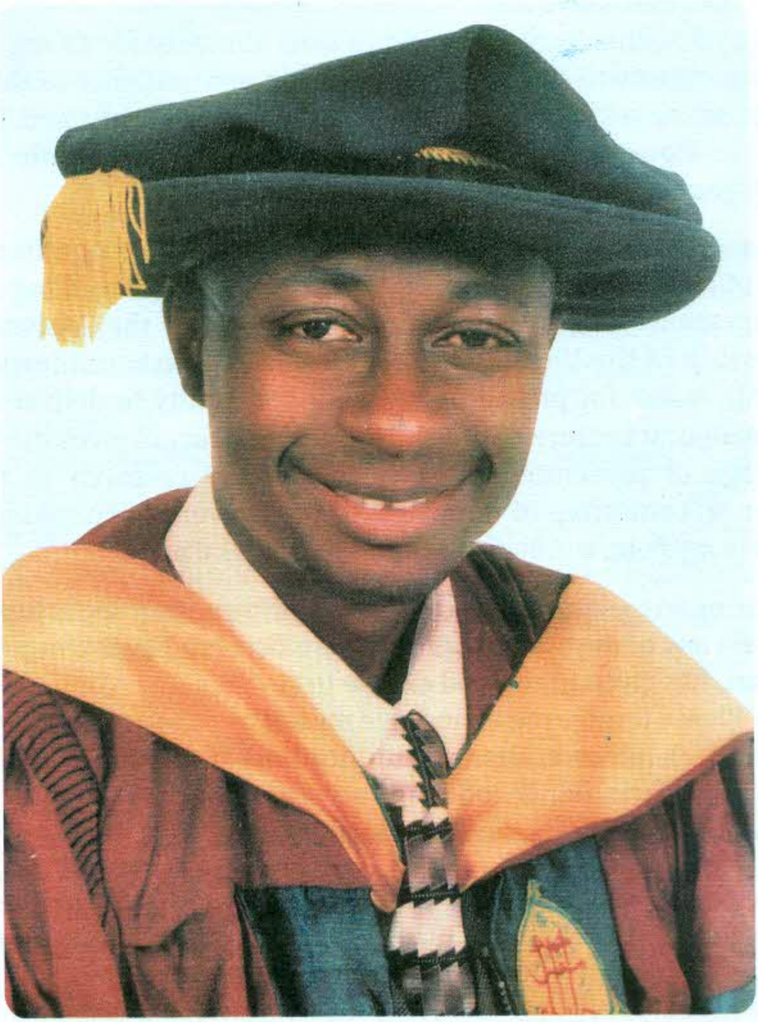
This 41st Inaugural Lecture was delivered under the Chairmanship of:

Professor M. A. Akanji, FNSBMB
Vice-Chancellor
Federal University of Technology, Minna

Published by:
University Seminar and Colloquium Committee,
Federal University of Technology, Minna.

17th March, 2016

Design + Print:
Global Links Communications, Nigeria
✆: 08056074844, 07036446818



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1. INTRODUCTION

I give praise, thanks and honour to God Almighty for giving n the opportunity to stand before this esteemed audience to sha a brief on my research activities, which has been captioned **Tl Electric Power Transmission Line - A Viable Link f Intelligence Transmission.**

An inaugural lecture marks the formal and official recognition promotion to Professorship, so I want to start by thanking tl management of this great university under the visiona leadership of the Vice-Chancellor, Professor Musbau Adewu AKANJI, FNSBMB, for providing me the opportunity to deliver tl 41st Inaugural Lecture of the University. This forum gives me tl privilege of presenting an overview of my research to tl audience, consisting of members of the University communi peers in my field, family, friends and the general public.

Preparing an inaugural lecture, particularly one that seeks to gi an overview of developments that have occurred over a numb of years, has given me a good excuse to revisit some of my earli work. Please forgive me if I indulge myself by reflecting a little my research in Powerline Communications at the Ahmadu Be University, Zaria, which led to the award of the degree of Doct of Philosophy (PhD) in Electrical Engineering.

My Vice-Chancellor sir, as powerline communications is somewhat quiet subfield of electrical engineering, kindly perr me to quickly run through Electrical Engineering and conventional subfields.

2. ELECTRICAL ENGINEERING AND ITS SUBFIELDS

Electrical engineering is a field of engineering that genera deals with the study and application of electricity, electronics a electromagnetism. Electrical engineering has now subdivid into a wide range of subfields. These include electronics, digi computers, power engineering, telecommunications, control systems, signal processing, instrumentation and microelectronics. The subject of electronic engineering is often treated as its own subfield but it intersects with all the other subfields, including the power electronics of power engineering.

2.1 Power

Power engineering deals with the generation, transmission and distribution of electricity as well as the design of a range of related devices. These include transformers, electric generators, electric motors, high voltage engineering and power electronics.

2.2 Control

Control engineering focuses on the modeling of a diverse range of dynamic systems and the design of controllers that will cause these systems to behave in the desired manner. To implement such controllers, electrical engineers may use electronic circuits, digital signal processors, microcontrollers and programmable logic controls (PLCs).

2.3 Electronics

Electronic engineering involves the design and testing of electronic circuits that use the properties of components such as resistors, capacitors, inductors, diodes and transistors to achieve a particular functionality.

2.4 Microelectronics

Microelectronics engineering deals with the design and microfabrication of very small electronic circuit components for use in an integrated circuit or sometimes for use on their own as a general electronic component. The most common microelectronic components are semiconductor transistors, although all main electronic components (resistors, capacitors, etc.) can be created at a microscopic level. Nanoelectronics is the further scaling of devices down to nanometer levels.

2.5 Signal processing

Signal processing deals with the analysis and manipulation of signals. Signals can be either analog, in which case the signal varies continuously according to the information, or digital, in which case the signal varies according to a series of discrete values representing the information. For analog signals, signal processing may involve the amplification and filtering of audio signals for audio equipment or the modulation and demodulation of signals for telecommunications. For digital signals, signal processing may involve the compression, error detection and error correction of digitally sampled signals.

2.6 Telecommunications

Telecommunications engineering focuses on the transmission of information across a channel such as a coaxial cable, optical fiber or free space. Transmissions across free space require information to be encoded in a carrier signal to shift the information to a carrier frequency suitable for transmission. This is known as modulation. Popular analog modulation techniques include amplitude modulation and frequency modulation.

2.7 Instrumentation

Instrumentation engineering deals with the design of devices to measure physical quantities such as pressure, flow and temperature. The design of such instrumentation requires a good understanding of physics that often extends beyond electromagnetic theory.

2.8 Computers

Computer engineering deals with the design of computers and computer systems. This may involve the design of new hardware, the design of PDAs, tablets and supercomputers or the use of computers to control an industrial plant.

2.9 Related disciplines

Mechatronics is an engineering discipline which deals with the convergence of electrical and mechanical systems. Such combined systems are known as electromechanical systems and have widespread adoption. Examples include automated manufacturing systems, heating, ventilation and air-conditioning systems and various subsystems of aircraft and automobiles.

Biomedical engineering is another related discipline, concerned with the design of medical equipment. This includes fixed equipment such as ventilators, MRI scanners and electrocardiograph monitors as well as mobile equipment such as cochlear implants, artificial pacemakers and artificial hearts.

Electrical engineers design, develop, test and supervise the manufacturing of electrical equipment, such as electric motors, radar and navigation systems, communications systems and power generation equipment as well as design and develop electronic equipment, such as broadcast and communications systems from portable music players to global positioning systems (GPS). Their work focuses on economy, quality, reliability, safety and sustainability.

3. THE ELECTRIC POWER TRANSMISSION LINES

Electric power transmission lines serve as a link between the generating station and the distribution station. A power system is composed of generation, transmission and distribution. Electrical power generation is that aspect of power system dedicated to the harnessing of primary energy resources with a view to the conversion of such energies to electrical energy. Nuclear energy, fossil fuels and water energy amongst others are the primary energy sources generally employed for electrical power generation purposes.

On generation, electrical energy has to be conveyed to the areas of utilization, which are, in most cases, urban areas and industrial plants, which may be located within or far from the urban areas.

The process of power transportation from the generating end to the areas of utilization is referred to as electrical power transmission.

Electrical power transmission systems basically consist of power transmission lines, which emanate from the generation station or power plant substation and terminates at the transmission substations also referred to as bulk receiving stations. The transmission lines apart from reaching the bulk receiving stations also serve to interconnect generating station or power plants.

An entire power system comprises high-voltage generators, transformers and associated switchgears at different locations separated by distance, all interconnected by high-voltage transmission lines forming a grid.

The Nigerian National Grid consists of many generating stations, 330kV transmitting stations and 132kV substations grouped into three major divisions, viz:

- Generating stations;
- Area control centres (ACC) and
- National control centres (NCC).

The voltage level of a particular system is determined by the amount of power to be transmitted and the distance over which it is to be transmitted. For high transmission efficiency, these voltages are made higher for longer distances. Transmission voltages above 230kV are referred to as extra-high voltages (EHV) and these are employed for very long distance transmission purposes. The higher the voltage level employed for power transmission, the higher the cost of insulation of transformer, switchgear and other terminal equipment that go with the system as well as the cost of cable insulators for underground cables where they are needed in the system. For very long distances however, the advantages far outweigh the disadvantages thus justifying the use of EHV for long distance power transmission.

At the distribution level, the voltage is stepped down using distribution transformers via sub-transmission levels (typically 33kV or 11kV) to distribution voltage levels (typically, 415V or 230V) to consumers.

4. POWER TRANSMISSION LINE AS INTELLIGENCE TRANSMISSION MEDIUM

A communication signal consisting of audio, video and digital data is called intelligence. The use of the high voltage, three-phase power transmission line itself as a communication medium is extremely useful for achieving the necessary diversification of signaling media which is required for high voltage transmission system protection, supervisory and control operations and fast information dispatch, etc. Realistically, the economic aspect is much improved when the carrier system provides facilities for more than one signaling function. By signaling is meant the transfer of information between separate locations and is usually accomplished using derived signals or messages which represent the information to be transferred. Such information includes voice, teleprotection signaling and SCADA (telemetering, teleindication and telecontrol). This is achieved by the use of a transmitter and a receiver separated by a communication medium – ***the power transmission line***!

5. RATIONALE FOR POWERLINE COMMUNICATIONS

Voltage (or power) and frequency are two primary parameters to be considered for signal transmission. Transmission of intelligence usually takes place at low voltage (typically not beyond hundred of volts) and radio frequencies, ranging from 300kHz to about 10GHz. This wide range is classified into bands of frequencies, called the radio frequency (RF) spectrum as shown in Table 1.

Table 1: RF spectrum classification

Frequency Range	Class (Abbreviation)	Applications
30-300Hz	Extremely low frequency (ELF)	Power transmission
300-3000Hz	Voice frequency (VF)	Audio
3-30kHz	Very low frequency (VLF)	Submarine communications
30-300kHz	Low frequency (LF)	Navigation
300-3000kHz	Medium frequency (MF)	AM radio
3-30MHz	High frequency (HF)	Short wave radio
30-300MHz	Very high frequency (VHF)	FM and TV (Ch. 2-13)
300-3000MHz	Ultra high frequency (UHF)	UHF TV (Ch. 14-83)
3-30GHz	Super high frequency (SHF)	Satellites and microwaves
30-300GHz	Extremely high frequency (EHF)	Radar
300-3000GHz $3\mu 10^{11}$ Hz $4.3\mu 10^{14}$ Hz $7.5\mu 10^{15}$ Hz 10^{17} Hz 10^{19} Hz +	Tremendously high frequency (THF) Infrared light Visible light Ultra-violet light X-rays Gamma rays	

Power transmission, on the other hand, is done at high voltages (typically 132kV, Nigeria) and extra high voltages (typically 330kV, Nigeria) within the frequency band of (30-300)Hz. Typical frequency values adopted are 50Hz in Nigeria and Britain and 60Hz in the United States of America. Power transmission frequency is therefore very small in comparison with intelligence transmission frequencies. Based on its voltage level, the associated current carrying capacity of the power line is very high compared with that of the communication line. For this reason, the power transmission line offers the potential of serving as a telecommunications link and not vice versa, with the provision of means to reconcile the divergent operating frequencies of the power system and the communication system. The rationale to transmit intelligence signals using the electric power transmission line brings about what is now known as powerline carrier communication system, which depicts the emergence of yet another field of electrical engineering called Power System Telecommunications, a hybrid of Power Systems Engineering and Communications Engineering simply referred to as Powerline Communications. This is my area of specialization!

6. POWERLINE CARRIER COMMUNICATIONS SYSTEM IN BRIEF

Carrier current is a means of communication where the transmitted information is channeled through a transmission line. Other transmission media include ordinary cable, coaxial cable, etc. The significant use of carrier current communication where the high voltage transmission line that carries the electric power is used as the transmission medium is termed powerline carrier (PLC). However, the PLC may be defined as a telecommunication system whereby carrier frequency is superimposed on a three – phase high voltage (typically between 10kV and 735kV) transmission line to convey information when such a high frequency is modulated. A powerline carrier system consists of three distinct parts:

1. The terminal assemblies, consisting of the transmitters, receivers and associated components;
2. The coupling and tuning equipment, which provides a means of connecting the terminals to selected points of the high voltage system;
3. The high voltage system itself, which must provide a suitable path for transmission of the high frequency energy between the terminals.

At the terminals, one or more transmitters and/or receivers are required, depending on the number of functions to be performed. The PLC is a band of frequencies (between 30kHz and 500kHz), which is transmitted over a powerline. While 30kHz is not an absolute lower limit, the bandwidth obtainable at lower frequencies with standard line coupling and tuning equipment is not adequate for most practical needs. The upper limit is in most cases, due to the extensive use of frequencies, between 200kHz and 415kHz for aircraft navigation and radio facilities (Hamsher, 1967).

The principal elements of the powerline carrier are transmitting and receiving terminals, which include line traps, coupling capacitors and tuning and coupling equipment. The schematic arrangement of these devices is shown in Fig. 1.

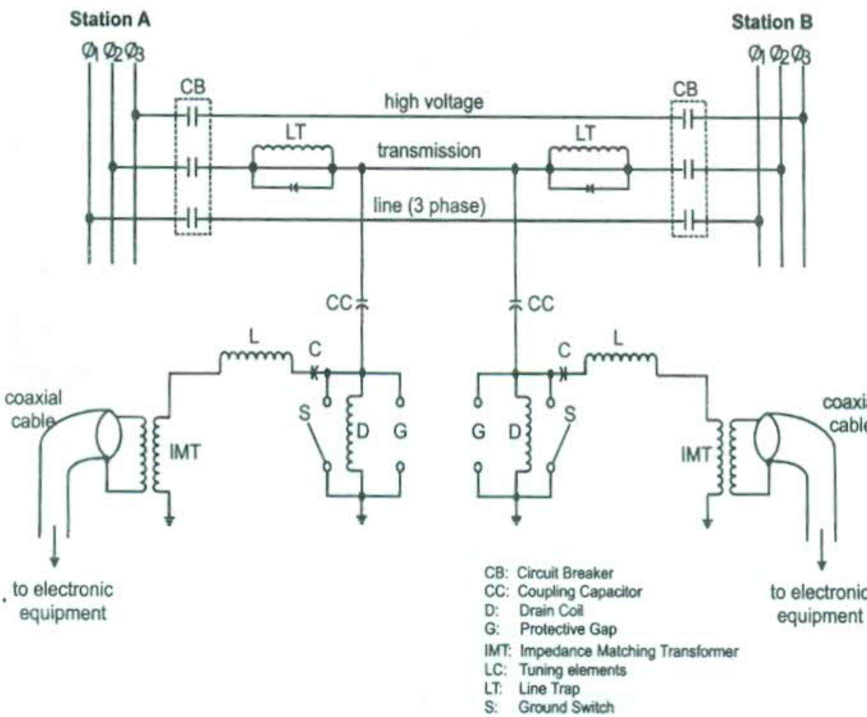

Fig.1: Elements of a powerline carrier channel

7. PLC TECHNOLOGY

PLC technology is of two types: the indoor (short range or last mile) and the outdoor (long haul). In the indoor type, the PLC equipment can use the household electrical power wiring as a transmission medium. Typically, these devices operate by injecting a carrier wave between 20kHz and 200kHz into the household wiring at the transmitter. The carrier is modulated by digital signals.

In the long haul technology, utility companies use special coupling to connect low frequency radio transmitters to the power frequency alternating current conductors. Frequencies are typically in the range of 30kHz to 300kHz, with transmitter power levels up to hundreds of watts. Hence the frequencies required in the PLC technology lie within the very low frequency (VLF) and low frequency (LF) bands.

8. BACKGROUND TO MY RESEARCH

My research focuses on long haul transmission. Research issues centre on bandwidth, equipment size (spatial considerations), propagation behaviour of transmission lines, etc. The basis of my research on long haul transmission is that the Nigerian Extra High Voltage (EHV) power transmission lines are currently being used for high frequency signal transmission in addition to conveyance of bulk power to major load centres. Because PHCN has many of its transmission lines erected in most parts of the country, there is need to research into the use of such infrastructural outlay for the conveyance of wider range of intelligence than currently being done. The concern is the speed at which intelligence transmission would be achieved, signal noise introduced and the attenuation on such transmission lines. These parameters describe the propagation behaviour of the lines.

In addition, it is economically advantageous and for security reasons to use the lines themselves to enhance the supervisory and control operations, provide fast information dispatch and to carry out discriminative protection of substation equipment by sending trip signals when faults occur therefore allowing the provision of efficient and reliable communications both within and among the power stations.

Moreover, electricity utilities cannot perform their statutory roles adequately without good telecommunication system. Based on the rapidly increasing complexity and interconnections of the power system network in addition to the large amounts of power that need to be carried, it has become imperative to monitor and control the various operating states of the power system at various important locations for the load dispatch centre.

For the above reasons, careful assessment and analysis of the potentials of the electric power transmission lines for intelligence transmission becomes necessary.

The objectives of my research with particular interest in the Nigerian electric power transmission systems are as follows:

- To develop equivalent analytical (matrix) models for the Nigerian high voltage (132kV) and extra high voltage (330kV) single circuit (SC) power transmission lines and characterize their signal attenuation and propagation velocities;
- To identify propagation modes that will provide significant output power (at the receiving end);
- To identify the configuration of 132kV SC lines that would effectively support intelligence transmission;
- To identify the transmission voltage level that would be more suitable for intelligence transmission;
- To determine the propagation behaviour of the Nigerian SC transmission lines;

- To study the effects of load cycle on the propagation behaviour of the transmission lines;
- To adapt the most acceptable configuration of transmission lines for intelligence transmission.

9. MY RESEARCH AND FINDINGS

Electric power transmission lines are composed of bundled conductors, therefore the conventional application method of transmission line theory fails. There is need to develop method for multi-conductor transmission line theory, known as the theory of modal analysis (Adegboye, 2004; Galloway, Shorrocks and Wedepohl, 1964), which is applicable to both power and communication lines. Attenuation is a measure of the energy loss when intelligence is transferred from the transmitting terminal to the receiving terminal. This loss depends on the line configuration, frequency, conductor size; presence and type of earth wires, transposition, earth resistivity and weather condition.

In addition, a transmission line experiences different loading conditions during the day. This loading depends on the season of the year which is, in turn based, on the geographical location which PHCN calls zone; Zone A denoting South while Zone B denoting North. It is imperative to determine the performance of a carrier channel with variations in the load current (Indulkar, Kumar and Kothari, 1983). This calls for the necessity to estimate temperatures corresponding to the load current, the tension and sag as a consequence of this temperature and then determine the resulting effective height and length of the conductors.

The fundamental step was to model the transmission system into basic series impedance matrix, **Z** and shunt admittance matrix, **Y** per unit length of the line. These matrices give the electrostatic and electromagnetic performance of the line and depend on the physical and electrical characteristics of the lines, their geometrical arrangement and height above the ground level and the earth resistivity. The accuracy of the results depends, on how close the mathematical expressions for the basic series impedance and shunt admittance matrices are to reality. The formation of ideal impedance and admittance matrices of the real transmission lines considered the actual physical layout of the lines (not on any assumptions about the geometrical layout of the conductors), the electrical properties of the conductor materials and the earth resistivity.

A true analysis of propagation along the multi-conductor line is very complex because of the multiplicity of self- and mutual impedances, which exist, so various theories have been applied to simplify the concepts of the complex phenomena associated with wave propagation on the multi-conductor lines (Theofilos, Grigoris and Dimitris, 2010; Mohammed and Kenji, 1994; Cristina and D'Amore, 1982). However, the natural mode concept, which served as the basis for the theory of modal analysis, is helpful in predicting the distribution of carrier-frequency current among the power conductors. A transmission line with n number of conductors has n natural modes which when combined in appropriate proportions, can represent any current or voltage distribution among the n wires.

9.1 132kV SC Transmission Lines Configuration

Two models of the 132kV SC transmission lines are investigated. Model_1 is a 132kV SC transmission line having all the phase conductors on the left side of the tower and one earth wire on the tower axis. This is shown in Fig. 2 and is called the vertical configuration. The code name is **BEAR**. The tower axis is taken as the reference axis. In model_2, the phase conductors are arranged in a triangular form (see Fig. 3) with one earth wire lying on the tower (reference) axis. This model is called the triangular configuration. The code name is **WOLF**. All dimensions are in metres (m).

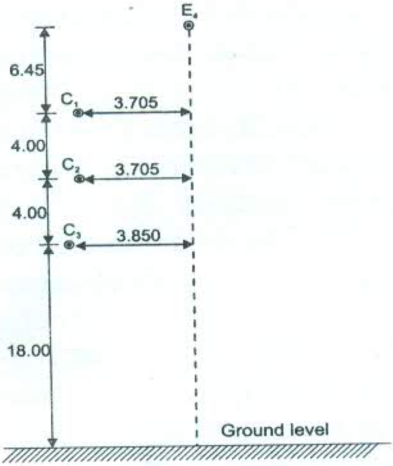

Fig. 2: Model_1 (BEAR)

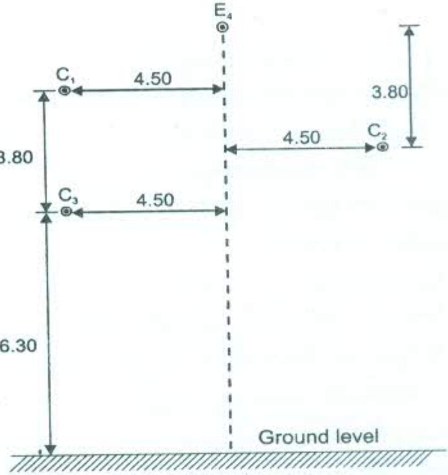

Fig. 3: Model_2 (WOLF)

9.2 330kV SC Transmission Lines Configuration

Model_3 is the 330kV SC transmission line having two earth wires above the phase conductors and each phase is composed of two sub-conductors. This is shown in Fig. 4 and is called the horinzontal configuration. The tower (reference) axis is taken as a vertical line passing through the phase conductor 2. The code name is **BISON**. All dimensions are in metres (m).

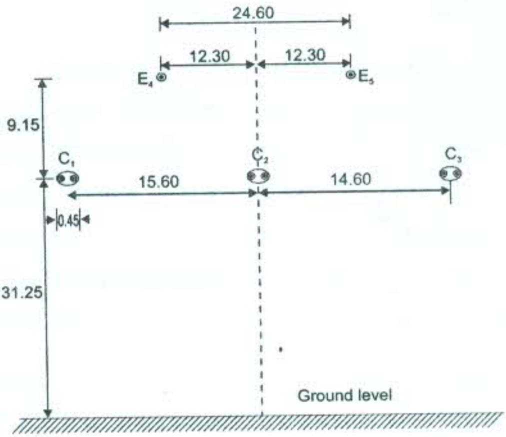

Fig. 4: Model_3 (BISON)

The 330kV SC line consists of sub-conductors constituting a bundle. These sub-conductors are subjected to mutual forces caused by electrostatic and electromagnetic fields. When these two forces balance each other, the sub conductors remain in their primary positions (see Fig. 5). However, the sub-conductors experience a shift from their primary positions and form a catenary with an increase in load current. The maximum shift of the conductor from its primary position at the middle of a span length and the average spacing between the sub-conductors of a phase is desirable. In particular, the spacing between the sub-conductors varies with the load current and this, in turn, affects mainly the resistive part of the **Z** matrix. This part depends only on the loading condition and is independent of the spacing between the sub-conductors.

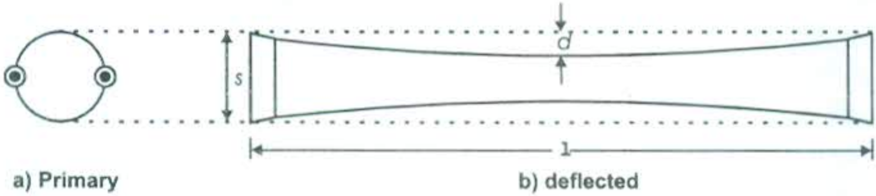

Fig. 5: Sub-conductor positions

9.3 Data for High Frequency Propagation

High frequency propagation requires data on the conductors and the earth wires for the determination of high frequency parameters.

Conductor Input Data

The aluminum steel reinforced concrete (ACSR) conductors are in use by PHCN. Some data relating to the conductors are shown in Table 2.

Table 2: Conductors data

PARAMETER	VALUE
Resistivity, μ_c	$3.82 \times 10^{-8}\mu m$
Earth resistivity, μ_e	$100\mu m$
Relative permeability, μ_r	1000

Measurements of the earth resistance were done using a highly sensitive Earth Resistance Tester. The value in Table 2 was arrived at following the measurements carried out in different locations. For example, between Kaduna and Shiroro, the terrains are similar and measurements were taken randomly over few distances starting from Kaduna. This was similarly done starting from Shiroro. The mean value was then computed and used as the general value. In the south, the little changes were expected because of the rocky areas and uneven terrains.

For each model, the input data relating to the conductors are summarized in Table 3.

Table 3: Conductor input data

PARAMETER	MODEL_1	MODEL_2	MODEL_3
Conductor resistance (μ /km) at 20°C	0.1095	0.1828	0.06672
Diameter (mm)	23.45	18.13	27.00
Diameter of one Aluminum strand (mm)	3.35	2.59	3.00
Diameter of one steel strand (mm)	3.35	2.59	3.00
Number of Aluminum strands	30	30	54
Number of steel strands	7	7	7

Source: PHCN Former Headquarters Annex, 19 Awolowo Road, Lagos (1999)

Earth Wire Input Data

The earth wire used by PHCN is galvanized steel having resistivity, μ_s of 20×10^{-8}m. The earth wire input data for each of the model are summarized in Table 4.

Table 4: Earth wire input data

PARAMETER	MODEL_1	MODEL_2	MODEL_3
Earth wire resistance (μ /km)	3.442	5.464	1.461
Diameter (mm)	9.8	8.0	13.2
Diameter of one strand (mm)	3.25	2.67	2.64
Number of strands	7	7	19

Source: PHCN Former Headquarters Annex, 19 Awolowo Road, Lagos (1999)

9.4 Data Relating to Powerline Configurations

The geometry of the transmission line is expressed in terms of the co-ordinates of the conductors. For the geometries of the three models of Figs. 2, 3 and 4, each position represents a propagation mode. Mode distribution refers to an injection between a conductor to ground with the remaining conductors grounded. For example, when the injection is between conductor 1 to ground, we have the mode 1 distribution. Therefore, in each mode, the co-ordinates of the conductors are as shown in Table 5.

Table 5: Mode co-ordinates

	MODEL_1	MODEL_2	MODEL_3
Mode 1	(-3.705, 26.0)	(-4.5, 20.1)	(-15.6, 31.25)
Mode 2	(-3.705, 22.0)	(4.5, 18.2)	(0.0, 31.25)
Mode 3	(-3.850, 18.0)	(-4.5, 16.3)	(14.6, 31.25)

It should be noted that the mode distribution does not apply to the earth wires. The geometries of the earth wires (E) and conductors (C) are shown in Table 6.

Table 6: Earth wire and conductor geometry co-ordinates

	MODEL_1	MODEL_2	MODEL_3
Position 1 (C)	(-3.705, 26.0)	(-4.5, 20.1)	(-15.6, 31.25)
Position 2 (C)	(-3.705, 22.0)	(4.5, 18.2)	(0.0, 31.25)
Position 3 (C)	(-3.850, 18.0)	(-4.5, 16.3)	(14.6, 31.25)
Position 4 (E)	(0.0, 32.45)	(0.0, 22.0)	(-12.3, 40.40)
Position 5 (E)	-	-	(12.3, 40.40)

General Constants

Some general constants used in relevant areas of computations are presented in Table 7.

Table 7: General constants

PARAMETER	VALUE
Resistance temperature coefficient (most alloys)	0.0004
Solar absorption coefficient	0.9
Solar constant	$1353 Wm^{-2}$
Thermal emissivity	0.6
Stefan's constant	$5.669 \times 10^{-8} Wm^{-2}K^{-4}$
Thermal coefficient of linear expansion	$17.8 \times 10^{-6}/\mu C$

9.5 Results

At high frequencies, profiles were developed for each model in order to enhance the understanding of the mode attenuation variation with frequency and the mode velocities variation with frequency. The attenuation-velocity profiles are also developed.

132kV Vertical Configuration Transmission Line (The BEAR)

Mode attenuations

The variations of attenuation with frequency for the three modes are shown in the frequency – attenuation profile of Fig. 6.

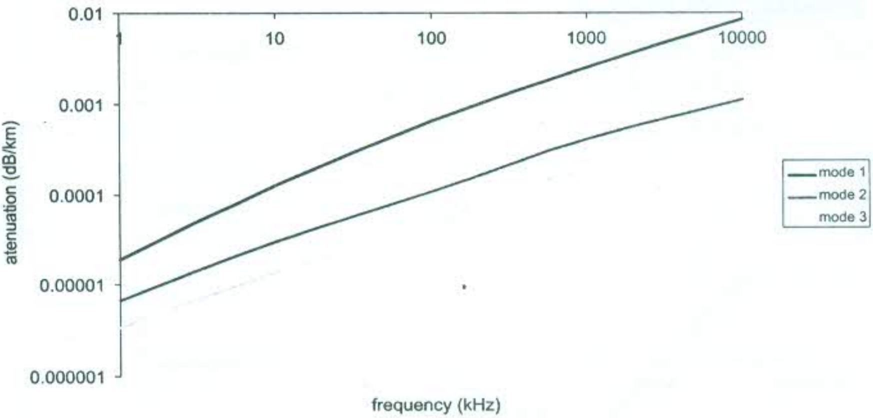

Fig. 6: Frequency-Attenuation profile for BEAR

At each level of frequency, modes 2 and 3 are associated with lower attenuation.

<u>Mode propagation velocities</u>

The variations of propagation velocity with frequency for the three modes are shown in the frequency – velocity profile shown in Fig. 7.

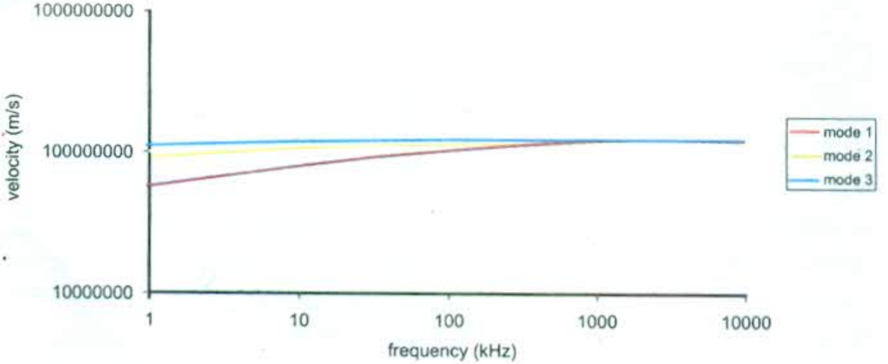

Fig. 7: Frequency-Velocity Profile for BEAR

<u>Mode propagation</u>

The attenuation and corresponding velocities are observed comparatively over frequencies in the attenuation-velocity profile shown in Fig. 8.

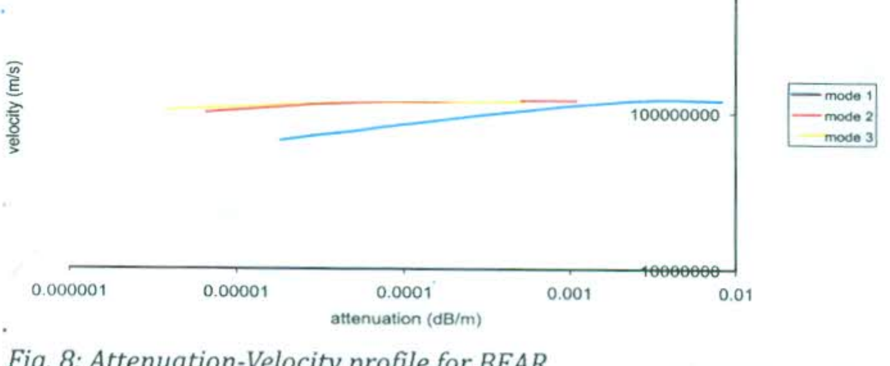

Fig. 8: Attenuation-Velocity profile for BEAR

In order to determine the modes suitable for intelligence transmission, we look for the propagation mode that would offer the least attenuation and the velocity closest to the free space velocity (3×10^8 m/s). Following suitable ranking procedure, the following propagation modes were found to be acceptable:

1 Mode 3 at 1kHz frequency AA – excellent 1
2 Mode 2 at 1kHz frequency AA – excellent 2
3 Mode 3 at 10kHz frequency BA – very good 1
4 Mode 2 at 10kHz frequency BA – very good 2
5 Mode 3 at 100kHz frequency BA – very good 3
6 Mode 2 at 100kHz frequency CA – good 1
7 Mode 3 at 1MHz frequency CA – good 2
8 Mode 2 at 1MHz frequency CA – good 3
9 Mode 3 at 10MHz frequency CA – good 4
10 Mode 1 at 100kHz frequency CA – good 5

As can be seen, modes 2 and 3 are the prominent modes (aerial modes); mode 1 surfaced only once and this is the least acceptable mode of propagation out of the fifteen possible modes.

Load Cycle

Temperature

The temperature-load profiles of the line run in the two zones are shown in Fig. 9 and Fig.10 during the cold and hot season, respectively. These profiles show that increase in load gives a corresponding increase in temperature.

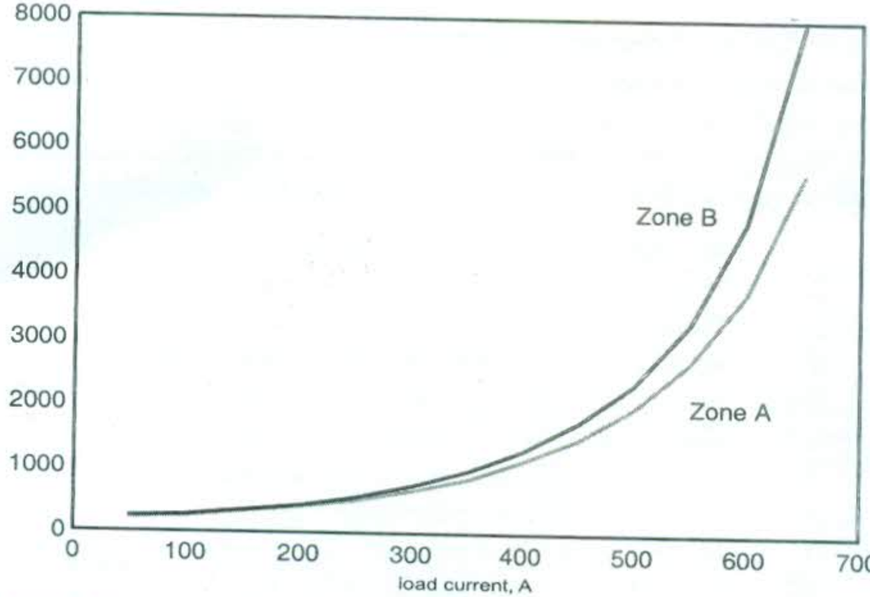

Fig.9: Temperature-Load profile during COLD season for BEAR

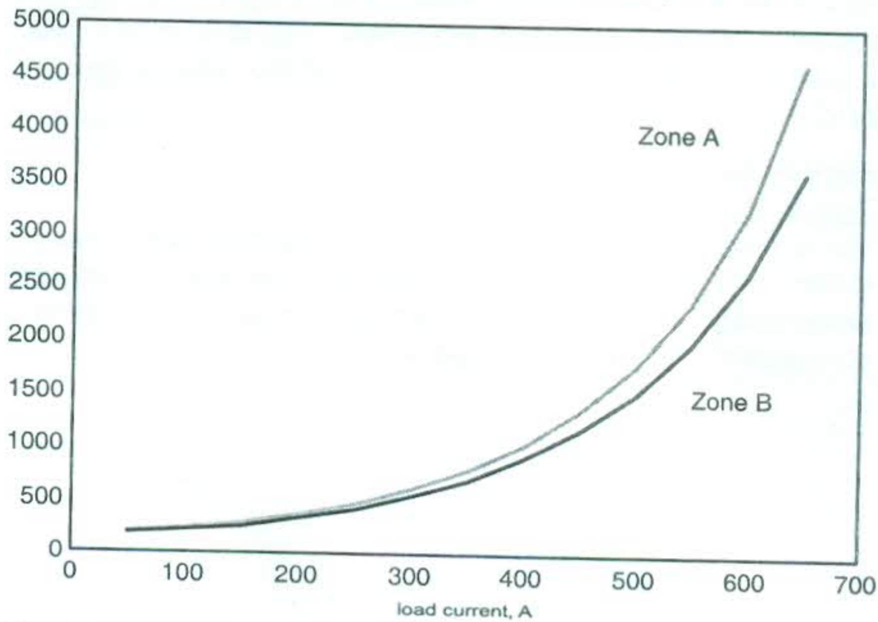

Fig.10: Temperature-Load profile during HOT season for BEAR

Conductor temperature in the hot season is higher in zone A than in zone B and conversely. The much higher wind speed in zone B than that in zone A makes the heat loss due to convection higher. The contribution of other components like the heat due to radiation and line current considers the ambient temperature. Meanwhile, the heat due to solar radiation is common to the two zones.

Tension and Sag

The prescribed tension limit of the line conductors is 31kN. Results show that, in the cold season, the maximum safe tension that does not exceed the prescribed limit is 28.39kN at a loading of 400A in zone A and 27.15kN at a loading of 500A in zone B. These tensions give sags of 0.8481m and 1.2284m, respectively. Similarly, tension values of 29.65kN at a loading of 400A in zone A and 29.52kN at a loading of 550A in zone B were obtained as the maximum safe values during the hot season. These tensions give corresponding sags of 0.8121m and 1.6172m, respectively. Fig. 11 and Fig. 12 show the tensions in each zone corresponding to the various load currents in the cold and hot seasons, respectively.

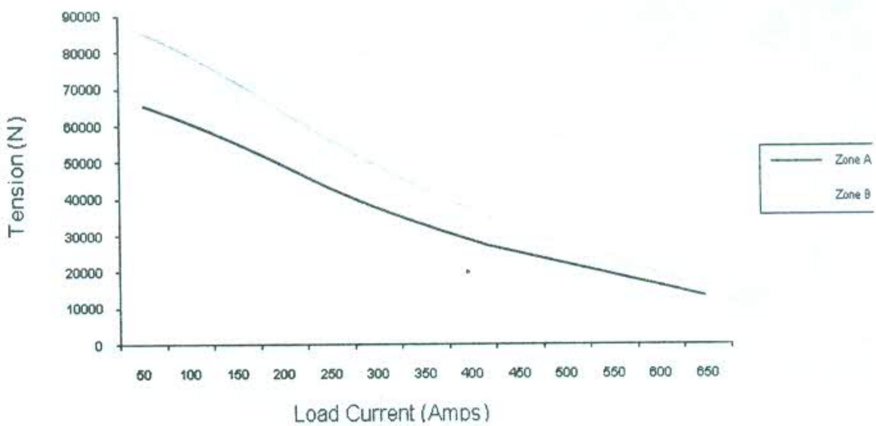

Fig. 11: Tensions corresponding to load currents in the cold season for BEAR

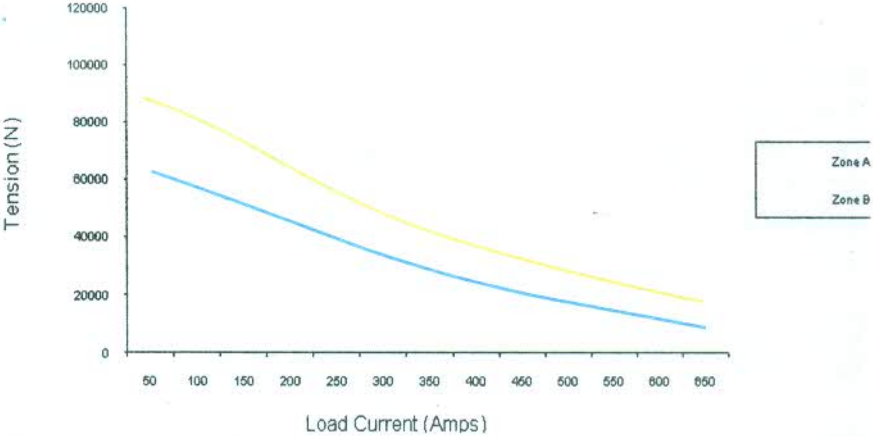

Fig. 12: Tensions corresponding to load currents in the hot season for BEAR

Effective Height and Length

As a result of the sags, results show that during the cold season, the heights of each conductor reduce by 56.54cm in zone A and 81.89cm in zone B. Similarly, these heights reduce by 54.14cm in zone A and 1.0781m in zone B during the hot season.

The extensions experienced by the lines are insignificant when compared to the line length. For example, the maximum extension is experienced during the cold season in zone B for the given tension and is 0.017375% of the entire span (97.3mm). In addition, the sags experienced are generally higher than the line extension, ; meaning that the overall line length has increased. It is this overall increase that accounts for the eventual level of sag, d_s (that is, $d_s = D_s -$).

Load Cycle Effects and Attenuation

Transmission line loading is observed to depend on the season and this directly affects the conductor temperature, the rise of which increases the line length and reduction in tension. The overall effect of the temperature, therefore, is increase in line length and sag.

The height of the transmission line is lower when the sag is considered than when it is not considered. This difference causes a corresponding change in the velocities of the aerial modes with a consequent reduction in the first peak and shifting of the critical frequency to a lower one. In our case, since modes 2 and 3 at 1kHz frequency are the best propagation modes as well as the aerial modes, the first and second critical frequencies occur at about 7.19kHz and 21.56kHz, respectively if the line were run from Otta to Aiyetoro line (length = 80km) or 5.001/15.003kHz for Benin North - Agbor - Asaba line (length = 115km). These lines are classified under zone A. Similarly, the first and second critical frequencies are 7.99kHz and 23.96kHz, respectively for the Kaduna - Zaria line (length = 72km) or 3.97/11.90kHz for Zaria - Kano line (length = 145km) (zone B).

Attenuation does not vary much with load current except when the load current lies around the critical frequency of, say, about 4kHz along the Zaria - Kaduna line. There exist marked variations in the attenuation with the load current although this may not be the case when the centre conductor is energized.

132kV Triangular Configuration Transmission Line (The WOLF)

Mode attenuations

The variations of attenuation with frequency for the three modes are shown in the frequency - attenuation profile of Fig. 13.

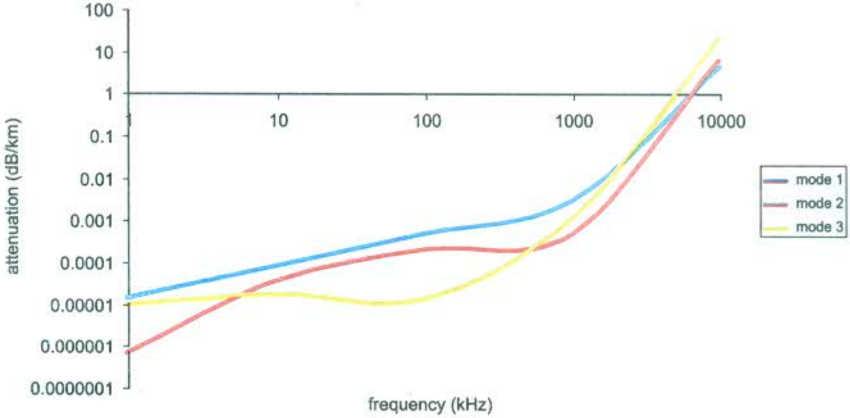

Fig. 13: Frequency-Attenuation profile for WOLF

The only level of frequency that is of interest in this case is 1kHz. This is because at 10kHz and above, irrespective of the attenuation level, the propagation velocity does not compare, at all, with the speed of light so it is of no use. It is not the matter being sure of getting our desired signal at the receiving end if we have to wait for so long.

Mode propagation velocity

The variations of propagation velocity with frequency for the three modes are shown in the frequency-velocity profile shown in Fig. 14.

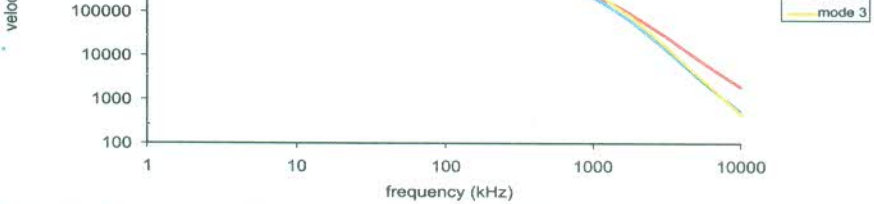

Fig. 14: Frequency-Velocity profile for WOLF

Mode 3 (1kHz) propagates at the highest velocity while mode 1 provides the least.

Mode propagation

The attenuation and corresponding velocities observed comparatively over frequencies are shown in Fig. 15. This profile would attempt to suggest mode 2 as the preferred propagation mode because of its attenuation and the associated propagation velocity. Ironically, however, these are the only two propagation modes acceptable by this model (model_2).

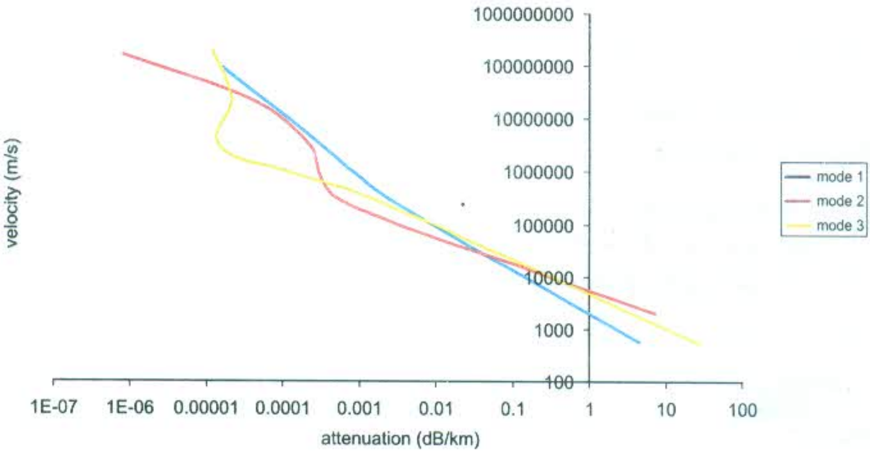

Fig.15: Attenuation-Velocity profile for WOLF

The load cycle effects are similar to those of the BEAR.

330kV Horizontal Configuration Transmission Line (The BISON)

Mode attenuations

The variations of attenuation with frequency for the three modes are shown in the frequency-attenuation profile of Fig. 16.

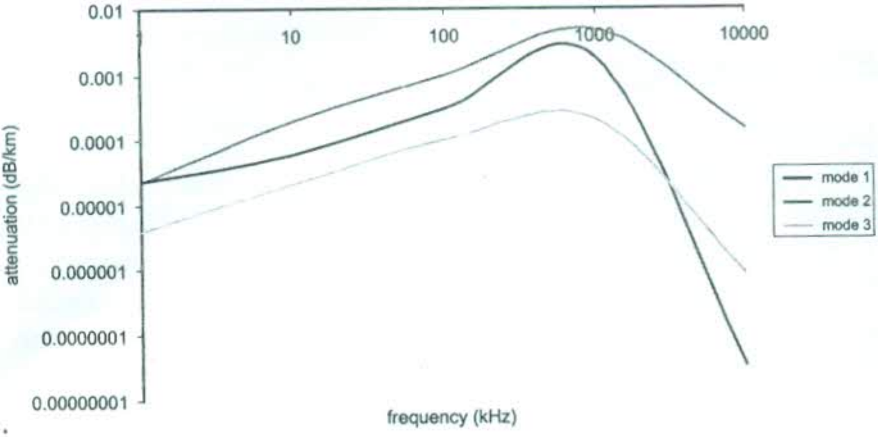

Fig. 16: Frequency-Attenuation profile for BISON

Between the frequencies range of 10kHz and 1MHz, modes 2 and 3 appear glaringly as the aerial modes.

<u>Mode propagation velocities</u>

The variations of propagation velocity with frequency for the three modes are shown in the frequency-velocity profile shown in Fig. 17.

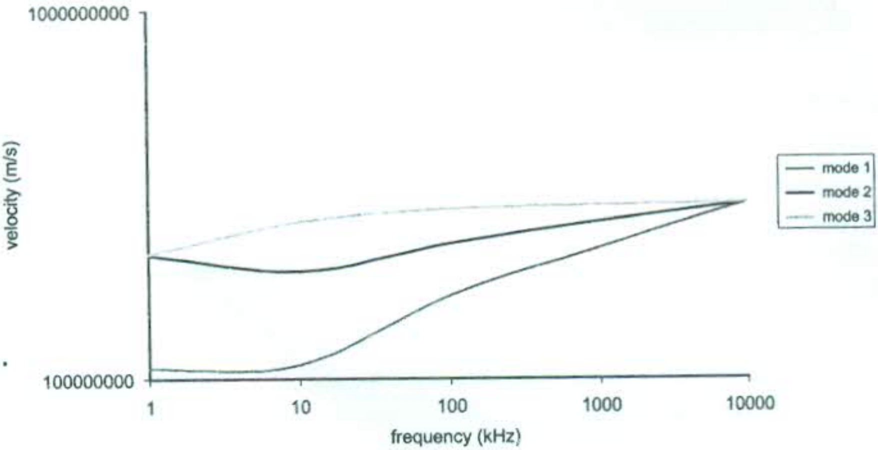

Fig. 17: Frequency-Velocity profile for BISON

Mode propagations

The attenuation and corresponding velocities are observed comparatively over frequencies in the attenuation - velocity profile shown in Fig.18.

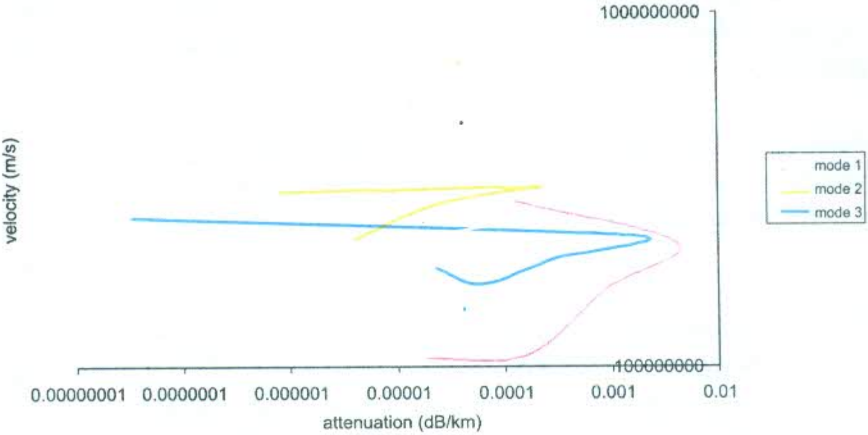

Fig. 18: Attenuation-Velocity profile for BISON

After applying the criteria used for model_1, the final rank of the individual propagation mode is based on the percentage change in successive velocities relative to the free space value viz a viz the percentage change in value of the rank of successive attenuations. These selection criteria provide the final ranks of the propagation modes as follows:

1 Mode 2 at 10MHz frequency - exceptional
2 Mode 3 at 1kHz frequency - excellent 1
3 Mode 3 at 10kHz frequency - excellent 2

Next promising modes are:

4 Mode 2 at 10kHz frequency - very good 1
5 Mode 3 at 100kHz frequency - very good 2
6 Mode 3 at 1MHz frequency - very good 3
7 Mode 2 at 100kHz frequency - very good 4

Others are:

8 Mode 1 at 1kHz frequency - good 1

9 Mode 1 at 10MHz frequency - good 2

The standards set for model_3 is higher than those for the other models. This is because of the more encouraging observations made from its results.

Although the prescribed tension limit of the 330kV line conductors is 62kN, the load cycle effects are similar to those of the BEAR and WOLF.

9.6 Deductions from Research and Generalizations

Various deductions were made from the results obtained for each of the three different models considered for the PHCN power transmission systems. The two 132kV single circuit transmission lines were comparatively assessed for the purpose of generalisation. They are, in turn, compared with the 330kV single circuit transmission lines. The essence is to establish the line configuration and voltage level that effectively supports intelligence transmission based on the characterization and propagation analyses of high frequency signals on the Nigerian 330kV and 132kV grid system considering the effects of load cycle.

By way of summary of the deductions, Table 8 was developed, which gives the comparison of the three models based on the propagation behaviour of the electric power transmission lines and the effects of the load cycle.

Table 8: Comparison of the three models based on propagation behaviour and load cycle effects

BASIS FOR COMPARISON	132kV VERTICAL CONFIGURATION	132kV TRIANGULAR CONFIGURATION	330kV HORIZONTAL CONFIGURATION
Analysis of propagation behaviour	1. Better (BEAR) than triangular (WOLF) 2. Possible in about ten different modes 3. Higher propagation velocities than those offered by the only two modes of WOLF 4. Modes 2 and 3 are the aerial modes with the best characteristics at 1kHz	1. Mode 3 and mode 1 at 1kHz	1. Offers best propagation behaviour 2. Least attenuation 3. Highest propagation velocity 4. Modes 2 and 3 are the aerial modes
Study of load cycle effects	1. High ambient temperature rise due to line loading 2. Low ability to withstand electrical loads 3. Conductor temperature increases with increasing load current 4. Ambient temperature rise is higher in the south (zone A) than in the north (zone B) during the hot season and vice versa 5. Tensions to which the line conductors are strung are higher in zone B than in zone A	1. Higher ambient temperature rise due to line loading 2. Same as WOLF 3. Same as WOLF 4. Same as WOLF 5. Same as WOLF	1. Low ambient temperature rise due to line loading 2. High ability to withstand electrical loads 3. Same as WOLF and BEAR 4. Same as WOLF and BEAR 5. Same as WOLF and BEAR 6. Highest stability

9.7 Measurements on the 330kV PLC Systems in PHCN

From results, the BISON (330kV single circuit transmission lines) exhibit better propagation behavior than the 132kV counterparts. For this reason, attenuation measurements were carried out on the PHCN digital PLC (ETL500 dPLC) equipment installed on a number of 330kV transmission systems. Table 9 shows the measured parameters in comparison with those obtained from the model. It is observed that the attenuation levels in the 330kV ETL500 PLC system are generally low. This is in agreement with the results of the attenuation over the 330kV single circuit powerlines (model_3). Mode 3 is observed to be associated with the least attenuation level.

Since the ETL500 is programmable over the carrier frequency range of 24kHz to 500kHz, the results shown in Fig. 16 for the attenuation values of the 330kV system (model_3) were interpolated within this frequency range. The variation of attenuation with frequency over this range is as shown in Fig. 19.

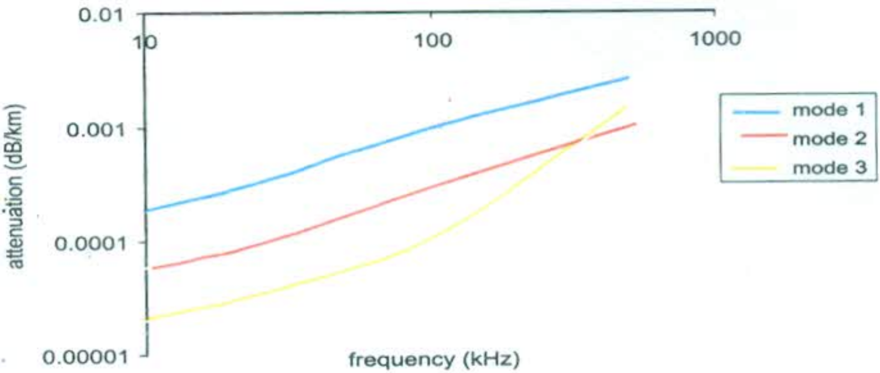

Fig. 19: Frequency-Attenuation profile for BISON

In order to have a comparative assessment of the modeled and measured attenuation values, the modeled values for mode 3 are plotted along with the measured values over the range of frequencies of some selected transmission routes. Measured and modeled attenuations (mode 3) over the range of frequencies show in Fig. 20 that both are in good agreement although the measured values are slightly higher. The modeled values are considered to be ideal considering the use of actual physical and geometrical layouts of the conductors that form each of the transmission models and accuracy of computations in model development.

Table 9: Comparison between computed and measured attenuation on BISON

330kV line	Frequency, kHz (±4)	Length, km	Attenuation, dB/km (measured)	Attenuation, dB/km (computed mode 1)	Attenuation, dB/km (computed mode 2)	Attenuation, dB/km (computed mode 3)
Alaoji- Afam	260	25	0.04	0.4704	0.15876	0.03304
Aja- Alagbon	404	26	0.057692	0.684	0.2421	0.0402
Onitsha- Benin (main)	492	137	0.043796	0.7448	0.26684	0.04032
Osogbo- Benin	220	251	0.014343	0.0755	0.025	0.00565
Osogbo- Jebba	232	157	0.006369	0.07332	0.024628	0.005405
Jebba- Shiroro	284	244	0.006148	0.08544	0.029136	0.00576
Jebba- Kainji	376	81	0.033333	0.04991	0.01748	0.003013
Alaoji- Onitsha	332	154	0.006494	0.099	0.03435	0.0063
Kaduna-Shiroro	276	96	0.002083	0.0261	0.008895	0.0018
Osogbo- Aiyede	384	137	0.005839	0.0924	0.032466	0.005544

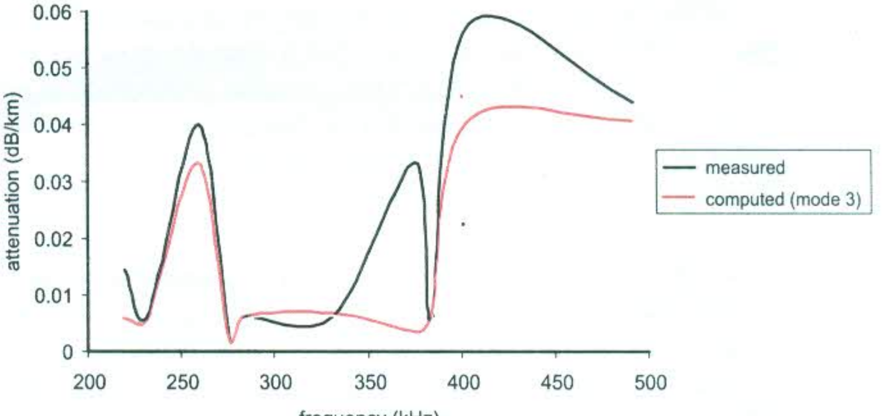

Fig. 20: Comparison between measured and computed attenuation values for BISON

9.8 Some Concurrent Related Researches and Comparative Findings

Some research conducted in other parts of the world concurrently with mine arrived at similar conclusions. A brief appraisal is as follows:

1. Nermin, *et al* (2004) present an approximate computation of high-frequency high-voltage power-line characteristics: amplitude, phase and group delay characteristic. Analytical approximate formulae are derived for the power line with three conductors in horizontal disposition and middle-phase to ground coupling.

2. Pouyan and Mohsen (2006) present a channel model suitable for multi-wire overhead medium voltage lines. This model, incorporating ground admittance, is more appropriate at higher frequencies than predicted by Carson's model of 1926. The proposed model is further used to evaluate the multipath channel impulse response and associated capacity limit in sample power distribution grids for applications in broadband over power lines communications. For a sample grid model, comparison is made to the capacity value predicted based on the Carson's model, and it is demonstrated that the older model underestimates the potential of the overhead lines for broadband transmissions, significantly.

3. Theofilos, Grigoris and Dimitris (2010) present a general formulation for the determination of the influence of imperfect earth on overhead transmission line impedances and admittances is presented in this paper. The propagation characteristics of an overhead transmission line over homogeneous and two-layer earth are investigated using the proposed model. A systematic

comparison of the proposed model with other approaches is also presented and the differences due to earth stratification are reported.

Subsequent studies on communication potentials of high/medium voltage powerlines agree with results and conclusions of my research.

One of such is Lazaropoulos (2012), who considers the end-to-end channel characteristics of various overhead HV/BPL multi-conductor transmission line (MTL) configurations using the chain scattering matrix or *T*-Matrix (TM) method. The overhead HV/BPL transmission channel is investigated with regard to its spectral behavior, its end-to-end signal attenuation, and phase response. It is found that the above features depend critically on the frequency, the coupling scheme applied, the physical properties of the cables used, the MTL configuration, and the type of branches existing along the end-to-end BPL signal propagation.

9.9 Major Conclusions

Major conclusions drawn on the intelligence transmission potentials of the Nigerian electric power transmission lines are as follows:

1. The vertical configuration exhibits better propagation behaviour than the triangular configuration.
2. The 330kV single circuit powerlines exhibit better propagation behaviour than the 132kV single circuit powerlines.
3. The 330kV lines can be used as propagation medium for intelligence transmission by careful design and selection of carrier equipment in order to achieve high speed rates, large channel capacity and bandwidth.
4. Mode 2 and mode 3 are the aerial modes, the better of

which (mode 3) can be used as the high frequency path for intelligence transmission while the other (mode 2) can be used as an alternative path. This provides for redundancy and increases the reliability of communications though at an increased (justified) cost as this would require the phase-to-phase coupling.

9.10 Some Features of the Research

Some documentation on the research includes Adegboye, 2010; Adegboye, 2006; Adegboye, 2004; Adegboye, Oyedokun and Gulma, 2002 and Adegboye, 2002). However, as line snap in transmission lines could lead to loss of communications in the PLC communication system, which is undesirable just as power outages on distribution lines are not desirable for efficient last mile access, my research is complemented with some studies for effective co-ordination. These are:

1. Power Systems Reliability Studies (Jimoh, Adegboye and Adegboye, 2013; Adamu, *et al,* 2012; Adegboye and Dawal, 2012; Adegboye and Ekundayo, 2012 and Adegboye, 2010);

2. Power Quality Assessment in Distribution Networks (Adegboye and Mele, 2012 and Adegboye, 2009).

9.11 Recommendations

For the purpose of design and operation:

(1) Measurement of carrier frequency response of all newly installed carrier channels is necessary to ensure proper operation;

(2) Line traps should be inserted in series with tap lines for the given permissible attenuation for the bandwidth of any carrier on the through circuit so as to prevent high frequencies from passing through the transmission line;

(3) Assessment of carrier performance should be made on all

installed carrier channels, especially, the recent ones, in order to be sure of proper operation;

(4) Sufficient margin should be allowed in the design of power line carriers so that weather and other environment effects would not affect their operation, adversely;

(5) The bandwidth of transmission using the latest model of the PLCs installed on the phase conductors of the PHCN 330kV transmission system can be improved if used in conjunction with optical fibre cable, which could be run inside a cavity inside the earth wires. This would prove very useful in high-speed applications such as the information super-highways;

For the purpose of further research and development:

(6) The characteristic impedance of a carrier circuit derived in this research, could be used to determine the restriking voltage transients associated with circuit breaker clearing faults in powerlines. This restriking voltage, which occurs during the critical period prior to the first reflection can be evaluated solely in terms of the characteristic impedance matrix and the appropriate energization condition;

(7) Research should be extended to twin circuit lines with one and two earth wire(s), respectively to study their peculiarities;

(8) The research should be extended to cover the PHCN distribution network as is currently being done in some developed countries;

As regards the records of data by the management of PHCN:

(9) Standardized method of data recording in such a way as to highlight the narrative aspects is encouraged for further use in planning, maintenance and operation of the systems;

(10) A database for all input data and other relevant data

needed for the operation of powerline carrier systems should be established to facilitate software development for automated analysis, computations and comparisons;

(11) Automation of PLC systems and other aspects of the network is proposed as this will ensure and assure the reliability and dependability of its systems. It also minimizes great risks to equipment and personnel and great financial losses that are incurred whenever such hazards occur;

In the area of training and policy, the management of PHCN should:

(12) Ensure periodic conduct of communication systems reliability studies on its installations;

(13) Conduct thorough power system reliability studies on the Nigeria's Grid system to ensure sufficient, efficient, consistent and reliable power system at the generation, transmission and distribution levels;

(14) Strive for effective intelligence transfer over such lines as well as for the forms in which other powerlines are utilized in order to achieve a high reliability standard of communication;

(15) Include recommendations stated in items (8) to (15) as part of the corporate policy of PHCN and given top management attention.

10. RESEARCH DIRECTION AND LEADERSHIP

After the conduct and involvement in researches, which has culminated into my current status as Professor of Electrical Engineering, my research direction is on how to address two (2) primary challenges in PLC communication system viz:

1. Spatial consideration: Development of technology to reduce bulky and hence costly equipment;
2. Bandwidth issue: Improvement on limited frequency spectrum.

My focus on bandwidth improvement is towards the incorporation of optical fibre within a cavity carefully routed inside the phase conductors without prejudice to the electrical and mechanical integrity (see recommendation 5). This has further been shown to have good prospects (Ezeh and Okwe, 2013). Few works on optical fibre approach to long haul transmission are focused on the earth wire. Many other researchers concentrate on last mile (Oyetunji, 2013; Oyetunji and Edeko, 2013 and Adejumobi, 2010).

11. CONCLUSION

As a concluding remark, I want to say that the Federal University of Technology, Minna has important role to play in this research direction.

Considering my research focus, which also involves nurturing and mentoring younger academics, my University under the visionary leadership of our amiable Vice-Chancellor, Professor Musbau Adewumi Akanji, *FNSBMB*, is encouraged to strongly support my research direction in the following ways:

1. Creation of collaboration with known University and the industry towards the development of portable, effective and reliable PLC equipment to address the problem of bulk and high cost;
2. Provision of enabling environment and funding research to enhance co-ordination of long-haul and last mile access for effective intelligence transmission for development of SMART homes with minimum error/distortion at minimum cost;
3. Research into the design and development of fibre-based powerline conductors for the purpose of addressing the problem of bandwidth.

ACKNOWLEDGEMENTS

So many things have happened between the point of my existence up to this moment. I need to give credence to all actors and participants.

First is to acknowledge God the creator, the author of the universe, the omnipotent and omniscience, the I am that I am, for giving me life and enablement and for keeping me even till this day.

I thank my parents, Late Pastor James Kolawole Adegboye and Deaconess Victoria Ibidunni Adegboye, the vessels God used in bringing me into the world, for the training and tireless efforts in ensuring that I become a responsible individual. My father has always encouraged us to play our own part by working hard as his toiling over us is to make us responsible so that we will not be liability to anyone. My mother, an educationist and guidance counselor, guided me through strict discipline, which helped me not to stray away. May God enrich you with long life. I sincerely acknowledge my siblings. My elder ones: Bros Bolaji and Soji and my younger ones: Segun, Leke and Bunmi. It is wonderful having the best brothers and sister to me.

I appreciate all my teachers and lecturers for imparting basic and specialized knowledge on me as well as all my classmates, friends and well-wishers for being good companions.

The leadership provided by Professor Musbau Adewumi Akanji, FNSBMB, encouraged me as an individual by recognizing that I had something to offer in a capacity relevant to my experience and specialization. I am thankful to Prof. Akanji and his management team for the insight and consistent emphasis on the need to deliver inaugural lectures.

I have enjoyed the support of all my senior and junior colleagues in the School of Engineering and Engineering Technology, Federal University of Technology, Minna and the Faculty of Engineering, Ahmadu Bello University, Zaria. I am always proud to say that I enjoy working with all of you.

A university would be empty if it were not for students. You rightly deserve a word of thanks too. Thank you for making classes fun to lecture, for genuinely being interested in what I am lecturing, and for your challenging questions. Thank you also for enjoying my jokes, even though, I gather, in many cases you do not understand them as instruments to facilitate your understanding of the subject. No wonder, at times, some of you return my jokes in examinations. I hope you both enjoy and understand my classes as I enjoy lecturing and learning from you.

Lastly, I want to thank immensely the entire University community and the wonderful audience, who took their precious time to participate in this inaugural lecture. I had to be on my toes to prepare, trusting God not to disappoint you because I was very sure you would make it my day. You have made this evening so wonderful for me and I hope I have been able to make it worth your while too.

Finally, I must thank my family. I can do all these because you are all around me. We are like a cross, with me at the centre. My heartthrobs, so loving and caring; dutiful and loyal: Glory and Juliet are on the either side of me. They are my pillar! My jewels, our children: Emmanuel, Victoria, David, Isaac, Jonathan, Peter and Mercy are ahead and behind me. They are my support! Emmanuel is so kind, patient, matured and understanding. Victoria prepares my morning tea, showers me with love and protects me. No wonder she calls me her son. David is my teacher, never tired of correcting my mistakes, especially, my oral English.

Isaac, the Pastor and Police is always for righteousness and justice. For any issue, Daddy must take responsibility and apologize. Jonathan is the administrator and praise worship leader. He is always on standby to ensure everything in the house be put in the right place. He takes his time to dress me up for work. Peter is the easy going principled disciplinarian, quiet, so kind, matured but strict. With him, I need no effort in wearing my sandals. Mercy is very strict in ensuring that I wake up very early in the morning; no compromise. She always looks at daddy with smiles admiringly to inspire him. With this wonderful family, you can see that I have every reason to strive towards accomplishment. I am sure you will agree with me that they can now be very proud of how well they have brought me up. If there is any glory in being a Professor, I give it to my family.

My Vice-Chancellor sir, I AM DONE.

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BRIEF PROFILE OF THE INAUGURAL LECTURER

Babatunde Araoye **ADEGBOYE** was born to the family of Late Pastor James Kolawole Adegboye and Deaconess Victoria Ibidunni Adegboye on September 26, 1970 in Zaria, Kaduna State of Nigeria. He attended several primary schools in Zaria, Kano and Offa (his home town) between 1974 and 1980 and then proceeded to the famous Offa Grammar School, Offa, Kwara State, where he completed his secondary education in 1985. He completed his advanced level studies at the School of Basic Studies, Ahmadu Bello University (ABU), Zaria in 1987. In 1991, he obtained the Bachelor of Engineering **(BEng)** degree in Electrical Engineering from ABU, Zaria and was awarded the Yaroson and Partner's prize for the Best Final Year Project in Power and Machines.

After observing the compulsory one-year National Youth Service Corp programme at ABU, Zaria, as Honorary Graduate Assistant, Mr. Babatunde Adegboye joined the services of the same University on October 2, 1992 as Assistant Lecturer. He served for twenty years and transferred his services to the Federal University of Technology (FUT), Minna on October 1, 2012. Within this period, he rose through the ranks to the post of Professor of Electrical Engineering in 2012.

While in ABU, he obtained his Master of Science **(MSc)** and Doctor of Philosophy **(PhD)** in Electrical Engineering in 1997 and 2006, respectively.

Quite early in his professional career, Professor Adegboye believed that a complete engineer needs to be well equipped with adequate knowledge and skills in Management. For this reason, he undertook a course of study at Ambrose Alli University, Ekpoma, which earned him the award of the Master of Business Administration **(MBA)** in 2005 specializing in Management and Organizational Theory. His curiosity about national and international issues led to his quest for more knowledge. He to up another programme in the Department of Political Scien ABU, Zaria, where he obtained a Masters degree in Internation Affairs and Diplomacy **(MIAD)** in 2008. He subsequen enrolled in the Department of History, University of Maidugu for a Postgraduate Diploma programme in Strategic Studi **(PGDSS)**, which he completed in 2012.

On the professional directive, Professor Adegboye is a Memb Nigerian Society of Engineers (**MNSE**), Registered Engine Council for the Regulation of Engineering in Nigeria (**Eng** Associate Member, Nigerian Institute of Management (**AMNIM** Member, The Institute of Electrical and Electronic Engineers, U (**MIEEE**), Fellow, Nigerian Institute for Biomedical Engineeri (**FNIBE**) and Fellow, Strategic Institute for National Resourc and Human Development (**FRHD**).

Professor Adegboye has attended and actively participated several conferences both at national and international levels. also has to his credit over fifty (50) publications as jour papers, conference proceedings papers and book chapters. also has several conference/workshop papers, technical repo etc, both at local and international levels. He has ma Professional/Proficiency Certificates in various disciplines. research interests are Powerline Communications and Pow Systems Reliability.

As an academic, Professor Adegboye has lectured many cours cutting across the field of Electrical Engineering and supervised many students both at undergraduate a postgraduate levels. He has produced so many graduates: so PhDs, several Masters, as for Bachelors, countless! There some diploma and postgraduate diploma graduates too. It worthy of mention that among the students of Profess Adegboye, known to him to be in the University Academic Syste two (2) are now Professors, many are Associate Professors w lots of Senior Lecturers, all spreading across Universities both in Nigeria and abroad.

On the administrative directive, Professor Adegboye has served in ABU, Zaria and so far in FUT, Minna in many capacities. He is the Head, Department of Electrical and Electronic Engineering, FUT, Minna (2012-Date), Member of Senate, FUT, Minna (2012-Date), Member, ABU Masterplan Review Committee (2007-2012), Head, Department of Electrical Engineering, ABU, Zaria (2006-2007), Member of Senate, ABU, Zaria (2006-2007), Representative of Heads of Departments of Faculty of Engineering to Senate Standing Committee, ABU, Zaria (2006-2007), Postgraduate School Representative during some PhD Oral Examination and PhD Research Proposal Defence, FUT, Minna, (2012-Date). He was Member, International Advisory Board, International Engineering Conference (IEC 2015), FUT, Minna, (2015), Assessor, Biennial Engineering Conference, FUT, Minna (2013), Member, Appointments and Promotions Committee, FUT, Minna, (2012-Date), Member, Faculty Teaching/Examinations Monitoring Committee, ABU, Zaria (2011-2012), Member, Faculty Specific Charges Committee, ABU, Zaria (2005-2012) and Chairman, Appointments and Promotions Committee, Department of Electrical and Electronic Engineering, FUT, Minna (2012-Date).

While in ABU, Zaria, he has held all administrative portfolios in the Department of Electrical Engineering in addition to such special assignments as Chairman, Editorial Board, Zaria Journal of Electrical Engineering Technology (ZjEEτ) (2010-2012), Member, Editorial Board, Zaria Journal of Electrical Engineering Technology (ZjEEτ) (2008-2010), Quality Control Officer (Affiliation) in Charge of Telecommunication and others (2008-2010) and Secretary to the Academic Board of the Department (1993-1997).

Based on his wealth of experience and expertise, Professor

Adegboye has made significant impact on the community at large, some of which include national assignments such as Member, Inter-Agency Committee of Evaluators of Telecommunication-Based Research Proposals from the Academia set up by the Nigerian Communications Commission, Abuja (2015), Engineering Expert, Technical Review Panel on the Environmental Impact Assessment (EIA) of some Electrical Power Engineering Projects and some Telecommunication Engineering Projects set up by the Federal Ministry of Environment, Abuja (2012-Date), Team Leader on some Resources Verification and Accreditation Visits (HND and ND programmes) to some Polytechnics in Nigeria organized by the National Board for Technical Education (NBTE), Kaduna (2013) and Participant, Review of National Energy Policy organised by the Energy Commission of Nigeria, Abuja (2013).

At the Ahmadu Bello University Teaching Hospital, Zaria, he served as Member, Educational Committee, School of Biomedical Engineering Technology (2007-2014) and Chairman, Ad-Hoc Sub-Committee on Revision/Resit Programme of the Educational Committee, School of Biomedical Engineering Technology (2008).

To sister universities, he has served as External Examiner to three (3) PhD students (2013-Date), several MSc/MEng students (2013-Date), postgraduate diploma programme (2006-2007 and 2014), undergraduate programmes (2008-Date) and polytechnic academic programmes (2007-2013). He also served as External Assessor of publications of four (4) candidates for promotion to the rank of Professors (2013-Date), three (3) candidates for promotion to the rank of Associate Professors (2013-Date) and a candidate's promotion to the rank of Chief Lecturer (2012).

Professor Adegboye has served as Assessor, Academy Journal of

Science and Engineering, Nigerian Defense Academy, Kaduna (2016), Assessor, Nigerian Journal of Tropical Engineering, Abubakar Tafawa Balewa University, Bauchi (2013-2014), Assessor, International Journal of Engineering Research in Africa, Trans Tech Publications Ltd, Switzerland (2012-2013), Facilitator, Electrical Aspect of Aerodrome Design Course, Nigerian College of Aviation Technology, Zaria (2004) and Guest Lecturer, Nigerian Institute of Transport Technology, Zaria (1997-2010).

To Professional organization and societies, Professor Adegboye has served as Guest Lecturer, Nigerian Society of Engineers, Maitama Branch, Abuja (2015), Audit Engineer **(European Union Expert)**, Water Supply and Sanitary Sector Reform Programme, Yobe State (2011), Technical Secretary, Nigerian Society of Engineers, Zaria Branch (2002-2008), Secretary to Interview Panel for Corporate Membership of the Nigerian Society of Engineers, Zaria Centre (2002-2008), Member, Board of Examiners for the Corporate Membership of the Nigerian Society of Engineers (Electrical Division), Zaria Centre (2002-2009) and Secretary, Rotary Club of Zaria, District 9120, Nigeria (2006-2007).

Professor Adegboye is the Immediate Past President, Association of Biomedical Engineers and Technologists of Nigeria and President, National Postgraduate College of Biomedical Engineering.

Professor Engr. Adegboye enjoys reading and listening to classical music. To the Glory of God, he is happily married with children.