37th INAUGURAL LECTURE

ELECTRICAL ENGINEERING: KEY TO DEVELOPMENT

by

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1.0 PREAMBLE

Some of the questions often asked in academic circles are:

- What is an inaugural lecture?
- When should it be given?
- What is its significance?
- Under what condition is it given?

The answers to these questions vary a great deal, as there are no prescribed rules and standards. There is, however a tendency to believe that an inaugural lecture gives a Professor an opportunity to showcase his or her academic achievements that should justify his or her appointment as a Professor. It is therefore mandatory for a professor to give an inaugural lecture.

The inaugural lecturer of today got his chair at the Department of Electrical & Computer Engineering, Federal University of Technology, Minna on October 17, 1991. His lecture was scheduled for the 1993/94 academic year, but did not take place because of the series of ASUU strikes which characterized that period. This lecturer transferred to Lagos State University 10th August, 1998.

On a recent request by the Dean of Engineering, the inaugural lecture prepared in 1993 which was totally outdated, is now completely updated. This inaugural lecture will begin with some definitions which make up the introduction. Then the contributions of electrical engineering to development in Nigeria are discussed. This will flow into the discussion of the contributions of this inaugural lecturer to advancement of technology and his contributions to

professional practice. Finally recommendations will be made for Nigeria to take advantage of.

2.0 HISTORICAL BACKGROUND

The first electrical engineer is said to be William Gilbert who, in the 17th century, designed a device that detected statically charged objects. He was the first to draw a clear distinction between magnetism and static electricity and to establish the word electricity [1]. In 1827, Georg Simon Ohm quantified the relationship between the electric current and potential difference in a conductor, Michael Faraday discovered electromagnetic induction in 1831, while James Clerk Maxwell published a unified theory of electricity and magnetism in 1873 [2]. These four great men can be said to be the fathers of electrical engineering.

The first department of electrical engineering in the world was established in 1882 at the Darmstadt University of Technology. In 1883, Darmstadt University of Technology and Cornell University introduced the world's first courses of study in electrical engineering. In 1885, the University College London established the first chair of electrical engineering in the United Kingdom [3]. In 1886, the University of Missouri established the first department of electrical engineering in the USA [4].

This will do for a brief history of electrical engineering, consisting of the founding fathers and institutions.

3.0 WHAT IS ELECTRICAL ENGINEERING?

Let us begin this lecture with clear-cut definitions of what this lecture is about. Therefore, the first question is "What is electrical engineering? Electrical engineering is the practical applications of electricity and electron devices in which the motion of electrons is controlled. Electricity itself is basically the controlled motion of electrons. Therefore, what is an electron and what is an electron device?

According to ***Collins Dictionary of English Language,.***

An electron is a stable elementary particle present in all atoms, orbiting the nucleus in numbers equal to the atomic number of the element, with a negative charge of 1.6022×10^{-19} coulomb, a rest mass of 9.1096×10^{-31} kilogram, a radius of 2.818×10^{-15}, and a spin of ½ .
For the definition of electron device, permit me to go by the McGraw-Hill ***Dictionary of Scientific and Technical Terms, 3rd Edition,*** which says:

An electron device is a device in which conduction is principally by electrons moving through a vacuum, gas or semiconductor, as in a crystal diode, electron tube, transistor, or selenium rectifier.

Sub-Disciplines

From the 19th century to the third-quarter of the 20th century, electrical engineering was broadly divided into two major areas namely [5]:

(a) high-power electrical engineering and
(b) low-power electrical engineering.

High-power electrical engineering is concerned largely with the generation, transmission and distribution of electrical power; and, in addition, with electrical machines and equipment design. The point of generation of power is not the point of its utilization. In Nigeria, power is generated in, for example, Kainji, Shiroro, Jebba, Afam and Egbin, and the utilization points are mainly Lagos, Kano, Port Harcourt and so on.

Low–power electrical engineering

It is also known as electronic engineering. Electronic engineering itself has given birth to computer engineering. Under electronics are communications, control and instrumentations engineering.

By the last quarter of the 20th century, the sub-disciplines of electrical engineering became

- Power
- Control
- Instrumentation

- Electronics
- Signal processing
- Computers
- Microelectronics
- Telecommunications

Emerging sub-disciplines are:

- Mechatronics
- Biomedical

Nomenclature:

It is not surprising that Faculties of Engineering have christened their departments "Department of Electrical Engineering", "Department of Electrical & Electronic Engineering", "Department of Electrical, Electronic and Computer Engineering". Most universities in the USA have adopted the name, Department of Electrical & Computer Engineering. So also did the Federal University of Technology, Minna, where this inaugural lecturer had his previous appointment.

Electrical Engineering Research

According to the ***New Encyclopedia Britannica, Vol. 18, 15th Edition***, electrical engineering research can be categorized as follows [5]:

- Basic research in physics, other sciences, and applied mathematics in order to extend knowledge applicable to the field of electronics.
- Applied research based on the findings of basic research and directed at discovering new applications and principles of operation.
- Development of new materials, devices, assemblies, and systems suitable for existing or proposed product lines.
- Design of devices, equipment, and systems for manufacture.
- Field –testing of equipment and systems.
- Establishment of quality control standards to be observed in manufacture.
- Supervision of manufacture and production testing.

- Postproduction assessment of performance, maintenance, and repair.
- Engineering management.

Applied research has been the interest of this inaugural lecturer. Some of these will be highlighted under his contributions to advancement of technology.

4.0 CONTRIBUTIONS OF ELECTRICAL ENGINEERING TO DEVELOPMENT IN NIGERIA

Low-Power Electrical Engineering

The major noticeable contributions of low-power electrical engineering to development in Nigeria is in telecommunications. Prior to 1999, there was restricted access to telecommunications facilities in Nigeria. The telephone penetration density was at best 1:400. By the International Telecommunications Union's (ITU) definition, that penetration density figure classified Nigeria as underdeveloped. By the adoption of Global System for Mobile (GSM) communication in Nigeria and with the general deregulation of telecommunication services, more Nigerians can now afford to communicate. This is a significant development in Nigeria.

Information Communication Technology (ICT) has revolutionalized the way business is conducted in Nigeria: the banking industry, airline industry, educational industry and a host of other businesses are on the World-Wide-Web.
These are notable contributions of low-power electrical engineering to development in Nigeria.

High-Power Electrical Engineering

High–power electrical engineering, as was earlier pointed out, is basically electrical energy, power and machines. Energy is needed to drive industries in the manufacturing sector of the national economy.

Significant aspects of electrical power are generation, transmission and distribution. The current power generation is much below the requirement for the population of Nigeria. Even for the amount of energy available, a great deal lost in distribution because the present structure of the Power Holding Company of Nigeria (PHCN) is not adequate for revenue collection. Imagine how much of electrical energy is consumed by the various road-side welders,. One wonders if they are metered and how much revenue is collected by PHCN.

With our common experience in the power sector, it is very difficult to quantify the contribution of high–power electrical engineering to development in Nigeria. A giant stride is required to turn around the electrical energy sector. Recommendations in this respect will be given towards the end of this lecture.

5.0 CONTRIBUTIONS TO THE ADVANCEMENT OF TECHNIOLOGY

The modest contributions of this inaugural lecturer to the areas of technology known as high tech began during the PhD research activities at the University of London King's College. The work involved the use of unencapsulated field-effect microwave transistors on microwave integrated circuit with a view to designing an 8 – 12GHz or an X – band solid – state amplifier on alumina substrate. The complete PhD work including the defence took two calendar years. The 2 – year PhD activities included

a. Microstrip transition characterization and
b. Microwave FETs modeling.

These two were invited for presentations at two colloquia at the Institute of Electrical Engineers, Savoy Place, Strand, London.

The colloquia took place in September and October 1976, bearly three months to the completion of the PhD defence, which was in December 1976.

In addition, the transition characterization technique was in *Electronics Letters*, a publication of the institution of Electrical Engineers UK [6]. The *Electronics Letters'* publication reviewed the work of Professor I. Stevenson, then of Warrick University and my

characterization technique was claimed to be superior. Interestingly, Professor Stevenson was introduced to this lecturer for the first time in his PhD defence room as his external examiner. The defence lasted five hours, at the end of which he got a warm handshake from Professor Stevenson with the word "Congratulations".

I became a staff member of the Faculty of Engineering, University of Lagos, in January, 1977. In August 1977, two papers of mine appeared in Vol.13 No.16 [7] and Vol.13 No.17 [8] of *Electronics Letters* with my address as the University of Lagos. These publications perhaps informed the international academic community of my relocation from London to Lagos. By September 1977, a library in the Israeli Defence Ministry wrote to me in Lagos to request for a copy of my PhD thesis. The thesis was sent to Israel with a proviso that it should be copied and mailed back to me, which they obliged.

In summer (June–September) 1978, I was invited to the Siemens Research Laboratories in Munich. There, I joined a group of Siemens Engineers to develop a solid-state 2-GHz 10-watt bipolar transistor amplifier. The amplifier was later incorporated on some 2-GHz NITEL toll routes in Nigeria.

In the summer of 1979, I was again at the Siemens Research Laboratories in Munich. That time the involvement was with the development of microstrip zigzag antennas for application in the control and monitoring of municipal bus transport service.

Between July 1981 and October 1982, I was a guest researcher at Comsat (Communication Satellite Corporation) Laboratories in Clarksburg, Marryland, just about 22 miles from downtown Washington DC. During the 15-month stay at Comsat, I was involved with a 19 - GHz field-effect transistor solid – state amplifier for incorporation on-board the next generation of communication satellites over the 20/30 GHz system. The preliminary results in this work started coming out after barely nine months of resumption. The 19-GHz solid-state amplifier with a little more than 10% bandwidth was constructed on a 0.01-inch fused Silica. The overall size of the amplifier with housing is 0.84 x 0.84 x 1.57 inches weighing about 29 grams. This work was published in the *International Journal of Electronics* in the U.K [9]. The novelty in this work is the payload advantage for incorporation on-board

communications satellite. The payload of a satellite is related to its life-time. The less the payload, the longer the life of the satellite.

On my return to the University of Lagos from Comsat in 1982, research into further miniaturization continued. This was in a quest for a further advancement in the frontier of technology. The first attempt was to consider the use of nonuniform lines as impedance matching components instead of uniform lines earlier used at Comsat. The first nonuniform line considered was a Hermite line. A Hermite line is a nonuniform line whose characteristic impedance Z(x) varies with the line length x in the form $Z(x) = a \exp((bx)^2)$. The result was quite exciting and it was published in the *Institution of Electrical Engineers (IEE) Proceedings,* in the U.K. [10].

While still researching at the University of Lagos, two other forms of matching components were considered. These were a hyperbolic cosine-squared tapered line and a general nonuniform line. The results of the former were published in the *International Journal of Electronics* in the U.K.[11] while the later were published in the *Institution of Electrical Engineering* (IEE). Proceedings in the U.K.[12].

The housing for the solid-state 19-GHz amplifier earlier reported was carefully designed using three waveguide transitions on each of the two ends. The housing design itself was novel and this was published in the *International Journal of Electronics*, (UK)[13]. In my research effort at further miniaturization toward satellite payload advantage, a double-sided exponentially tapered rectangular waveguide was investigated. The exciting results achieved were published in the Institution of Electrical and Electronics Engineers (IEEE) *Transactions* in the USA, [14].

Permit me, distinguished audience, to discuss briefly two more contributions to the advancement of knowledge. This audience may be aware that telecommunications networks and indeed most other electronics networks are going digital. Signals are now being processed digitally. Therefore, this inaugural lecturer, a couple of years back, began research in the area of digital signal processing. His first achievement in this research area, entitled, "Design of digital elliptic bandpass filter" was published in the *International Journal of Electronics* in the U.K.[15].

Computation of attenuation, phase rotation, and cross-polarization of radio waves due to rainfall in Nigeria has recently engaged the attention of this inaugural lecturer. The reason is that rainfall has been known to affect satellite – earth signals and the terrestrial microwave links above 10GHz. The results of this work appeared in the Institution of Electrical and Electronic Engineers (IEEE) *Transactions on Antenna and Propagation* in the USA [16].

Effects of dust, for example harmattan, on radio wave propagation is next to engage the attention of this author. This subject is still not clear to scientists, but the experiences in the operation desert storm on the weapon guiding and delivery systems, the communications satellites signals and the military satellites signals call for more research efforts on the effects of dusts and mirages on radio waves.

6.0 CONTRIBUTIONS TO PROFESSIONAL PRACTICE

Some of the inaugural lecturer's humble contributions to professional practice may be catalogued as follows:

Design of the Telecommunications Network for Abuja:

In 1979, I was invited to join the Nigerian Consulting team which, in collaboration with the Hidroservice Company of Sao Paulo, Brazil, designed the telecommunications network for Abuja. In addition, I was principally involved with the terrestrial microwave link between Kaduna and Abuja. Travelling along the Kaduna – Abuja road, the active repeater stations will be observed with the towers at Dutse, Sabongarri Bini, Jere and Diko while a passive repeater tower is located at Zuba. The antenna at Zuba is also used for the traffic between Suleja and Abuja to complete a local circuit in which case Suleja and Abuja have the same code.

Inmarsat Contract:

The International Maritime Satellite Organisation (Inmarsat) is an international company with the headquarters in London. Inmarsat has been known to provide ship-to-ship, ship-to-land and land-to-land telecommunications services for over 40 years. At the planning stages of air-to-air and air-to-land services, this inaugural lecturer was involved. The services would

enable people, especially top business executives, to phone their offices or homes from the airplanes and to browse the Internet from their seats on the airplane. Inmarsat required the analysis of spectrum availability for these services in all the regions of the world. I was given the inmarsat contract for the Africa region which involved extensive travels to countries in the north, west, east, central and Southern Africa. My assignment began in October 1990 and the report was presented in London, with commendations, in March 1991.

Motorola Contract:

In a similar development Motorola, with a plan for a global telecommunications service, consulted your inaugural lecturer for a spectrum analysis over Africa. Motorola service was scheduled to be operational by 1997. It employed a constellation of 77 small lower-earth-orbit Satellites to provide global mobile service such that man, using a pocket telephone handset, could talk to anywhere on earth, in the airplane, on sea, or in the remotest jungle of the globe.

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This assignment, which began in April 1991, also took the lecturer to various regions of Africa for data collection. The report was presented in Washington DC in October 1991.

World Bank Mission to Federal Civil Aviation Authority (FCAA):

In July 1992, your lecturer was invited by the World Bank to team up with Col. Jerry Parker of the U.K. on a World Bank mission to the FCAA for the proposed Aviation Infrastructure Rehabilitation Project in Nigeria. Both of us were engaged by the World Bank as Communications and Equipment Consultants. Our investigations covered navigational aids, radar, communication between aircraft and ground, between airports and within airports, runway lighting with associated lights and indicators. The report was presented to the World Bank in August, 1992. The report formed a blue print for the Nigerian Aviation Industry and it is still being implemented at the present moment.

Nigeria Communication Policy and Birth of Nigerian Communications Commission (NCC):

In 1986, the then Federal Minister of Communications, called on this inaugural lecturer for ideas on the development of telecommunications in Nigeria. The advice was that Nigeria first had to have a communication policy. The Minister was then assisted to put together a team of experts to formulate the policy for Nigeria. This inaugural lecturer was a prominent member of the team.

It was the team that recommended the formation of the Nigerian Communications Committee (NCC) as a Regulatory Body. The structure of the NCC which is virtually in its present form was a prominent aspect of the recommendations.

Global System for Mobile (GSM) Communication:

In 2000, the immediate past Executive Vice-Chairman of NCC Dr. Nnamna set up a Committee, chaired by this inaugural lecturer, to draw up a blueprint for GSM in Nigeria.
The Committee came up with a comprehensive analysis which shows that if Nigeria were to adopt GSM 900, the maximum number of operators possible would be four. However, GSM 1800, if adopted, would allow for nine operators. The analysis is recorded in "Technicalities of GSM and the Nigerian Entry" In fact all the plans for Nigeria's full entry into GSM had been put in place before Dr. Nnamna was abruptly removed and replaced by Engr. Ernest Ndukwe who then came in to implement the plan.

7.0 RECOMMENDATIONS

Low-power Electrical Engineering

With the recent adoption of global system for mobile (GSM) communication there has been a tremendous improvement in the low-power electrical engineering contributions to development in Nigeria.

The regulatory body, the Nigerian Communications Commission (NCC) has done very well but more is expected in the improvement of grade of service. It is hereby strongly recommended that for GSM 900 operations, the maximum number of operators be kept at four and for GSM 1800 operations, the operators be kept at maximum nine.

High-power Electrical Engineering

The major problems of public electricity supply in Nigeria has been in generation and distribution. We have encountered transmission problems which have been principally due to equipment vandalisation along the transmission lines. The transmission problems could be minimized if the energy generation points could be close enough to load centres. Almost 60% of energy consumption in Nigeria is in Lagos, because the majority of industries are in Lagos. It therefore makes economic sense to build generating stations close to Lagos and it is hereby recommended.

Electricity Generation

The present electricity generation capacity in Nigeria is abnormally low for our perceived population of 150 million.

Ransome Owan, the Executive Chairman of the Nigerian Electricity Regulatory Commission (NERC) was reported to have stated in the *Vanguard Newspaper* of 4 September, 2007 that Nigerian's power generation capacity reached 3000 Megawatts. He stated that the reason for this apparent level of generation could not be unconnected with increase due to heavy rains in the reservoirs which power the hydro power stations in the country.

All Africa community reported that Nigeria targeted 10,000 Megawatts electricity capacity in 2007. It is not on record that the target was met.

For meaningful development and for foreign investors to come in, as we have always hoped, we require massive power generation of about 50 Gigawatts. Government cannot provide this amount of power. It cannot be provided with gas or diesel especially with unsteady supply due to militancy. The only option is nuclear power plants. Nigerian Government cannot provide nuclear energy, but can only provide stringent regulation through the Nigerian Nuclear Regulatory Agency for Private Operations. It is hereby strongly recommended that legislation be put in place for the nuclear power generation of electricity in Nigeria.

As was said earlier, close to 60% of electricity consumption in Nigeria is in Lagos where the load centers are concentrated. Therefore, the Lagos State Government must take the bull by the horn and initiate a move for the said legislation on the generation of electricity through nuclear power plants.

The good news here is that there is a serious concern for safety. There are moves for portable nuclear plants designed to be very safe. Toshiba is planning to install in Japan by 2008 a 200 kilowatt portable micro nuclear plant. It is self-sustaining and can deliver power for up to 40 years very cheap about half the cost of grid energy.

US Department of Energy is developing small, sealed, transportable, autonomous reactor (SSTAR) which will generate power for up to 30 years without the need for refuelling or maintenance. The sealed reactor can be delivered to a site, left to generate power for up to 30 years, and retrieved when its fuel is spent. It is safe because the fissile material from the reactor would be inside a tamper-proof case. The capacity of such a plant is 100 megawatts. This is very promising. A prototype is expected by 2015.

One other recommendation for Lagos State Government is to encourage it citizens to complement electricity supply with alternative sources. This will reduce drastically the demand on power from the grid.

Recommended here are

- Solar energy/photovoltaic + inverter which can provide up to 5 KW.
- Affordable Wind generator which can provide up to 220KW.

Currently a 10KW wind generator goes for about $13,000.00 and a 29KW for about $24,000.00.

These systems are clean and noiseless unlike the noise pollution contributed by diesel and petrol engine generators.

Electricity Distribution

This is where the Power Holding Company of Nigeria (PHCN) really has problems. Some of the problems can be enumerated as follows:

- Bypassing of meters by consumers most times with the connivance of PHCN officials. This is common with road-side welders and quite a number of supposed-to-be responsible Nigerians.
- Meters which do not read correctly because they were not calibrated or serviced over the years. Some of the meters have been manipulated to give false reading.
- Some PHCN meter readers connive with consumers to defraud PHCN.

Even with these three problems listed, one can imagine the colossal waste of PHCN revenue. It is no exaggeration to state that close to 50% or more of the PHCN revenue is lost through fraud.

This is where one will appreciate the local government as the grass roots government closest to the people. Local governments should be empowered to take up the responsibility of buying energy, distributing to consumers and collecting the revenue. All the electricity generating transmitting company needs to do is to meter the energy delivered to the local government leaving the local government to do the retailing.

With this foregoing explanation or argument, it is hereby recommended that legislation be put in place for the local governments to begin the retailing of electrical energy.

Lagos is almost 60% of Nigeria in terms of energy consumption, as earlier stated. Lagosians are affected mostly by the epileptic power supply. It is therefore recommended that Lagos State Government takes a lead in this direction in order to provide a solution to the power problems of the State

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8.0 CONCLUSION

Mr. Vice-Chancellor Sir, it gives me a great pleasure to deliver this inaugural lecture at least to showcase some of the modest contributions that this lecturer has contributed to knowledge of electrical engineering and to the professional practice in the chosen field.

Permit me to reiterate that Nigeria has done reasonably well in low-power electrical engineering with the adoption of GSM and CDMA telecommunication technologies. In high-power electrical engineering, and electricity generation in particular, we are very far behind. The recommendations given in this lecture are from my heart and I pray that Nigeria, particularly Lagos State Government, give them serious consideration.

Finally, Mr. Vice-Chancellor sir, permit me to recognize my lovely, darling wife, Dr. Oluwafunmilayo Ajose, who has always been my support, and my children:

- Mrs. Bisi Sowunmi, an LLM graduate of London School of Economics, practising in London and happily married with two boys and a girl;

- Dr. (Mrs.) Mobola Ogunlana, a PhD (Chemical Engineering) graduate of the University of Houston practising in Houston and happily married with a boy and a girl. She is a COREN Registered Engineer.
- Mr. Olumide Ajose, a BSc (Electrical/Electronics Engineering) graduate of the University of Lagos, practising with Zain, Nigeria and now with Vocadom South Africa.
- Master Ademide Ajose, an SS3 student of St Gregory's College, Lagos, whom I fondly refer to as my walking stick.
- My step children Bisola, Folake and Ope.

I thank you for your attention.

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