THE NIGERIAN SOCIETY OF ENGINEERS
BENIN BRANCH

2009 ANNUAL LUNCHEON/INDUCTION CEREMONY

GLOBAL ENERGY CRISES VISION 20 – 2020 PROSPECTS AND CHALLENGES FOR NIGERIA

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GLOBAL ENERGY CRISIS, VISION 20 – 2020: PROSPECTS AND CHALLENGES FOR NIGERIA

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SUMMARY OF CONTENTS

1.0 INTRODUCTION

- Energy is at the core of virtually every problem facing humanity. ***We cannot afford to get this wrong.*** We should be skeptical of optimism that the existing energy industry will be able to work this out on its own."

(Ref.: Testimony of witness Dr. Richard E. Smalley to the Senate Committee on Energy and Natural Resources – Full Committee Hearing on sustainable low-emission electricity generation, 27 April, 2004

Dr. Smalley is Director of the Carbon Nanotechnology Laboratory at Rice University)

- "... the momentous decisions we take in the next few years will determine whether our heirs(children) thank us or curse us for the energy choices we bequeath to them."
  (Ref.: Alex Kirby, BBC News Online environment correspondent, 19 April 2004)

2.0 MR. PRESIDENT'S 7 POINT AGENDA

2.1 SUMMARY OF POINTS

- Deals with ISSUES & POLICY challenges
- Transport sector(intermodal system, rail, road, marine)/Telecommunications
- **Power & Energy(sufficient/adequate) – modern economy & industrial nation by 2020[**
- Food security(agric 42% GDP/more than 65% workforce
- National Security,
- Education & human capital development
- Land Tenure Reforms and Home Ownership
- Wealth Creation

REF. Information Section Nigeria High Commission, 9, Northenberland Avenue London WC2N 5DX, 24/02/09

2.1 DETAILS ON POWER AND ENERGY SECTOR REFORMS

The infrastructural reforms in the power sector would aim at

- the development of sufficient and adequate power supply (to)
- ensure Nigeria's ability to compete as a modern economy and achieve full industrialization by the year 2015.
- He declared a national emergency on energy and power supply.

- The plan is to increase power supply to 10,000 megawatts (71.43W/person) in 2011 and 50,000 mw(357.14W/person) by 2015.(present world average is1000W/person)
- **THIS IS A DIRECT TRANSLATION OF THE VISION AND OUR FOOD FOR THOUGHT THIS EVENING!!!!**

3.0 OVERVIEW OF VISION 20 -2020(V20)

3.1 OBJECTIVES

- "By 2020 Nigeria will be one of the 20 largest economies in the world able to consolidate its leadership role in Africa and establish itself as a significant player in the global economic and political arena."

3.2 CONCEPT FOR VISION 2020

- A vision is a clear mental picture of the future which must represent a significant improvement on the current state. It however must be supported by a clear and realistic path to its realisation and requires consistent and sustained effort for its achievement.

3.3 KEY GOALS FOR VISION 2020 - VISION STATEMENT

- "By 2020 Nigeria will be one of the 20 largest economies in the world able to consolidate its leadership role in Africa and establish itself as a significant player in the global economic and political arena."

- Macro Economy
- Infrastructure (Adequate infrastructure services that support the full mobilization of all economic sectors).
- Education(adequate/competitive manpower)
- Health(increase life expectancy – 70 years/decrease infectious disease)
- Agriculture(food security/foreign exchange)

- Building a solid foundation for V2020(2008 – 2010)
- Achieving the MDGs enroute to V2020(2011 – 2015)
- Becoming a top 20 Economy by 2020(2015 2020)

(REF. http//www.nv2020.org/)

3.4 AN OVERVIEW OF THE MDGs

- Hunger
- Poverty
- Basic Education
- Gender equality

- Women empowerment
- Child mortality
- Maternal health
- HIV/AIDS
- Environment

3.5 CONCLUSIONS FROM WSSD ON DEVELOPMENT

- Economic,
- Environmental,
- Social,
- S & T, are vital for Sustainable Development

3.6 BLAIR COMMISSION REPORT

Opines that to deal with issues of

- Health,
- Education,
- Sanitation,
- Water supply,
- Energy, our Science, Engineering and Technical capacity must be well developed

3.7 CONCLUSIONS FROM THE NEW PARTNERSHIP FOR AFRICAN DEVELOPMENT, NEPAD

- Science, Engineering, Technology, and Innovation (SETI),
- Regional interaction,
- poverty eradication,
- Economic growth are key to Sustainable Development

(Ref: Proceed of the 16th Engineering Assembly of COREN, 29/08/07)

4.0 A GLIMPSE INTO FAILED STATE POLLS

In your opinion, which of these is the most critical cause of state failure?

- Corruption
- Environmental Damage
- External Actors
- Group Hatred
- Lack of Basic Education
- Lack of Social Equality
- Malnutrition and Disease
- Natural Disasters
- Poverty

(REF.: Failed States Index Scores 2009)

5.0 COMPARISON OF MR. PRESIDENTS 7 POINT AGENDA (P7) WITH V20

5.1 KEY PONITS IN THE AGENDA

Deals with ISSUES & POLICY challenges

- **Transport sector (intermodal system, rail, road, marine)/Telecommunications**
- **Power & Energy(sufficient/adequate) – modern economy & industrial nation by 2020**
- **Food security(agric 42% GDP/more than 65% workforce**
- **National Security, Niger Delta & Energy Security**
- **Education & human capital development**
- **Land Tenure Reforms and Home Ownership**
- **Wealth Creation**

5.2 KEY POINTS IN NIGERIA'S VISION 20:2020

- **Hunger**
- **Poverty**
- **Basic Education**
- **Gender equality**
- **Women empowerment**
- **Child mortality**
- **Maternal health**
- **HIV/AIDS**
- **Environment**

V 20

6.0 RELEVANCE OF ENERGY IN THE ATTAINMENT OF V20 & P7

- **Everything Depends on Energy**
- **Whatever cause motivates you** concerning the ff:

- Raising standard of living in developing nations
- Reducing disease and illiteracy
- Eliminating hunger and famine in Africa, Asia, South America
- "Sustainable development" and economic growth
- Extending democratic institutions around the world

Will be a lost cause if we do not have the energy to sustain society, industry, and agriculture in something like its present form.

7.0 GLOBAL ENERGY CRISIS

What does the global energy crisis connotes?

- **Any great [illegible] (or price [illegible]) in the supply of [illegible] resources to an economy.**
- **often refers to one of the energy sources used at a certain time and place (the world over including Nigeria)**
- The ***world*** is gradually marching towards a severe ***energy crisis***, with an ever-increasing demand of ***energy*** overstepping its supply.

8.0 THE NIGERIAN ENERGY SITUATION: PROSPECTS & CHALLENGES

- The Nigerian power sector operates well below its estimated capacity, with power outages being a frequent occurrence. To compensate for the power outages,

- The commercial and industrial sectors are increasingly using privately operated diesel generators to supply electricity.
- In 2004, total installed electricity capacity was 5.9 giga watts (GW).
- Total electricity generation during 2004 was 19 billion kilowatt-hours (Bkwh), while total consumption was 18 Bkwh.
- Only 40 percent of Nigerians have access to electricity, the majority of who are concentrated in urban areas.
- Despite endemic blackouts, customers are billed for services not rendered, partially explaining Nigeria's widespread vandalism, power theft and Power Holding Company of Nigeria's (PHCN) problems with payment collection(and possibly why the prepaid meter scheme is no longer ongoing).

Despite these challenges our prospect through NV20 is detailed hereunder:

- **He said electricity, which is a major part of this infrastructure, is on course to hit 6000 mw by 2009 and 10,000 mw by 2011 (ReF: Declaration by the Chief Economic Adviser to the President, Dr. Tanimu Yakubu – National Identity Management Conference, Abuja, 28/11/2008)**

9.0 ELECTRIC GENERATION ABILITY (PER CAPITA) BY COUNTRY (MOST RECENT)

DATA: Totals Per capita

Rank Countries Amount (top to bottom)

Norway: 5.92206 kilowatts per person
- Kuwait:3.6387 kilowatts per person
- Canada:3.38363 kilowatts per person
- United Arab Emirates:2.18494 kilowatts per person

- Japan:1.7737 kilowatts per person
- Qatar:1.73802 kilowatts per person

- Singapore:1.51378 kilowatts per person
- Bahrain:1.45276 kilowatts per person
- [illegible]:1.38297 kilowatts per person
- Italy:1.18755 kilowatts per person

Kazakhstan: 1.13921 kilowatts per person

- Brunei: 1.10108 kilowatts per person
- Portugal: 1.04108 kilowatts per person
- Korea, South: 1.02794 kilowatts per person

- Venezuela: 0.827586 kilowatts per person

Oman: 0.699534 kilowatts per person

- Argentina: 0.607011 kilowatts per person
- Mexico: 0.36628 kilowatts per person
- Thailand: 0.296015 kilowatts per person
- Ecuador: 0.261898 kilowatts per person
- [illegible]: 0.215208 kilowatts per person

- Philippines: 0.136586 kilowatts per person
- Guatemala: 0.0957217 kilowatts per person
- Indonesia: 0.0884393 kilowatts per person
- Vietnam: 0.0598544 kilowatts per person
- Ghana: 0.0546797 kilowatts per person
- Cote d'Ivoire:0.051451 kilowatts per person
- Angola: 0.0495476 kilowatts per person
- Nigeria: 0.0458195 kilowatts per person
- Senegal: 0.0200752 kilowatts per person

- CDR 0.00194194 kilowatts per person

Libya: 0 kilowatts per person

- **Weighted average:**1.0 kilowatts per person
- **DEFINITION:** Per capita figures expressed per 1 population.

(Ref: Energy Information Administration, US Department of Energy)

Note: Nigeria yet far lower than world weighted average

10.0 RECOMMENDATIONS/CONCLUSIONS

What do we need to do to get out of the energy crisis and actualise our dream of being one of the top 20 economies of this world?

- Declare Energy Emergency
- Go green
- Conserve energy
- Optimize use of existing capacity
- Promote the use of Energy Efficiency device
- Introduce Incentives
- Promote Development of alternatives(solar, biofuels,wind etc)
- Mass mobilization/Education

- Proper policy framework
- Adequate capital Injection
- Ban the use of incandescent lamps and promote the use of CFLs
- Carry out proper Energy audit
- Promote competition and pay as you go tariffs
- Identify all stake holders and task them with specific roles and responsibilities
- Encourage and foster partnerships(local/international, Regional/continental)

ENERGY MATTERS

- Presently, energy utilization in our national economy is far from efficient. Apart from direct losses, using energy inefficiently has three major implications to the national economy, namely, investments in energy supply infrastructure in excess of what is required with more efficient equipment and practices; increased environmental problems; and increased cost of goods.
- The potential for energy savings in the Nigerian economy is huge, especially in the three main energy demand sectors, namely household, industry and transportation. In the household sector, there is considerable energy loss due to inefficient traditional three-stone stoves, used for cooking mainly in the rural areas. Similarly, there is considerable scope for energy conservation in the Nigerian industries. Energy audit studies have shown that as much as twenty five percent of industrial energy can be saved through simple housekeeping measures. Also, our transport sector has substantial opportunities for savings, most especially the road transport sub-sector. It is therefore imperative to promote energy conservation and efficient energy utilization in all sectors of the economy.

ECONOMIC DEVELOPMENT MATTERS

- Securing higher living standards for the increasing population of the developing world implies high rates of economic growth.
- The process of economic development that underlies improving living standards in developing countries involves a number of changes, including higher agricultural productivity, growth of manufacturing, construction of a modern public works infrastructure, urbanization, and increased transportation. Higher standards of living also lead to expansion in the ownership of consumer appliances. All of these changes have profound impacts on the amounts and types of energy used. Commercial energy consumption typically rises faster than economic growth as the development process gets underway, and the share of commercial energy in total energy consumption grows as it takes the place of traditional biomass fuels. Even though the relative share of traditional fuels has declined, the absolute amounts consumed have continued to rise, by an estimated 2.5 percent per year.

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MEASUREMENT OF DIELECTRIC PROPERTIES OF LOCAL CEREALS IN THE AUDIO FREQUENCY RANGE.

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ABSTRACT

This paper deals with the measurement of dielectric properties of some local cereals (corn, beans, rice) in the audio frequency range (0.3 – 20KHz) since dielectric properties of various agro-foods and biological materials are finding increasing applications, as fast and new technologies adapt/adopt these cereals for use in their respective industries and research laboratories.

A Marconi instrument, 0.1% universal impedance bridge together with a specially designed and constructed coaxial sample holder was used for the required measurements. The properties measured include the dielectric constant, the dielectric loss factor, the loss tangent (or dissipation factor) and the dielectric conductivity. The frequency dependence of these properties was explored in this research. The following characteristics were obtained:

(i) Dielectric constants for the cereals (corn, rice and beans) decreased with increase in frequency in the audio frequency range.

(ii) Dielectric conductivity increased with increase in frequency in the audio frequency range.

(iii) Dielectric loss factor and loss tangent values for the cereals decreased with increase in frequency in the audio frequency range.

(iv) The capacitance of the samples decreased with increase in frequency in the audio frequency range.

These electrical characteristics of the cereals are important for many potential applications viz the use of electric energy for moisture measurement, grain drying, seed conditioning, stored grain insect control and remote sensing for measurement or process control.

1.0 INTRODUCTION

Adequate storage and preservation of cereals is important to countries the world over. The earlier methods of storage and preservation of cereals required them being exposed to natural sunlight or being smoked and stored in bans or bags.

In order to reduce the quantity of wasted cereals, scientists delved into determining some of their useful properties, such as their dielectric properties. One such method uses the universal impedance bridge together with a specially designed and constructed sample holder. This same method was adopted for this research.

Dielectric properties are affected by moisture content, bulk density and frequency variations. This paper discus widely the frequency dependence of dielectric properties for dry cereals at room temperature in the audio frequency range. No attempts were made to investigate the dependence of such properties on bulk density and moisture content but from history, the trends will follow the same pattern to those showing the frequency dependence of the dielectric properties.

Electrical characteristics of cereals find great applications in areas including the use of electric energy for moisture measurement, grain drying, seed conditioning, stored grain insect control and remote Sensing for measurement and control. (Instructional manual, TF 1313A 0.1% Universal Impedance Bridge)

Dielectric properties can be used to understand the behavior of food materials during microwave processing. Dielectric properties influence the level of interaction between food and high frequency electromagnetic energy. Dielectric properties are, therefore, important in the design of foods intended for microwave preparation. (Sakiyar et al, 2007)

The following are uses of dielectric properties measurements (not related to microwave heating of food) that can be of interest to agro-food researchers. Some of them are;

- An important use of the dielectric properties of grain and other agricultural products in their exploitation for rapid, nondestructive sensing of moisture in materials.

• Moisture content is often the most important characteristic of agricultural products, because it determines their suitability for harvest and for subsequent storage or processing. It often determines the selling price of the products for intended purposes.

• Dielectric properties have been utilized with properly designed electronic sensors with reasonable accuracy. Such moisture testing instruments, operating in the 1-50 MHz
range, have been developed and used for rapid determination of moisture in grains for many years.

• More recently, techniques have been studied for sensing the moisture content of single grain kernels, seeds, nuts, and fruits so that instruments for measuring the moisture content of individual objects can be developed. In addition to moisture measurement, the dielectric properties measurements have been useful in several diagnostic tests as well as for the processing of materials (sectors such as: agro-foods, pharmaceuticals, biomedical, forestry, textile, metallurgy).(Venkatesh et al, 2005)

1.1 AVAILABLE MEASUREMENTS TECHNIQUES

There various methods and techniques that can be used to measure dielectric properties .

(Venkatesh et al, 2005)

- Permittivity measurement principles and techniques
- Perturbation techniques
- Transmission line techniques
- Open-ended probe techniques
- Free space transmission techniques

The task of the research lies in the design and construction of the coaxial sample holder. Over the years there has been a transition in the type of sample holder used in the investigation of dielectric properties of cereals.

Earlier experiments utilized a parallel plate sample holder made out of aluminum. Due to the difficulty to fill this holder and edge effects due to fringing fields at the corners of the holder, this form of sample holder was discarded. This lead to the birth of the coaxial sample holder made out of brass due to cost and availability of materials, aluminum and perspex were used to construct the coaxial sample holder used for this research work. (Caneoran et al, 1972)

1.2 ANALYSIS, DESIGN & CONSTRUCTION

1.2.1 DESIGN & CONSTRUCTION OF THE SAMPLE HOLDER

A dielectric sample holder was designed with appropriate specification and required dimensions.

When the paper work was set out, a model was made out of cardboard paper to visualize the size of the holder for feasibility. This was then replaced by a model carved out of sheet metal slightly above the desired specification. The inner cylinder had a conical finish. Both the inner and outer cylinders were furnished with electrodes.

A special mould was formed using clay-like soil into which the models were inserted. The soil was guarded by a rectangular wooden mould. When the wooden mould was filled with soil, two vents were provided to serve as a filler route for pouring the molten aluminum and as an outlet indicating that the carved models in the mould were completely filled up. The aluminum lump was then placed in a steel container and put into an oven regulated to a temperature slightly above the melting point of the aluminum so as to melt the aluminum. The molten aluminum was then poured into the mould and allowed to solidify. The soil was disposed of from the wooden mould and the respective models for the sample holder were allowed to cool. After cooling the sheet metal were discarded and the moulded cylinder were now machined to specification.

To fix the electrodes to the cylinders, they were drilled at the base and the pencil shaped electrodes were hammered into the drilled holes. The cylinders were then bonded by a carved cylindrical piece of wood which also served as a stand for the completed holder. A doorway was created at the lower end of the wood to expose the electrode attached to the inner cylinder. (Caneoran et al, 1972)

1.2.2 ANALYSIS OF THE SAMPLE HOLDER

At any given frequency, a dielectric material may be represented by a parallel equivalent circuit consisting of a capacitance and a resistance.

The electrical equivalent circuit of the coaxial sample holder is as shown in Fig.1.

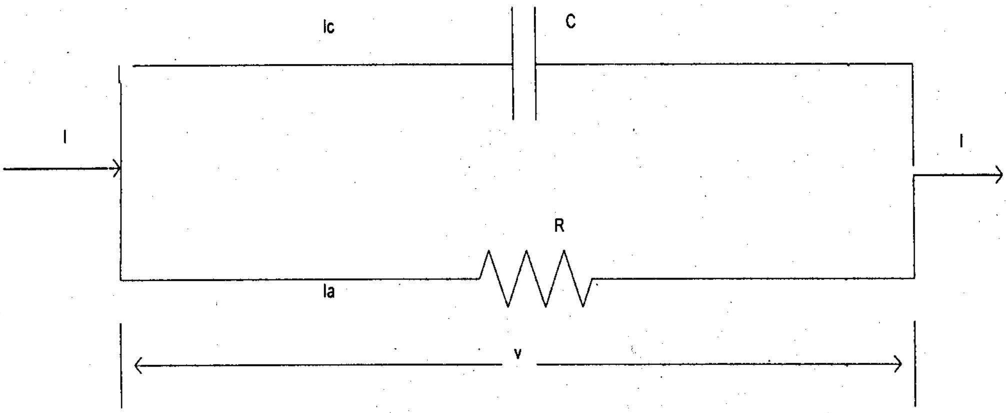

FIG 1: PARALLEL CIRCUIT OF THE SAMPLE HOLDER.

Fig. 1 serves for both empty and filled sample holder; the only difference is the additional resistance and capacitance introduced by the sample in the holder.

For any dielectric material, the complex relative permittivity can be represented thus:

$$\varepsilon = \varepsilon_1 - j\,\varepsilon_2 \text{..........................} (1)$$

Equation one specifies the behaviour of any dielectric material.

ε_1 is the dielectric constant and ε_2 is the dielectric loss factor known as loss factor hereafter. The loss tangent or the dissipation factor, D, is the loss angle, δ and is expressed as shown in the equation 2:

$$D = \tan\delta = \varepsilon_2 / \varepsilon_1 \text{.........................} (2)$$

The dielectric conductivity, σ is expressed as shown in equation 3

$$\sigma = w\varepsilon_0\varepsilon_2 \text{..................................} (3)$$

$$\text{and } w = 2\pi f \text{....................................} (4)$$

With ε_0 as the permittivity of free space $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m.

This research investigates the parameters defined by equation (1) to (4). Analysis of Fig. 1 leads to the derivation of these formulas as related to the work.

1.3 TESTS AND RESULTS

1.3.1 TESTS

Series and parallel tests were carried out respectively, the meters were mechanically zeroed and the mains lead connected to the power supply. With the supply switch on, as indicated by the pilot lamp, the L C R switch was set to C, the D- Q switch set to D and the 1 kHz – 10kHz switch set to the desired frequency. The loss balance, fine D ad fine and coarse balance controls were set midway. The sensitivity control was set to give a meter deflection of half scale and the range switch adjusted to give the lowest meter reading. The coarse balance control was adjusted for a minimum meter reading. When the approximate balance position was found, the loss balance control was adjusted for a sharp null, by advancing the sensitivity control as required.

Finally as near as possible a zero meter reading was obtained by adjusting the fine balance control together with the loss balance control. The values for the capacitance and dissipation factor were then read off the meters. This procedure was repeated for 0.3, 0.5, 1, 2, 3, 5, 10 and 20 kHz frequency values respectively for both the series and parallel measurement.

1.3.2 RESULTS

The results obtain were as shown in Table 1.

1.3.2.1 Results with Empty Sample Holder

Table 1: Series Tests

Frequency (f) (kHz)	Series Capacitance C_{s0} (pF)	Dissipation Factor D_{so}
0.3	28050	0.9524
0.5	27050	0.8000
1.0	19050	0.6667
2.0	16050	0.5000
3.0	15050	0.4167
5.0	14050	0.3333
10.0	12050	0.2500
20.0	1150	0.2000

Table 2: Parallel Test

Frequency (f) (kH)	Series Capacitance C_{po} (pF)	Dissipation Factor D_{po}
0.3	28050	0.9600
0.5	27050	0.8000
1.0	19050	0.6600
2.0	16050	0,5000
3.0	15050	0,4200
5.0	14050	0,3100
10.0	12050	0,2900
20.0	1150	0,2000

1.3.2 (b) Tests with full sample holder

Table 3: Series and Parallel Tests using Rice

Frequency (f) (kHz)	C_s (pF)	C_p (pF)	D_s	D_p
0.3	56050	56050	0.6061	0.6000
0.5	53050	53050	0.4651	0.4500
1.0	46050	46050	0.3704	0.3600
2.0	41050	41050	0.3333	0.3200
3.0	37050	37050	0.3030	0.3000
5.0	34050	34050	0.2500	0.2400
10.0	30050	30050	0.2500	0.2700
20.0	28050	28050	0.1667	0.1600

Table 4: **Series and Parallel Tests using Corn**

Frequency (f) (kHz)	C_s (pF)	C_p (pF)	D_s	D_p
0.3	49050	49050	0.6410	0.6200
0.5	44050	44050	0.5405	0.5300
1.0	36050	36050	0.4546	0.4400
2.0	29050	29050	0.4167	0.4000
3.0	27050	27050	0.3704	0.3600
5.0	25050	25050	0.2857	0.2600
10.0	10950	10950	0.1100	0.1000
20.0	10950	10950	0.2300	0.2000

Table 5: Series and Parallel Tests using Beans

Frequency (f) (kHz)	C_s (pF)	C_p (pF)	D_s	D_p
0.3	40050	40050	0.6667	0.6600
0.5	37050	37050	0.5714	0.5500
1.0	29050	29050	0.5000	0.5000
2.0	250505	250505	0.3846	0.3800
3.0	23050	23050	0.3333	0.3100
5.0	10950	10950	0.3241	0.3000
10.0	20050	20050	0.2000	0.2500
20.0	10950	10950	0.2000	0.2500

Where:

C_{so} is the series capacitance of the empty holder.

C_{po} is the parallel capacitance of the empty holder

D_{so} is the series dissipation factor for the empty holder

C_s is the series capacitance of the filled holder

C_p is the parallel capacitance of the filled holder

D_s is the series dissipation factor of the filled holder

D_p is the parallel dissipation factor of the filled holder.

The results show that dissipation factor and capacitance **drop off** with increasing frequency in the audio frequency range.

1.4 CALCULATION OF DIELECTRIC PROPERTIES,

The working formulae include the following

1. $D_O = D_{SO}$

2. $C_{PO} = \dfrac{C_{SO}}{1 + D_O^2}$

3. $D_M = \frac{1}{2}(D_S + D_P)$

4. $C_{PM} = \frac{1}{2}(C_P + {}^{CS}/_1 - Dm^2)$

5. $D = \dfrac{CpmDm - C_{po}D_o}{C_{pm} - C_{po}}$

6. $\varepsilon_1 = 0.0062\,(Cpm - Cpo) + 1$

7. $\varepsilon_2 = \varepsilon_1 D$

8. $\sigma = 0.556\, f\varepsilon_2$

All the parameters are as were defined during the course of the work and the formulae were as derived.

NOTE: For simplicity the calculations were done in tabular form and the results obtained were used to produce the graphs below.

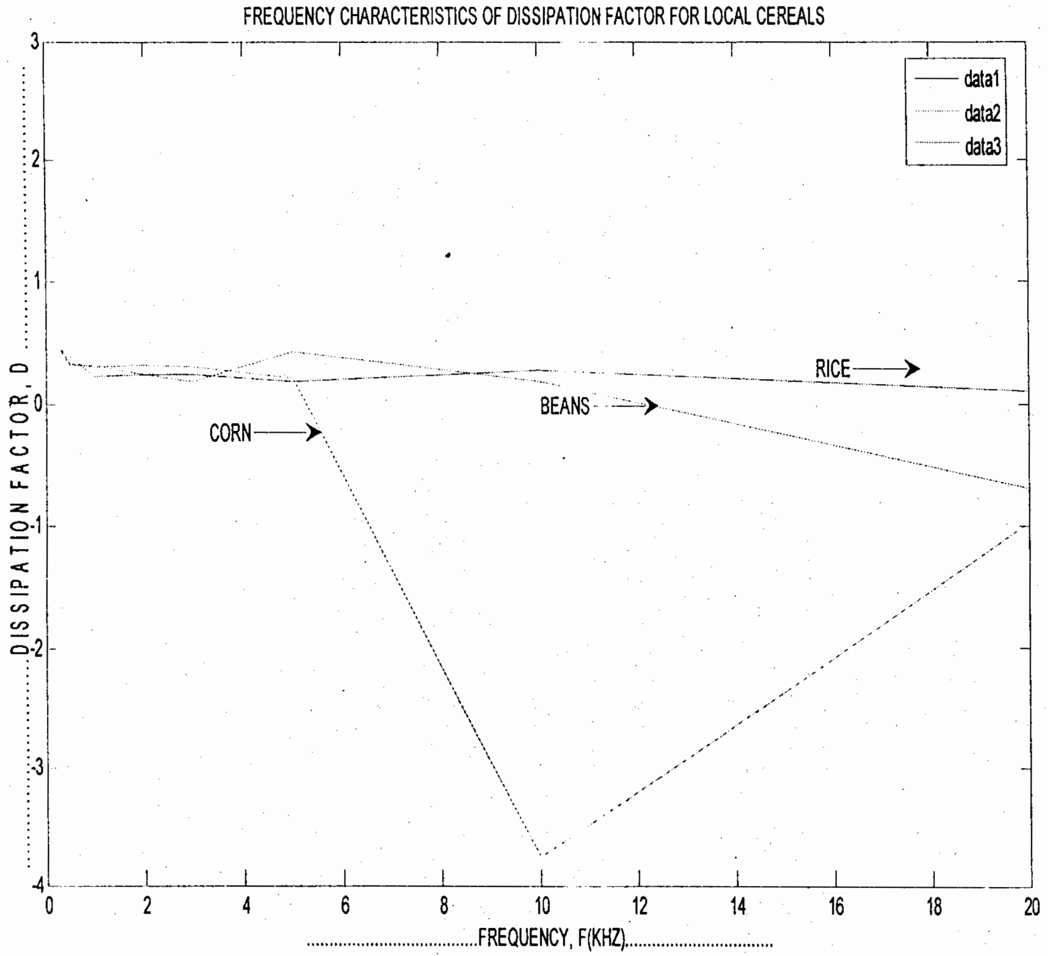

FIG 2 : Frequency characteristics of dissipation factor for local cereals.

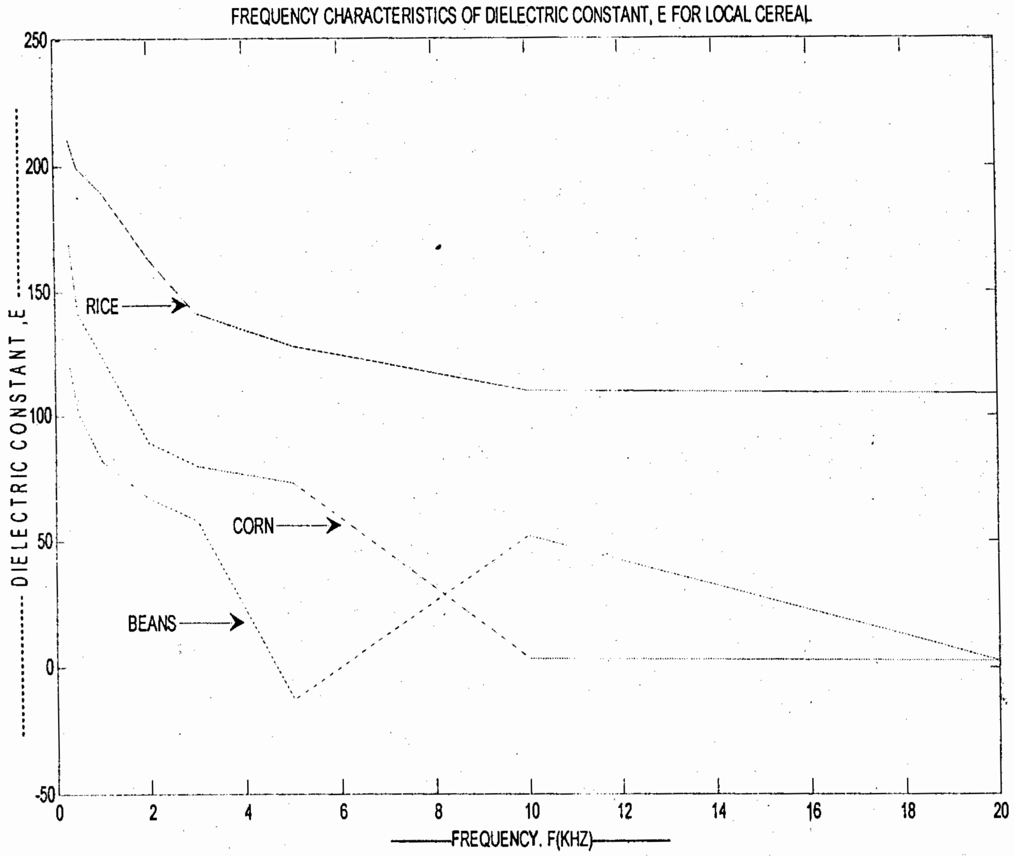

FIG 3: Frequency characteristics of dielectric constant, E for local cereals.

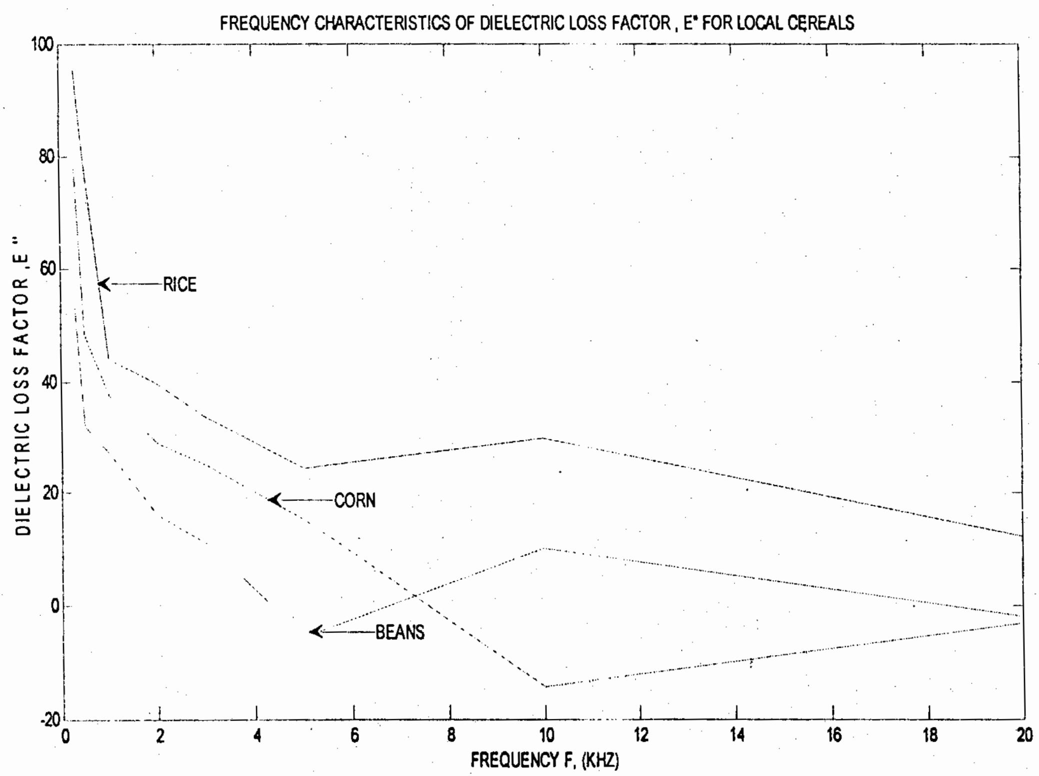

FIG 4: Frequency Characteristics of Dielectric Loss Factor, E'' For Local Cereals.

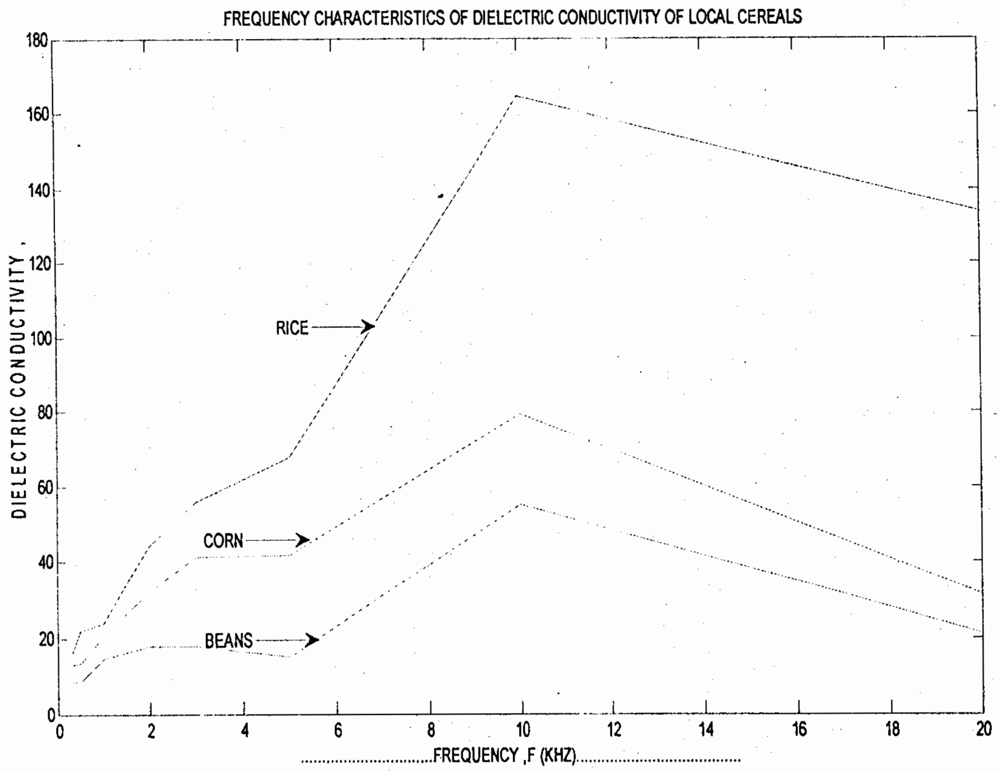

FIG 5: frequency characteristics of dielectric conductivity, σ of local cereals.

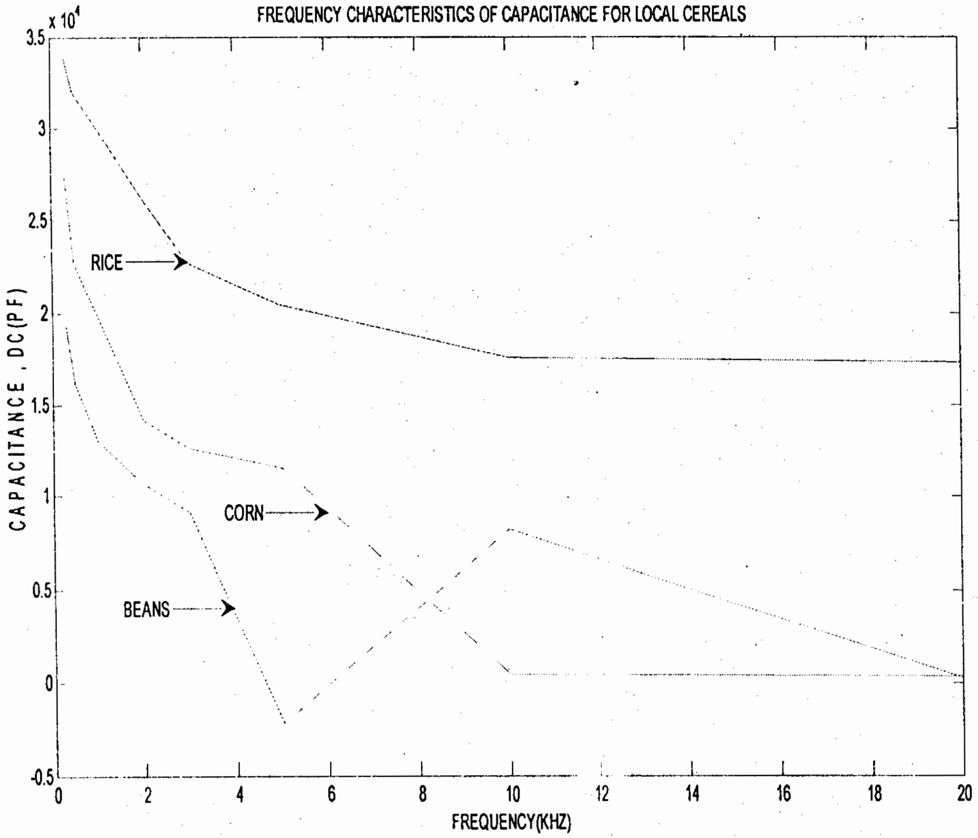

FIG 6: frequency characteristics of dielectric conductivity, σ of local cereals.

1.5 DISCUSSION, CONCLUSION & RECOMMENDATION

1.5.1 DISCUSSION

From table (1) & (2) (measurements made with empty holder), It can be seen that values for the series and parallel capacitance and dissipation factor decreased with increase in frequency from 0.1 to 20kHz. Though the same trend is maintained as can been in tables 3, 4 and (measurements made with the filled holder) the values of the capacitance have increased much more (almost double) the values in tables 1 and 2.

Never-the-less, though there was a decrease in dissipation factor with increase in frequency for the filled holder, the value had decreased to about a third of the value measured using the empty holder. The increased capacitance introduced by the sample in the holder in parallel with the capacitance of the empty holder.

From figures 2, 3, 4 and 5 there was a general decrease in the dissipation factor, dielectric constant and dielectric loss factor with increase in frequency for rice, corn and beans while for the same samples, the dielectric conductivity increased with increase in frequency.

Some irregularities exist due mainly to the electrical properties of the material used in the design and construction of the same holder. The irregularities might have as well been caused by slight variations in bulk density and moisture content.

1.5.2 CONLUSION AND RECOMMENDATION

Dielectric properties were measured at various frequencies for different cereals. The properties measured include the dielectric constant, □, the dielectric loss factor, □'', the dielectric loss tangent, D and the dielectric conductivity, σ.

The following conclusions were reached showing their frequency of dependence:

1. Real permittivity (dielectric constant) values for grains and seeds in the audio frequency range drop off with increase in frequency (Fig. 3).
2. For accurate values of grains and seeds dielectric property measurements on individual seed lots were essential, but the data presented provide a basis for reasonable estimates of dielectric properties for several kinds of grains and seeds in the audio frequency range.
3. Dielectric loss factor and dielectric loss tangent values for grains and seeds drop off with increase in frequency in the audio frequency range. (Fig.2 &4).
4. Dielectric conductivity increases with increase in frequency in the audio frequency ranges (fig 5).

Thus dielectric properties information is essential in effectively selecting frequency or moisture ranges which may be useful for any particular sensing applications such as electric energy for moisture measurement, grain drying, seed conditioning, stored grain insect control and remote sensing for measurements or process control.

Since dielectric properties for grains and seeds vary with moisture content and bulk density and since this project only dealt with the frequency dependence of such properties, further works should investigate the dependence and bulk density. Also, the sample holder should be bonded in due course with epoxy or resin whose electrical properties are known. This should replace the wood used in bonding the concentric aluminum cylinders; due to cost the department can construct a sample holder using brass.

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