AC 2007-626: INCORPORATING EQUATORIAL ENVIRONMENTAL CONDITIONS INTO AN APPROPRIATE TECHNOLOGY

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Incorporating Equatorial Environmental Conditions in an Appropriate Technology

Abstract

The development of technology coupled with the idea of global village is driving a trend that is advancing development of under developed nations through transfer of technology. To date, the transfer has mostly been in the form of finished products such as equipment being sold to developing nations. The designs for the pieces of equipment were initially inspired by technological needs in temperate regions. The design criteria were therefore in part, based on the environmental conditions of the temperate regions.

Incorporating equatorial regional environmental conditions as part of the design criteria may extend the life time of any equipment intended for use in the equatorial regions however, this may imply added costs that manufacturers may have to bear. This paper discusses how industry and academic institutions may cooperate in training a workforce whose objective will be to ensure best practices in the design, manufacture and operating equipment designated for equatorial regions.

The approach used in this paper is by suggesting design parameters that may be incorporated in design criteria for technologies that may be employed in equatorial regions. The paper will also discuss the initial step that has been taken through the support of Engineering Information Foundation (EiF).

Introduction

Advancements in technological development has always been associated with developed nations, however market forces have always opened up developing nations to the results of the developments. It is therefore not surprising that technologies that are new in developed nations can also be found in developing nations. What can present a difference is that in developed nations, adequately trained manpower would be found to operate the system whereas this may not be the case in all developing nations. Due to costs involved in many such endeavors, it is important that the particular technology is proficiently evaluated to ensure that it is the system needed for the particular application desired and that the results when the technology is applied, will effectively achieve the planned objective.

With the view to adapting the technology to local conditions, the factors that are used in assessing it for the planned objective should involve a study of applying the technology in the equatorial environment. The aim is to ensure that the technology is appropriate for the environment, and will produce the needed results.

Information Dissemination

Currently in many African nations, education is receiving emphasis in support of development programs. Some of the areas being focused on are building capacity in both technical and non-technical endeavors, and getting people informed in making life choices in areas such as health. The intention is to empower the people by enabling them to participate fully in the developmental process[1] the nations have engaged in. To achieve this end result in a nation such as Ghana, there are various technologies that can be employed, and that are in current use such as radio and television. However, to reach the greater number of people and to give them access to the vast resources available through the use of computers, Broadband Powerline Communication (BPL) is deemed the appropriate technology. This is in light of the fact that electrification in Ghana covers about 92 % of the nation. This means that the power grid covers about 92 % of the nation, and this will include both urban and rural areas. Other factors that may be considered as advantages are the fact that only one authority manages and administers all matters in connection with the power grid, and that the government has oversight of the authority.

From the cost effective point of view, radio and television broadcasts have extensive coverage over the nation and have both proved effective in their applications. Both are technologies that have their infrastructures already in place, hence there will be no extra costs in building the system. The only costs will be related to utilization. But neither has the information resource capability that computer applications have. Considering computer applications in Ghana, systems such as DSL and Fiber have limited usage nationally in that these are mainly found in some of the urban centers. To extend their use to cover the whole nation will mean added costs in extending the facilities. BPL on the other hand will be based on the national grid which is already in place. The fact that the grid covers about 92 % of the nation is yet another advantage. This will incur some cost in providing components such as couplers and modems, but the cost will be much lower compared to the other systems. Where necessary, a hybrid network can be formed by combining aspects of the existing data transmission infrastructure with the BPL. This approach will ensure information being disseminated across most of the country, if not the whole country and in the process, help alleviate the problem of digital gap[2] in the country. The beneficiaries will be people from all walks of life including students at all levels.

Broadband Powerline Communication

Broadband over Powerline is a technology that has gained the interest of organizations such as the Federal Communications Commission[3], and companies such as Nortel[4]. Three areas that have to be investigated for this application are (i) Antennas, (ii) Electric Power Transmission, and (iii) Data Transmission.

(i) Antennas

The structure under discussion is a power line that is being used as a medium of transmission for electrical signals. Along the line will travel two signals, (i) electric

power and (ii) data. In considering the structure as a whole, the problem can therefore be described as *wave propagation on a transmission line*[5]. Generally, transmission lines demonstrate loss as a result of finite conductivity and hence it will be necessary to assess attenuation along the transmission line. It will therefore be necessary to determine how far the signal can travel and not be seriously attenuated, and maintain its integrity.

It is to be expected that the transmission line radiate electromagnetic energy. It will also absorb electromagnetic energy that will manifest as noise. This will manifest as electromagnetic interference (EMI). EMI can have both man-made and cosmic sources. The line will therefore behave as an antenna. As such, it is important to evaluate the electromagnetic effect on the structure.

(ii) Electrical Power Transmission

As previously stated, Ghana is about 92 % electrified, the generation occurring at Akosombo Dam. The transmission level is 220 volts at 50 Hertz. The frequency level of the power is thus sufficiently different from what will be required for the transmission of data. Even so it will be necessary to ensure that there is no interference in the data.

(iii) Data Transmission

This will be the transmission of information along the line, and it will be essential to ensure that its integrity is not seriously compromised. It will therefore be necessary to determine the levels of interference from other sources of electromagnetic waves such as radio and TV transmissions and the earth's magnetic field. These factors are important due to the fact that the line will act as an antenna and will therefore be able to absorb other electromagnetic emissions as noise as previously stated. Another source of noise is *additive white Gaussian noise* which affects each transmitted symbol independently[6]. The need is therefore to assess the atmospheric, environmental and system conditions that can impact the design to determine the extent to which each can degrade the data transmission. In this sense, the ambient temperature and the heating effect within the different components of the complete system constitute the total heating effect in the system.

In dealing with data, it is desirable to discuss the transmission in terms of energy waveform, and the signal as energy signal. Whereas a ratio of signal power to noise power is a useful figure of merit for analog communication, for digital communication the figure of merit is bit energy to noise power. A useful metric of performance is therefore the bit-error probability versus bit energy to noise power ratio. Trade-offs for the different parameters such as intersymbol interference (ISI) which should be zero, and the appropriate choice of pulse-code modulation (PCM) waveform type that is used for baseband transmission to yield the performance metric can be effected to achieve the desired result[6].

Educational Implications

This project is planned to be a student project and students of Kwame Nkrumah University of Science and Technology (KNUST) will be involved in the project. Considering the different activities involved, the project in divided initially into three phases. The first phase will involve determining the different sources of radiation at the chosen site for the experimentation and characterizing the electromagnetic presence at the site. The second phase will involve analysis of the collected data and design of the system. The third phase will be connecting the system up and testing it. Currently, the project is at the stage where the first phase can be implemented. The following therefore discusses the different aspects of the first phase.

As stated above, EiF has provided funding for the equipment needed for laboratory experimentation for Telecommunications program at KNUST. Experiments designed will study the electromagnetic environment of the KNUST campus. The data obtained can also be used in the first phase of the project. A sample of student projects is presented below.

Measurement of the Earth's Magnetic Field Strength Around KNUST

Abstract

The effort to understand magnetism has led in part to extensive study of magnetic induction. Some of the work done in this area, which also involves electromagnetic (EM) emissions, has centred on magnetic and EM fields created through the use of technology such as in the cases of machines and antennas. The earth's magnetic field has also been studied extensively in some regions of the world. It is yet to be done to the same extent in the equatorial regions. This work is to initiate such study in Ghana.

Objective

1. Select suitable sites around UST campus.
2. Measure and record the earth's magnetic field at the selected sites.
3. Plot the magnitudes on a map.

(Note: Areas that have no or little human settlements will be chosen.)

Equipment List

Magnetometer
Geographical Positioning System (GPS)
Surveyor's Tape
Plumb Line
Hammer and Pegs
Rope and Paint or Marking device

Measurement Procedure

1. Search for and remove any metallic (magnetic) objects from the selected site.
2. Use the GPS to locate a point and put a peg in the ground at that point. Note the coordinates of the point.
3. Record the date, time of day and weather conditions.
4. Measure a distance of 100m from the first point and put a second peg at that point. Note the coordinate of the second point with the GPS.
5. Tie the rope to the two pegs and mark sections of 10m lengths along the rope.
6. Connect the two rods of the magnetometer together
7. Initialize the magnetometer by setting each of the three knobs to zero, and turn the Milligauss Range to the 1999.9 scale.
8. Place the white pointed end of the rod, and record the magnitude and direction.
9. Repeat steps 2 through 8 at each of the 10m marks.
10. Repeat steps 1 through 9 at each selected site, while covering as much land areas around UST as possible
11. Plot all these on a map of UST.

Lab Report

Write a report on the experiment performed using the following guidelines.

Title Page: **Title of experiment, name of author and date experiment was performed.**

Introduction: **The introduction should contain a description of the technology on which the experiment is based. Also state some practical applications of it.**

Equipment: **List the components/equipment used in the experiment.**

Procedure: **Briefly describe the procedure used.**

Results: **Provide results of the experiment.**

Conclusion: **Write a conclusion for your work, discussing the results obtained. Include any observations made during the experiment.**

References: **List references used where applicable.**

The report should be written in narrative form, and in the third person.

The sample of student project shown above has for the first part, the work to be done by the student (or group of students) and the second part shows the format the report should

follow. It is anticipated that the work above will be extended to cover other aspects in characterizing the electromagnetic space around the campus. The data collected from this experiment together with data from other experiments will be used in the second phase for the analysis of the electromagnetic space.

Conclusion

The need for incorporating environmental conditions to technological developments to make it appropriate for the equatorial region has been presented. In doing so, an example has been used in which the electromagnetic presence in the designated space will be measured and analyzed. The data resulting from the work will be included in the design requirements to ensure that the designed system is well suited to the environment.

A grant obtained from EiF was used in acquiring equipment that will be used to facilitate student learning while achieving the objective of incorporating local conditions to appropriate technology.

References

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[5] Pozar, D. M., "Microwave Engineering" 3rd Edition, John Wiley, Chp 2

[6] Sklar, B., "Digital Communications, Fundamentals and Applications", 2nd Edition, Prentice Hall, Chp. 1-4