Development and Configuration of UHF and Ku Signals Measuring Instrumentation System Across Climatic Zones of Nigeria

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Abstract – This paper presents a developed and configured Ku and UHF bands integrated cloud-connected, multicentre instrumentation system. The instrument are connected to the computer via USB interfaces, while logging software is bonded to these interfaces to exchange data with the systems. The logging software displays the various detected quantities and plot the graphs, while viewing software fetches the data of selected location from cloud service, displays its values and also plot the graphs in its graphical user interface (GUI). The Amazon web service (AWS) houses the cloud infrastructure which runs a web application that connect to various centers and make their acquired data available in real time through the viewing software. The system configuration flexibility permits changes in Ku signal polarization to either vertical or horizontal polarization scenarios and depict the characteristics of the satellite whose downlink signal is being measured with other information relative to its position. Upgrading can be effected across the logging and view locations from a particular location through the web application that connect the locations together. Configurations also enhance the possibility of instant view of information on variations of Ku and UHF signals of any other locations across the climatic regions of Nigeria from a particular centre. This instrumentation system provides substantive data for radio scientists and engineers for developing extensive and accurate models for (Ku and UHF) signals fading and attenuation which will enhance effective and efficient terrestrial and satellite links budget and planning across climatic region of Nigeria.

Keywords – Configuration, Ku, UHF, Instrumentation, System.

I. INTRODUCTION

Synchronizations of data from different sources, particularly when the parameters are measured by different instrumentation systems of different sensitivities, resolutions and accuracy usually lead to accumulated errors during data analyses [1]. Hence, this paper presents a real time network of UHF and Ku bands instrumentation systems developed and configured across different geographical climates of Nigeria in order to measure and analyze accurately the real time effects of atmospheric variables on satellite and terrestrial radio waves propagations so as to enhance the development of accurate atmospheric and radio data models across Nigeria. Obviously, atmospheric conditions play a key role in the provision of reliable communication both on terrestrial and satellite path [3], [4], [5], [11] and [16]. Its characterization is essential to achieve efficient communication since it cannot be re-designed to suit the need of a radio planner like other communication channels such as fibre optics and co-axial cable [10] and [14]. Over decades, characterization and modeling effects of atmospheric conditions on both terrestrial and satellite communication paths have been an area of focus by radio researchers globally some developments have been achieved in developed countries through models and various techniques to subside the atmospheric effects [4], [5], [8] and [15]. Hence, most models and techniques developed were more suitable for temperate regions and may not provide accurate evaluations for tropical regions like Nigeria. Due to poor economy and lack of research facilities in most Africa countries, effects of atmospheric variables on both
terrestrial and satellite communication paths are been estimated with few available data using foreign models from temperate regions of the world rather than real time measurements using integrated instrumentation systems. Evaluations through models from temperate regions whose atmospheric variables are key factors of the models can hardly provide accurate results in tropical regions as compared to real time measurements and analysis of the radio waves and atmospheric parameters through development, deployment and configuration of instrumentation systems for real time in-situ measurements and analysis. Hence, this paper presents the results of integrated instrumentation system that provides information on the behaviors of Ku and UHF transmitted signals under variable atmospheric conditions.

II. SYSTEM DESIGN DESCRIPTION

General overview of the Ku and UHF bands cloud-connected, multicenter instrumentation system is presented in figure 1. The two instruments (Ku and UHF signal measuring systems) are connected to the computer via USB interfaces, while logging software is bonded to these interfaces to exchange data with the systems. The logging software displays the various detected quantities and also graphs while viewing software fetches the data of selected location from cloud service, displays its values and also plot the graphs in its graphical user interface (GUI). Amazon web service (AWS) houses the cloud infrastructure which runs a web application that connect to various centers and make their acquired data available in real time through the viewing software. USB modem is used for internet connection of the logging computer to the cloud server through mobile network.

Fig. 1. General overview of the whole instrumentation system.

III. EXTERNAL COMPONENTS OF THE INSTRUMENTATION SYSTEM

The instrumentation system has both external and internal components, the external components specifications are as shown in figure 2 and plate 1. It comprises of a mounted metallic pole with lightening protection system, 90cm diameter satellite dish and a metallic box which houses part of the UHF instrumentation system. Each component specification is as displayed on the schematic diagram.

Fig. 2. Design specifications of the External UHF and Ku instrumentation system.
IV. UHF BAND COMPONENTS DESIGN OVERVIEW

The UHF-band measuring system was designed (figure 3) to measure the signal intensity of 3 GSM networks through embedded modems fitted with the network of choice’s SIM card, the system also has a Global Positioning System (GPS) onboard to give its location. A microcontroller queries the modems for the network signal intensities at regular intervals and also sets up the GPS to give NMEA signals at 1 second rate. The NMEA received is parsed by the microcontroller for the Longitude, Latitude, altitude and the number of satellites locked to. This processed information is sent to the indoor unit through a 2.2 GHz transceiver. The indoor units receives the data, and then displays the network signal intensities and the location (longitude and latitude) on a Liquid Crystal Display (LCD) (figure 9b). This information is also conveyed through a USB connection to a computer which is running a logging program. Graphing, display of values and onward transfer to a cloud-based server application are carried out by the software (figure 3).
V. Ku Band Components Design Overview

The Ku-band system measures the RF signal received by an outdoor 90cm offset type satellite dish fitted with a Ku band Low Noise Block (LNB). The dish is mounted on a metallic pole at about 8 FEET from the ground. The RF signal is transferred from the LNB to the instrumentation system (situated indoors) through an RG-6u coaxial cable. The Instrumentation system automatically generates the appropriate power and control signals to the LNB in order to select the appropriate polarization (either vertical or horizontal) and frequency band (low band-10.7-11.7 GHz or high band 11.7-12.7 GHz). The signal is passed through matching networks into the Logarithmic Diode RF Power Detector which produces a linear analog D.C. output corresponding to the RF input signal. The output is filtered for ant-aliasing before entering the Controller Unit. The controller converts the analog signal to a digital signal and also interfaces a windows PC through the Universal Serial Bus (USB). A logging program running on the computer stores the data locally and also links with the controller of the instrumentation system which sends control signals to it, and also receives the measured RF power. Values are displayed and plotted in the GUI interface (figure 10). The software also links to the cloud server which receives the logged values, stores them in a database and also forwards data to the viewing program developed to display the status of the logging computer and make plots of the logged signals per selected location.
VI. OVERVIEW OF OTHER COMPONENTS OF THE INSTRUMENTATION SYSTEM

A. The AD8318 is a Demodulating Logarithm Amplifier

The AD8318 (figure 6) is a demodulating logarithmic amplifier, capable of accurately converting an RF input signal to a corresponding decibel-scaled output voltage. It maintains an accurate log conformance for signals of 1 MHz to 6 GHz [2]. The input range is typically 60dB with error less than ±1 dB. The device provides unprecedented logarithmic intercept stability vs. ambient temperature conditions. A 2 mV/°C slope temperature sensor output is also provided for additional system monitoring [7].
B. **PIC18F4550 Microcontroller**

The PIC18F4550 microcontroller (figure 7) serves to generate control signals for the LNB power supply to switch it between 12V and 18V, also it is responsible for generating the 22kHz tone which switches the LNB to the higher reception band (of 11.7GHz to 12.7GHz) and also configures its USB module in Human Interface Device (HID) mode for easy connection to the computer system through USB cable [13].

C. **Universal DVB Power Board**

The Universal DVB power board is a locally available board used as a replacement for the power modules of TOP box satellite receivers. It is a switching mode power supply which accepts an AC input of between 100 volts and 260 volts and produces stable DC output voltages of 5 volts at 1.2A, 12volts at 500mA, and 22volts at 500mA. The 5v supplies the microcontroller and the logarithmic power detector. The 22v supplies the LNB power supply [6], [7] and [12].
D. LNB Power Supply

LNB power supply acts as a phantom power for the LNB (figure 8). It also superimposes 2v peak to peak square waves of 50% duty cycle into the supply voltage when required. It is made around the LM317, a programmable regulator.

Fig. 8. Circuit diagram of LNB power supply.

Fig. 9. (a) Ku fabricated Unit (b) UHF fabricated unit (c) Screen view of system activities

Fig. 10. Locations activities viewing page.
VII. DISCUSSION

Ku signal strength at the configured frequency range are measured and logged periodically every two minutes alongside with UHF signal strength of three mobile networks (figure 11) which are uploaded to cloud server for storage purpose. The system configuration flexibility permits changes in Ku signal polarization to either vertical or horizontal polarization scenarios. The instrumentation system was configured to depict the characteristics of the satellite whose downlink signal is being measured with other information relative to its position. The system configuration also enhances the possibility of instant view of information on variations of Ku and UHF signals of any other locations across the climatic regions of Nigeria from a particular centre. Changes or corrections can be effected across the logging and view locations from a particular location through the web application that connect the locations together. Moreover, vantage pro precision weather equipment with a user-friendly console that display multiple weather conditions at a glance were installed at every locations with the instrumentation system. All data are available with their corresponding time, date and season on the configured cloud server service for accurate analysis and modeling of Ku and UHF variations due atmospheric weather parameters across climatic regions of Nigeria.

VIII. CONCLUSION

The developed and configured Ku and UHF integrated instrumentation system provides accurate information on the causes of distortions and losses of Ku and UHF bands signals relative to weather and other impairments factors and also provides real time information on the depth and magnitude of fading, losses and attenuations of terrestrial and satellite radio waves propagation signals at all seasons. This instrumentation system will provide substantive data for radio scientists and engineers for developing extensive and accurate models for (Ku and UHF) signals fading and attenuation across climatic regions of Nigeria and also help in effective and efficient terrestrial and satellite links budget and planning.

ACKNOWLEDGMENT

The authors would like to appreciate Tertiary Education Trust Fund (TETFUND) of Nigeria for providing fund towards realization and implementation of this project.
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