A versatile telemetric system based on mixed Internet and wireless transmission

V. TSIRIGGAKIS[1], K. EFTHIMIATOS[1], G. KOULOURAS[3], I. STAVRAKAS[1], P. KAPIRIS[1], K. NINOS[1], G. KATSIMAGLIS[1], K.VOUDOURIS[1], K. BANITSAS[3], K. EFTAXIAS[2], A. KOULOPOULOS[4], L. PANAGIOTOPOULOS[4] and C. NOMICOS[1]

[1] Department of Electronics, TEI of Athens, Egaleo, Athens, GREECE
[2] Physics Department, Athens University, Panepistimioupoli, Athens, GREECE
[3] School of Engineering and Design, Brunel University, West London, UK
[4] Department of Agricultural Machinery and Irrigation, TEI of Messologi, Messologi, GREECE

Abstract: - A novel telemetric technique for carrying data from distant field stations to a central point, upgrading an existing high cost network, is presented. This new technique can be applied for educational purposes since it enables students to overview the installation, operation and maintenance of a high tech complex network, spread in distances of the order of several hundreds of kilometres. The proposed technique followed by the appropriate visual aids can help students to understand better long distance data transmission.

Key - Words: - Electromagnetic variations, Telemetry, Datalogger, FHSS, Wireless link.

1 Introduction

The aim of this paper is to present a versatile telemetric system based on a novel network model that has been designed and is experimentally implemented, aiming to upgrade an existing high cost network used for carrying data from distant field stations to a central point.

A field station based on this innovative network design has been recently installed and attached to the existing network. An interesting fact is that the new design field station has increased the network's flexibility and endpoints mobility while at the same time it has reduced the telecommunications cost. Additionally, it provides real time telemetry of enhanced performance, high quality and availability, increased security; and therefore reliability.

The aim of this study is the redesign – (upgrade of the telecommunications part) of an existing telemetric system for more flexible and enhanced operation with less maintenance cost. The existing telemetric system has been maintained by the National Observatory of Athens (NOA – http://www.noa.gr) for the last seven years. It consists of eleven field stations installed in specific areas within the Hellenic domain and a central station located within NOA. Each field station measures the electromagnetic variations (EMV) of the area where the station is installed and creates files of these measurements. The data recorded from each remote field station is collected by the central station via the network of the telemetric system. The whole system has the purpose of real-time observation of electromagnetic activity.

Each field station is equipped with antennas, which actually receive the electromagnetic signals, receivers that strengthen the received signals, and a digital storing device that measures the electromagnetic signals and stores the measurements in digital format. On the other hand, the central station is responsible for establishing a communication with each field station in order to collect, format and record the data [1-4].

2 Problem description

As far as the communication part of the current system is concerned, data is transmitted from a field station to the central station via base-band modems in combination with multiplexers over the digital and analogue leased telephone line network. The digitalised data of the Electromagnetic variations are multiplexed with other information concerning the collection of data recorded from climate or weather sensors. However, the bandwidth required in order to transmit multiplexed data via the leased line cable is much less than the bandwidth that the leased line can offer. Hence, by leasing lines a much higher bandwidth than is actually needed is dedicated. Therefore, such a structure increases the overall cost and increases the transmission failure probability.

3 Proposed solution

The new communication model is based on the Internet structure, since Internet is introduced as the telemetry medium. According to the new communication policy each field station has to be located a few kilometres away from the Technological Educational Institute (TEI) or University or any other organisation that is willing to contribute to the research program. Access to the Internet is achieved via the LAN of the organisation. Hence, data collected from the field station have to be wirelessly transmitted to the Internet Access Point of the Organisation. Specifically, a radio link of Frequency Hopping Spread Spectrum (FHSS) technology is established in order to transfer the collected data from the endpoints to the nearest Internet access point. Therefore, in the new communication model each field station only needs to reserve an Ethernet port instead of an analogue leased line that the current communication model uses. Consequently, the usage of Internet, that is the encapsulation of digital data of the field station into TCP/IP protocol packets, is a vital factor that simplifies the design and the overall cost of the system [5].

Since the geographical position of the University or Organisation may have extremely high levels of electrical noise, which would influence the measurements of the electromagnetic signals, the field stations are not installed within the foundation of the University or Organisation where the Internet Access Point is hosted. The installation of the field station in a remote area from the Organisation is the best solution since the electrical noise is reduced. Furthermore, by using Spread Spectrum techniques (FHSS or DSSS) the over-the-air signal is less prone to interference: most interferers transmit in a narrow band area and will only affect a small part of the transmitted signal as the useful signal is spread into a much wider frequency band.

3.1 Aims and Objectives

The objective aims that have been set in order to develop the new communication design are summarised in the following paragraphs.

The basic aim of this project is the study, installation and implementation of a wireless communication system in order to establish a wireless (radio) link between a field station and the foundation, where an Ethernet port is reserved in order to transmit the data collected by the field station to the central station in Athens. However, the error free wireless transmission of data or at least with a very low probability of errors (Bit Error Rate - BER) is an objective that needs a very serious consideration.

Another critical objective is the establishment of TCP/IP protocol based (real time) communication of the central station with the Ethernet port of the organisation. The new communication system transfers the data to the central station via the reserved Ethernet port using the two known telemetry techniques: real time and data logging.

Real time communication is achieved by the use of the existing infrastructure of digital leased lines (Internet). After having assigned a real IP address to the RF Modem with the Ethernet interface, the modem can be 'visible' from any other computer in the world that can access the internet, which means that there is a real time communication with the Ethernet RF Modem and thus with the EIA232 RF Modem on the other end. By using the appropriate software the operator of the central station has the ability to remotely configure the equipment of the field station. Such configuration may concern uploading new datalogger's software, the control of the communication - data transmission between the field station and the central station. Having the ability to upgrade the datalogger's software from a distance, provides versatility to the system since the datalogger (storing device) can be remotely programmed to handle and process the received signals by the antennas in a different way. Consequently, the remote user has the ability to check the state of the field station and thus has a satisfactory level of troubleshooting the system such as in case of power supply problems.

The data logging technique is very useful in the event of a scheduled or even non-scheduled outage of the wireless link or Ethernet network for several hours or even days or in case the file transfer between the RF modems or between the reserved Ethernet port and the central station has errors.

Datalogging has been achieved using Campbell datalogger which is also the hardware of the real time system in order to implement the conversion of the output signal of the receiver (analogue signal) to a digital, discrete, signal as needed to feed the communication device. The device that transfers the data is an RF modem equipped with a serial input (EIA232) connected to the datalogger. The digital data modulate a carrier signal according to FHSS digital modulation technology. The modulated carrier signal is emitted by the directional antenna of the EIA232 RF modem and carries the EMV information to the directional antenna of the Ethernet RF Modem. Finally, the data received by the Ethernet RF Modem is transmitted to the central station through an Internet connection.

After receiving the data from each field station, a program installed to the central station is responsible for sectioning and filing the collected data. This process is very useful since scientists have a more convenient view of the obtained data and supports the programs responsible for real time representation and evaluation.

3.2 Managing the Project (Adopted Experimental and Investigative Methods)

A new field station based on the new communication design has been recently installed in the TEI of Messologi and attached to the existing telemetric system - network. The new field station gains Internet access through the TEI's network infrastructure. This is achieved by transmitting the data using FHSS standard to the TEI and then to the central station using Internet. The wireless link has been tested for distance up to 5km without any obstacles between the two network entities and performed with BER of the order of 1%. However, this field station is also equipped with sensors for measuring temperature, humidity and other weather and climate factors. Before the installation of the experimental field station, both the new and the existing communication model have been thoroughly studied. In the following paragraphs the methods adopted for the conduction of the experiment are presented.

3.2.1 Studying the existing communication infrastructure

The study of the existing communication infrastructure has indicated the needs that must be taken into consideration in order to design the new system, which will gradually substitute the existing one. A thorough study of the existing system has helped scientists to compare the two systems and predicate about the advantages of the new one. Since this project is in its experimental phase the new communication system is not yet an independent communicational design. It has been applied to an existing implementation with a very specific function; therefore it has been tuned to cover those needs. However, the possibilities regarding the necessary resources to implement the new communication design in relation to the existing one have been investigated.

3.2.2 Programming and configuring the datalogger device.

Campbell datalogger is the device responsible for converting the signal, received by the antenna and amplified by the receivers from analogue, to digital and storing it. The datalogger device provides a lot of possibilities on how it will process and save the digitalised analogue signal. It can be programmed by a set of instructions to control several attributes. Therefore the internal program of the datalogger has been reconsidered and redesigned in order to adapt the device according to the needs of the experiment.

3.2.3 Configuring the RF modems.

The EIA232 RF modem device is responsible for modulating EIA232 datalogger signals according to FHSS technology and transmitting the modulated signal via air. However, the Ethernet RF modem is responsible for demodulating the received signal in order to extract the original datalogger EIA232 signals. The Ethernet RF modem has an embedded device called Lantronix X-Port Module. X-Port Module is a very sophisticated and compact micro-device responsible for converting EIA232 signals to TCP/IP protocol packets and thus providing internet connectivity to the system. As with the datalogger, the RF modems and especially the X-Port Module have many capabilities. Hence, the appropriate combination of cabling and configuration has been made in order to achieve the suitable function. Since, the Ethernet RF Modem has a real IP address the appropriate security configurations to the Lantronix X-Port Module have been made in order to prevent any unauthorised access to the configuration menu of the modem (X-Port Module), which would directly affect the behaviour of the system.

3.2.4 Installing virtual COM on PC and perform communication tasks through the RF modems

After having set the IP address, cabling and configuration, the Ethernet RF modem has been plugged to an Ethernet port with an Internet connection. Then the software of the modem has been installed to a computer that has Internet access and registered on the same LAN with the Ethernet modem. The modem has been viewed from the computer as a virtual COM and hence the necessary communication tests have been performed.

3.2.5 Connecting data logger with the EIA232 RF Modem, upload program and obtain data.

As soon as data can be transferred between the RF modems by the FHSS carrier and afterwards by TCP/IP packets, the datalogger is connected to the system and uploaded a program from the computer using the TCP/IP and the wireless connection. Inside the laboratory, where the field stations are constructed, each field station undergoes a testing procedure of proper operation before its final installation in the desired area. A waveform generator has been connected to the datalogger input; the computer has been set to collect data from the datalogger for some time and has been checked for proper operation by comparing the values.

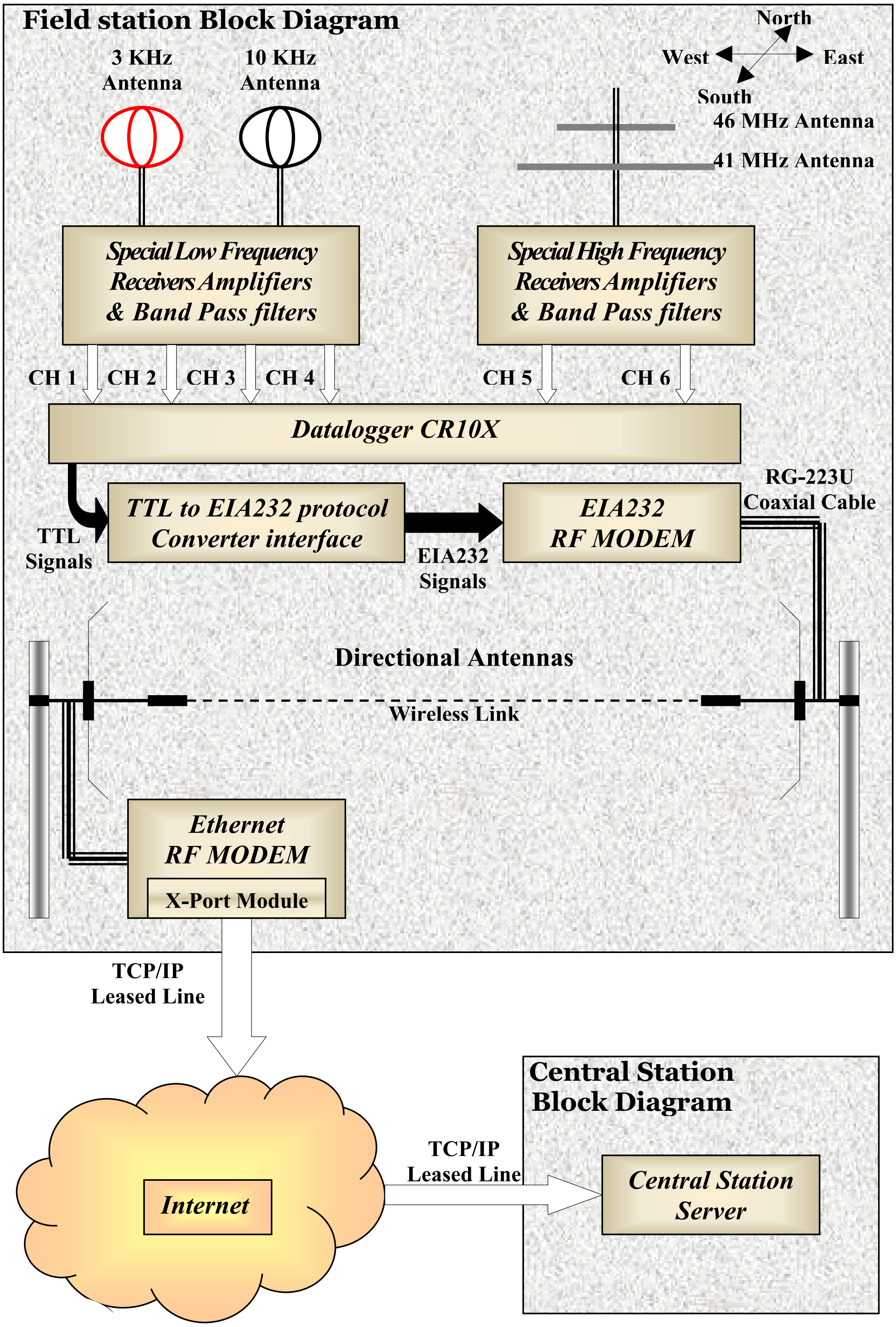

Fig.1 - Block diagram of the new communication design of the system

3.2.6 Connecting datalogger with EIA232 RF Modem, obtain section and file data.

This procedure concerns the implementation of a program designed to automatically section data and generate files in predefined size and format records. The software of the datalogger gives the ability to incorporate other programs. Therefore, after the size of the incoming data record reaches a certain value of 64KB, the program sections it and transforms it into a more concise form without interrupting the collection of data.

The experiments corresponding to the key activities are conducted in the research laboratory and the Networks laboratory of the Department of Electronics of T.E.I. of Athens using the existing TCP/IP infrastructure and establishing a wireless link between the RF modems.

4 Conclusions

Apart from the high importance of developing the current telemetric system, it was proven to be very interesting to redesign it. The combination of the wireless-based and Internet-based transfer of data allows for on line communication between the central and the field stations; in contrast with asynchronous ways of communication by which the central station needs to connect and receive the data in defined time windows during the day. Therefore, it allows for real time data representation and evaluation. Compared to the existing communication system it offers all the communication gains the Internet can offer. On the other hand the field stations will be placed a few kilometres away from the organisations with leased line Internet connections. A study has been made in designing a wireless link that will give the ability to the field station to use the existing infrastructure.

This network can become a prototype telemetric system enabling its inspection and maintenance from a distance. Although the new telemetric system that this paper presents has a very specific aim, such network designs can be used to a wide range of applications. Apart from research programs, this new technique can also be applied for educational purposes since it enables students to overview the installation, operation and maintenance of a high tech complex network spread in distances of the order of several hundreds of kilometres. Up until now students had their laboratory exercises in the limited space of a classroom. The proposed technique, followed by the appropriate visual aids, can help students to understand long distance data transmission. Finally, a comparative availability and cost study took place to justify the used technique and network design. A block diagram of the proposed network technology is illustrated in Fig. 1.

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References:

[1] F. Vallianatos and C. Nomicos, *“Seismogenic Radioemissions as Earthquake Precursors in Greece”*, 1998 Phys. Chem. Earth, Vol.23 p.953-957

[2] C. Nomicos and F. Vallianatos, *“Electromagnetic variations associated with the seismicity of the frontal Hellenic arc.”*, 1998 Geologica Carpathica, Vol.49, p.57-60

[3] C. Nomicos and P. Chatzidiakos, *“A telemetric system for measuring electroteluric variations in Greece and its application to earthquake prediction”*, 1990 Tectonophysics 224 p.39-46

[4] C. Nomicos, G.Alexopoulos, F.Vallianatos and G.Stavrakakis : *“A real time telemetric system for measuring electromagnetic variations associated with earthquakes in Greece”* : International Conference Hazards 98: Chania Crete Isl., Greece p107, 1998

[5] Andrew S. Tanenbaum, *Computer Networks*, Prentice Hall International, 1996 Third edition, Vol III , pp 521 ISBN 0-13-394248-1