Wireless Communication System for Environmental Monitoring

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Abstract- In environmental measurements wireless technologies are the solution for remote instruments control and long distance range value readings. It is presented a complex system that is intended to use hardware and software components. This paper involves knowledge's and applications from different areas like environmental parameters measurements, data transmission protocols, virtual instrumentation and data logging proceedings.

I. Introduction

The invention of the four-element theory of matter (earth, air, water and fire) is attributed to Empedocles of Agrigentum (around 450 BC) [1]. Two and a half millennia since, in our age, there is general recognition and concern that the first three of these ancient elements have become polluted by human activity, often involving the fourth ancient element as an agent [2]. Environmental concerns are so deeply felt that they have become the basis for organized political activity on national levels. Today, mankind must address serious problems connected to the natural resources exhausting, environmental pollution, and ecosystem destruction. One of the main goals of modern society consists of stopping these degenerative processes. This requires the development of systems for large-scale environmental monitoring that are able to provide high-level information to the public offices that make decisions about the environment. Efficient and affordable sensor systems that show autonomous and intelligent capabilities are needed [3]. An area of increasing activity is that of environmental remediation and restoration. Many sites are known to be polluted and there is a recognized need to remove hazardous materials from the environment and restore the contaminated ecosystem to approximate pre-pollution conditions.

Traditional laboratory analysis is sophisticated and sensitive, but is often inconvenient for field use because of the need to transport samples to the laboratory and await determination of results. Field work can be particularly difficult in the case of gaseous compounds which may be present only in small concentrations [2]. This is a good reason why wireless communication with the instruments for controlling and data reading are more appropriate then "on site" work.

II. Communication Protocols

The hardware part contains complex devices with computer interface, wireless modems (2.4GHz standard), a serial multiplexer, a local processing unit (laptop) and a central workstation. Software part is based on transmission protocols (RS232/485, wireless) and virtual instrumentation for application control and data logging. Serial transmission media provide low-cost interconnection typically between data acquisition systems or instruments and computers dedicated to manage the collected data. Ignoring the long distance connectivity advantage, the number one reason why RS-232 is very popular is because it's everywhere. Consumers are slowly migrating to USB but RS-232 will be strong in commercial and industrial sector. So as the consumer market goes away from RS-232 to USB, there's still a strong need for RS-232 in commercial, industrial sectors. The reason why is that for a lot of those sectors, they don't need the fast data rate of USB and RS-232 is quite adequate and they can see equipment out there right now that a lot of people are not willing to change over yet. Even there are instruments without this port, RS-232 transceivers are really cheap in the market and can be found everywhere. That's why it's used widely [4].

Public and private sector enterprises are always in pursuit of ideas that can make them more efficient and flexible, qualities that have a direct effective on both profitability and performance. As wireless networking moves into the mainstream, many organizations find that the addition of mobile network components offers undeniable business benefits, both direct and indirect. Seen directly, wireless solutions can improve the connectedness of a workforce and enhance decision-making by providing faster access to more current information. They can also be easier to maintain and configure, reducing

the need for IT staff. Indirectly, mobile solutions can improve worker satisfaction by providing easier, more flexible access options. They can even improve public perception, and introduce new, “cutting edge” mechanisms for customer interaction.
A wireless network consists of several components that support communications using radio or light waves propagating through an air medium. Some of these elements overlap with those of wired networks, but special consideration is necessary for all of these components when deploying a wireless network. Environmental monitoring drive the development of wireless technologies in many areas: habitat monitoring, environment observation and forecasting systems. A wireless communication system has a number of advantages, not least the mobility of the devices within the environment. It is a simple matter to relocate a communicating device, and no additional cost of rewiring and excessive downtime is associated with such a move.

III. Communication System’s Description

The system is presented in Figure1 and accomplishes three major tasks: acquiring environmental parameters values, logged data and configuration data transmission and results processing.

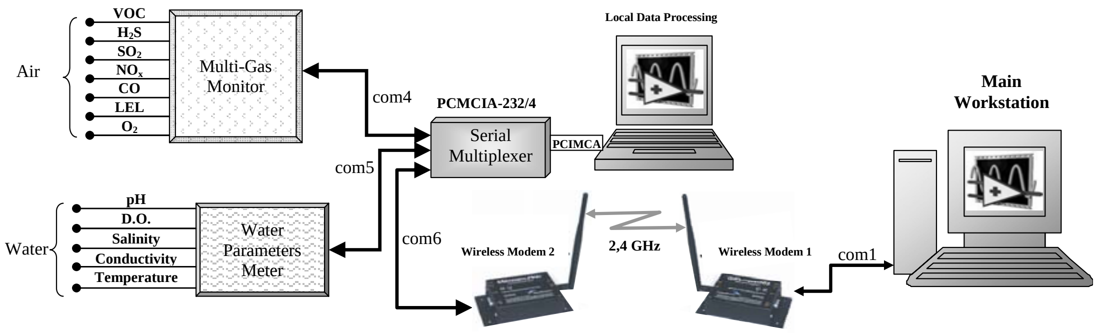

Figure 1. Wireless Monitoring System’s Architecture

A. Environmental Parameters Monitoring Instruments

Two advanced instruments are used for real-time water and gas parameters measurements.
For gas parameters a PGM-50 MultiRae System is used. MultiRae Plus is a programmable multi-gas monitor designed to provide continuous exposure monitoring of toxic gases, oxygen and combustible gases. It monitors three classes of hazardous gases: 1.Organic vapors in the ppm range with the supplied Photo-Ionization Detector (PID) using a 9.8, 10.6 eV or 11.7 eV gas discharge lamp; 2. Combustible gases near their lower explosive limits (LEL) with a catalytic bead sensor, and 3. Inorganic compounds, including oxygen deficiency, with the electrochemical sensors. In next table are presented some specification of Multi-Gas Monitor measuring parameters.

Parameter	Range	Resolution	Response Time
CO	0-500 ppm	1 ppm	20 sec
H_2S	0-100 ppm	1 ppm	30 sec
SO_2	0-20 ppm	0.1 ppm	15 sec
NO	0-250 ppm	1 ppm	20 sec
NO_2	0-20 ppm	0.1 ppm	25 sec
Cl_2	0-10 ppm	0.1 ppm	60 sec
O_2	0-30 %	0.1 %	15 sec
VOC	0-200 ppm	0.1 ppm	10 sec
VOC	200-2000 ppm	1 ppm	10 sec
LEL	0-100 %	1 %	15 sec
HCN	0-100 ppm	1 ppm	60 sec
NH_3	0-50 ppm	1 ppm	150 sec
PH_3	0-5 ppm	0.1 ppm	60 sec

Table 1. Multi-Gas Monitor Specification

The MultiRAE PLUS monitor uses one to five different sensors to measure a variety of gases. A newly developed electrodeless discharge UV lamp is used as the high energy photon source for the PID sensor (see Figure 2). The PID sensor will detect a broad range of organic vapors. Up to two electrochemical toxic gas sensors can be installed in the monitor to measure inorganic toxic gases. Many different types of toxic sensors are offered. They can be plugged into these two sensor sockets and are interchangeable. A catalytic bead sensor is used to measure combustible gases. An electrochemical sensor is used to measure oxygen. The PID sensor for this monitor is constructed as a small cavity in front of the UV lamp. The other sensors are mounted next to the PID sensor. A diaphragm pump is installed inside the monitor to draw the air sample into the sensor manifold and then distribute it to all sensors. A single chip microcomputer is used to control the operation of the alarm buzzer, LED, pump and light sensor. It measures the sensor readings and calculates the gas concentrations based on calibration to known standard gases.

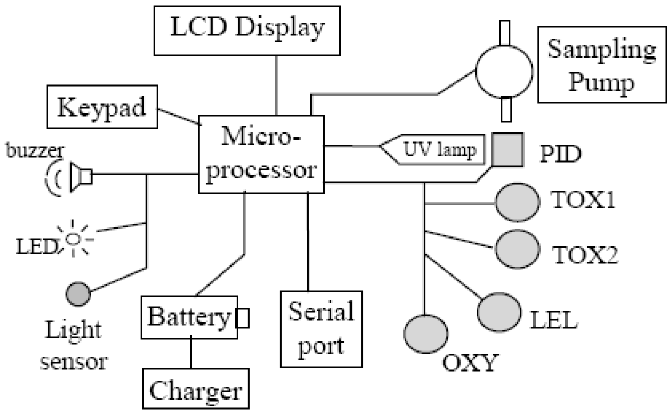

Figure 2. Block Diagram of MultiRAE PLUS Monitor

The data are stored in non-volatile memory so that they can be sent to a PC for record keeping. RS-232 transceivers provide a serial interface between the monitor and the serial port of a PC. A 2-line by 16-character LCD display is used to show the readings. The user interacts with the monitor through three keys on the front panel keypad or via RS232 interface.

For water parameters the Thermo Orion Model 1230 is used. This portable meter is fully waterproof and it allows monitoring of pH, dissolved oxygen, salinity, conductivity and temperature. It can be used for a wide variety of applications. It is designed for convenient use in field, plant, or laboratory and is available with a wide range of probes and accessories. Data logging and printing options are used to send the results to local data processing unit. Orion's D.O. (Dissolved Oxygen) probe is a fast, stable probe with very low oxygen consumption and zero current at zero oxygen concentration. This means fast, stable response and convenient one point air calibration. Under normal use, the probe can be used for about six months without servicing. pH measurements can be made using the Orion Waterproof Triode. Conventional Orion pH electrodes may be used with the adapter that is provided with the meter. Conductivity measurements can be made using either DuraProbe Conductivity Cells, with 4-Electrodes Cell Technology, or conventional 2-electrode cells.

This meter features microprocessor design, which automates complicated and time-consuming calibration and measurement procedures for a wide variety of applications. Data management is enhanced by 120 point data logging and convenient communication to computers and printers.

B. Software setup and communication algorithm

Primary, all data flow is processed by a local processor. As serial communication port (COM) is become old-fashioned (only few laptops have a serial port), for applications that require more than one COM port is necessary a multiplexer to extend the number of ports. Such a multiplexer is PCMCIA-232/4 made by National Instruments.

The major task executed by local processing unit are: reception of measurements information via serial port or other interface, recording and storing the received data sets, configuring the instruments, analyzing the data for extracting the average, minimum or maximum values, displaying the results and the most important is the communication with the main workstation via wireless RF modems.

The modems transfer a standard asynchronous serial data stream between two or more users. They are XTREAM-PGK type and working frequency is 2.4GHz. Its built-in RS-232/485/422 interfacing facilitates rapid integration into existing data systems. Long data range (up to 180m indoor, up to 11Km outdoor) is the most important advantage regarding to other wireless communication technologies Bluetooth and IrDA (<10m indoor), ZigBee (70-100 m free space) [5].

Via wireless modems the server receives data flows. Thereafter a general processing is done and the values are displayed like single data points and graphic charts. The values are also recorded to a database for further analyzing. The National Instruments application running on the server provides the possibility to configure the PGM-50 instrument. It is possible to change data logging interval (1second-1hour), upper and lower alarm limits, instrument's date and time, site ID and user ID.

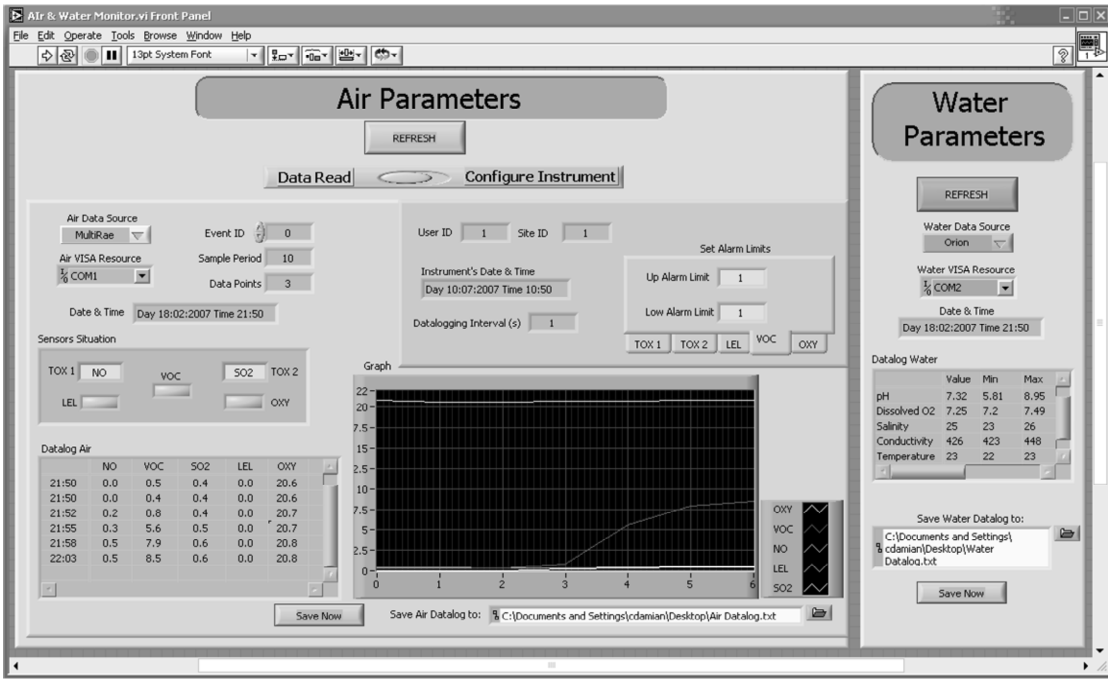

Figure 3. Front Panel of the Monitoring System

The front panel of the measurement system consists in two parts: Air Parameters and Water Parameters (figure 3). In the air parameters window it is possible to read or to configure the instrument. The read values are listed in table and graphical displayed on a Graph Indicator. This allows a better surveillance of the recorded parameters. It is also possible to configure the instrument changing the switch position. This option interrupts the read mode because it's a "one way communication" line. The water parameters windows provide only the reading of the measured data because the Orion instrument has nothing to configure. There is a correction that must be done in case of conductivity measurements regarding the temperature of the sample. The conductivity of a solution with a specific electrolyte concentration changes with a change in temperature.

Sample	Percent/˚C
Ultrapure Water	4.55
Salt Solution (NaCl)	2.12
5% NaOH	1.72
Dilute Ammonia Solution	1.88
10% HCl	1.32
5% Sulfuric Acid	0.96
98% Sulfuric Acid	2.84
Sugar Syrup	5.64

Table 2. Some Typical temperature Coefficients

By convention, the conductivity of a solution is that which it exhibits at 25˚C. a measurement made at 25˚C, therefore, needs no compensation. Measurements made at any other temperature need compensation. Temperature coefficients are different for different solutions. Some examples are shown in the table 2. The temperature coefficient used for compensation varies from one manufacturer to

another. Most Orion meters allow for user adjustment of the coefficient to best fit their application. In this case software compensation with temperature can be made regarding the measurement conditions.
From case to case it is possible to made Salinity Correction. Salinity correction is used to correct the change in oxygen solubility due to salt concentration in the sample. It is typically used in sea water and brackish surface water and in beverages or other samples where is present.

IV. Conclusion

A wireless system for environmental parameters monitoring is discussed. The system's advantages are based on the measurement accuracy with high quality instruments, big number of measurement parameters, long data range provided by two RF modems and good flexibility given by a serial multiplexer used at the measurement place. For air parameters measurement we used a programmable multi-gas monitor PGM-50 MultiRae System and for water parameters a Thermo Orion Model 1230 is used. The front panel allows the data reading and saving and the possibility to configure the gas instruments.
The distance of wireless communication is best advantage of this remote system (up to 180m indoor, up to 11Km outdoor) regarding to other wireless communication technologies Bluetooth and IrDA (<10m indoor), ZigBee (70-100 m free space).

Acknowledgements

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