Environmental station for meteo measurements

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Abstract-Unmanned weather stations play an essential role in the effort to analyze and predict the world's ever-changing weather patterns. The unmanned stations, based on sensors investigation, collect large amounts of weather data and then download the data in real time to a back-end host for analysis and long-term storage. When a monitoring, control and data storage application involves the presence of the sensors and actuators on a large area, the distributed input-output systems FieldPoint, offer an integrated, modulated and economical solution for industrial use. This paper presents a possibility of using FieldPoint module in the weather forecasting.

I. The unmanned environmental station

Monitoring weather conditions or environmental parameters is paramount for agriculture, sailing, flying and more. Weather is thunderstorms, tropical depressions, tornados, blizzards, squall lines, stationary fronts, cold fronts, and hurricanes. The onset of any one of these events can be detected by monitoring a few basic conditions. The weather station records standard meteorological observations including air temperature, relative humidity, dew point, wind speed, wind direction, barometric pressure, precipitation and soil conductivity.

The wireless weather station is composed of a remote station and a base station. The remote station is solar-powered, collects and transfers data. The base station receives and buffers the incoming data and then transfers it via a PLC (Power Line Communications) connection to a PC for processing. By the communication system PLC useful data are delivered modulated in beams. The signal is of the *broadband* type and the physical environment enables multiple operations roll on the same existent infrastructure.

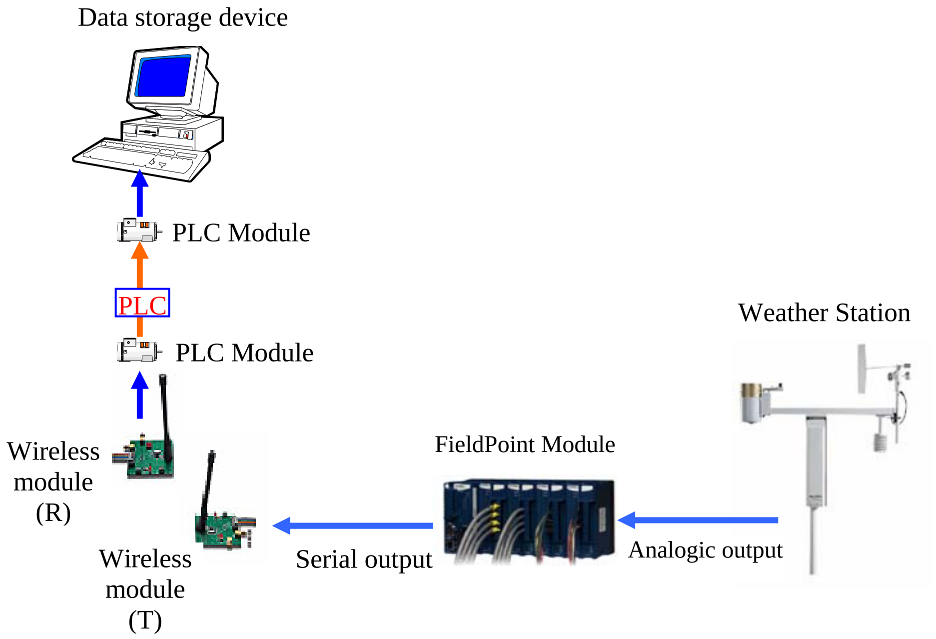

Figure 1. The architecture of the measurement system

A. The remote station

The remote station consists of four functional sections: the station, the FieldPoint module, the wireless module and the power supply. The weather station (WS) consists of an anemometer (A) and wind vane (to measure wind speed and direction), a self-empting rain gauge (RG), soil conductivity (SC), temperature, RH and barometric pressure sensors (STU). The station is powered by a solar panel. When the sun is shining on the solar panel, it is generated enough power to drive a 50 mA current, necessary to charge the inside batteries. For the air relative temperature and humidity measurement, it is used an incorporated sensor on numerical output STU, made in CMOS technology, which makes it thermally safe and stable. This generates a useful signal of superior quality, has a very quick response time and insensibility at external noises (EMC).

The data delivered by this sensor are used to forecast the degree of the water evaporation off the ground.

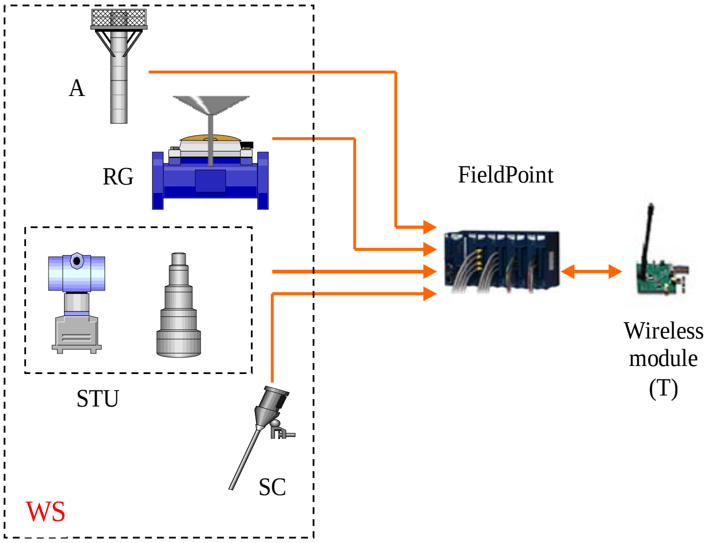

Figure 2. The architecture of the remote station

The FieldPoint module used in data acquisition is connected straight to the sensors and transducers, and filtrates, calibrates and scales the signals. After that the signals are transmitted through serial interfaces RS-232. From the FieldPoint module the information is record by a wireless transmitter. Using the wireless modules, the acquired values can be sent over large distances, not being necessary the human presence.

B. The base station

The base station is equipped with a wireless receiver, the same type as the transmitter. Data flux communication has as a physical support the existent infrastructure of power supply of the receiver and is developed through the Power Line Communications technique (PLC). By the PLC teletransmission the useful information is received by the control centre, on a computer server. Power line communication is a method of having bi-directional communication by using a power line as a transmission channel and superposing high frequency signals over a 100 V (50/60 Hz) power line with the following advantages. Since incoming lines and electric outlets can be used unaltered for PLC, making new wiring unnecessary, it is a reasonable alternative.

Power line communications (PLC) or Broadband over Power Lines (BPL) allows transmission of data over power lines. Power line communications uses the RF signal sent over medium and low voltage AC power lines to allow end users to connect to the Internet. The RF signal is modulated with digital information that is converted by an interface in the home or small business into Ethernet compatible data.

PLC is based on the idea that any copper medium will transport any electrical signal for a certain distance. Basically a radio signal is modulated with the data we wish to send. This radio signal is then sent down the copper medium (our power lines) in a band of frequencies not used by for the purposes of supplying electricity and managing electricity.

The frequencies and encoding schemes used greatly influence both the efficiency and the speed of the PLC service. Most PLC radio traffic generally occurs in the same bandwidth roughly 1.6 MHz to 80 MHz.

The data storage device housed in the weather station must be robust enough to work continuously for long periods of time while exposed to a wide range of temperatures. It should also be able to collect readings from diverse sensors that use different data transmission protocols, and have the capability to store large amounts of data.

The practical implementation of the distributed control systems suppose the utilization of distributed hardware and software equipments. An advantageous solution the employment of the FieldPoint input – output modules SCADA software, like Labview, made by National Instruments. This program allows the reading of the values indicated by the sensors in real time. The FieldPoint modules are easy to use and configure, reliable and robust, and allows to the conditioning and conversion components (A/D and D/A) to be placed near the process. The FieldPoint module used in data acquisition is connected straight to the sensors and transducers, and filtrates, calibrates and scales the signals. After that the signals are transmitted through serial interfaces (RS-232 and RS-485), Ethernet, CAN, FOUNDATION Fieldbus, wireless or radio.

C. The measurement principle

The meteorological sensors transform the data measured onto electric current. To determinate the air temperature, the temperature and relative humidity sensor contains a platinum resistance temperature (PTR) detector. The electrical resistance of the PRT varies with temperature; as the ambient temperature increases, the PRT internal resistance increases.

For measuring the relative humidity, the temperature and relative humidity probe contains a Vaisala Intercap capacitive relative humidity (RH) sensor. A capacitive humidity sensor contains a polymer dielectric material between two capacitive plates. Absorption of water vapor by the polymer changes the capacitance - an increase in humidity results in a decrease in capacitance.

Dew point temperature is calculated from temperature and relative humidity probe measurements.

The barometric pressure is determinated by using a a barometric sensor, with a Barocap silicon capacitive pressure sensor. The sensor is an aneroid (without fluid) barometer in which pressure from the overlying atmosphere deflects a diaphragm, thereby altering the distance between the diaphragm and a nearby electrically capacitive plate. As atmospheric pressure increases, the distance between the diaphragm and plate decreases and the electrical capacitance increases.

The sensor for wind speed measures horizontal wind speed at 3 meters above the surface with a 3-cup anemometer. A cup anemometer provides a simple, durable, and cost effective way of measuring wind speed. A constant wind results in a linear cup speed over a wide range of wind speeds. However, cup anemometers do not record low wind speeds (below 0.5 m/s or 1.1 mph) with accuracy. The wind speed at 10 meters depends on a variety of conditions (including time of day, weather conditions, and change of wind direction with height), so precise comparisons between 3-m measurements and 10-m measurements are extremely difficult. In general, wind speeds at 10-m height may be 10-20% larger during the day and 20-90% larger at night than 3-m height measurements.

The sensor for wind direction measures wind direction at 3 meters above the surface with a mechanical/electrical wind vane. The mechanical vane is connected to a variable resistor (potentiometer) that changes electrical resistance as the vane points in different directions. The wind direction at 10 meters height depends on a variety of conditions (including time of day, weather conditions, and turbulent nature of the atmosphere), so precise comparisons between 3-m measurements and 10-m measurements are extremely difficult. However, wind direction at 10-m height should differ by only a few degrees from 3-m height observations under most conditions.

The informations collected from all those sensors are filtrated and converted by the FieldPoint module, transmitted and received with the wireless modules, and then with the PLC module the datas are comunicated, through PLC interface, to the central computer. The PLC module receives datas from the wireless module and transmits those through PLC interface. This, with the LabView software, allows analyzing the sensors values and the weather forecasting: air temperature, air relative humidity, barometric pressure, wind speed and direction and the rain character.

Another important characteristic of the proposed meteo station is to determinate the rain acid character through conductivity measurements. So, it will be searched a new correlation between the PH and the conductivity of the water sample. The water acid character will be establish through spectral analyze of a discharging electrical arc in moist atmosphere (water – air mixture).

D. Tests and experimental results

To the FieldPoint module can be connected a large variety of sensors with the outputs 4 – 20 mA, or a variety of digital signals from 5 – 30 VDC to 0 – 240 VAC. By using the FieldPoint modules for Ethernet communications, we may transpose on these LabView Real – Time applications. In addition to this, the system has the possibility to work independently, without computer connection.

In figure 3 is presented the block diagram of the virtual instrument which assures the communication between the FieldPoint module and the workstation's computer. The functions implemented by the main instrument are merged in a While structure.

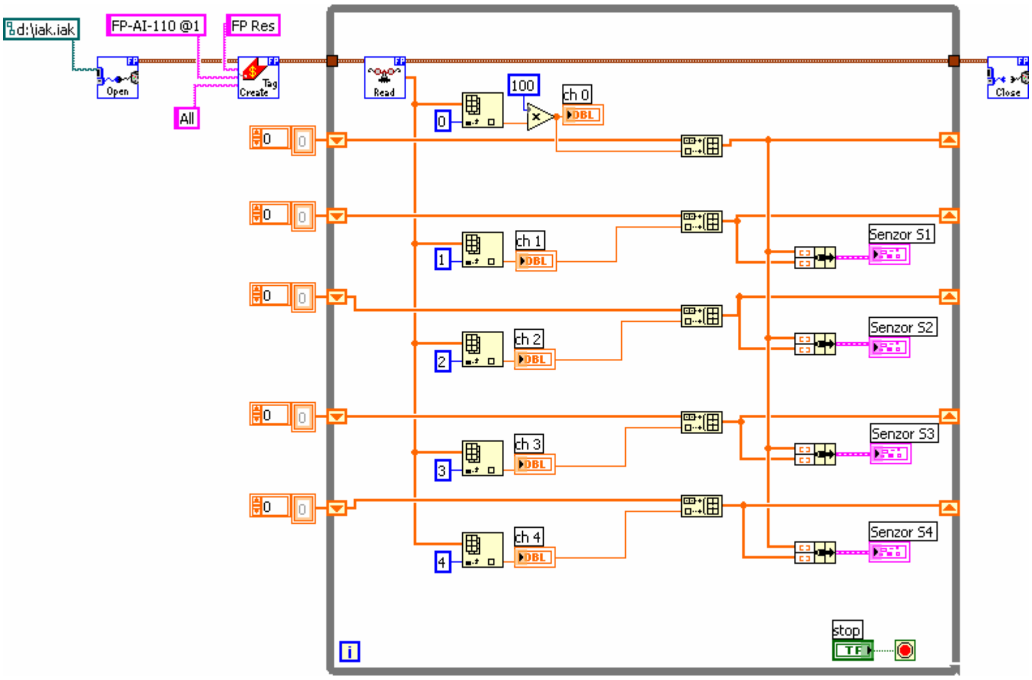

Figure 3. The Block Diagram of the communication between the computer and the FieldPoint Module

II. Conclusions

The resulted system can be used in a large area: weather forecasting, commercial and private farms, agricultural engineers, agronomy researchers. The versatility of the measurement system allows him to be used in a variety of applications including: evapotranspiration, soil moisture, frost prediction.

The system use vanguard techniques like: wireless transmitting, Power Line Comunications, FieldPoint modules. The station is based around state-of-the-art instrumentation that features proven reliability, even in harsh environments.

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