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Drinking Water Supply Control and Water Theft Identification System

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Abstract: The fast growing of the broad urban residential areas imposes the expansion as well as the sophistication of the present water supply facilities. Along with this one more problems is recognized in the water supply channels, some people use ½ HP to 1 HP pump to suck the water directly from the channel of their home street. This automation system based upon utilization of an electronic sensor unit ESU and PC systems including all the network components like Zigbee helps us the best way to improve the water distribution technological process. The theft of water can be best monitored by the flow variations calculated by the flow sensors mounted on the channels. The system includes Remote Terminal Units – RTU, specific transducers distributed on a wide geographical area and control and power panels for the pump stations. The reliable instrumentation connected to Electronic Sensor Unit ESU or RTU assure real time monitoring of the main technological parameters of large water distribution networks. The data acquired of SCADA system (Supervisory Control and Data Acquisition) signify the support for optimization of the process and data- driven decision Support System. The system uses a monitoring system implemented on PC to ensure the process supervision and remote control functions based on UART technologies and wireless communication components for WAN data transfer. The complete SCADA system for water distribution enable the user to get a high operation safety of the network, a cost effective use of equipment, energy efficiency and optimize the daily operation and maintenance procedures.

Keywords- Zigbee, LPC2148, ESU, SCADA, Water flow sensor

I.INTRODUCTION

The water supply systems are a part of the urban infrastructure which must assure the continuity of the water distribution, the water quality Control and the monitoring and control of the technological process parameters, and deal with the restrictions imposed by the water availability, hydrological conditions, the storage capacity of the tanks and water towers and the increasing diversity of water use [1], [2]. The system includes pumping stations, filtering/chemical treatment utilities, and storage tanks and towers, the piping distribution network and the central dispatching unit.

The complete SCADA system structure includes one or more central PC main-station(s) that communicates with more ESU's implemented into the pumping stations or RTUs located in control panels throughout the network (pressure and flow measurement or valves remote control).

The ESU(s) handle the direct control of the technological process whereas the central dispatching unit user interface- HMI, the treatment of data is implemented by the central PC station, "Fig. 2". The reducing of the operating costs and the decrease of the technological water losses is now possible by the implementation of an intelligent control system which offers the support for the optimization of the functional exploitation strategy and the optimization of equipment use.

The global online supervision of the water distribution network is realized by the central dispatching operator as well as the remote control of the sensors installed into the most important points of the system. According to the requirements of the water flow condition, the pressure and flow transducers are installed in booster stations or measuring points throughout the network. These electronic devices are connected to the RTUs which transmit the data to the central dispatching station in order to offer the possibility to monitor the system dynamic behavior. The RTUs provide the data acquisition from different sensors and transducers (specific for water pressure, flow rate, by the digital and analog modules, insure the preliminary signal treatment and wireless data communication to the dispatching unit using Zigbee communication.

Figure 1 – Dispatching unit main user interface

The SCADA system implemented to the central dispatching unit manages the data communication [3] with all the RTUs and LPC2148, stores the received data from the measuring point and from the pumping stations and offer to the operator advanced analysis functions as well as the remote control of the main technological parameters "Fig. 2".

II. WATER SUPPLY NETWORK STRUCTURE

The data acquired from the remote site panels RTU pole mounted to avoid damage, from the pumping stations ECUs data are transmitted to the dispatching unit computer installed in the water distribution company's headquarter. The computer software system integrates an SCADA application program specifically developed for water distribution management. The program emulates the operator console HMI and the technological user interfaces in order to monitor the pressure measurements points and supervise the correct functioning of the distributed system and elaboration of the remote control of the pumping stations equipment. Figure 2

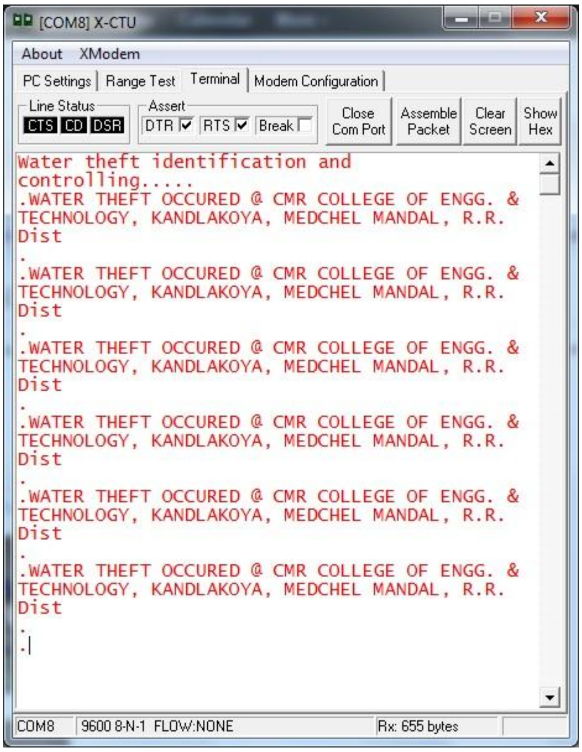

Figure 2 – Technological monitoring parameters of the HMI PC station

The dispatching unit SCADA system displays the theft occurrence when ever happened, depending on the error condition aroused from ECUs.

III. ELECTRONIC CONTROL UNIT

The ECU is built on LPC2148 micro controller, which is continuously checks for the pressure and flow of the water flowing inside the pipes from each channel, if the rate of flow increases the permissible limit then it will immediately turn ON a buzzer and the micro controllers triggers the zigbee wireless module to send a wireless data to the central monitoring unit Figure 3

The SCADA system offers the on line support for the management of the process events, generates alarms, triggers the signals status change, support the operator exercises, elaborates the time controlled procedures, It is possible to define and select the class events to be recorded or retrieved.

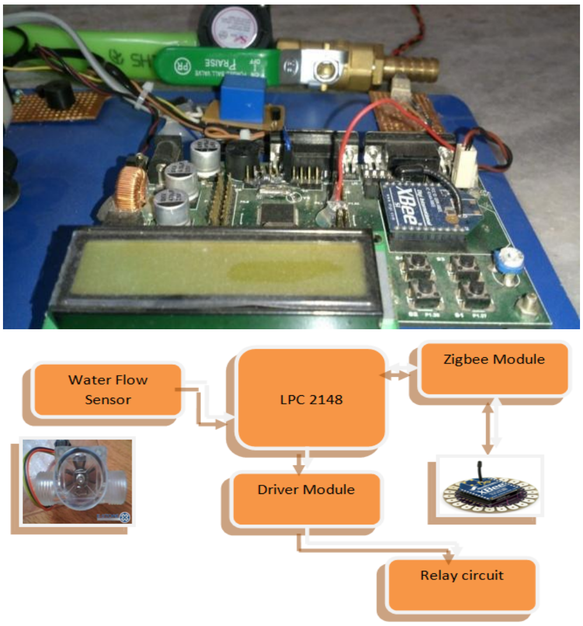

Figure 3: Remote Terminal Unit:

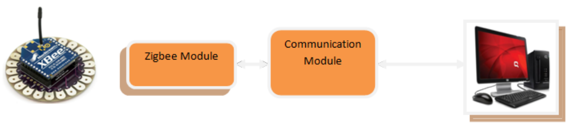

Figure 4: System Control Unit:

The events are defined by their own features: the tag number of the signal or variable; the process domain; the alarm or event structured level; specific signal status or logical level to trigger the event recording; analogue parameter technological control set limit.

IV. LPC2148

The LPC2141/2/4/6/8 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/2/4/6/8 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTs, SPI, SSP to I2Cs, and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical systems.

Features:

16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.

• 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash program memory.

128 bit wide interface/accelerator enables high speed 60 MHz operation.

• In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software.

Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.

• Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high speed tracing of instruction execution.

• USB 2.0 Full Speed compliant Device Controller with 2 kB of endpoint RAM.

In addition, the LPC2146/8 provide 8 kB of on-chip RAM accessible to USB by DMA.

• One or two (LPC2141/2 vs. LPC2144/6/8) 10-bit A/D converters provide a total of 6/14 Analog inputs, with conversion times as low as 2.44 s per channel.

• Single 10-bit D/A converter provides variable analog output.

• Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.

• Low power real-time clock with independent power and dedicated 32 kHz clock input.

• Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.

• Vectored interrupt controller with configurable priorities and vector addresses.

• Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.

• Up to nine edge or level sensitive external interrupt pins available.

• 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 s.

• On-chip integrated oscillator operates with an external crystal in range from 1 MHz to 30 MHz and with an external oscillator up to 50 MHz.

• Power saving modes include Idle and Power-down.

• Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.

• Processor wake-up from Power-down mode via external interrupt, USB, Brown-Out Detect (BOD) or Real -Time Clock (RTC).

• Single power supply chip with Power-On Reset (POR) and BOD circuits:

– CPU operating voltage range of 3.0 V to 3.6 V (3.3 V 10 %) with 5 V tolerant I/O pads.

LPC2148 PIN DIAGRAM

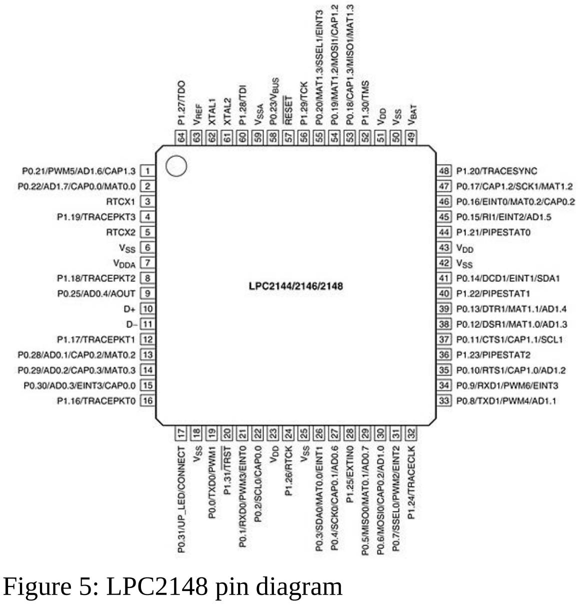

Figure 5: LPC2148 pin diagram

V. WATER FLOW SENSOR

Can be used to create a flow meter or calculating amount of liquid passing.

Measure liquid/water flow for your solar, computer cooling, or gardening project using this handy basic flow sensor. This sensor sit in line with your water line, and uses a pinwheel sensor to measure how much liquid has moved through it. The pinwheel has a little magnet attached, and there's a Hall Effect magnetic sensor on the other side of the plastic tube that can measure how many spins the pinwheel has made through the plastic wall. This method allows the sensor to stay safe and dry.

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse Signal.

The sensor comes with three wires: **red** (5-24VDC power), **black** (ground) and **yellow** (Hall Effect pulse output).

By counting the pulses from the output of the sensor, you can easily track fluid movement: each pulse is approximately 2.25 milliliters. Note this isn't a precision sensor, and the pulse rate does vary a bit depending on the flow rate, fluid pressure and sensor orientation. It will need careful calibration if better than 10% precision is required. However, its great for basic measurement tasks!

Figure 6: Water flow sensor

Electrical Specifications

- Working Voltage: 5 to 24VDC
- Max current draw: 15mA @ 5V
- Working Flow Rate: 1 to 30 Liters/Minute
- Working Temperature range: -25 to 80°C
- Working Humidity Range: 35%-80% RH
- Maximum water pressure: 2.0 MPa
- Output duty cycle: 50% +-10%
- Output rise time: 0.04us
- Output fall time: 0.18us
- Liquid temperature <120 °C
- Flow rate pulse characteristics: Frequency (Hz) = 7.5 * Flow rate (L/min)
- Pulses per Liter: 450
- Durability: minimum 300,000 cycles
- Weight 43 g

VI. ZIGBEE

ZigBee defines a network layer above the 802.15.4 layers to support advanced mesh routing capabilities. Xbee can be used for wireless communication with low power consumption. A 3.6V 600mA Lithium battery may last 6 - 12 months for powering up an Xbee while the wireless range can up to 1 mile. It talks with well known UART interface and makes it easy to use. It is simple and straight forward if you only use 2 Xbee for communication.

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

Zigbee 802.15.4 wireless communication. Do you want to free your robot of wires? Send sensory data back to your PC? Control your robot from up to 300 feet away without having to worry about interference issues inherit in most 2.4ghz technology? Zigbee technology is the answer. From simply 'cutting' your serial cable, to creating a wireless mesh network perfect for swarm robotics, you can take your robotics projects to the next level with Zigbee!

Figure 7: Zigbee wireless module

VII. CONCLUSIONS

The automated system implemented into the water distribution network insures the update of the refurbished water supply urban utilities; it offers new ways of monitoring and optimized exploitation of the water resources and technological equipments. The informatics SCADA system by its wide geographical area distributed intelligent components allows: - The overall supervision and remote control of all the water network equipment and the management of the water flow according to the users demand, the available water volume related with the reservoirs level and capacities including correction determined by the pressure in the key points of the network, - Measurement data reliability by the global monitoring of the network in the central dispatching unit, - Continuity of the water distribution and protection of the water quality; decrease of the water resources losses; water leakages detection done by the online consumption monitoring or pressure drop, - The real time operator alarm information triggered by any equipment failure in the distribution system, - Optimization of the exploitation and maintenance costs, - Water distribution technological process tractability, - Automated database elaboration as a first step for the future specific data driven decision support system.

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