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Design of Monitoring System for Water Supply for Metropolitan City Using Embedded Technology

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Abstract- In this paper, in order to manage and use the city's water resource reasonably, a wireless monitoring system for water supply based on ARM 11 microprocessor is designed for metropolitan city . This system uses ARM 11 microprocessor of low power and high performance as the main chip, and designs software with µC/OS-II real-time operating system to achieve remote real-time monitoring for water consumption of enterprises. The system will use ZigBee and GSM through GPRS system for communication protocol. The ZigBee is used since the application don't need high speed data rate, need to be low powered and low cost. Each ZigBee node will be connected to the collector node and from collector node the data will be sent to the central computer by using GSM through GPRS.GSM network with its vast coverage in most countries and also its competitive ever growing market, is becoming popular as a medium for machine to machine applications which utilize the GSM network to send its water usage reading using short message service back to the energy provider wirelessly. In addition, during the debugging process, the electromagnetic flow meter has non-linear output because of interference by a strong current , so this system uses the first order Taylor expansion for the working point in order to linearization. In a word, this system avoids the work method of the traditional meter-reading and reduces water waste to a certain extent.

Keywords- Wireless monitoring system; Embedded technology; µC/OS-II; ARM7;Taylor expansion, Zigbee, GPRS/GSM

I. Introduction

With the continuous economic growth, the water demand of enterprises is also increasing. The monitoring of water resource for these enterprises can prevent the occurrence of stealing water and leaking water effectively. Therefore, the monitoring system of water supply in metropolitan has aroused extensive attention in recent years [1,2]. Such a system is a combination of sensor technology, communication technology and embedded technology, and this system achieves remote real time monitoring for water consumption of enterprises instead of the traditional meter-reading. There are three key elements in a wireless monitoring system: consumption measurement, meter reading and data transmission, and data processing and billing. The system has to be cost-effective. That means reducing the costs of implementation, maintenance, while providing robust and reliable performance. On top of that, the relationship between the customer and the supplier must be considered.

Wireless sensor networks bring advantages in the form of lowering the cost of sensor installation. Lowering the cost is achieved by avoiding the need for cabling, materials and testing which all raise the costs of labor. Secondly, 'the last meter connectivity problem' – cable connectors getting loose, lost, misconnected or broken - is no longer an issue. Wireless automatic meter reading system presented in this text - comprised of a meters with ZigBee radio on one side and database management system on the other side takes into account all of the previously mentioned issues. Therewithal, certain specific demands and constraints have to be taken into consideration to provide an effective solution both for the consumer and the supplier, including long battery lifetime, signal range, packet latency, ease of installation and maintenance. In the high-end applications of embedded system, ARM company has introduced a 32-bit ARM family which includes ARM7, ARM9, ARM9E, ARMI0E, ARM 11 and so on. Where, the ARM11 has some advantages, such as running the µC/OS-II embedded operating and low cost and so on. So it can meet the design's requirements of this system fully. Therefore, in hardware design this system uses ARM11 as the main chip. Meanwhile, according to different water consumption and requirements of accuracy, this system uses two different sensors. One is IC card flow meter, which is based on per ton as the basic unit. The other is the electromagnetic flow meter, which is based on 0.01 tons as the basic unit. In software design, µc/OS-II embedded operating system is ported to the ARM11 microprocessor, which can well solve some questions for real-time and concurrency. In addition, the collected data is encoded to avoid the data disturbing by a variety of electromagnetic signal during transmission.

II. Overview of System Architecture

The system will be having digital meter, analog meter, microcontroller and zigbee module. The output from the digital meter will be pulse .All the data's will be stored in the temporary storage buffer. The microcontroller will be programmed such that

for once in every thirty days the data, i.e. meter readings will be sent to the zigbee module. The power source will be operated by the Li battery of 5 volts. The monitoring point system will be in Sleep mode . once in thirty days the module will transmit the reading through the antenna ie Transreciever. The antenna used in the module is microstrip antenna. The figure shows the system overview.

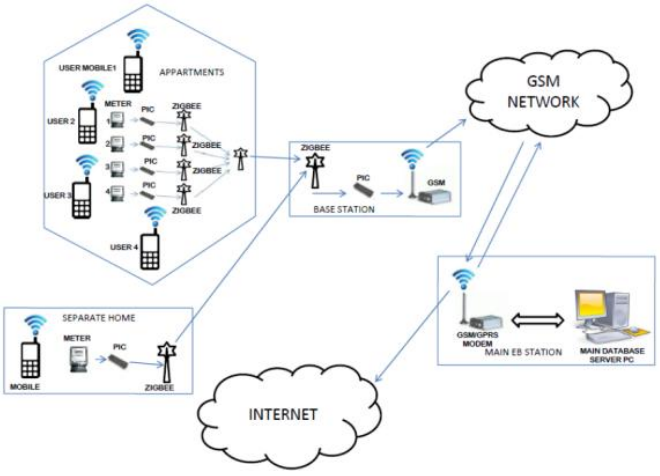

Fig 1: Architecture of monitoring system

III. Design Hardware

A. Monitoring point

Every monitoring point is composed of the controller
module, the sensor module and the communication module. The hardware is shown in Figure 2.

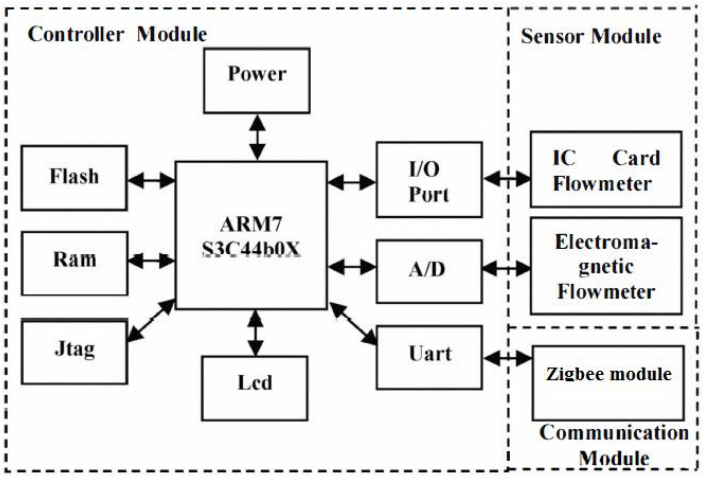

Fig 2: Hardware for monitoring point

1. Controller Module:

The controller module is composed of microprocessor, memory, serial port, led and so on. Where, the microprocessor is Samsung's S3C44BOX chip, it is based on 32-bit high-speed processor of the ARM7TDMI core, and the operating voltage is 3.3V. S3C44BOX has some following features: 8 memory banks; 71 general purpose I/O ports; 8-ch external interrupt source; 2-ch uart with handshake; the led controller supports monochrome, 4 and 16 level grayscale. Thus, this microprocessor has a high integration. It can simplify the system hardware's design greatly and shorten the developmental cycle of product. In addition, the controller also need expend a 2MB nor flash to store data, it uses sst39vfl60 chip. This chip has some features, such as the operating voltage of 2.7V-3.6V, sector erase function and high-performance word programming function. Meanwhile, the controller uses the SP3232 chip to response for communication between the processor and the data radio. In order to make user see cumulative flow and instantaneous flow more intuitive, the controller also extends an led screen. This led screen is TCM-A0902 which is produced by EPSON, it is monochrome and resolution of 320*200, we can use S3C44BOX chip's BANK4 to control led directly.

2. Sensor Module:

The system uses two different sensors completely. When using small amount of water relatively, the system uses the electromagnetic flow meter of high precision LZD series. It outputs 4-20mA current, and we can tum current into voltage signal, voltage signal is passed to the microprocessor and converted into digital signal through the ad, and these digital signals are saved to the flash or passed to the central station. When using large amount of water relatively, the system uses IC cards flow meter of low accuracy. IC cards flow meter is counted by pulse, pulse signal is collected by ARM7's I/O ports, and the data is saved to flash or sent to the central station. In addition, the use of IC cards can achieve this function which makes user payment before using water, and avoids causing water waste because of the outstanding fees.

3. Communication Module:

The system uses Zigbee module for communication. The communication unit will be consists of a zigbee module attached with a Transceiver microstrip antenna , microcontroller These features meet the design's requirements of the system.

B. Base station

The data which is transmitted from the AMR module will be received in the base station unit . the Base station unit will be consists of a zigbee module attached with a Transceiver microstrip antenna , microcontroller and GSM modem. The datas will be collected in the base station unit from each and every node. The frequency of communication will be in 2.4 GHZ. the data will transmitted to the central station.

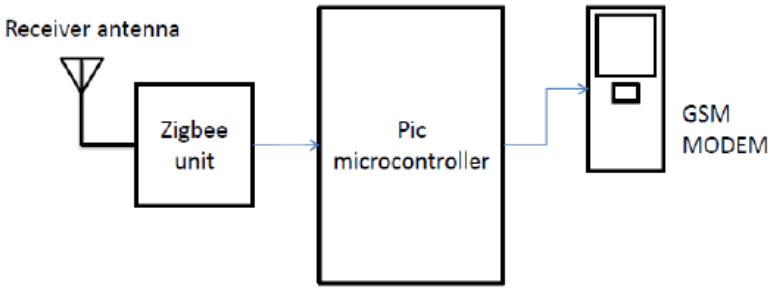

Fig 3: Base station unit

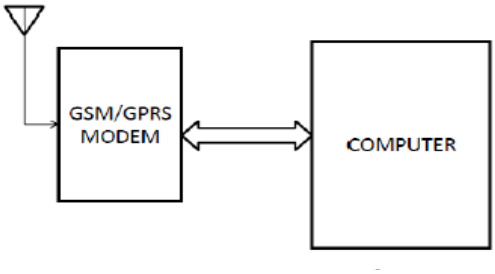

Fig 4 : Central station

IV. The Linear Processing of Data

Due to the strong current interference, electromagnetic flow meter produces nonlinear output. By on-site debugging avset of test data can be got as is shown figure . The vertical axis is the water flow rate, the abscissa is the value of AD translation. From the figure we can see that the relationship between the two is non-linear. Therefore, firstly data may be polynomial fit. According to the required accuracy and the ability of processor, we set the

$$F(x) = a_3x^3 + a_2x^2 + a_1x + a_0 \qquad (1)$$

where a3 = 2.642xlO-7 , az = 2.678xlO-4 , aj = 0.2937 , ao = -0.3421 , x is the value of AD translation.

Secondly, we may select some work points to the first order Taylor expansion. Taylor first order expansion formula(2) is applied and figure 8 is shown after Taylor expansion. If x E [a -10, a + 10) , this interval linear curve is used to calculate the water flow rate.

$$G(x) = F(a) + F'(a)(x - a) \qquad (2)$$

Where a is a work point

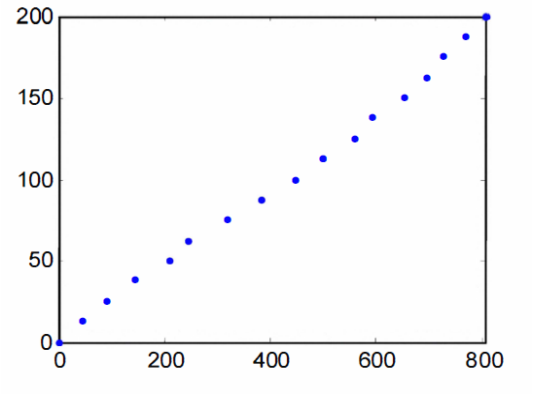

Fig: output from the sensor

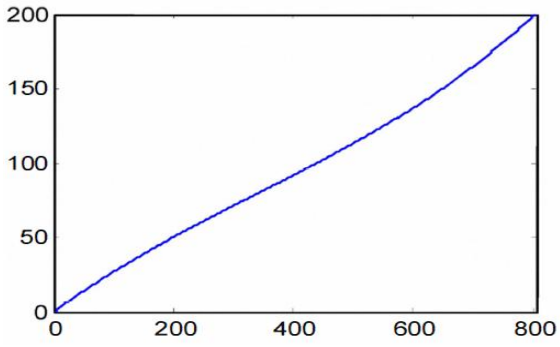

Fig 6: Fitting curve

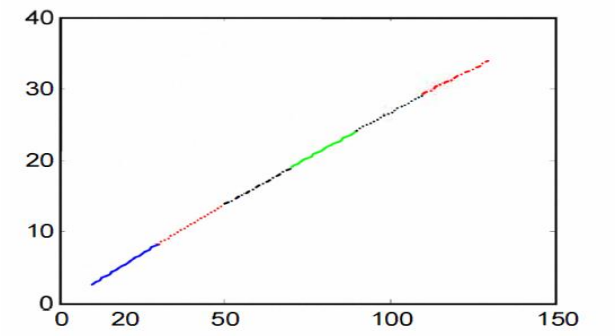

Fig 7: The linear curve

V. Conclusion

A wireless monitoring system of urban water supply based on the ARM7 microprocessor is designed. It takes full advantage of low-power and strong anti-jamming of ARM7 microprocessor, these features make this system work in harsh industrial site properly. At the same time, the use of embedded operating system µC/OS-II makes this system more coherent and concise. Other, the electromagnetic flow meter produces non-linear output because of interference by a strong current .By simulation and debugging, for the work point the first order Taylor expansion's method can solve such problem. The system use ZigBee and GSM through GPRS system for communication protocol, provides low cost and long distance communication which helps in monitoring water supply in metropolitan city. The development of the wireless monitoring system can reduce the waste of water resources substantially, and make the management of water even more effective and convenient in the city,

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