Development of Interactive Wireless AMR with Distribution Automation System

Chang-Hwan Yoon, Dong-Doo Lee, Chang-Hwa Lee

ADMOTECH Inc, 1320 Gwanpyung-Dong Yusong-Gu, Dagjon 305-509, South Korea
(Tel : +82-42-936-1353; Fax :+82-42-936-1350)
E-mail : {chyoon, ddlee, chlee}@admotech.com

Abstract : Recently WSN has become one of the most interesting ubiquitous networking technologies and its application for the AMR is rapidly growing. To introduce this concept, interactive wireless automatic meter reading node integrated with distribution automation system has been developed in the ADMOTECH Inc.. In our developed system, wireless communication is based on IEEE 802.15.4 and half duplexer interactivity is implemented. Our prototype can handle up to 75 AMR nodes and can be easily extended to larger scale for interactive meter reading application. This paper presents the conceptual structure of system layout and shows details of physical hardware, communication protocols and UI. Furthermore, our system is capable of measure, record various data - such as energy consumption, power factor and additional parameters - and control electric load operation.

Keywords : AMR, Interactive**,** Automation**.**

I. INTRODUCTION

Traditionally, the electricity meters are installed on consumer's premises and the consumption information is collected by meter-readers on their fortnightly or monthly visits to the premises. This method of gauging electricity consumption has the following disadvantages:[1]

(i) Sometimes the meters are installed inside people's homes and, if the consumer is not at home, the meter-reader cannot record the fortnightly or monthly consumption and then the utilities' company has to resort to considering the average bill-amount of the previous months as an indicator of the likely consumption for the current month. This results in burden for both consumer and the electricity supply company. May be the consumer has not utilized similar amount of electricity in the current month as in the previous months for reasons such as, holidaying elsewhere or being in the hospital, etc. during the month, and sending him a bill for a larger amount based on his history of electricity consumption may result in his/her financial hardship. This method of billing is also not suitable for the electricity supply company because it gives inaccurate account of the overall electricity consumption in the consumer's area and may ultimately result in errors in future planning by the company.

(ii) Hiring of a number of meter-readers by utilities' companies and providing means of transportation to them is an expensive burden on the companies' budgets. Moreover, these visits of the meter readers to consumers' premises generate pollution in the air which has negative impact on the environment and the greenhouse effect.

(iii) Dissatisfaction of some customers who consider meter-readers' entrance to their homes as some sort of invasion of their privacy. This is especially applicable in countries, like Oman, where during the day most men are outside of their homes earning a living and only women are at home doing the housework.

In order to overcome these disadvantages of the traditional meter reading system, efforts are underway around the world to automate meter reading and to provide comprehensive information to the consumer for efficient use of the utilities[2,3,4].

This paper is organized as follows: In Section II, detailed design of 3-phase Electric power meter module has been presented. This is followed by IEEE 802.15.4 wireless interface and its implementation explained in Section III. Distribution Automation System are given in Section IV which are followed by conclusion in Section V.

II. 3-PHASE ENERGY MEASURING

The block-diagram of a 3 phase meter developed is shown in Fig. 1. The meter can be used in a 3 or 4 wires system and is capable of performing the following measurements.

. Apparent energy (kVA) . Active energy (kWHr)

. Power factor (0-1.0) . Phase voltages (Vrms)

. Phase currents (Arms) . Reactive energy (kVarHr)

The line voltages and line currents are sensed and properly scaled by voltage dividers and current transformers to within the operating ranges (2V

approximately) of the measurement unit. These scaled voltages and currents are then sampled by the energy measuring circuit which performs 16-bits Delta-Sigma A/D conversion and calculates all energy

Such a 16-bits digitization resolution of voltages and currents in the energy measuring circuit gives the meter an accuracy of class 0.5 that guarantees less than 0.5% error – as shown in figure 2 (the calibration setup) - through a wide range of voltage, current and power factor. These data are then read from the energy measuring circuit by the embedded-processor(EPU) which also performs appropriate energy collection, updates real-time clock, displays the energy data on an LCD panel and controls two communication devices, i.e. IEEE 802.15.4 standard PHY chip.

This meter also has a battery back-up system using a CR-2032 type 1.5V coin cell. When there is a power failure, the brown-out detector unit in the EPU will automatically inform the EPU to shut down all units except the time keeper and store all important energy data in the battery back-up Flash RAM. During this time, the EPU is put into sleep mode and the total current consumed from the back-up system is kept minimum at 800nA or less.

III. THE ZIGBEE RF HARDWARE

In our prototype design, we adopt the IEEE 802.15.4 standard compliant transceiver CC2520 from Texas Instruments. CC2520 provided IEEE802.15.4 PHY hardware for 2.4GHz/Zigbee.

The CC2520 also includes digital RSSI/LQI (Receive Signal Strength Indicator/Link Quality Indication) support and 12-bit ADC (Analog-to-Digital Converter) with up to eight inputs and configurable resolution.

Powerful USARTs with support for several serial protocols. Combined with the Zigbee protocol stack (Z-Stack) supported from TI. 2520EM board is used to develop the initial state proto-type system.

The data gathering/collection approach may be carried out on a cluster-based, tree constructive based network.

The selection of appropriate network organization depends on the physical location of AMR nodes and the data features. In addition, distributed data compression and aggregation method may be implemented to improve the efficiency of data gathering.

The software is developed using IAR Embedded Workbench EW430 based on TI's Z-stack.

The ZigBee RF hardware in this system has the following features:

- Operating frequency : 2.4GHz, ISM band
- Antenna : mono-pole, chip type (selectable)
- Transmit power : 0dBm ±3 dB
- Receiver Sensitivity : -92 dBm
- Coverage(Radius) : 30m (indoor), 100m (outdoor)
- Maximum Data Rate : 250 kbps
- Internal packet memory : 127 Bytes
- Data interface : SPI for Energy Circuit, serial to DM
- Serial data rate :1200-115200 bps
- Channels : 16 Direct Sequence channel
- Addressing Options : PAN ID, Channel and Addresses

It is natural to set the data packet format in the communication channel according to ANSI C12.18 regulation since this is already used for the optical reading. Hence the same application layer used in the infrared system is also implemented for the RF system. Each data packet consists of the following fields.

IV. DISTRIBUTION AUTOMATION SYSTEM

Distribution automation system(DAS) is PC based AMR data management automation platform. [Fig. 4]

This system consists of developing layer for which both development and execution is enabled as well as execution layer for which only execution is enabled.

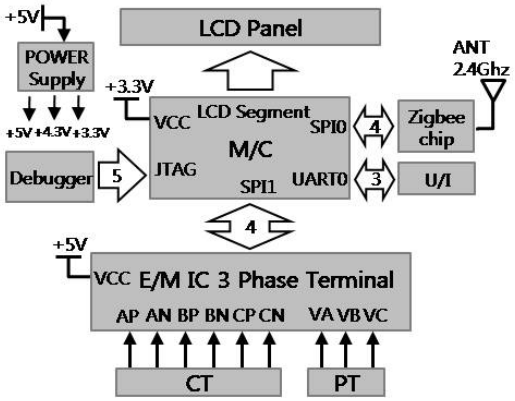
Each layer type has at least 75 point products based on the number of the real AMR nodes. Designed as the open system architecture, it can not only satisfy various special needs of users, but also provide system interfaces with other software systems. Features of the open system architecture of DAS considered in its design include OLE automation, ODBC, VB script, OCX, etc.

User programs operable inside DAS can be created using script language. User can apply various functions without special training since VB script language is supported. With the use of the internal functions of DAS in addition to the general functions provided by VB Script, whole systems can be controlled in more various ways.

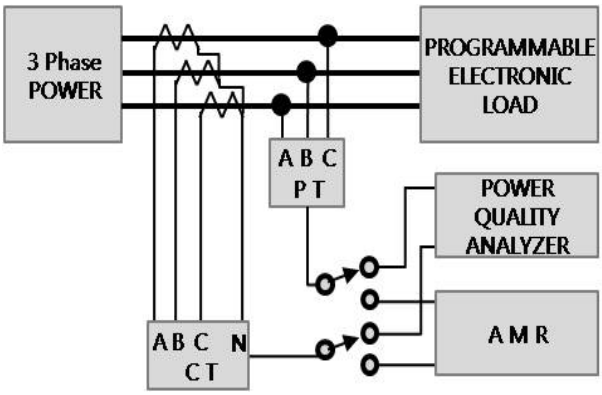
Using ODBC, DAS can be freely connected to various general purpose DB servers. Since standard Structured Query Language is supported, all DB applications including record inquiry, modify, add, and delete functions can be implemented.

DAS can be connected various networks such as RS232C/422, LAN and wireless communication and it supports the standard protocol such as OPC and MODBUS. Therefore DAS can communicate with most PLCs. [Fig. 5]

Table 1 illustrates the summarized our system specifications

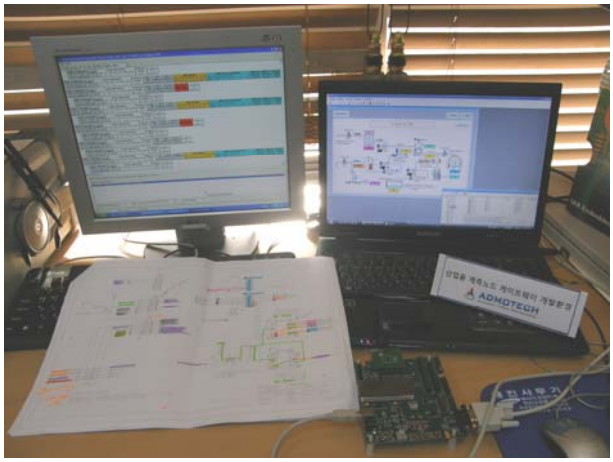


[Fig. 1] The internal hardware architecture of the AMR

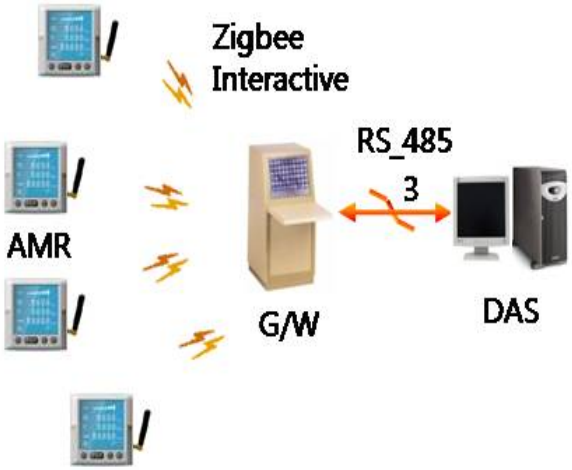


[Fig. 2] Block diagram of calibration setup.

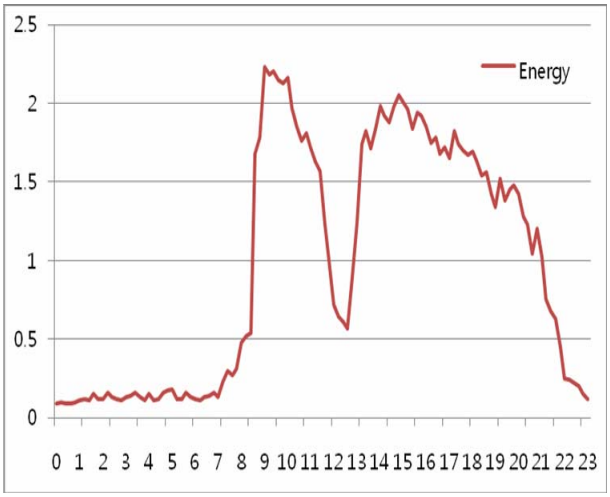
[Fig. 3] Precision analysis based on commercial equipment.



[Fig. 4] Developing layer environment of DAS.



[Fig. 5] Block-diagram of interactive wireless AMR



[Fig. 6]. A 1 day energy profile plot

<Table 1> Specifications of wireless AMR

Item		AMR
Wire connection		3P3W or 3P4W
Network		ZigBee wireless Network.
Electric parameters		V, A, W, Var, VA, PF, Hz, WH, etc.
Conversion Rate		1 / sec.
CT, PT Ratio		1 ~ 9999
Power Supply		AC 110~220V, 50/60Hz
Input	Current	0 ~ 100A or external CT
	Voltage	0 ~ 600V
	Frequency	45~65 Hz
Communication		RS232 or RS-485 and Zigbee

V. CONCLUSION

A prototype interactive wireless 3- phase AMR with a ZigBee 2.4GHz RF unit and DAS is developed. This system will be suitable for an industrial plant as it can measure and accumulate active energy, reactive energy, apparent energy. Its distinctive feature is the ability to interactively communicate with a remote management DAS server using 2.4GHz band IEEE 802.15.4 standard wireless media.

ACKNOWLEDGEMENTS

The work developed in this paper has been supported by the DAEDEOK INNOPLIS ("R&D Hub Cluster project").

REFERENCES

[1] Tariq Jamil, "Design and Implementation of a Wireless Automatic Meter Reading System" *Proceedings of the World Congress on Engineering 2008 Vol I*, WCE 2008, July 2 - 4, 2008, London, U.K.

[2] T. Whittaker, "Final word," *IET Control and Automation*, Vol. 18, No. 3, June/July 2007, p. 48.

[3] M. Venables, "Smart meters make smart consumers," *IET Engineering and Technology*, Vol. 2, No. 4, April 2007, p.23.

[4] C. Brasek, "Urban utilities warm up to the idea of wireless meter reading," *The IEE Computing and Control Engineering*, Vol. 15, No. 6, December/January 2004/05, pp. 10-14.