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A Novel Advanced Gauge Reader System Based on M-Bus Technology

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Abstract

Applications in the signal processing technology corresponding to various gauges have been widely popularized exploration. However, there is rarely proposed corresponding to how to employ gauge reader with lower cost but longer distance. M-Bus (Meter-Bus) is an inexpensive solution for widespread networking and remote meter reading for the consumption data collection. This work based on the M-Bus technology presented a novel signal processing technology of Advanced Gauge Reader System (AGRS). In particular, this paper also implemented the proposed device for real applications. The proposed AGRS is a cost-effective, stable and reliable remote water meter reading system. Numerous simulations and tests have been made to demonstrate the efficiency of this work. The empirical findings may provide some valuable references for the related applications.

Keywords: *signal processing technology, advanced gauge reader system, M-Bus, water resources planning and management, micro-chip processor*

1. Introduction

With the rapid increase in economic development, the problems of energy crisis and global warming effects are a cause for increasing concern. Smart grid, advanced metering infrastructure (AMI), home automation, and reduction energy consumption and carbon emission have become the popular buzzwords today. A lot of research has been widely investigated on these issues. Smart grid is the next-generation power grid which is interconnected via a two-way communication network. Much research has been done on the smard grid [1-3]. AMI always refers to measure, collect and analyze usage data through communication network and connected smart meters [3-5]. Smart meters play a key role in AMI [6-8]. Furthermore, many energy management technologies have been developed to reduce energy consumption for green-home and green-building [9-13]. An automatic meter reading (AMR) system is a system used to remote reading the consumption of energy. Many studies have been conducted on the AMR based on ZigBee and GPRS (General Packet Radio Service) technologies for home automation [14-16]. ZigBee network is for short distance communication, and GPRS network is for remote communication. However, the involved networks associated with data acquisition, storage and transfer modules are quite complex and limit the measured distance. In addition, they frequently forcus on the electricity power monitoring system.

The M-Bus is a European standard (EN 13757-2 [17] and EN 13757-3 [18]) for the remote readout, monitoring of consumption meters and sensors. The M-bus is an inexpensive solution for remote monitoring and reading of a great numbers of meters. Employing the M-Bus and signal processing technologies, this paper proposes an Advanced Gauge Reader System (AGRS) to construct the networking and remote reading of water meters. The reading data should be used as a base for water resources planning and management. Furthermore, a web server application can be used to process the data, allowing for worldwide available on the internet. The designed smart metering is basically performed with AGRS. It provides the following benefits: (1) real-time, automated and reliable metering, (2) frequent meter reading and more accurate analysis, (3) improved information for water planning, (4) quick detection of faulty meters and leaks, and (5) achieved significant water savings. A scale-down laboratory prototype is built and tested to verify the feasibility of the proposed scheme. The results of the study may be useful to researchers attempting to develop AMI.

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The paper is organized as the following manners: Section 2 higflights the basic M-bus operation. The hardware implementation of the master and slave for AGRS are given in Section 3. Finally, a brief conclusion of this work is drawn in Section 4.

2. Research Method

The M-Bus is a field bus which is specialized to provide system for the data collection from consumption meters of various types, such as commercial electric energy, gas, heat or water meters. It is a master-slave structure with two-wire bus and baud rates of 300 to 9600bps and 0.1 to 0.5sec response time. The typical M-Bus system is shown in Figure 1. The master interface is required between the PC (Personal Computer) and the M-bus network for adapting RS232/USB signals. The master of the proposed AGRS can connect and power up to 256 slave-devices directly.The master can read the interconnected consumption meters at an adjustable interval, and save the meter readings to permanent memory. Furthermore, the remote data read-out of M-Bus systems is possible via public telephone lines. Analog and ISDN (Integrated Services Digital Network) telephone cables, as well as wireless GSM (Global System for Mobile Communications) networks are utilized for data transmission.

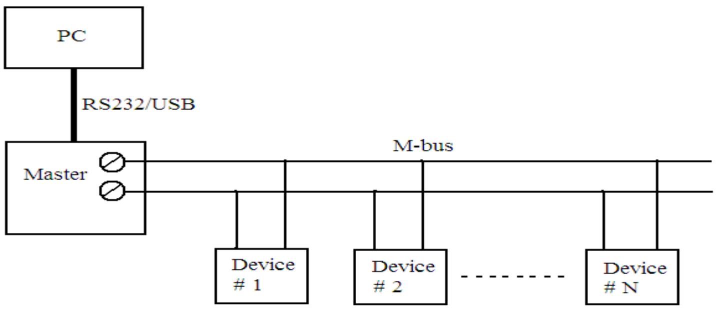

Figure 1. M-Bus Structure

2.1. Downstream Transmission

Bi-directional data transmission from master to slave is triggered by changing voltage in the M-Bus. For the M-Bus with 1000 meters long distance, the downstream transmission from master to slave is accomplished by voltage modulation. As shown in Figure 2, the master sends voltage logic pulse "1" (Mark) or "0" (Space) to slave-devices. The logic "1" and logic "0" are represented by 12V and 7V, respectively. There is a tolerance voltage of 5V to ensure transmission against fail. The slave-devices can get electricity from the bus because there always exits the voltage on the bus. Figure 3 shows the corresponding circuit diagram of the voltage modulation for the M-Bus master.

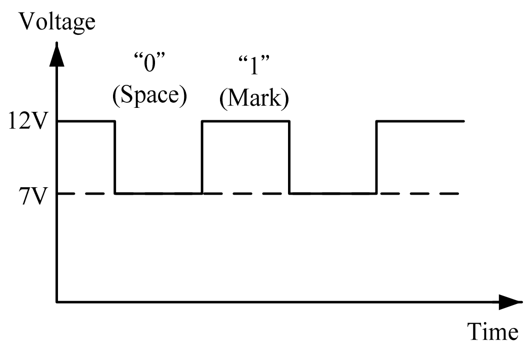

Figure 2. Voltage Pulse for the Downstream Transmission

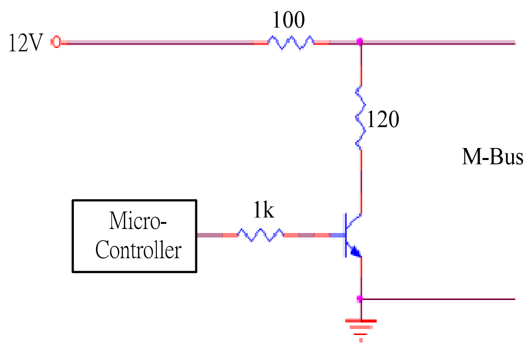

Figure 3. Downstream Voltage Modulation Circuit

2.2. Upstream Transmission

Data transmission from slave to master is triggered by changing current at the terminal device. The upstream transmission from slave to master is coded by modulating the current consumption of the slave-devices. As shown in Figure 4, the logic pulse "1" (Mark) and logic "0" (Space) are 10mA and 1mA respectively. The transmission manner can avoid the interference with voltage noise. In addition, the mark state current can be used to power the interface, meter or sensor itself. Figure 5 shows the corresponding circuit diagram of the current modulation for the M-Bus slave.

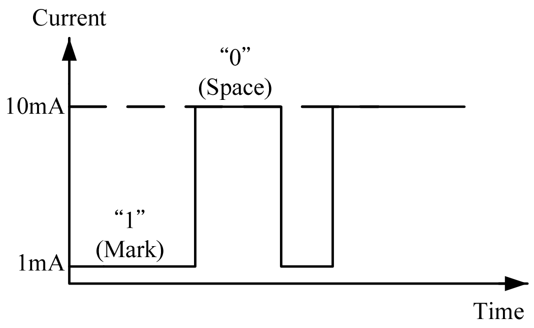

Figure 4. Current Pulse for the Upstream Transmission

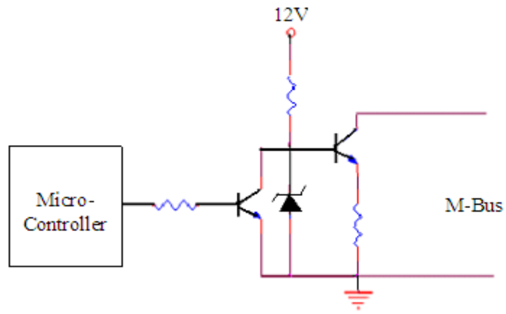

Figure 5. Upstream Current Modulation Circuit

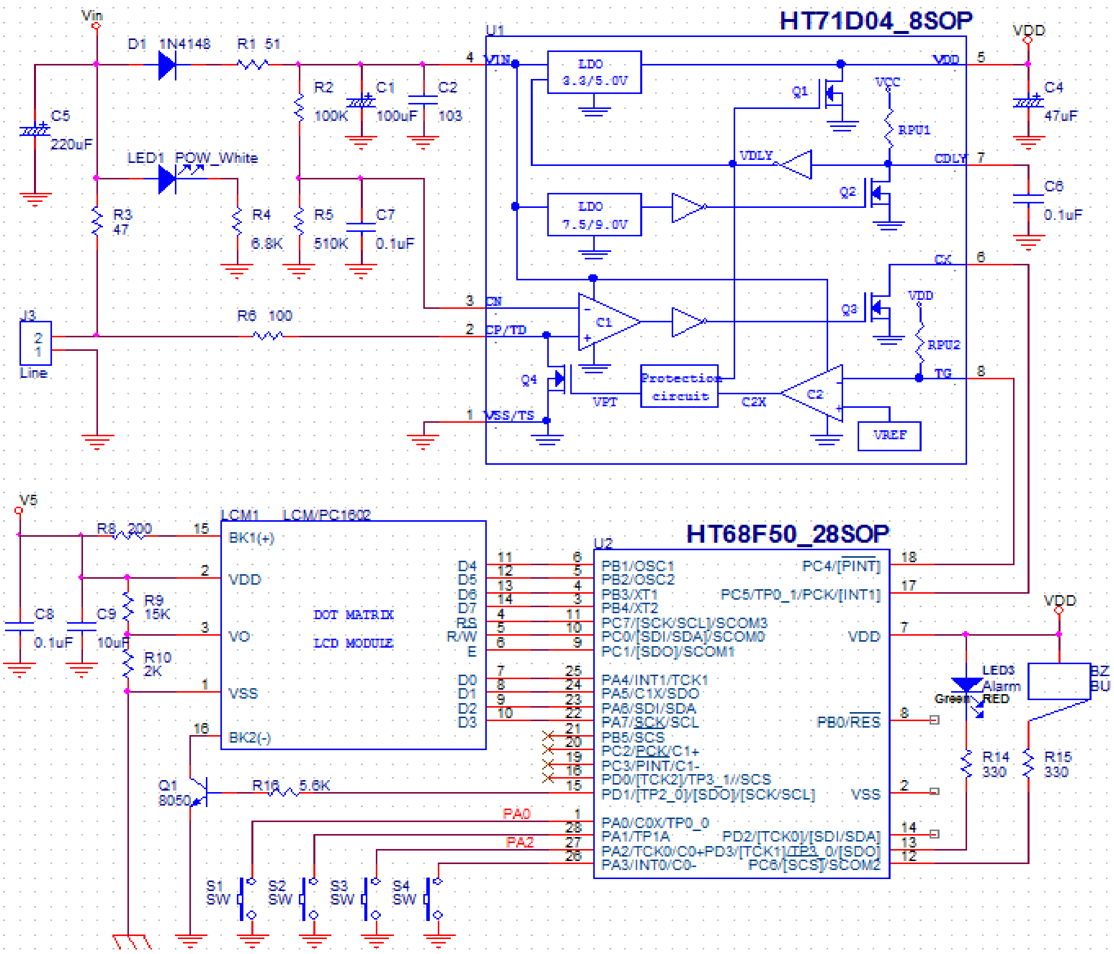

Figure 6. Signal Processing Technology for the AGRS Master

3. Results and Discussion

M-Bus is the preferred standard for the data collection in intelligent smart meters. The M-Bus protocol is a kind of half-duplex transmission mode. Employing the M-bus and signal processing technologies, a prototype of the system has been designed and developed for system exploration and experiment. The hardware implementation of the master for AGRS is displayed in Figure 6. It consisted of the power line data transceivers HT71D04 and HT68F50 with LCD (liquid crystal display) module PC1602. The communication action was all controlled by master with baud rate up to 4800bps. The key features of the master include the following: (1) input voltage up to 24V, (2) employ flash MCU (microprocessor control unit) to read/write ROM (read only memory), (3) adopt power line carrier communication, (4) support half-duplex communication for single to multiple devices, and (5) use LCM (liquid crystal display module) to display the water meter on the slave and its reading data. The internal circuit diagram of the slave for AGRS with 4 digits BCD (binary coded decimal) is further shown in Figure 7. It was composed of HT71D04 and HT45F23. The MCU of the slave was build-in M-Bus transmission. All meters connected to the M-Bus system could be read centrally.

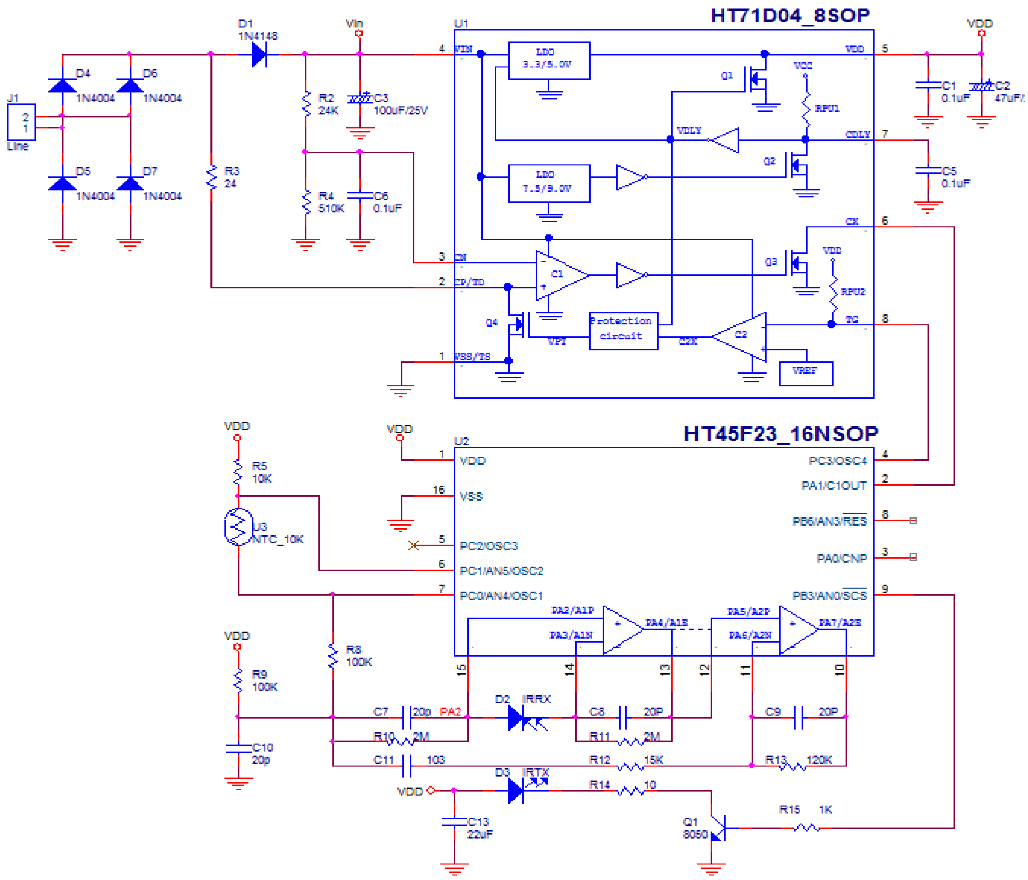

Figure 7. Signal processing Technology for the AGRS Slave

The research examined the use of M-Bus technology for remote reading the consumption of waters. To verify the feasibility of the proposed AGRS, a practical demo prototype was built and tested. Figure 8 shows the designed prototype. The prototype was used for quick and remote mornitoring and reading the data of the four water meters through telephone lines. As seen in Figure 8, the data displayed on LCM are all highly consistent with the four simulated water meters. Numerous simulations and tests have been made to demonstrate the effectiveness of the work. The AGRS provided two-way communication between the master central and slave-devices. The work achieves the following features:

(1) Allows the meter data to be read accurately without a loss,
(2) Ideal for complex buildings with a great number of meters,
(3) Connects over 256 slave-devices,
(4) Low power consumption, bus-powered, and easy to expansion,
(5) Communication cable with length up to 1000 meters,
(6) A cost-effective, stable and reliable system.

Furture works should be performed on the wireless AMR-based M-Bus, reducing costs and complexity further.

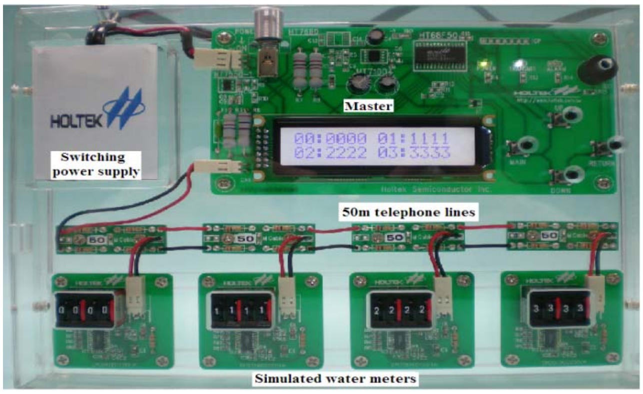

Figure 8. Novel Signal Processing Technology for the AGRS Prototype

4. Conclusion

This paper focused on the design as to the remote reading for a class of water meters, especially, with the cost-effective but longer distance detection technology. Based on the corresponding technologies of the signal processing technology as well as the M-Bus technology and combined with the micro-chip processor, a novel advanced gauge reader system–AGRS was presented. The effectiveness of the designed AGRS was confirm experimentally. The proposed design may be suitable for practical application of smart grid and AMI.

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