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MICROCONTROLLER BASED EMBEDDED SYSTEM DESIGN FOR AMR

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ABSTRACT
The automatic meter reading (AMR) system has become a necessity for most utilities because of deregulation, free customer choice and open market competition. A trend towards replacing the electromechanical meters with new designs, that can transmit their reading without any human intervention is in progress. In spite of developing new systems, this paper describes methodology that can modify existing electromechanical disc-type energy meters to AMR. Visual Basic (VB) programming language is used to interface our prototype design with personal computer at company's end. All the programming of microcontroller is done using Keil software. One such designed hardware unit can convert sixteen different meters data to AMR.

KEY WORDS
AMR, Micro Controller, EEPROM, Keil software, Visual Basic, RS232.

1. Introduction

A lot of work has been done on developing AMR technology. Novel technology based energy meters are available that can transmit the amount of consumed energy. The motivation behind all these efforts is that AMR system has become a necessity of new competitive environment.

The electromechanical disc-type energy meters provide a record of the amount of energy being consumed and the customer are invoiced accordingly. Normally, meter readings are taken manually once a month or every two months. While automatic meter reading (AMR) has gradually been introduced in many places, the cost involves in retrofitting the existing systems may not be justified if they are used merely for meter reading. Discussion on AMR systems is available in [1-5].

From the operator's viewpoint, the existing situation should be improved because of the following reasons:

a) To reduce the time lag between energy supply and actual revenue collection.
b) To minimize the non-payment of bills by customers.
c) To economize the costs and overheads incurred in meter reading, invoicing and revenue collection.
d) To account for the differences between power generated and revenue collected due to energy losses and thefts.
e) To improve the accuracy in meter reading and to eliminate possible mistakes in data entries.
f) To obtain real-time information on the actual energy consumption by the end-users.
g) To enable implementation of flexible or innovative tariffs.

While part of the above issues such as (a), (b), and (c) can be addressed by utilizing Prepaid Meters, the other problems remain unsolved. In particular, updated and accurate information on the actual power consumption at the customer's side will be very useful for planning, operation and load management.

From the customer's viewpoint, one of the main reasons for accepting any changes to the existing metering system must be based on much improved customer services. With the rapid advances in electronics, computer and information technology, a new generation AMR meter will provide solutions to the above issues. Coupled with the challenges of deregulation and increasing competition, the need for a new generation of power meter is imminent. But these new meters are costly. Distribution companies (Discos) of developing and third world countries are not in a position to buy and replace thousands of already installed disc-type meters. One solution is that these meters are modified to AMR system using cost effective hardware and simple communication media. Our proposed prototype design is an implementation of this concept.

This paper presents a prototype design and implementation of automated meter reading (AMR) system using Frequency Modulation (FM) and Micro Controller based embedded system. The most important feature of AMR system is that it will eradicate persons employed as meter readers.

2. Prototype Design Development

All electromechanical meters are a combination of two coils, one having the load voltage across it and the other carrying the load current. There are two options to get reading from this meter-dial. First one is to get reading of meter from dial directly. The other possibility is to count the revolution of disk with the help of a sensor. The developed prototype system uses second option. In the following sections, we will discuss the Designing of sending and receiving end hardware and software, communication, programming, interfacing, feasibility and benefits of prototype energy meter. In prototype system the revolution of disk is sensed by use of opto-electronic sensor. The system hardware is divided into two main blocks i.e. hardware at user end and hardware at Power Distribution Company's end as shown in figure 1.

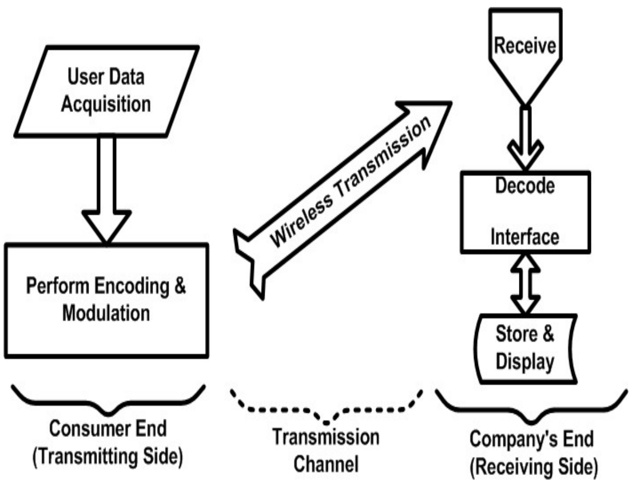

Figure 1. Block Diagram of overall System

2.1 Hardware at consumer end

Figure 2 shows block diagram of hardware design at the consumer's end. The blocks labeled sensor 1, 2, 3 …, 16 comprise meter interfaced with an Opto-electronic sensor. It means that we can connect sixteen different energy meters with one unit of hardware at both ends.

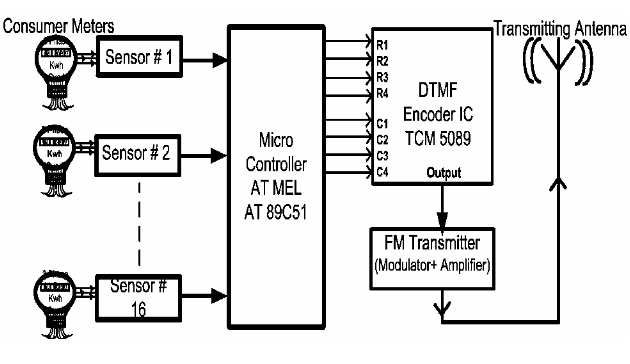

Figure 2. Block Diagram of Hardware at consumer end.

Figure 3 shows sensor interfacing with disk rotation. The holes shown in the disk are used to interrupt the light of Opto-electronic sensor which results in two pulses per revolution of disk. This Opto-electronic sensor is the only thing that needs to be placed inside the electromechanical-meter and only wires of this sensor comes out of meters which are then connected to rest of prototype system design. The rest of hardware can be placed at any suitable place away from the meter e.g. in distribution box located in street. The sensor has three wires. Two wires supply DC power to it and the third gives output pulse. When there is no light on sensor, pulse- out pin is at zero volts. When there is light on sensor, it gives an output pulse of 5 volt. This output pulse is given to one of the pins of microcontroller.

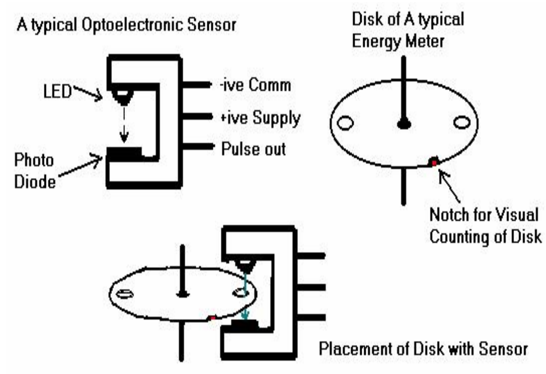

Figure 3. Interfacing between Meter Disk & Opto-electronic sensor.

ATMEL microcontroller (AT 89C51) [6-7] has 32 Input/Output pins divided into 4 ports each of 8 pin. Any of these ports can be used as input or output port. The microcontroller treats 5 volt pulse from the sensor as high input state and programmed to count one. In this way it counts one revolution of disk as it passes through sensor and so on. Microcontroller is so programmed that revolutions of disk are converted to energy-units consumed. The FM transmitter is used to transmit amount of energy consumed. The ordinary FM transmitter modulates the signal with a fixed carrier frequency. This means that we can only send information of one sensor.

This will not make system cost effective, so we have utilized a DTMF (Dual tone multi frequency) encoder IC [8]. It generates 16 predefined frequency combinations depending upon combination of inputs at its 8 input pins. Microcontroller is programmed using Keil [6-7] software, to give information of a maximum of 16 sensors against these 8 lines of DTMF encoder in time division multiplexing.

Microcontroller gave out data of one sensor to DTMF encoder. For each combination given by Microcontroller, DTMF encoder gave an output at a predefined frequency which is used as a modulating signal to FM transmitter which modulates it with a fixed frequency carrier and finally transmits it. Figure 4 shows the sequence of operation within hardware at consumer side.

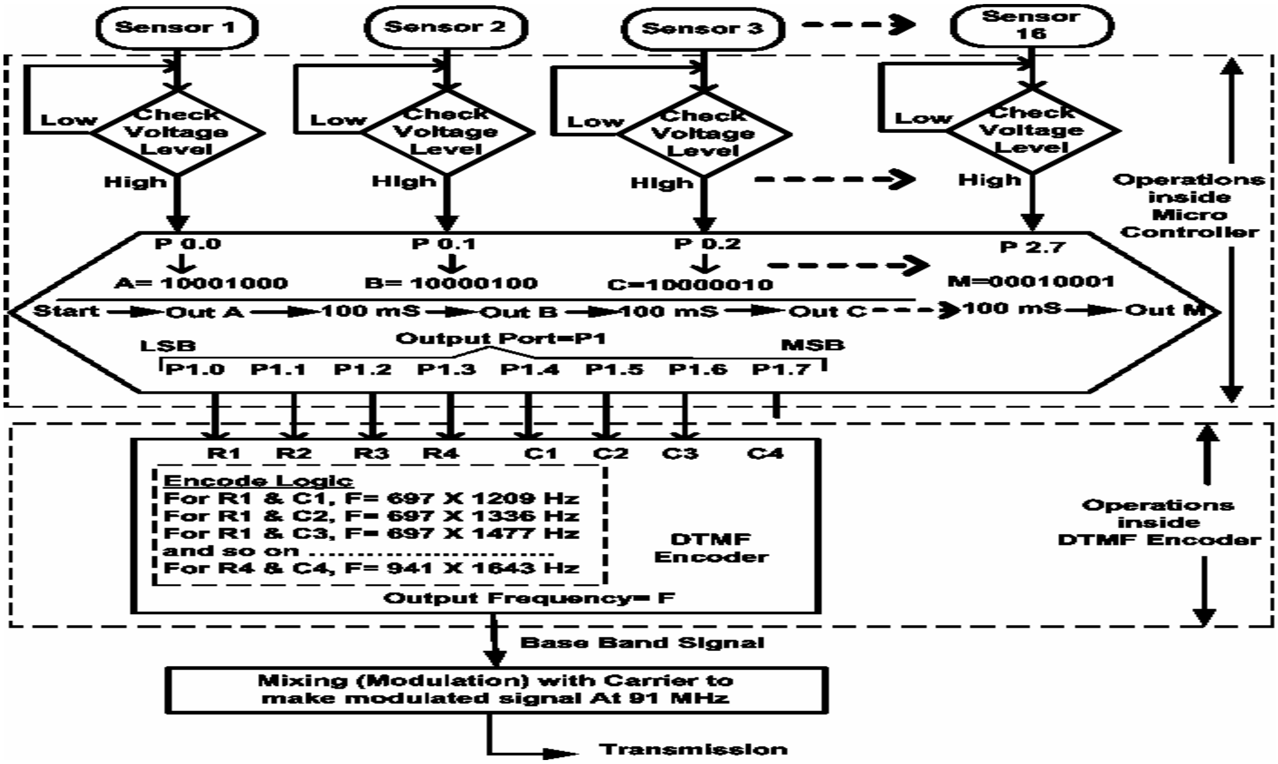

Figure 4. Sequence of Operations performed inside the hardware on consumer end

2.2 Hardware Design at company end

Figure 5 shows block diagram of hardware design at the company's end. The Microcontroller at receiving end programmed with same time interval for getting data of one sensor from DTMF decoder at receiving end. The output of FM receiver is fed to DTMF decoder IC (CM-8870) [9], that performs in exactly opposite decode logic to that of DTMF encoder IC used at transmitting side. The output of DTMF decoder is fed to Microcontroller. Hence we obtain information of each meter at user side. The microcontroller displays the units consumed on a seven segment LED display. This reading is the number of units consumed when Microcontroller was reset last time. The Microcontroller can be reset by removing its power or activating its reset input pin. This means that if either of the above occurs, the record of energy-consumed for each consumer will be lost. To overcome this, an EEPROM (Electrically Erasable Programmable Read Only Memory) is connected externally to the Microcontroller at Company's end. This EEPROM does not lose its data on power failure or resetting of Microcontroller. Microcontroller is programmed in such a way that it reads data stored in EEPROM, every time it is reset. Then it starts counting from that value and also displays it on seven segment LED displays units. In this way, it can count usage of energy for the whole month. Figure 6 shows the sequence of operation within hardware at company side.

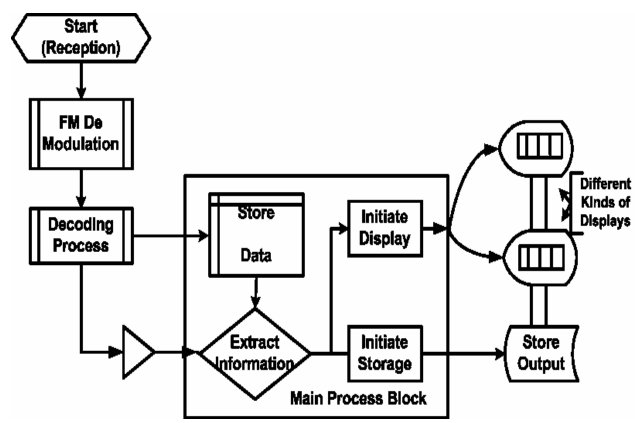

Figure 5. Signal Flow chart in Hardware at Company side.

HIN-232 IC [10-11] is use which converts Microcontroller data to RS232 format. Visual Basic [12] programming language is use to interface this prototype design with personal computer at company's end to get and display these values.

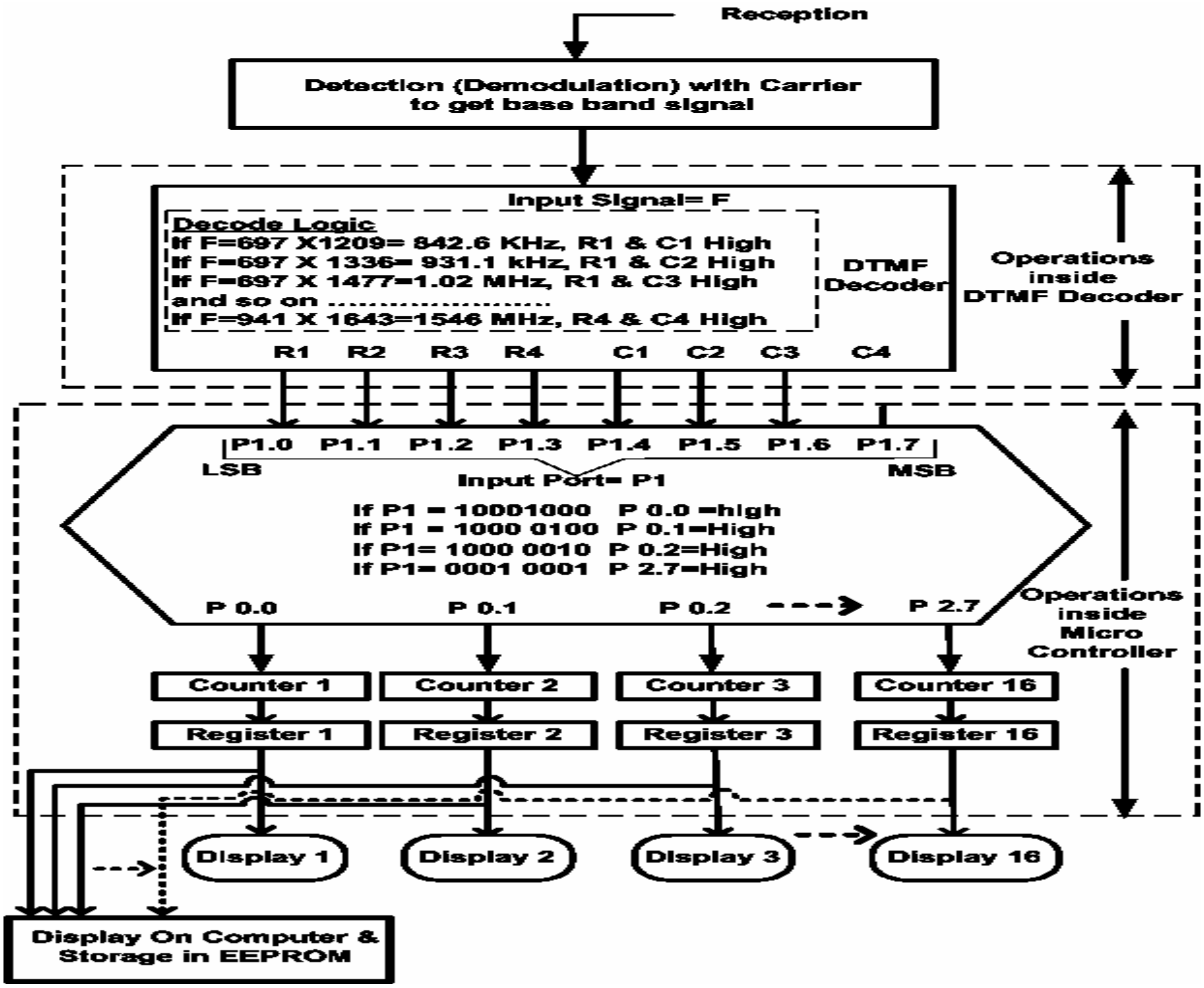

Figure 6. Sequence of Operations Performed inside the hardware at company's end.

3. Feasibility of System

In order to evaluate the feasibility of a system following factors were analyzed;

a) Installation of system.
b) Space requirement
c) Operation.
d) Reliability.

The size of hardware is small especially at consumer side, so there is no problem of space for its installation. We need only to place an Opto-Electronic sensor in the meter and routing of the wires of sensor outside it. The remaining all hardware can be placed either underground near the meter or away from the meter in street's distribution box.

Coming to operation, first of all, this circuit needs 15 volt DC. Since one such power supply can be used to serve 16 different meters, so it is cost effective. Another issue that arises with use of many of such hardware units is the communication of data at different frequencies for each unit.

This can be solved by making the frequency of transmission of each unit different from the other. The difference can be kept as small as 0.3 MHz. This can be done by changing R & C values of FM transmitter circuit used on consumer side as shown in Figure 7. Changing these values will change the carrier frequency and hence transmission frequency.

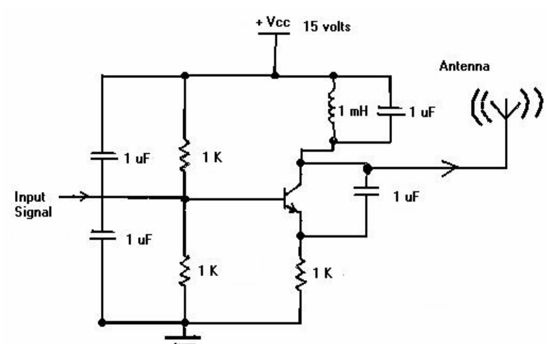

Figure 7. A typical FM Transmitter Circuit.

The receiver side of each circuit is then adjusted on frequency of its corresponding transmitter circuit. The whole circuit is composed of discrete components operating at low power levels. There is hardly any chance of failure of a component. This ensures good hardware reliability.

4. Cost vs. Benefit

The cost of one such system is nearly about cost of one domestic meter. As one unit can support 16 meters meaning that if this is implemented in a large area the overall cost will be 1/16th for one AMR unit. Due to economic constraints, the system has to be implemented in a phased manner. Once the benefits of the system start pouring in, the system can be expanded to include greater number of consumers. Owing to its advantages, the system is bound to play an important role in streamlining the power distribution system and improving power sector.

5. Conclusion

In this paper, we have reviewed the technical issues related to the effective construction of AMR system using Microcontroller, while enhancing our understanding about the challenges of designing, wireless communication, programming, interfacing a system. There is no need of a full time observer for this system at both ends. The system at the consumer side may be checked on regular basis if needed. But at the company's end, no human recording is required because system itself displays and stores data. We have developed a prototype for testing its capability and performance for long time to the varying extent, with a view to effectively consolidate and empirically examine the sending and receiving end hardware and software.

6. References

[1] Rochelle A. Fischer, Aaron S. Laakonen, and Noel N. Schulz, A General Polling Algorithm Using a Wireless AMR System for Restoration Confirmation, *IEEE Transactions on Power Systems,* vol.16, No.2, May 2001

[2] Krishna Sridharan and Noel N. Schulz, Outage Management Through AMR Systems an Intelligent Data Filter, *IEEE Transactions on Power Delivery*, vol. 16, No.4, October 2001

[3] Yan Liu and Noel N. Schulz, Knowledge Based System for Distribution System Outage Locating Using Comprehensive Information, *IEEE Transactions on Power Systems*, vol. 17, No. 2, May 2002.

[4] B. S. Park, and D. H. Hyun, and S. K. Cho, Implementation of AMR System Using Power Line Communication, IEEE 2002.

[5] Chun Che Fung, Kit Po Wong, Kok Wai Wong, Ong Sing Goh, and Terence Law, Intelligent Meters for Improved System Operation and Customer Relationship Management, IEEE 2002.

[6] www.grupelektronik.com/entegre/micro /89c51.pdf

[7] www.ele.neu.ac.th/datasheet/microperip/89c51rd2.pdf

[8] www.chipdocs.com/datasheets/ datasheet- pdf/Texas-Instruments/TCM5089.html

[9] www.alldatasheet.com/datasheet-pdf/ CALMIRCO/CM8870.html

[10] www.digchip.com/datasheets/parts/ datasheet/235/HIN232.php

[11] www.datasheetcatalog.com/datasheets_ pdf/H/I/N/2/HIN232.shtml

[12] www.vbtutor.net/vbtutor.html