A Low Cost Energy Meter Internet Interface

Eugen COCA, *Member, IEEE,* Dan Alin POTORAC, Valentin POPA

***Abstract*— Internet communications facilities are present in almost all power substations. Unfortunately, automation devices aren't web enabled, being unable to transmit or receive IP data. This article presents a low/cost energy meter reading interface application suitable for using with old meters equipped with pulse generators. Energy pulses for every quarter of an hour are counted on a microcontroller and stored on a non-volatile memory, data required by the application being transmitted to the energy dispatcher control unit via an Internet communication embedded microcontroller. We used a very low cost microcontroller to interface the existing meters and the energy balance software application. Using standard Ethernet network communications is also a new idea in this field, all data will be available in real time to the energy management unit. The application presented in this paper does not interfere with the billing data from the meter memory, so there is no need for metrology testing and other legal approvals. This solution may be applied in power substations but it is also useful for medium and large size consumers who have multiple exchange points with the energy company, equipped with standard meters that are able to provide only free potential relay contacts for billing purposes.**

***Index Terms*— communication system, energy measurement, microcontrollers, network interfaces**

I. INTRODUCTION

ENERGY measurement is a very usual problem for any electricity distribution company. For this purpose we may chose from a large variety of meters, from mechanical and induction based ones to full electronic versions. Regardless of the type of meter or its working principle, the information recorded locally must be transmitted in a way to the company headquarters where a bill must be issued every month. If it is a residential consumer we have only one set of data on the bill but, if we speak about an industrial client, we have to manage several sets of recorded data at various tariffs. There are many practical situations when, due to changes in regulations, an electronic meter should be re-programmed. Electricity companies are very interested in knowing the exact quantities of energy supplied to every customer, but presently, only data from large and some small ones are transmitted at least on a daily basis, representing only 70 to 75 percent of the total.

Data supplied are very useful in making prognosis about the demand for the next day, month or year, with a great impact on the energy acquisition price. In a few words, this task is very easy to describe. The whole process is illustrated in Fig. 1.

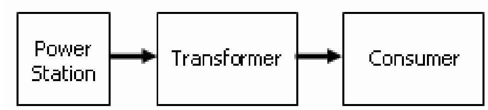

Fig. 1. Energy flow diagram from the power station to the end customer

We may figure out that the energy flow is from the power generation (the power station if we speak about energy distribution companies) to the end consumer, industrial or residential one.

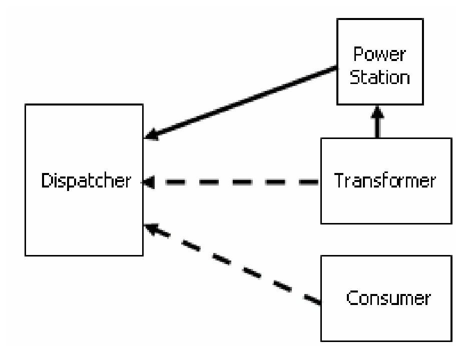

Fig. 2. Data flow from consumers to the dispatcher

In terms of data required from the process, we may notice we have to reverse the flow, from the consumer to the dispatcher management unit. If from power stations and sometimes from the power transformers there are communication paths, for the end customer we have no data transmission at all. Information for residential customers are in the vast majority of cases human read.

The solution proposed in this paper is taking into account every practical situation that could be found, and almost every type meter. For compatibility reasons, despite the meter working principle, we take as an input only pulses delivered outside the meter case, without making any modification inside. In the case of old induction meters, reading the data could be a challenge, because we could not interfere with the measuring mechanism and the whole device must be metrological approved. Most of these old meters are equipped with pulse generators witch deliver a number or pulses directly proportional with the energy demand. This information could not be used to issue the bill, but there are some agreements with residential customers when this piece of information in used monthly for the bill and every 12

E. COCA is with the Electrical Engineering Department, University of Suceava, Suceava, RO 720330, Romania (e-mail: ecoca@eed.usv.ro).
D. A. POTORAC is with the Electrical Engineering Department, University of Suceava, Suceava, RO 720330, Romania (e-mail: alinp@eed.usv.ro).
V. POPA is with the Electrical Engineering Department, University of Suceava, Suceava, RO 720330, Romania (e-mail: valentin@eed.usv.ro).

month a correction is made, based only on the direct data reading. For electronic meters, pulse generators are used too, but in this case we have also a serial RS232C compatible port available, making possible to read all internal data and to program the meter.

II. METER INTERFACE

Our interface, used for testing, is built around a PIC16F876A microcontroller and a SitePlayer embedded web microcontroller. Every interface may be customized depending on the number of input required. For a residential customer we use only one input and for an industrial up to 4 inputs (2 for the active energy and 2 for reactive energy).

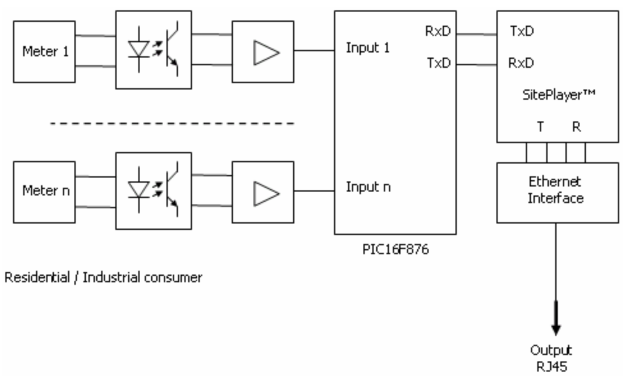

Fig. 3. Schematic diagram of the meter interface

The main advantage of our configuration is that it is not necessary to change anything in the microcontroller software in the case we change the feeder or the energy meter itself [3]. All the changes will be made on the client site, without any intervention on the core PIC16F876A microcontroller software. By identifying the interface with a unique serial number (most common we used the IP address of the SitePlayer) modification where made in the central acquisition software interface. All the hardware inputs are optically insulated from the rest of the electronic components and from the process. High voltages interferences in power substations or even in the customer wiring may lead to input circuit destruction.

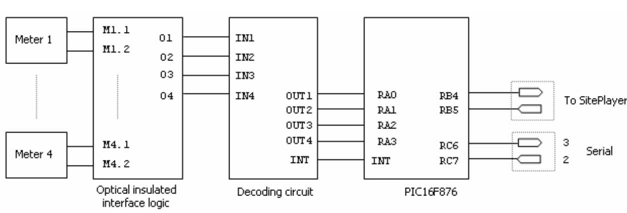

Fig. 4. Detailed schematic input block and the decoding circuit

These inputs are protected from over voltages with varistors and Zenner diodes. Fuses are usually not such efficient; the blow up time is much longer than the time needed to damage the interface input [7]. All meter output signals are converted from analog to digital levels in the optical insulated interface logic block, as seen in Fig. 4. The decoding circuit between the interface logic and the microcontroller itself is necessary in order to avoid any pulse loss. We may use two possible strategies to count the pulses. The first one is to scan the input pins of Port A of the microcontroller at known time intervals, fast enough to eliminate any possible pulse lost. A most convenient strategy is to intercalate a decoding circuit witch will generate an interrupt every time a pulse is detected on inputs. If there are more almost simultaneous transitions, the circuit will generate the corresponding codes. Due to high working frequency of the microcontroller, it is very unusual to loose a pulse with this circuit configuration [4, 5].

III. ETHERNET AND INTERNET INTERFACES

In order to send the data collected from the meters to the central dispatcher there are some possible transmission mediums. The first one is over phone lines, but this solution is best suitable for industrial consumers not for residential one, due to the costs involved. A second transmission path is over internet, regardless of the way the connection is made. But the meters are not "web-enabled". A way to embed the Internet in a device, without writing any TCP/IP source code, is to use an embedded web server. The most powerful solution on the market today is the SitePlayer™ microcontroller witch could make this task very easy. Only few extra components are needed and an external filter that serves as a protection circuit for the link with the Ethernet switch. A MAX232 circuit is present to provide the levels for a standard RS232C serial interface. The PIC16F876A microcontroller has an RS232 compatible serial interface (USART). We used it to communicate with the embedded web server circuit, built around the SitePlayer™ Ethernet controller, as shown in Fig. 5. The Ethernet connection could be assured in a standard low cost hub or a switch. The link to the dispatcher unit may made at any speed with at least 1200bps (phone modem, ISDN phone modem, cable or wireless link) depending on the number of meters in the substation [6]. In any case, the data may be compressed to save bandwidth.

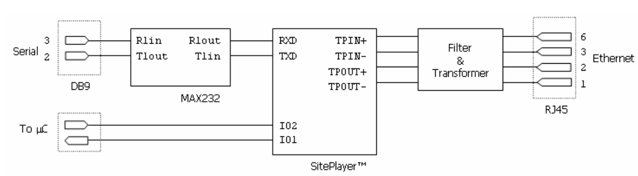

Fig. 5. Schematic diagram of the SitePlayer microcontroller and Ethernet coupling

If the number of inputs is greater than 8, and this is the case of an industrial consumer, many interfaces with different addresses may be connected to the same Internet switch to collect and transmit data. For residential customers the interface may be equipped with a minimal number of electrical components that are required for only one input, reducing the final cost. In the case of an industrial consumer, only used inputs are equipped. If the measuring panels are at some distance one from another in the range of hundreds of meters, we used power line carrier devices to collect all data in a single point connected to the Internet.

IV. Central System overview

As we may see in Fig. 6, data transmitted over the Internet are collected by the central point software interfaces to provide both billing data for the accounting department and statistical data for the energy demand forecast. As the energy price depends on how the prognosis is done we may easily understand the importance of the accuracy of the input data.

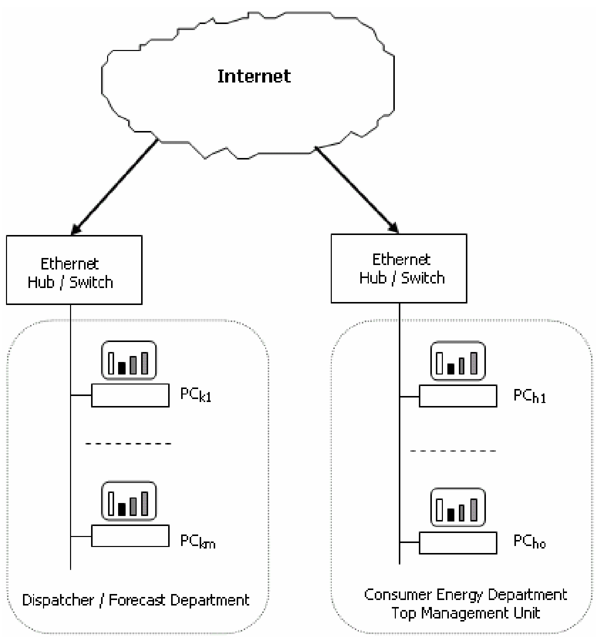

Fig. 6. Schematic diagram of the energy management center

Data collected from all the meters could be organized in local databases, depending on the other specific programs used by the company for billing and prognosis.

SitePlayer microcontrollers may be programmed to serve pages only for on a password authenticated client, eliminating some of the possible fraud attempts. If data security is very important, it may be useful to assign non-routable IP addresses to web microcontrollers and integrating them in the corporate Intranet or a dedicated network with no packet routed to or from the outside world. For residential customers, where a direct reading of the meter is done every 12 month and the consumption is on a relatively periodically curve, errors are not so important but for industrial customers a special attention must be paid to data integrity.

V. Conclusion

The need to reduce the energy costs by correctly evaluating the future demand requires a fair evaluation of the energy absorbed in each exchange point. Electric energy meters in use for almost all residential customers in out country are based on the electromagnetically induction phenomena, the only electronic device present inside deliver a number of pulses directly proportional with the quantity of energy measured. Depending on the manufacturer, a standard one pulse for every rotation is supplied. Large consumer feeders are equipped with electronic meters, supplying pulses on free potential contacts. Due to the large number of these small customers there is a need to develop practical solutions to read meters data from remote locations. The device proposed in this paper is a possible solution when there are no sufficient funds to change the entire measuring infrastructure. For the first step our device may be used for measuring the demand in rural transformer points, the collected date being used to calculate the energy balance in every power line. Extending the system in every home, the energy company could calculate precisely the total power loss in the electrical line. By integrating the energy meters in the company Intranet network, using top technology solutions, without changing the energy meters and with minor modifications in balance software we could change the way the energy loss is calculated. All circuit components are easily to integrate on a custom ASIC or even on a SOC device, thus reducing the overall costs at a minimum. Further developments are on development; the main task is to design a device capable to be integrated in a local wireless network spot, eliminating all the wires between the meter and the communication equipment in the power station or on a given array. In this way, data could be collected in a point, the most easily being the power transformer location and transmitted to the headquarters via a dedicated radio link or a fiber optic cable. Other research efforts are done in the direction of integrating such devices with power line carrier communication networks, this way reducing to zero the communications costs.

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