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Research Article

Towards Efficient Power Consumption based on Smart Meter Monitor

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Abstract:
Electricity is the source of life, and the demand increases every day. The rising energy a concern to many nations to explore a new solution to acquire an accurate quantification and management of energy consumption for residential, commercial, and industrial sectors. Besides, consumers need to track their daily power consumption in their houses with the use of different appliances. In Morocco, the monthly follow-up of the National Office of Electricity and Drinking Water (ONEE) company is carried out manually by inspectors. The latter brings challenges in controlling the electricity meter, conserving time, avoiding mistakes, and conserving company resources. Furthermore, this manner cannot satisfy the client's requirements. Motivated by these considerations, this paper presents a design and realization of an open-source meter called "Efficient Power Consumption " (EPC). The proposed approach provides the ability to measure and analyze power consumption to know the information of the consumption of appliances in an automatic and dynamic way.

Keywords: smart Meter, consumption, efficient, EPC.

1 Introduction

In recent years, the energy cost is on the rise. Hence, it is in the interest of both private and commercial customers to track their daily power usage of different appliances. In Morocco, the monthly follow-up of the National Office of Electricity and Drinking Water (ONEE) company is done manually by inspectors as well as the delivery of electricity is completely dependent on conventional energy meters **[1]**. These meters play a key role in measuring the consumption of electrical energy in commercial buildings, like shopping malls and airports, for industries as well as residential buildings. However, these meters cannot offer monthly feedback to the consumers. Consequently, the consumers will not have knowledge of cost or how much energy the individual appliances consume, and we need to check it manually. Another reason to measure energy is obvious – environmental protection. By having full knowledge of the

information of the consumption of electricity, we can be able to reduce CO2 emissions **[2]**. In order to overcome the problems of traditional electricity meters, smart electricity meters **[3]** have been upgraded and developed.

With the use of Smart Meter, energy alerts will be provided to the consumers based on hourly utilization of energy. However, smart meters available in the market nowadays are too expensive and complex to be handled. In addition, these smart meters are mainly configured to measure only the current. Whereas, the most sophisticated measurement is an actual value variant (RMS) **[4]** voltage and current. The latter is considered the waveform and corrects phase shifts. An important aspect of measuring real power is that it based on a precise sensor.

Therefore, the contribution of this paper is to design and implement an open-source, low-cost precise, reliable power and electric energy meter called "Efficient Power Consumption " (EPC). The proposed solution requires only two component called A hall and transformers sensors that are measured current and the voltage simultaneously. The solution has also contained an application software on the server to calculate and report the actual power consumption, power factor, cost consumption per hour, and the total cost consumption for a certain period of time.

To collect data, we will use a master module, or an ARDUINO **[5]** for which we have developed a firmware with improved features based to similar projects. we developed a firmware that will be easily used by the ARDUINO, even outside the system, also communicate seamlessly with the server.

The rest of the paper is organized as follows: Section 2, we will explain the motivation and positioning of our contribution. Section 3, we will present the design of efficient power consumption meter. Section 4, we will present the main circuit including the technical specifications and the schema electronic. Section 5, we will while the main conclusions are summarized in Section 5.

2 Motivation

In this research we analyzed the existing meter system of our country and found out the different problems of the present system. We studied the different technologies available in the world to reduce the meter reading problems and modeled out a feasible solution for our country even to increase the reliability and precision of it. We have visited many company and factory and even the houses to know their problems and what he needs to facility the use of meter. Several web site and research papers have been studied to produce a good and feasible model.

After our research we find that we can produce a smart meter that can resolve a lot of problems, and better than the old one used in our country, the table below show the difference between our proposed meter and the old one:

Table1: Comparison between Smart meter and old meter

EPC meter	**Old meter**
Electric sensor [6]	Mechanical sensor
LCD display	Mechanical display
New choices. Most of us pay a rigid rate for electricity that hardly ever changes. But smart meters break that mold, opening the door for flexible, money-saving electricity plans, such as Real-Time Pricing and Peak-Time Rebates, which provide incentives for using power during low-demand, cheaper times of day.	No choice we pay every consumption
Eliminate estimated billing. The old meters were supposed to be read in-person each month, but regulations allowed ComEd to skip readings and estimate usage. Unfortunately, the estimates were often inaccurate, leading to huge make-up bills and consumer headaches. The new meters, with their ability to easily transmit meter readings to ComEd, should all but put an end to estimated bills.	Estimated Buildings

Improve efficiency/reduce waste. All customers pay for wasted power that is not charged to a particular account. Smart meters would allow ComEd to turn that power off. They also would help cut down on electricity theft and unaccounted energy—such as when a customer moves into a new home and uses power before the account has been opened.	
Better reliability. Smart meters and other improvements to the power grid will help notify the utility of a power outage much more quickly, and even reroute power to avoid costly, widespread blackouts.	
• *Reduce market electricity prices*. If special power pricing plans and other "smart grid" improvements can reduce "peak demand"—the busiest part of the day when businesses and homes devour the most electricity—they can help lower power prices for everyone.	
Send all information in electric company without visual checking	Visual chocking

3 Proposed System Design and Architecture

In this section, we describe the architecture of our proposed model. As presented in Figure 1, the architecture is distributed into five basic units: Reading unit (measuring circuits), calculate unit, Data processing unit, display unit, transmission unit, and archive unite.

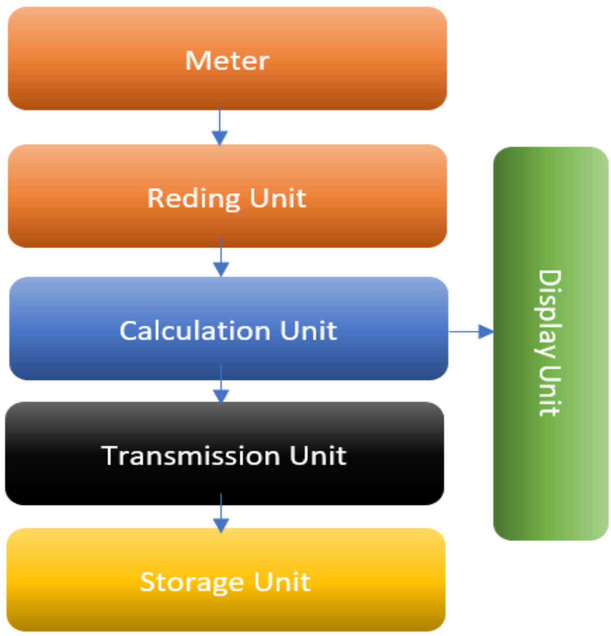

Fig.1: ACS712 current sensor schematic

3.1 Reading Unit

In this section we will explain the sensors used in our project. In general, many sensors are used to measure the consumption of energy, but the technique is the same, we must first calculate the power. The electrical power that is often noted P and which has as unit the watt (symbol W) is the multiplication of the electrical voltage U across which the device is connected (in volts) and the intensity of the electrical current I which crosses it (in amperes) for purely resistive devices. In continuous mode, the power is defined by the following equation:

$$P = U * I$$

If the voltage v (t) or the current I (t) vary, the instantaneous power p (t) consumed by a continuous current load is equal to the product of the instantaneous values of the current flowing through it and the voltage at its terminals:

$$P(t) = I(t) * U(t)$$

Instantaneous power is useful when we are interested in the study and transient analysis of the current at the load terminal (Example: the peak of the current at start-up, the shape of the current at the moment of change of the duty cycle by a PWM [7] signal (Ex: Change from 60% to 70%).

The average power P is the integration of the instantaneous power p (t) in a given period T divided by the period T.

$$P = \frac{1}{T}\int_{0}^{T} P(t)dt$$

The average power is equivalent to a low pass instantaneous power filter. The average power (integration effect) has the particularity of being stable compared to the instantaneous power: The value changes slowly depending on the integration period, the power is updated each integration period (Ex: 1s, 10s or one minute depending on the targeted application). It is practical as a power measurement indicator.

- **ACS712 Current sensor**

Major drawback: It is not possible to observe the transient phenomena of the power (ex: PIC at start-up, overload, overcurrent, etc.) because they are filtered by the integration. The most important thing to know the power is to know the current. We use in our project a current sensor ACS712 **[8]** because the ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, automotive, commercial, and communications systems.

The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer.

A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC **[9]**, which is programmed for accuracy after packaging. The output of the device has a positive slope

(>VIOUT (Q)) when an increasing current flow through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sensing. The internal resistance of this conductive path is 1.2

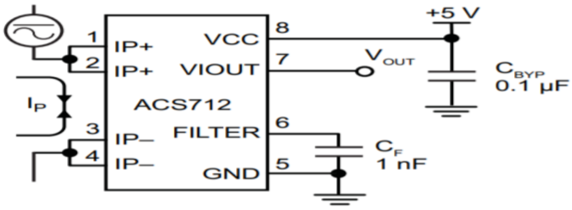

Fig.2: ACS712 current sensor schematic

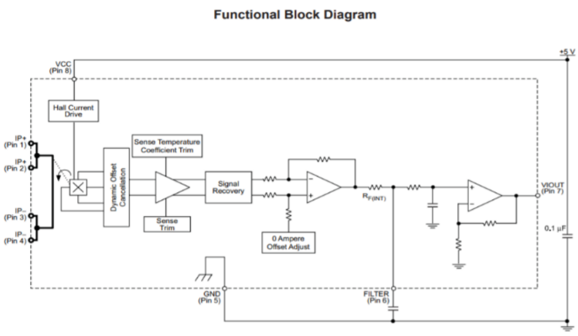

Fig.3: Functional Block Diagram.

loss. The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the sensor leads (pins 5 through 8). This allows the ACS712 current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

The ACS712 is provided in a small, surface mount SOIC8 package. The lead frame is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature Pb-based solder balls, currently exempt from RoHS. The device is fully calibrated prior to shipment from the factory.

- **ZMPT101B voltage transformer**

The ZMPT101B **[10]** is voltage sensor based on transform of the voltage from a high voltage to low voltage, for the aim to measure the voltage with the analog pin in the microprocessor.

Fig.4: Voltage sensor schematical

The use of this sensor is very simple that's why we chose it, and also the price is very cheap.

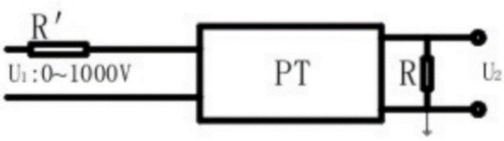

Fig.4. Functional block.

U1 : Input Voltage U2 : Output voltage
R': limiting resistor R: Sampling resistor

We can calculate the output voltage with the equation below:

$$U2 = \frac{U1}{R'} \, X \, R$$

Determination of maximum output rms voltage Umax : Umax is decided by the AD peak voltage in the sampling loop in principle:

As for Bipolar AD:

$$Umax = \frac{Peakvoltage}{\sqrt{2}}$$

As for unipolar AD:

$$Umax = \frac{Peakvoltage}{2\sqrt{2}}$$

With this tow sensor we can calculate the power and the consumption, with the help of the program of the microcontroller.

3.2 Calculation Unit

This entity is the part responsible to collect the analog value from the sensors and to give us the power used, the consumption by using a program, (this program can use a sophisticated equation to calcul the objective value), this unit communicate tow with the display unit to display the calculated values, also with the communication unit to send information to the server.

3.3 Transmission Unit

After the measurement of the current and voltage, we need to show all the information calculated in the microcontroller, there many types of display in the Marquette, but we need the cheap one and with good quality to work a long time, that is why we chose the LCD display with 4 ling and 20 columns.

To collect the information from the Arduino system, we used USB cable in first time. After the validation of the test, we replaced the USB Cable with GSM shield [11]. It's a card based on SIM900 circuit [12], which can be integrated into a great number of IoT projects. We u can use this shield to accomplish almost anything a normal cell phone can; SMS text messages, Make or receive phone calls, connecting to internet through GPRS, TCP/IP, and more! To top it off, the shield supports quad-band GSM/GPRS network, meaning it works pretty much anywhere in the world, this is the reason to choose this circuit for communication.

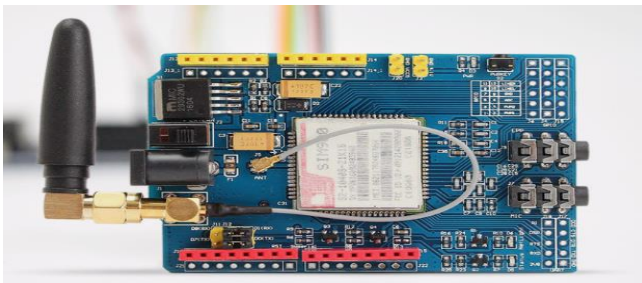

Fig.5: GSM shield.

The GSM shield Is commanded with AT COMMANDE language, we can make a call send and receive messages, delete, add, and do the same thing like a phone.

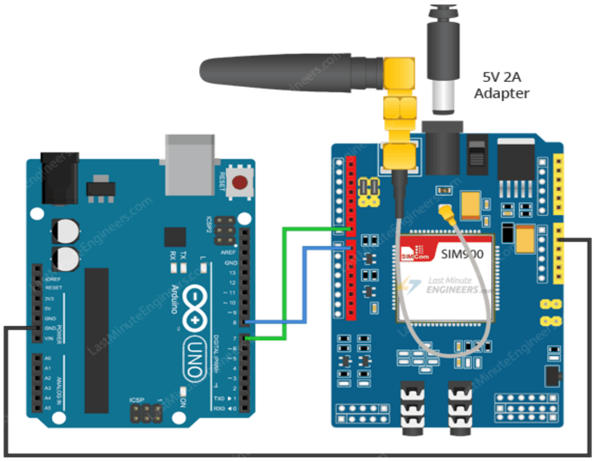

Fig.6: GSM shield wiring

The SIM900 GSM/GPRS [13] shield is designed to surround the SIM900 chip with everything necessary to interface with Arduino, plus a few extra goodies to take advantage of the chip's unique features.

3.4 Display Unit

The display unit is very important in this project, because it help us to see the consumption value in the board, we us in this section an LCD 20X4, because it's very sheep and very simple to use.

3.5 Storage Unit

The archive unit is the server how will archive and receive the data from the calculation unit the place of this unit is on electricity company, to control and supervise his customers, it equipped by an application how realized by VB.net, and a GSM modem, we will explain the application in the software and storage part.

3.6 Project Realization

After choosing the components of the project, we test the functionality of the circuit in a simulator "ISIS PROTEUS" [14], of NATIONALE INSTRUMENT company, with this simulator we validate our schematic and program, the Fig.5 show our circuit with all components used in our project.

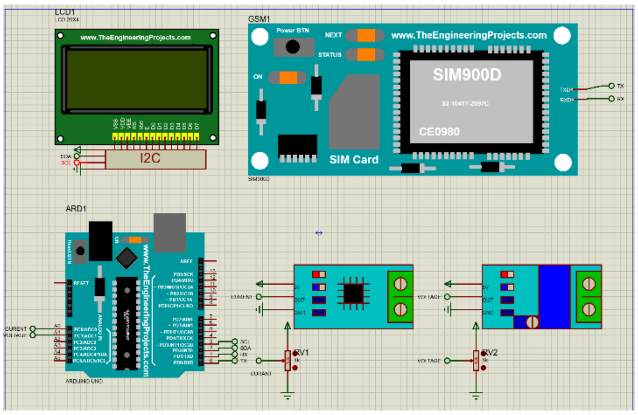

Fig.7: EPC Meter Wiring

In this figure we can find the Arduino how is the unit calculator, to calculate the power consumption and other thing, also it's connected to the display lcd (unit display) to show the information of the energy. the GSM shield used for transmitting the data to do electric company,

With the help of this schematic, we can calculate the power of consumption by the relation: $P = U * I$, so the current sensor can give us the current value and the voltage schematic can give the voltage value, so we can find the power of material connected, and then with a simple programmed and the save of this value we can calculate the consumption of this materiel in the minute, hours and of course for the month with the exactly measurements. We can see these values on an LCD 20*4. And send it to phone by SMS with the help of GSM shield.

3 Software application

We use a VB.net language [15] to create a software application, to receive the data received from GSM modem, the data will be saved in a database (Access database), and shown in the application, we try to create a simple application that can automatically calculate the data and display on a chart parts, like in the Fig.6.

Fig.8 : Management application

This application can show too the Annelle consumption, current value, voltage value and the power used. The information of every counter (number, name of the proprietary, city, and address of location) is displayed on the application.

4 Simulation and Evaluation

After many days of testing many programs in simulation, we find the right one and we start the realization with the real and simple materiel for the first time, the program works too in the real schematically like in the picture below.

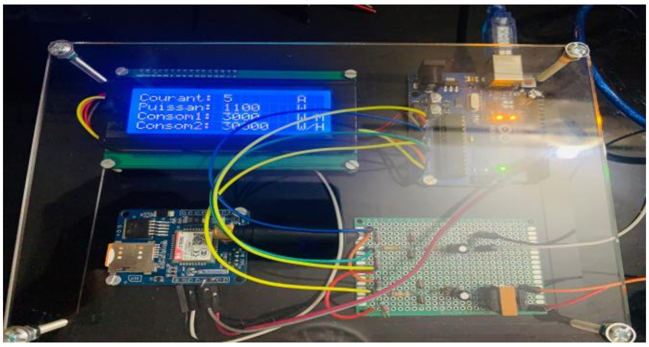

Fig.9: Real schematical

5 Conclusion

In this paper we have solved a big problem in the trucking system of the consumption of electricity, and also the people can supervise his on houses consumption, we are using an Arduino Uno and other shield board to create a smart meter, the program of the Arduino was validated and tested in ISIS PROTEUS. The project was realized and tested for 10 days in real area, the result was ok we can see the daily consumption and the current, voltage. In an application how can collect all monthly information of the smart meter.

This article is the start of a big project in the same sector, we will be developed it to work in wide area, that's mean the application must work with a lot of client's meter, and more function will be added in the meter, the application also.

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