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A PATH FOR HORIZING YOUR INNOVATIVE WORK

ENERGY METER

PANKAJ SAHANI, JIM FULTO, RONIL HIRAN, TEJAS PATEL

Electronics and Telecommunication Department St. John College of Engineering & Technology, Palghar

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Abstract: Currently, there are two energy meters types installed: electro mechanicals and electronics. The more commonly used energy meters are electromechanical working on Kilowatt hour meter. However, new facilities tend to use electronics energy meters based on solid-state technology. Electro mechanicals devices used traditionally allowed us to measure only energy consumption. However detailed information on the energy consumption of each client is needed. In this point, electronic meters seem to be the best option to face the new challenges. This study will review the operating principles of solid-state energy meters. The behavior of some three phases models under no sinusoidal conditions is studied. Experimental setup and test methodology are discussed as well.

Keywords: Energy meter, single phase, power, watt-hour.

Corresponding Author: MR. PANKAJ SAHANI

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INTRODUCTION

The basic objective of this project is to implement a single phase electrical energy meter based on a microcontroller from Microchip Technology Inc. This electronic meter does not possess any rotating parts, and the energy consumption can be easily read from a four-digit display. Energy consumption is stored in the microcontroller's EPROM memory. This action is necessary to ensure a correct measurement even in the event of an electrical outage or brown out. As soon as the supply is restored, the meter restarts with the stored value. As this meter is compatible with the electromechanical ones, no additional costs will be incurred by the utility companies in their replacement.

Prepaid energy meter:

Power utilities in different countries especially in the developing ones are incurring huge losses due to electricity theft. In this system a smart energy meter is installed in every consumer unit and a server is maintained at the service provider side. Both the meter and the server are equipped with GSM module which facilitates bidirectional communication between the two ends using the existing GSM infrastructure. Consumers can easily recharge their energy meter by sending a PIN number hidden in a scratch card to the server using SMS. It contains some measures to control meter bypassing and tampering. The bidirectional GSM communication using SMS ensures the effectiveness of these measures. Pilferage of electricity can be substantially reduced by incorporating the proposed measures along with the prepaid metering scheme. Legal actions against dishonest consumers can also be taken in this system.

SMART METER:

The demand for energy is increasing as a result of the growth in both population and industrial development. To improve the energy efficiency, consumers need to be more aware of their energy consumption. In recent years, utilities have started developing new electric energy meters which are known as smart meters. A smart meter is a digital energy meter that measures the consumption of electrical energy and provides other additional information as compared to the traditional energy meter. The aim is to provide the consumer and supplier an easy way to monitor the energy. Smart meters are considered a key component of the smart grid as these will allow more interactivity between the consumers and the provider. Smart meters will enable two-way and real-time communication between the consumers and the provider. This meter can measure the energy and send the information to the service provider, who can store this information and notify the consumer through SMS messages or through the internet.

Measurements of electric energy for billing purposes are known to be performed by meters capable of making measurements for different times of use or consumption basis so that different billing rates can be applied for electric energy. Earlier meters of the so-called time of day type utilize an induction watthour meter movement dials under the control of a mechanical clock mechanism. Accordingly, it is desirable to have an AC electric energy meter which is capable of providing multiple measuring functions for indicating different parameters of the consumption of AC electric energy and to totalize such parameters in different measuring time categories during each day of measurement [3].

The application of solid state electronic circuits and devices to time of day electric energy measurements affords greater flexibility in increasing the number of electric energy measurement parameters that may be made and increased flexibility in rate selection schedules possible for the electric energy billing operation than was afforded by earlier primarily electromechanical meters[1]. The use of such solid state electronic circuits and devices present a number of different considerations so that the meters remain with the same operating capabilities of earlier electromechanical billing meters in that they must be accurate and reliable in operating in outdoor environments subject to wide variations in environmental temperature extremes and remain compact in size, capable of being assembled and manufactured by mass production techniques and have acceptable cost[1]. High accuracy in both measuring and time and date recording operations is necessary as well. The meter must be secure from tampering and alteration of the operation thereof, require minimum service and maintenance, and be further capable of operating for extended time under battery power during the power outage conditions of the electric energy quantity being measured.

Both classical electromechanical and electronic meters have demonstrated that are accurate enough in common sinusoidal conditions so the continuity of electromechanical meters in the market is mainly based on[1]:

• Long working life.

• Low price.

• High reliability.

From the point of view of cost, electronic energy meters are cheaper than electromechanical ones. However, it isn't clear how accurate they are under typical disturbances and non-sinusoidal conditions. It is also well known that these devices are rather sensitive to external conditions so there are many factors that can lead to their miscalibration[1].

This research work is focused on the analysis of electronic energy meters errors under the next non-ideal conditions:

• Harmonics.

• Unbalance.

• Frequency variations.

The advantages of these meters include greater stability and accuracy in comparison with the conventional ones (electromechanical). In addition, they generally have multiple functions. It is possible to check many others parameters related with the state of the net as, powers, voltages and currents of every phase. And what can be more interesting, they let to know the distortion level that exists in the system at this moment.

The paper includes a theoretical review of different technologies widely used in electronic meters: i) Time division; ii) Hall Sensor and iii) Digital sampling. After that, the paper introduces a test system and a methodology.

The hardware of the test system consists of a device able to generate the typical disturbances present in electrical systems, and a resistive load (wye connection). The energy meter under test is supplied by the arbitrary waveform generator in order to obtain their behaviour under non-ideal supply conditions.

Both the equipment and the methodology are put to the test with three commercial solid state energy meters based on different technologies. Among others, the most important results included in the paper are:

• Measurement error of solid state energy meters under active harmonic energy.

• Measurement error of solid state energy meters under unbalanced energy.

• Measurement error of solid state energy meters under variations of the nominal frequency.

FEATURES:

- It must be capable of displaying details of electricity consumption.
- It will present information on the current electricity consumption.

- It will present information on historical consumption, allowing customers to compare current and previous usage.
- Usage information must be display in pounds and pence, as well as kW and kWh.
- There must be a visual (non numerical) presentation, which allows users which allows users to easily distinguish between high and low levels of current consumption.

1. BLOCK DIAGRAM

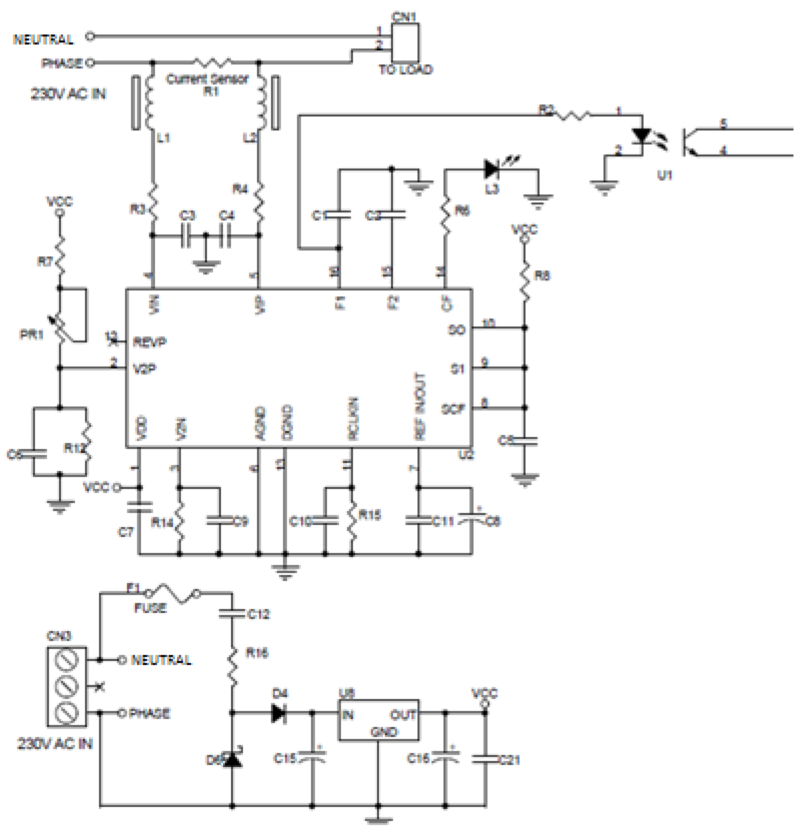

Fig: 1 Energy meter

2. RELATED EQUATIONS

The main task of any electronic energy meter is the calculation of power. The definition of the active power P, considering periodic waves, in the temporal domain is[2]:

$$P = \frac{1}{T}\int_{T} u(t)\, i(t) dt$$

Where u(t) is the instantaneous voltage, and i(t) the instantaneous current. The most general form, considering a frequency domain formulation, is

$$P = \sum_{n=0}^{N} U_n \;\; I_n \;\; \cos\phi_n = P_0 + P_1 + P_H$$

Where Un and In are the harmonic voltage and current respectively, and ϕn the phase shift between the previous magnitudes.

In a three-phase system, the energy meter should respond to the algebraic sum of active power of all the phases[2].

$$P = \sum_{k} P_k \qquad\qquad k = a,b,c$$

After the power calculation, it is necessary to integrate it to obtain the correspondent energy, w, consumed in period T[2].

$$w(t) = \int_{0}^{t} p(t)\, dt$$

3. MEASUREMENT PRINCIPLE

Time Division: Several electronic principles have been developed in order to multiply two signals. The multiplier with double modulation (TDM for time division multiplier) is classified as the most accurate and is widely used in precision wattmeter's. The impulse signal is modulated in width according to the voltage and in amplitude according to the current, in such a way that the mean value of the impulse signal is proportional to the product of v and i. Also due to the rapid development of integrated electronic circuits, digital electronic circuits are challenging the known analog principles [3].

Hall Sensor: The Hall sensor is based on the physical principle of the Hall effect. This means that a voltage is generated transversely to the current flow direction in an electric conductor (the Hall voltage), if a magnetic field is applied perpendicularly to the conductor. The current flow will be proportional to the line voltage and the magnetic field will be proportional to the line current. As the Hall effect is most pronounced in semiconductors, the most suitable Hall element is a small platelet made of a semiconductor material [3].

Digital Sampling

A solid state meter that incorporates a sampled data system obtains energy with a discrete summation instead of an integral[3]:

$$W = \frac{\Delta t}{3.6x10^6} \sum_{i=1}^{N} P_i$$

In kilowatt-hours (kWh), where Δt is the interval of time (seconds) and Pi the power in watts. The power is obtained from the multiplication of pairs of synchronous voltage-current samples taken at regular intervals. The summation of these products multiplied by the sampling interval gives a representation of the instantaneous energy.

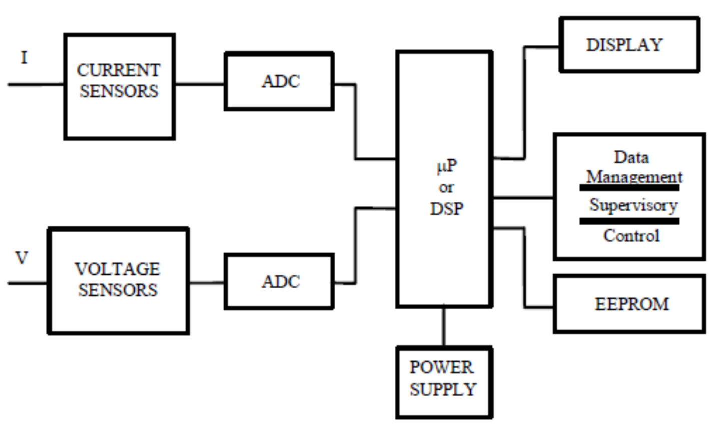

Fig: 2 Basic Scheme of digital sampling based energy meter

4. LABORATORY SETUP

The set-up consists of a device capable of generating the typical disturbances present in electrical systems, and a resistive load (wye connection). The energy meters to be tested will be inserted in this simple system. Their readings will be compared with the reference, thus obtaining the measurement error. The methodology used to test the energy meters is described below:

1) Program the AC Power Source to generate a particular waveform.

2) Configure the Reference Meter.

3) Set the Pulse Counter to zero.

4) Turn on/off the switch (I), at the beginning/end of the test, respectively.

5) Record results and make the corresponding error calculations.

5. LITERATURE SURVEY

In [1], the central EB office has been discussed which has immediate access to all consumer homes in a locality with the help of an RF system. The EB meter present in each house is connected by wireless network with the EB office which periodically gets updates from the meter. The EB office using a backend database calculates the amount to be paid according to the number of units consumed and sends it back to the meter for display and also to the user's mobile phone.

In [2] the idea of pre-paid energy meter using AVR controller has been introduced. In this method 8051 has been replaced by AVR controller because, which is energy efficient i.e. it consumes less power, it is fastest among all the microcontroller families and has inbuilt ADC and has advanced RISC architecture. In this paper, energy meters have not been replaced which is already installed at our houses, but a small modification on the already installed meters can change the existing meters into prepaid meters, so these meters are very cheaper. The use of GSM module provides a feature of pre-paid through SMS.

In [3], the project uses two micro controllers and one energy meter IC. It's not like traditional one. AT mega chip have been used to calculate the energy consumption, it has one smart card to recharge the amount and utilize it.

In [4], traditional metering method for retrieving the energy data is discussed which is not convenient and the cost of the data logging systems is also high. So design and development of Automatic meter reading (AMR) system is proposed. AMR system is a boom for remote monitoring and control domestic energy meter. AMR system gives the information of meter reading, power cut, total load used on request or regularly in particular interval through SMS. This information is being sent and received by concerned energy Provider Company with the help of Global system for mobile communication (GSM) network. Energy provider receives the meter reading within a second without visiting person. AMR minimize the number of traditional visits required by employees of energy Provider Company. This system not only reduces the labour cost but also increases the meter reading accuracy and saves huge amount of time.

Energy meter or watt hour meter is classified in accordance with several factors such as:

- Type of display like analog or digital electric meter.
- Type of metering point like grid, secondary transmission, primary and local distribution.
- End applications like domestic, commercial and industrial.
- Technical like three phases, single phase, HT, LT and accuracy class meters.

On the whole we have seen two basic types of Energy meters:-

- **1. Electromechanical induction type Energy meter:**

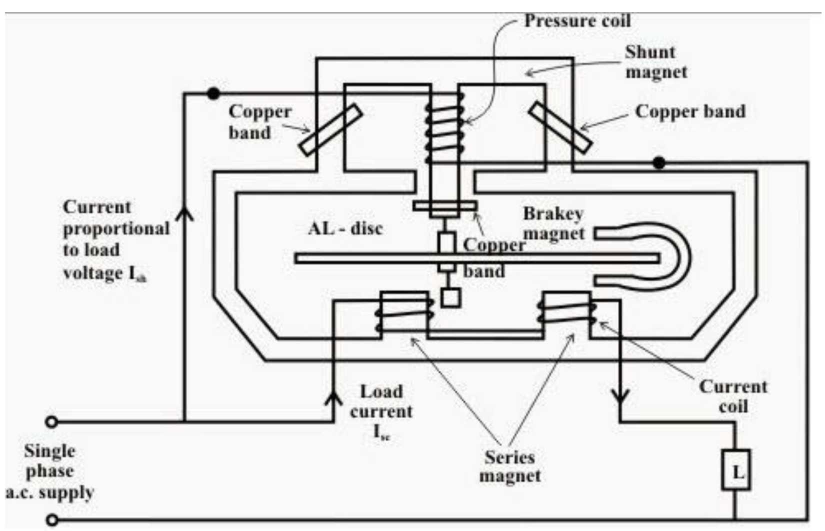

Fig:3 Electromechanical induction type Energy meter

It is the popularly known and most common type of age old watt hour meter. It consists of rotating aluminum disc mounted on a spindle between two electro magnets. Speed of rotation of disc is proportional to the power and this power is integrated by the use of counter mechanism and gear trains. It comprises of two silicon steel laminated electromagnets i.e., series and shunt magnets.

Series magnet carries a coil which is of few turns of thick wire connected in series with line whereas shunt magnet carries coil with many turns of thin wire connected across the supply.

Breaking magnet is a permanent magnet which applies the force opposite to normal disc rotation to move that disc at balanced position and to stop the disc while power is off.

Basic working of electromechanical meter:

This meter works on the same principle as the induction motor. An aluminium disc is placed inside a magnetic core with two limbs. One carries a voltage coil so its flux is proportional to voltage, the second carries a current coil so its flux is proportional to current. The two fluxes induce eddy currents into the disc, each of which interacts with the flux of the other to produce a torque, which accelerates the disc. This torque of course is proportional to flux × the eddy current, which equates to V × I, or power. A permanent magnet creates another eddy current resulting in a torque proportional to speed that brakes the disc, the combined result of these actions is that the speed of the disc is proportional to power, and the total number of revolutions is proportional to the energy that has passed through the meter. The disc drives a chain of gears that turn a mechanical counter, called a 'register'.

- **2. Electronic Energy meters**

These are of accurate, high procession and reliable types of measuring instruments as compared to conventional mechanical meters. It consumes less power and starts measuring instantaneously when connected to load. These meters might be analog or digital. In analog meters, power is converted to proportional frequency or pulse rate and it is integrated by counters placed inside it. In digital electric meter power is directly measured by high end processor. The power is integrated by logic circuits to get the energy and also for testing and calibration purpose. It is then converted to frequency or pulse rate.

Electronic meters can further be classified into following two categories

Analog Electronic Energy Meters

In analog type meters, voltage and current values of each phase are obtained by voltage divider and current transformers respectively which are directly connected to the load as shown in figure.

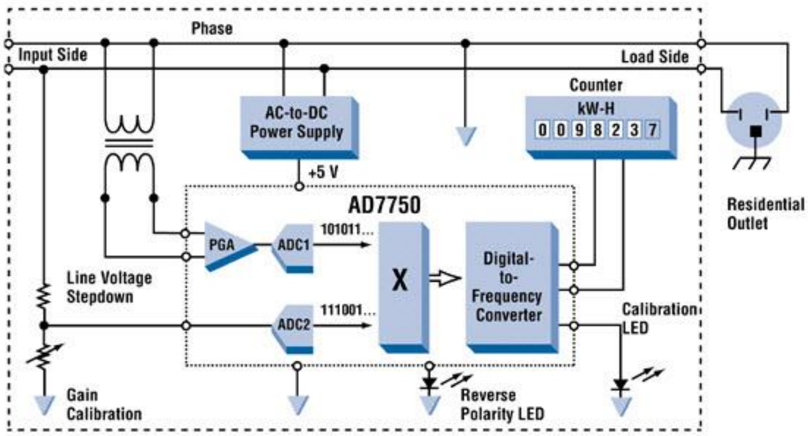

Fig:4 Analog Electronic Energy Meters

Analog to digital converter converts these analog values to digitized samples and it is then converted to corresponding frequency signals by frequency converter. These frequency pulses then drive a counter mechanism where these samples are integrated over a time to produce the electricity consumption.

Digital Electronic Energy Meters

Digital signal processor or high performance microprocessors are used in digital electric meters. Similar to the analog meters, voltage and current transducers are connected to a high resolution ADC. Once it converts analog signals to digital samples, voltage and current samples are multiplied and integrated by digital circuits to measure the energy consumed.

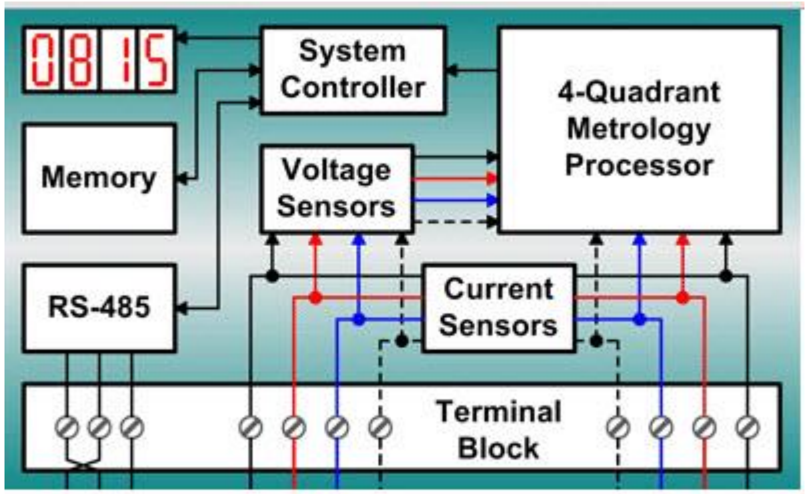

Fig: 5 Digital Electronic Energy Meters

Microprocessor also calculates phase angle between voltage and current, so that it also measures and indicates reactive power. It is programmed in such a way that it calculates energy according to the tariff and other parameters like power factor, maximum demand, etc and stores all these values in a nonvolatile memory EEPROM.

It contains real time clock (RTC) for calculating time for power integration, maximum demand calculations and also date and time stamps for particular parameters. Furthermore it interacts with liquid crystal display (LCD), communication devices and other meter outputs. Battery is provided for RTC and other significant peripherals for backup power.

Table: 1 Comparison of various energy meters

Context	Advantage	Disadvantage	Reference
Electronic meters	Greater Stability, High Accuracy Long Life.	Costly & more Complex.	Analog & Digital power meters[1]
Electromechanical meters	Simple, Reliable & Low Cost.	Short Life, Error prone & Less Stable.	Analog & Digital power meters[1]
Single phase meters	Cheaper, Both Voltage & Current in phase.	No Constant Torque & Less efficient.	Single phase & Three phase power[4]

Three phase meters	Smaller, More Efficient & Supplies more Power.	High Cost of Units, Inconvenience in repair.	Single phase & Three phase power[4]

6. CONCLUSION

The energy calculation in the case of electronic meters is more stable since it is performed digitally. In contrast, due to all their mechanical and magnetic components, electromechanical meters are more prone to suffer errors due to the effects of the environment, usage and age.

7. ACKNOWLEDGEMENT

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8. REFERENCES

1. J. Driesen, T. Van Craenenbroeck, D. Van Dommelen, “The registration of harmonic power by Analog and Digital power meters,” IEEE Transharmonics on equipment,” IEEE Trans. Power Delivery, vol. 8, Apr. 1993.

2. IEEE Working Group on Nonsinusoidal Situations, “Practical definitions for powers in systems with nonsinusoidal waveforms and unbalanced loads: a discussion,” IEEE Trans. Power Delivery, vol. 11.

3. http://energymeter-distribution-google.com

4. http://eletricalengineeringportal.com/single-phase-power-vs-three phase power.

5. http://energymetercircuit-google.image.com