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3-Phase Power Measurement using MEMS for Smart Grid Energy Meters

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Abstract

For the last century, electrical meters is used as measuring device in areas where electricity is used. It is used for household as well as industrial areas. Normally the meters used are in analog form and power consumption measured is not accurate. The users are getting higher bills than the actual amount. Hence 3-phase smart energy meters can solve the problems which occur. Digital energy meters will be more accurate in measurements compared to analog meters. They can be used for multi-functions which are able to measure power in various forms such as RMS(root mean square), apparent power or even reactive/active power.In this paper we are going to present on 3-phase power measurements for smart grid energy metes. The paper is designed for modernization of the electric power grid, often called "smart grid" by it. Efforts such as the Advanced Metering Infrastructure (AMI), Automated Meter Reading (AMR) and the other phases of intelligent grid management are all part of the smart grid. Having better control of the power grid will improve its reliability and efficiency and, as applications are developed for end users, point-of-use monitoring and control of power usage will benefit utilities by reducing peak loads and benefit consumers by providing a way to save on their energy costs by reducing their peak usage.

Index Terms:-3-Phase, Survey, Smart Meter, Smart Grid, Power Grid

Keywords:-Root Mean Square, Apparent Power, Reactive/Active Power

I. INTRODUCTION

Smart meters as part of the smart grid series technology, brings in the advancement in energy saving consumption, compatibility in terms of size, faster outage detection and environmental savings of resources. It is estimate by the next decade, most of the countries from the world will use smart meters to replace the olden electromechanical meters. Traditional electrical meters such as electromechanical meters are passive meters [1]. They have mechanical problems, technical problems, management problems and some social problems. The mechanical parts inside these meters due to wear and tear over time, will cause errors in the readings and make false information on billing records. On the other hand, as these meters are easier to adjust with fraught work, that means for example, people who would like to pay lesser bills on their electricity may have done some changes in the reading's settings, it may not be reliable. Smart energy meters today surpassed all the disadvantages of electromechanical meters. Apart from measuring energy, these energy meters provide parameters such as reactive power and rms which show real-time data useful for balancing electric loads and reducing power outages. They can also help to support the specific period (off peak and peak hour measurement) billing methods in the electricity bills which allow users to tariff their usages etc. Overall, smart energy meters are operated by using the measurement readings voltage and current in instantaneous forms and multiplied them to become electrical power. This power is further integrated against time to produce used energy (eg: joules/kilowatts) [2].

The project scope is to design a three phase energy meter which has the function of measuring and reading of power consumption. This design will be the prototype which has the analog base front end and meter design cater for device evaluation. The design should have to be low energy efficiency and low cost. To implement it, it is necessary to understand how the overall CY8C29466, CY8C29666 automotive PSOC works.We are using smart grid as power supply and hall effect current sensor is used as the Micro electro mechanical system.

The project objective is to design a three phase energy meter that can be used for measuring energy and measure consume electricity by the three phase load.For developing a board we have to go through few steps which are as follows:

1. We should first read through the internal circuit of energy meter before begin to design the three phase energy meter.
2. Then we should measure the power by using the formula P=IV.
3. If there are any offsets in the active power calculation then we must first remove the offsets and then proceed.
4. Then we should design our our three phase energy meter which will replace the recent energy meters

II. BLOCK DIAGRAM AND IT'S DESCRIPTION

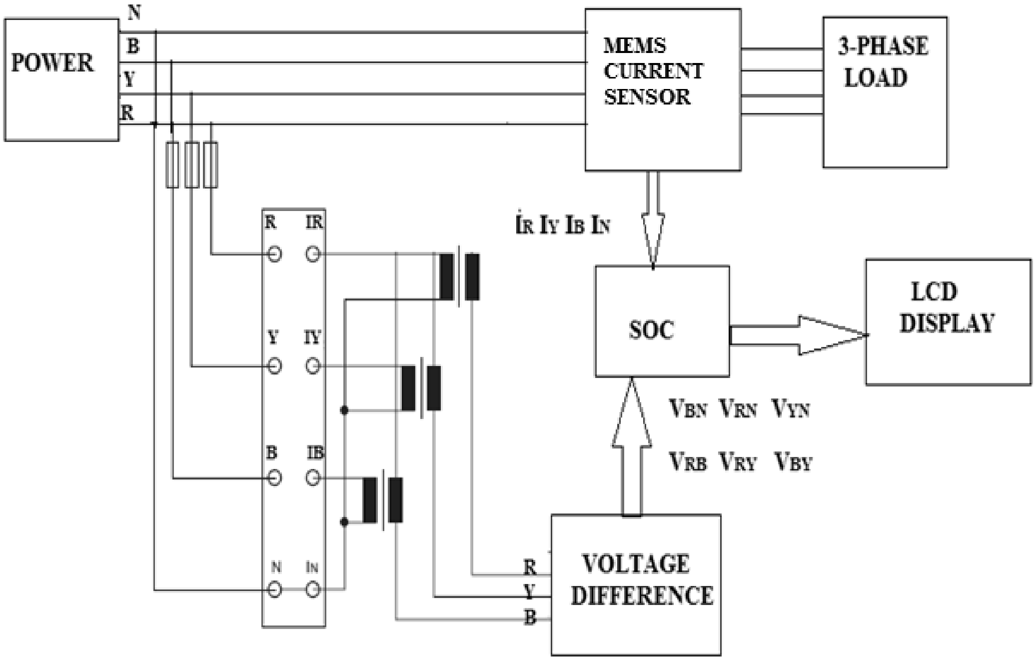

Figure1. Block Diagram of three phase power measurement

The Power supply is applied to the R, Y, B and N. The 3-Phase load is applied to MEMS (Micro Electro-Mechanical system) current sensor. We are using hall effect current sensor. The MEMS current sensor produce a MEMS current that is I_R, I_Y, I_B, I_N. Three current transformers are used for R, Y and B. These current transformers are connected to the voltage difference block which will give the voltages V_{RN}, V_{BN}, V_{YN}, V_{RB}, V_{RY}, V_{BY}. The outputs of voltage difference and MEMS current block are given to the system on chip which we are using as Automotive Programmable system-on-chip. The output of system on chip is then displayed on the LCD 16×2.

III. POWER SUPPLY AND DISTRIBUTION

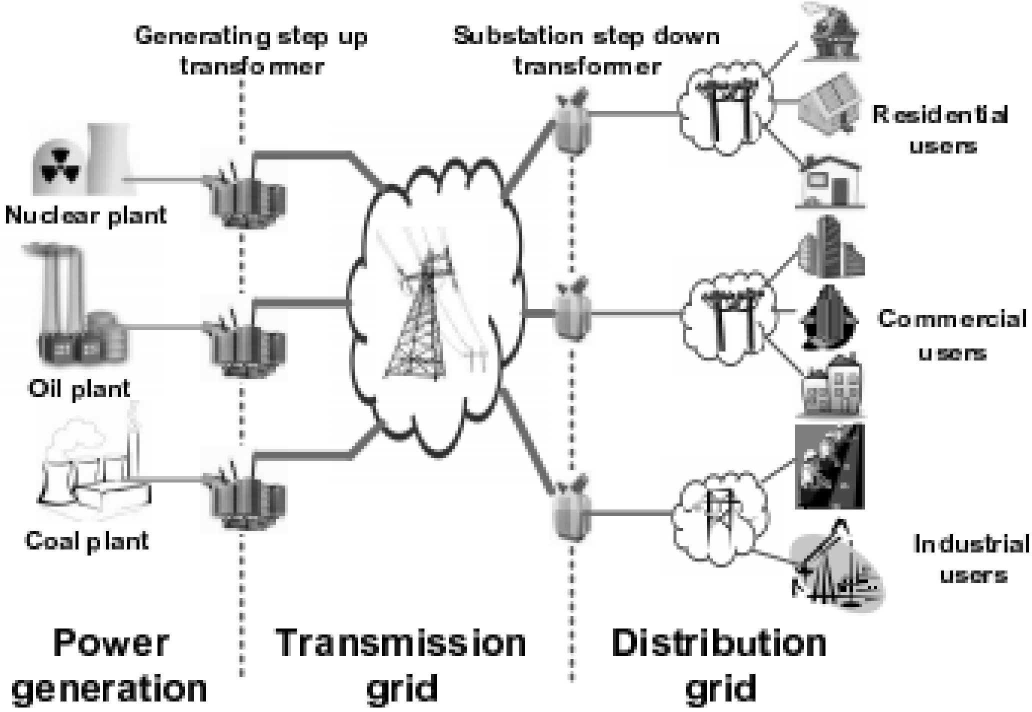

Figure 2. Power Supply and Distribution

A. Power Generation

Electricity generation is the process of creating electricity from other forms of energy, which may vary from chemical combustion to nuclear fission, flowing water, wind, solar radiation and geothermal heat. The Power Generation domain is electrically connected to the Operations, Markets and Transmission domains. Some benefits to the Power Generation domain from the deployment of the smart grid are the ability to automatically reroute power flow from other parts of the grid when generators fail [3].

B. Transmission Grid

Transmission is the bulk transfer of electrical power from generation sources to distribution through multiple substations. The Transmission domain is electrically connected to the Bulk Generation and Distribution domains, as well as communicating with the Operations, and Markets domains. A transmission network is typically operated by a Regional Transmission Operator or Independent System Operator (RTO/ISO) whose primary responsibility is to maintain stability on the electric grid by balancing generation (supply) with load (demand) across the transmission network.

The Transmission domain may contain distributed energy resources such as electrical storage or peaking generation units. Energy and supporting ancillary services (capacity that can be dispatched when needed) are procured through the

Markets domain and scheduled and operated from the Operations domain. They are then delivered through the Transmission domain to the utility-controlled distribution system and finally to customer. Actors in the transmission domain may include remote terminal units, substation meters, protection relays, power quality monitors, phasor measurement units, sag monitors, fault recorders, and substation user interfaces [3].

C. Distribution Grid

The Distribution domain is electrically connected between the Transmission domain and the Customer domain at the metering points for consumption. The Distribution domain also communicates with the Operations and Markets domains. Historically distribution networks have little instrumentation installed, and there was very little communications within this domain that was not manually done by humans. Many communications interfaces within this domain were hierarchical and unidirectional.

With the advancement of distributed storage, distributed generation, demand response and load control, the ability of the Customer domain to improve the reliability of the Distribution domain exists. Distribution networks are now being built with much interconnection, extensive monitoring and control devices, and distributed energy resources capable of storing and generating power [3].

IV. HALL EFFECT CURRENT SENSOR

Hall Effect current sensor has much more benefits in wide measuring range, good linearity and accuracy, high isolation between input and output, diverse sensor configurations and applications etc. It can be used both for AC and DC current measurements of all applications mentioned above.There are two Hall Effect current sensing methods, i.e. open loop and closed loop configurations. Both kinds of sensors use a magnetic core with air gap, where a Hall Effect sensor is inserted. A primary conductor of current to be measured passes through the magnetic core. The magnetic flux generated by the primary current is concentrated in the core, which is proportionate to the current and detected with the Hall Effect sensor [4].

V. CY8C29466, CY8C29666 AUTOMOTIVE PSOC

The PSoC programmable system-on-chip family consists of many devices with On-Chip Controllers. These devices are designed to replace multiple traditional microcontroller unit (MCU)-based system components with one, low cost single-chip programmable device. PSoC devices include configurable blocks of analog and digital logic, as well as programmable interconnects. This architecture enables the user to create customized peripheral configurations that match the requirements of each individual application. Additionally, a fast central processing unit (CPU), flash program memory, SRAM data memory, and configurable I/O are included in a range of convenient pinouts and packages.

The PSoC architecture, is comprised of four main areas: PSoC core, digital system, analog system, and system resources. Configurable global buses allow all the device resources to be combined into a complete custom system. The automotive PSoC CY8C29x66 family can have up to three I/O ports that connect to the global digital and analog interconnects, providing access to 16 digital blocks and 12 analog blocks. The M8C CPU core is a powerful processor with speeds up to 24 MHz, providing a four million instructions per second (MIPS), 8-bit Harvard-architecture microprocessor. The CPU uses an interrupt controller with 25 vectors, to simplify programming of real time embedded events. Program execution is timed and protected using the included sleep timer and watchdog timer(WDT) [5].

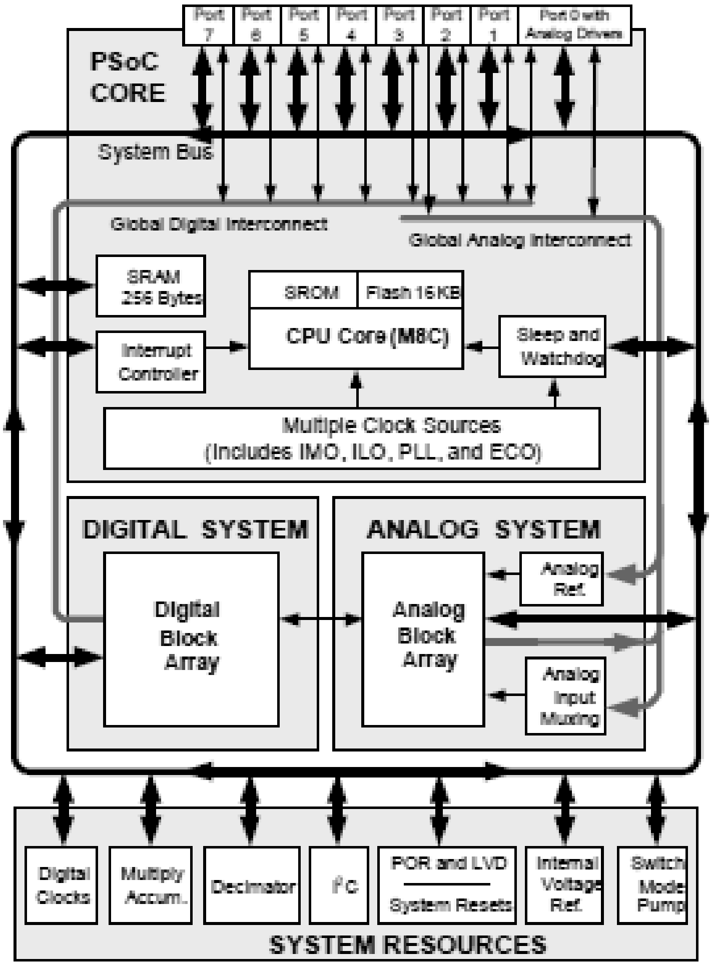

Figure 3. PSOC Architecture

A. Digital System

The digital system is composed of 16 digital PSoC blocks. Each block is an 8-bit resource that can be used alone or combined with other blocks to form 8-, 16-, 24-, and 32-bit peripherals, which are called user modules. Digital peripheral configurations include:

1. PWMs (8-to 32-bit)
2. PWMs with deadband (8-to 24-bit)
3. Counters (8-to 32-bit)
4. Timers (8-to 32-bit)
5. Full-or half-duplex 8-bit UART with selectable parity
6. SPI master and slave
7. I2C master, slave, or multimaster (implemented in a dedicated I2C block)
8. Cyclic redundancy checker/generator (16-bit)
9. Infrared Data Association (IrDA)
10. PRS generators (8-to 32-bit).

B. Analog System

The analog system is composed of 12 configurable blocks, each comprised of an opamp circuit allowing the creation of complex analog signal flows. Analog peripherals are very flexible and can be customized to support specific application requirements. Some of the common PSoC analog functions for this device (most available as user modules) are as follows:

1. ADCs (up to four, with 6-to 14-bit resolution, selectable as incremental, delta-sigma, or successive approximation register (SAR).
2. Filters (two-and four-pole band pass, low pass, and notch)
3. Amplifiers (up to four, with selectable gain up to 48x)
4. Instrumentation amplifiers (up to two, with selectable gain upto 93x)
5. Comparators (up to four, with 16 selectable thresholds)
6. DACs (up to four, with 6-to 9-bit resolution)
7. Multiplying DACs (up to four, with 6-to 9-bit resolution)
8. High current output drivers (four with 30-mA drive)
9. 1.3-V reference (as a system resource)
10. DTMF Dialer
11. Modulators
12. Correlators
13. Peak Detectors

VI. POWER MEASUREMENTS

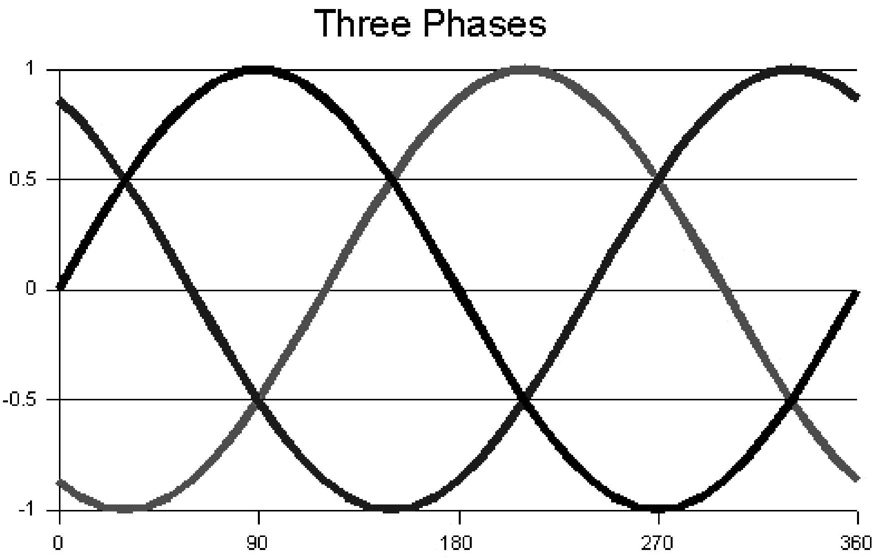

Figure 4. Power Measurement

Let x be the instantaneous phase of a signal of frequency f at time t: Using this, the waveforms for the three phases are as above

$x = 2\pi ft$

$$V_{L1} = V_P \sin x$$

$$V_{L2} = V_P \sin\left(x - \frac{2}{3}\pi\right)$$

$$V_{L3} = V_P \sin\left(x - \frac{4}{3}\pi\right)$$

where:

V_P is the peak voltage and the voltages on L1, L2 and L3 are measured relative to the neutral.

And current is given by:

$I = kW / (\sqrt{3} \times pf \times V_{LL})$, in kA

VII. ADVANTAGES

1. Measurement accuracy meets even the most aggressive global standards.
2. High integration and programmability meet changing customer requirements.
3. Accelerate meter development.
4. Improved reliability and cost savings.
5. Meets the four core timing requirements for smart metering
    i. Accuracy (< ±5.0ppm)
    ii. Stability (< ±5.0ppm)
    iii. Power (< 3.0μA)
    iv. Compliance testing (1Hz output)

6. Safeguards against power loss.
7. Reduces cost and saves space.

VIII. FUTURE WORK

We are going to design a three phase power meter using Micro electro mechanical systems for a smart grid energy meter.We are going to present the further development of self-powered MEMS sensor modules that can be installed in commercial, residential, distribution and transmission electrical circuits.We are going to measure electrical quantities such as current, voltage, and instantaneous power. The module will find energy needed for its operation from the electrical circuit it is monitoring. The module will contain a radio chip, which will allow it to wirelessly communicate the measured results.

IX. ACKNOWLEDGEMENT

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REFERENCES:

[1] Mr.Rahul Ganesh Sarangle, Prof.Dr.Uday Pandit Khot, Prof. Jayen Modi / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 4, June-July 2012, pp.664-671 664 " Gsm Based Power Meter Reading And Control System".

[2] H.G. Rodney Tan, C. H. Lee, and V. H. Mok, Automatic Power Reading Using GSM Network, *The 8th International Power Engineering Conference (IPEC2007)*. Web.30 November2010.

[3] H. Gharavi and R. Ghafurian. Smart grid: The electric energy system of the future. *Proceedings of the IEEE*, 99(6):917 – 921, 2011.

[4] Bao M (2005): Analysis and design principles of MEMS devices. Elsevier BV, Amsterdam (The Netherlands), 312pp.

[5] CY8C29466, CY8C29666 AUTOMOTIVE PSOC(Programmable System on chip)