IoT Based Phasor Measurement Unit (PMU)

Himani K. Bundele[1], K Chandra Obula Reddy[2]

P.G. Student, Department of Electrical Engineering, MSS's Collage of Engineering, Jalna (MH), India[1] Professor, Department of Electrical Engineering, MSS's Collage of Engineering, Jalna (MH), India[2]

Abstract:

Simply monitoring the energy system includes taking readings or measurements at defined time intervals from energy systems while these devices are in service. Specific instruments are used to measure particular parameters on energy systems. The phasor measurement unit (PMU) is a main instrument for offering the energy system network with situational awareness, operation and reliability. This article offers a microcontroller based prototype phasor measuring unit with IoT (Internet of Things) for voltage amplitude measurement and energy system frequency measurement. The phasor measuring unit's objective is to provide accurate voltage and frequency data for the energy scheme.

Keywords: Phasor Measurement Unit (PMU), IoT, Voltage Amplitude, Frequency, Microcontroller.

1. Introduction

The primary instrument in PMU development is the early 1970 invention of the microprocessor-based symmetric distance relay of components (SCDR). The next phase in the growth of PMU is the invention of the Global Positioning Satellite System (GPS) at the beginning of 1980. In the late 1980s Prof. A.G. Phadke and his Virginia Tech research group. First introduce PMU ideas using GPS technology. Macrodyne created first commercial PMU in 1988 and 1992.The PMU is described as a "device that generates estimates of synchronized phasor, frequency and frequency change rate (ROCOF) from voltage and/or current signals and a time synchronization signal"[1].

In this work, we have tried to develop microcontroller based the phasor measurement unit prototype with IoT (Internet of Things) for measurement of voltage amplitude and power system frequency. The purpose of the phasor measurement unit is to provide the power system voltage and frequency information accurately.

2. Literature Survey

A PMU is a device used to estimate the magnitude and phase angle of an electrical phasor quantity (such as voltage or current) in the electrical grid using a common synchronization time source. PMUs are capable of quick succession gathering samples from a waveform and reconstructing the phasor quantity, composed of angle measurement and magnitude measurement. The measurement arising from this is called a synchrophaser [2]. Rohini P. Haridas [3] gives introduction to GPS based phasor measurement techniques in power system. As compared to traditional SCADA measurements GPS based phasor technology provides high speed coherent data in order to monitor power system dynamics. The voltages and currents taken from the secondary winding of the three-phase voltage and current transformers and the Anti aliasing filter restrict the bandwidth to fulfill the Nyquist criterion, which is also used to filter input frequencies that are larger than the Nyquist rate. Proakis et al. [4] described the concepts of digital signal processing, algorithm and implementation. Discrete Fourier Transform (DFT) and its application is briefly described in order to alter a signal from one domain to another. In 2015, Gopakumar et. al. [5] suggested a fault-localization methodology based on a support vector machine to correctly detect and locate any transmission line faults for the entire smart grid. Using quick Fourier transform, this approach uses frequency-domain assessment of the equivalent voltage phasor angle and equal present phasor angle to identify the transmission line fault in the intelligent energy grid and exactly identify the bus attached to the defective branch.

Shiroei, M. et al. [6] suggested the use of PMU measured information for low-order dynamic models for stability research of energy structures. Here, the use of PMU was expanded to estimate the synchronous machine's second-order equivalent. In addition, writers for the assessment of electromechanical oscillations provided a fresh strategy for estimating two-machine and single machine infinite bus (SMIB) equivalent systems. N. H. Abbasy, H. M. Ismail [7] proposed a unified approach for estimating the power system state by formulating a binary integer linear programming (BILP) to determine the optimum number and locations of PMUs. In which the factors of binary choice (0, 1) determine whether to install a PMU on a bus that takes into account the observability and economy of the scheme. The suggested unified approach takes into account the effects of single or multiple PMU losses on the optimum PMU allocation issue decision strategy. Mishra, Chetan, et al. [8] utilizes the method of binary particle swarm optimization to minimize the amount of substations installed in PMUs. PMU facilities have been suggested to allow observation of all voltage concentrations subject to different practical limitations.

3. System Development

Figure 1shows the block diagram of system, which consist of ATMEGA328P, Node MCU and Thingspeak website for reading display. Figure 2 shows the actual system. In this proposed system, all data thus obtained through the smart energy meter using ATMEGA328P and by using application of IOT. The data from the PMU integrated into the WSN are sent to Thingspeak website which has real time data information of Energy meter. This smart system uses application of Internet of Things (IOT), which will lead to sustainable consumption of energy and it can be monitored by the users who can limit wastage of energy and the utility to better understand the energy consumption of users.

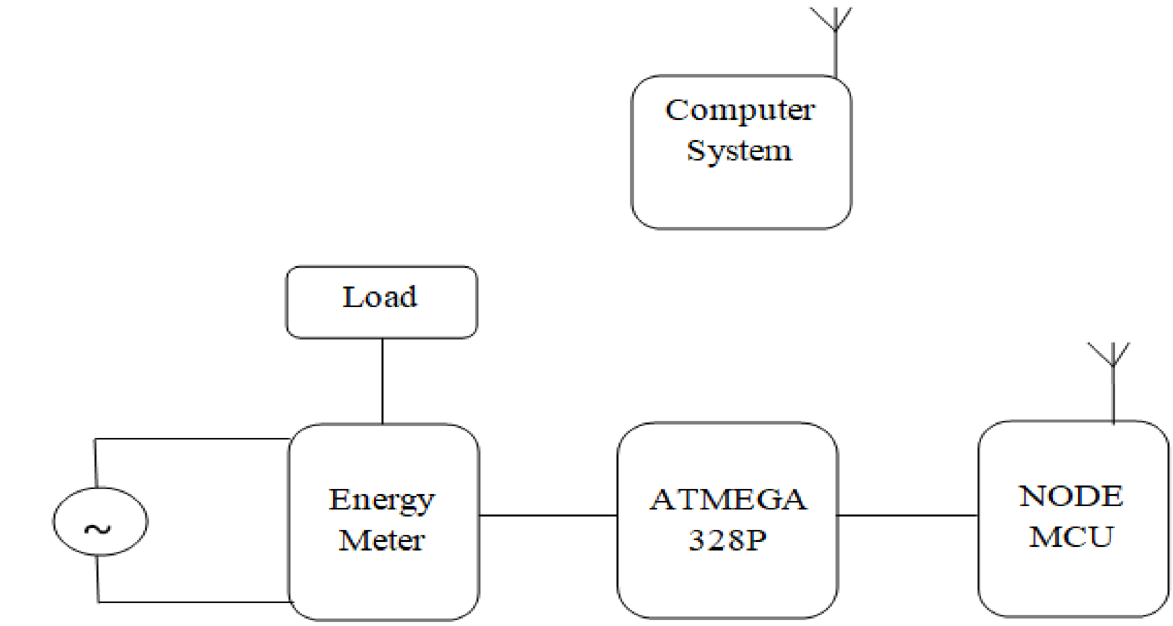

Figure 1 Block Diagram of system

Figure 2 Actual system

a. ATmega-328:

The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. It is basically an Advanced Virtual RISC (AVR) micro-controller and supports the data up to eight (8) bits. It has 32KB internal built-in memory, 1KB EEPROM (Electrically Erasable Programmable Read Only Memory), 2KB SRAM (Static Random Access Memory) and has 3 builtin Timers. Operates ranging from 3.3V to 5.5V but normally we use 5V as a standard. ATmega 328 has several different features which make it the most popular device in today's market. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable Serial USART, programming lock for software security, throughput up to 20 MIPS etc. ATmega-328 is mostly used in Arduino [10].

Features:

- Compatible with MCS-51 Products.
- 8K Bytes of In-System Reprogrammable Flash Memory.
- Endurance: 1,000 Write/Erase Cycles.
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock.
- 256 x 8-Bit Internal RAM.
- 32 Programmable I/O Lines.
- Three 16-bit Timer/Counters.
- Eight Interrupt Sources.
- Programmable Serial Channel.
- Low Power Idle and Power Down Modes

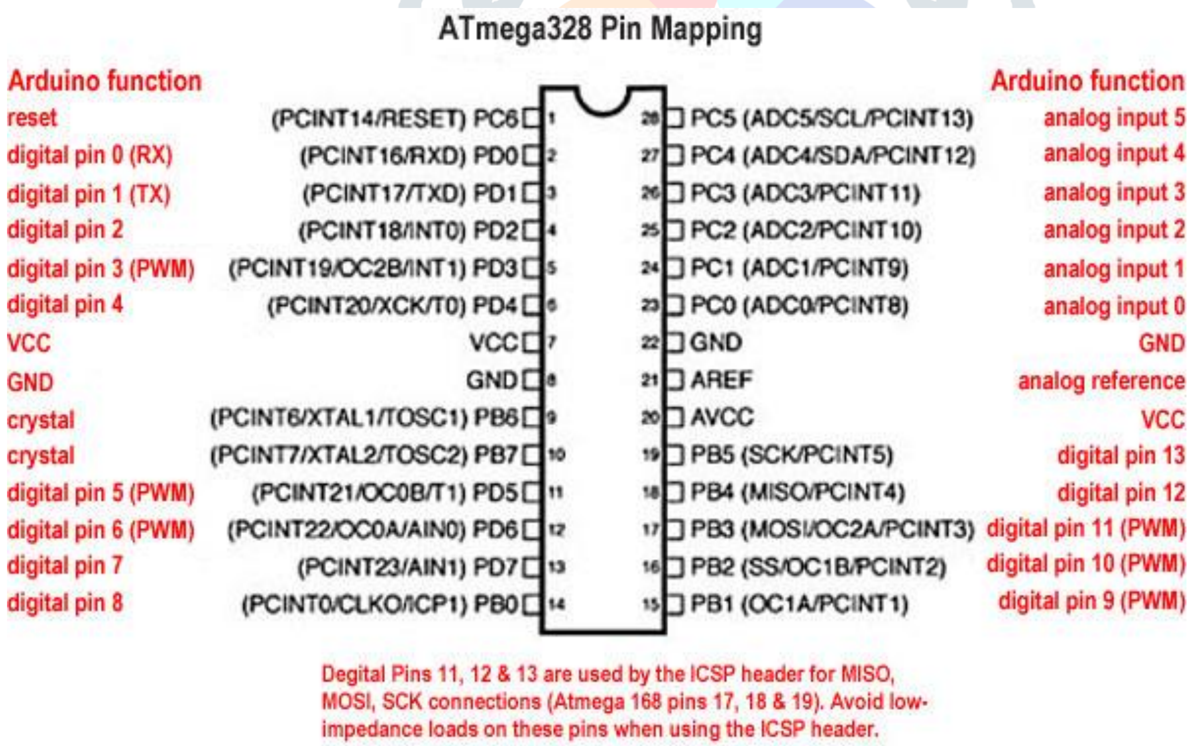

Figure 3 Pin diagram of ATmega328

b. Node MCU

NodeMCU is an open source IoT platform and consists of firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems. Also it will runs on hardware which is based on the ESP-12 module. NodeMCU is based on the eLua project, also uses many open source projects, such as lua-cjson and SPIFFS. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. Figure 4 shows the NodeMCU. The ESP8266 is the name of a micro controller designed by Espressif Systems. The ESP8266 itself is a self-contained WiFi networking solution offering as a bridge from existing micro controller to WiFi and is also capable of running self-contained applications. This module comes with a built in USB connector and a rich assortment of pin-outs. With a micro USB cable, you can connect NodeMCU devkit to your laptop and flash it without any trouble, just like Arduino. It is also immediately breadboard friendly [9].

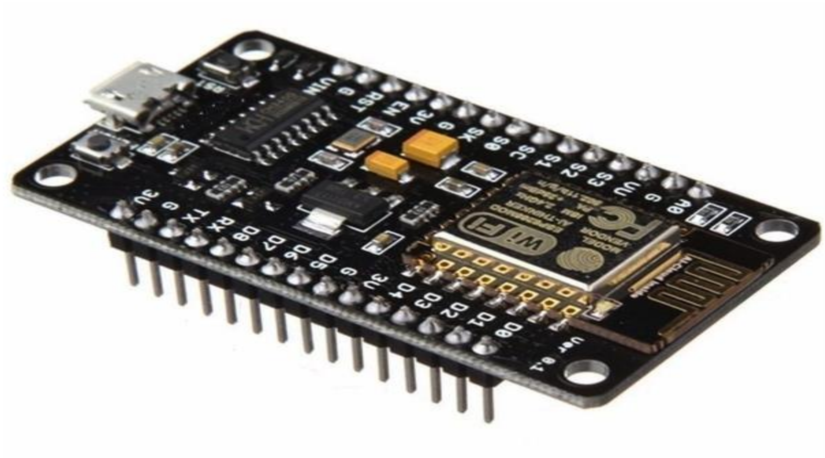

Figure 4 NodeMCU

Specification:

- Voltage: 3.3V.
- Wi-Fi Direct (P2P), soft-AP.
- Current consumption: 10uA~170mA.
- Flash memory attachable: 16MB max (512K normal).
- Integrated TCP/IP protocol stack.
- Processor: Tensilica L106 32-bit.
- Processor speed: 80~160MHz.
- RAM: 32K + 80K.
- GPIOs: 17 (multiplexed with other functions).
- Analog to Digital: 1 input with 1024 step resolution.
- +19.5dBm output power in 802.11b mode
- 802.11 support: b/g/n.
- Maximum concurrent TCP connections: 5.

4. Result

From above diagram of 5,6,7 we can see the clear and actual image of the result by using iot (internet of things) we can calculate exact phasor i.e calculation of voltage, current and frequency with time sampling frequency .this is used in the transmission line so frequency is constant even if load increases or decreases or also you can calculate units and for the privet customer you can see excel sheet for that particular year.

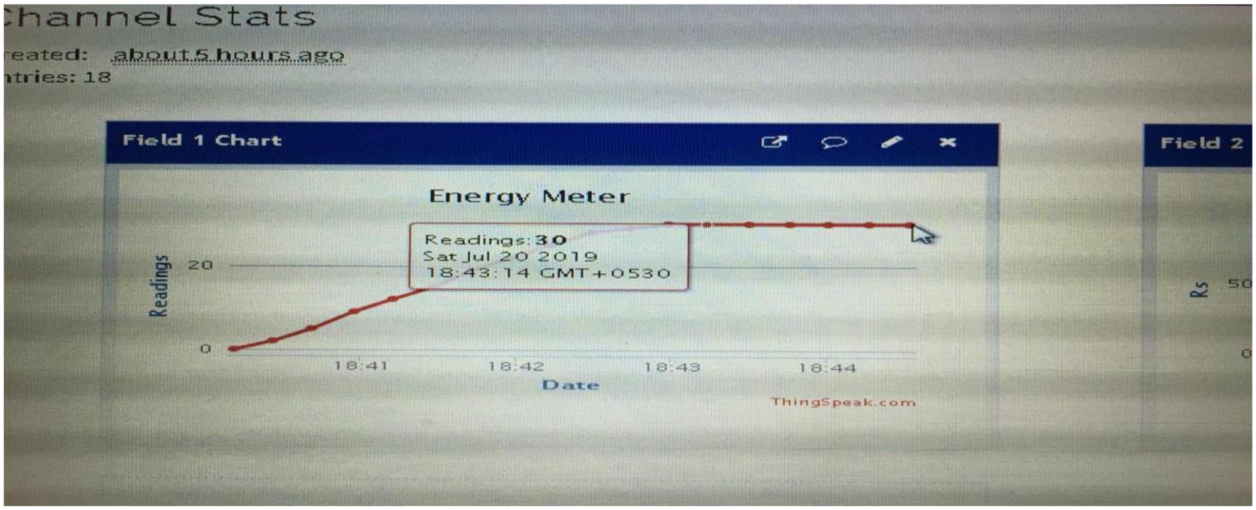

Figure 5 Actual energy reading

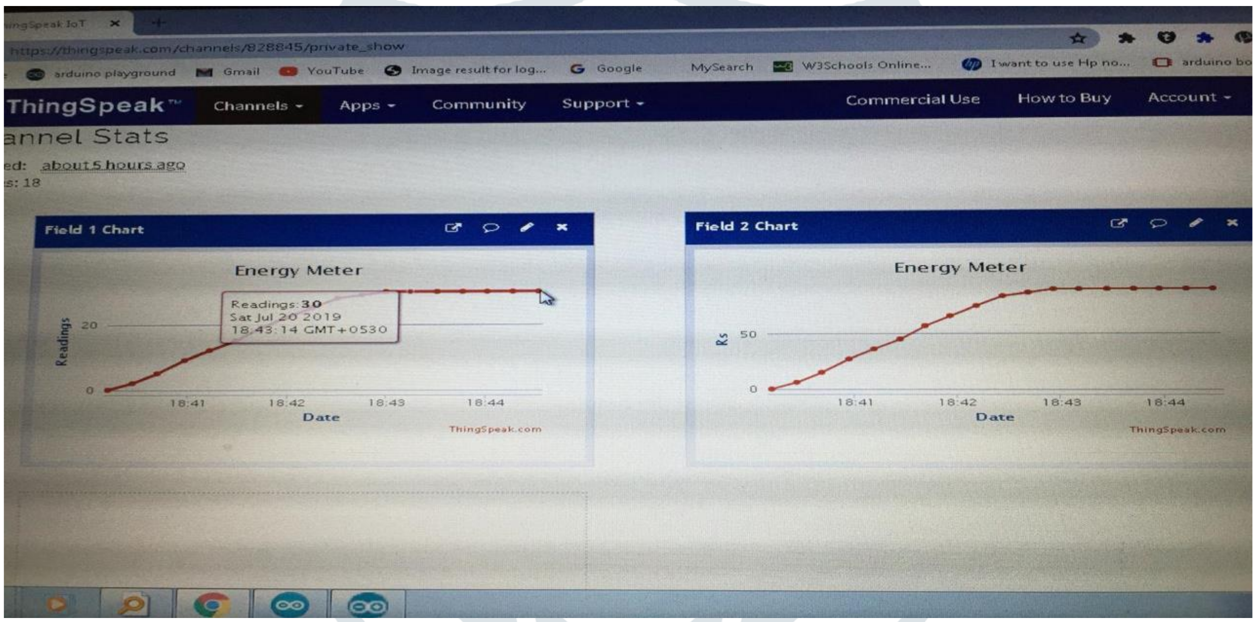

Figure 6 Unit Calculations by Using Thingspeak

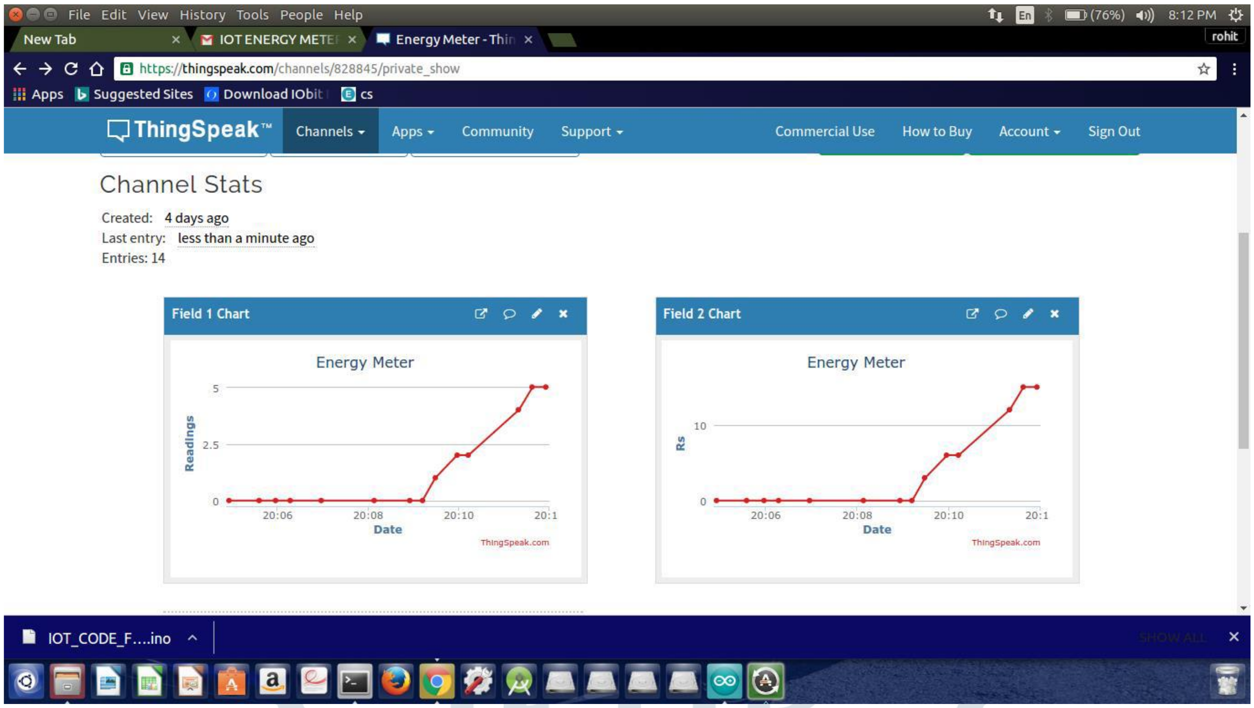

Figure 7 Channel Status

5. Conclusion

This paper presents the microprocessor based phasor measurement unit prototype without GPS system which has been developed in laboratory using Grid track hardware based literature. This design limited to single phase and without harmonic consideration. Future work involves the design and development of GPS system and IEEE synchrophasor based three phase PMU prototype with harmonic and DC decaying component consideration.

References

[1] IEEE Std. C37. 118. 1-2011, "IEEE Standard for Synchrophasor Measurements for Power Systems," 2011.

[2] https://en.wikipedia.org/wiki/Phasor_measurement_unit

[3] Rohini P. Haridas, "GPS Based Phasor Technology in Electrical Power System", International Journal of Electronics and Electrical Engineering Vol. 3, No. 6, December 2015.

[4] J.G. Proakis, D.G. Manolakis, "Digital Signal Processing-Principles, Algorithms and Applications", Prentice Hall International, New Delhi, India, Third Edition, pp 394-408, 2011.

[5] Gopakumar, Pathirikkat, Maddikara Jaya Bharata Reddy, and Dusmanta Kumar Mohanta. "Fault Detection and Localization Methodology for Self-healing in Smart Power Grids Incorporating Phasor Measurement Units."Electric Power Components and Systems 43.6 (2015):
695-710.

[6] Shiroei, M., B. Mohammadi-Ivatloo, and M. Parniani. "Low-order dynamic equivalent estimation of power systems using data of phasor measurement units." International Journal of Electrical Power & Energy Systems 74 (2016): 134-141.

[7] N. H. Abbasy and H. M. Ismail, "A Unified Approach for the Optimal PMU Location for Power System State Estimation," in IEEE Transactions on Power Systems, vol. 24, no. 2, pp. 806-813, May 2009.

[8] Mishra, Chetan, et al. "Binary particle swarm optimisation-based optimal substation coverage algorithm for phasor measurement unit installations in practical systems." IET Generation, Transmission & Distribution 10.2 (2016): 555-562.

[9] https://www.handsontec.com/pdf_learn/esp8266-V10.pdf

[10] https://www.theengineeringprojects.com/2017/08/introduction-to-atmega328.html

[11] https://www.sparkfun.com/datasheets/Components/SMD/ATMega328.pdf