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AUTOMATED TESTING OF ENERGY METER

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ABSTRACT

Electricity is one of the most necessary forms of energy that we utilize in our daily life; through accession in the demand and the cost of electricity, power theft and tampering is unrestrained; this influences the power sector across the country also causing loss in revenue. The objective of this project is to design and develop a test setup that avert such tampering made to the energy meters by testing it prior to the acquisition of the consumer .This setup is built opting microcontrollers and its operation is coded; the setup so built is used in testing of the energy meters in the manufacturer premises to detect whether it is able to distinguish tampered condition or not; if so to display the test result as Pass or Fail on LCD and the same indicated by green and red LEDs. Detailed test results are also available through Ethernet where an IP address when given has all the test information. Thus meters which pass the testing creates a defense system against tampering of the energy meters.

INTRODUCTION

Electrical energy iscustomarily measured byelectromechanical energy meters. These days digital energy measurement has become more popularand they are continuously replacing conventional meters due to its increased accuracy, tamper detection, less bulkier, bigger feature set, no moving parts, digital display, low power consumption, robust, temperature independency, storage facility, remote communication, security etc. All electronic meters have a digital processor, microcontroller, microprocessor, or mixed-signal IC that performs energy measurement. In thisproject we mainly deal with the tamper testing of the electronic energy meter. Meter tampering in the broadest sense is an illegal method employedby consumers to gain entry, break in, or some cases break the meter to deplete key functionalities, with the goal of reducing or completely eliminating the cost of energy usage. Traditional electricity meters have no ability to detect or deal with tampering because they only measure energy based on the voltage and current flowing between the inlet and outlet terminals. In such meters, tamperingbecomes very easy and detectionharder. Just as metering and anti-tamper technologies have improved, in parallel, bad consumers continue to get smarter with newer methods to tamper and combat existing anti-tampering schemes. Theft of electricity is the criminal practice of stealing electrical power. It is a crime and is punishable by fines and/or incarceration. According to the annual Emerging Markets Smart Grid: Outlook 2015 study by the Northeast Group, LLC, and the world loses US$89.3 billion annually to electricity theft. The highest losses were in India ($16.2 billion), followed by Brazil ($10.5 billion) and Russia ($5.1 billion).Meter readers are trained to spot signs of tampering, and on identification of such activities with the meters, the maximum rate may be charged on each billing period until the tamper is removed, or the service is disconnected or penalty is imposed for power theft, resulting in fines of different amounts and various lengths of jail time. Power companies often install remote-reporting meters specifically to enable remote detection of tampering, and specifically to discover energy theft. The change to smart power meters is useful to stop energy theft.

Various methods of tampering have been identified, including physical tampering, magnetic interference, bypassing currents, removing wires, adding passives to cause interference, and electroshock technologies (including electrostatic discharge) to break meters. Predictably, single-phase meters used in most residential complexes are targets for tampering; anti-tamper techniques for these are most needed. Hence we have worked on the single phase energy meters in this project. Physical tampering includes trying to break the case, inserting metal objects to prevent measurement, etc. Magnetic interference is the most common and easiest way to tamper with a meter and the typical sources of magnetic interference are powerful magnets and strong AC fields. Magnetic core-based components in meters such as CTs and transformer-based power supplies saturate in such conditions, resulting in a complete shutdown of metering.

Newer computerized meters usually have counter-measures against tampering. AMR (Automated Meter Reading) meters often have sensors that can report opening of the meter cover, magnetic anomalies, extra clock setting, glued buttons, inverted installation, reversed or switched phases etc.

So in this project we are designing and developing an automated test set up consisting of a very popular PIC18 family microcontroller PIC18F46K22 is used along with Ethernet communication IC ENC28J60 and supporting

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firmware to test the condition of the microprocessor based single phase energy meter. The test process begins with scanning the single phase energy meter using 1D-Barcode scanner and the tests are conducted on various tamper techniques, after which the display of the test results as Pass or Failthrough LED indication and on LCD. Detailed information on test results are also available on a host personal computer which can be accessed through Ethernet by giving in the IP address

BLOCK DIAGRAM OF TEST SETUP

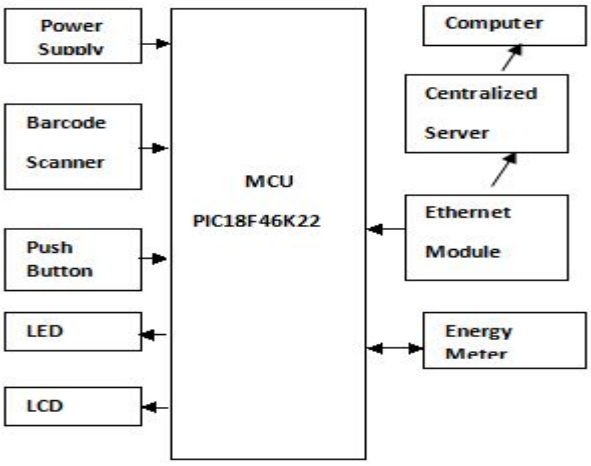

Fig.1 Block Diagram of Automated testing of Energy Meter

CIRCUIT DIAGRAM

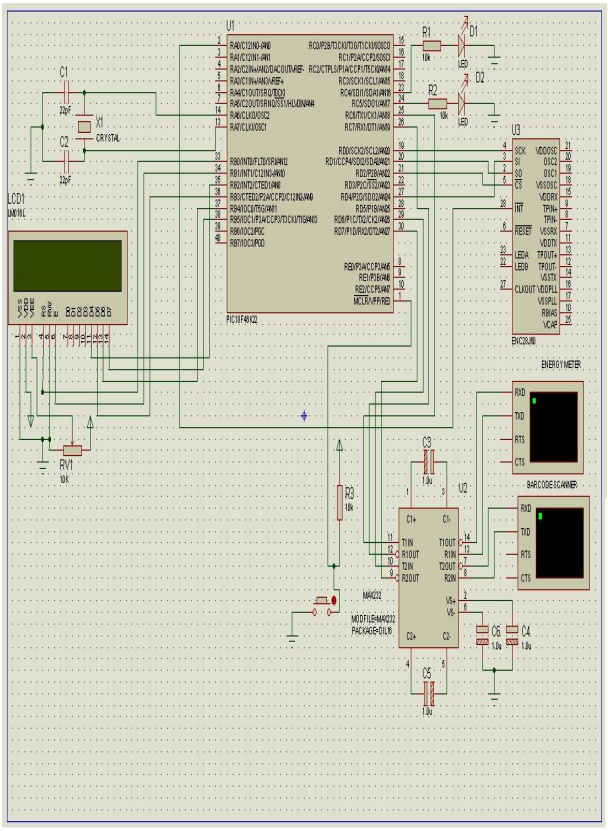

Fig 2: Circuit diagram of Automated testing of Energy meter

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The block diagram and circuit diagram of automated testing of Energy Meter setup is as shown in the Fig 1 and Fig 2 respectively. The circuit diagram is built using Proteus software which made possible to develop and test design before a physical prototype was constructed. The working of this test setup is as follows: When the adapter is turned on, 5v is supplied continuously to the PCB with the help of regulator IC LM7805and bridge rectifier; where the MCU gets powered up, LCD is turned on and indicates "SUPPLY ON" also the green LED blinks indicating the PCB is supplied with the required voltage. Having this initial verifications done, the energy meter is scanned with the help of 1-D Barcode scanner and its details are obtained, the testing is activated and at the end of the testing the results are obtained which is stored in the Local Area Network Server using Ethernet and the detailed results are obtained whenever required by giving the IP address. Also the test results are shown in the test setup as Pass or Fail. A push button is used to reset the entire process.

A. POWER SUPPLY

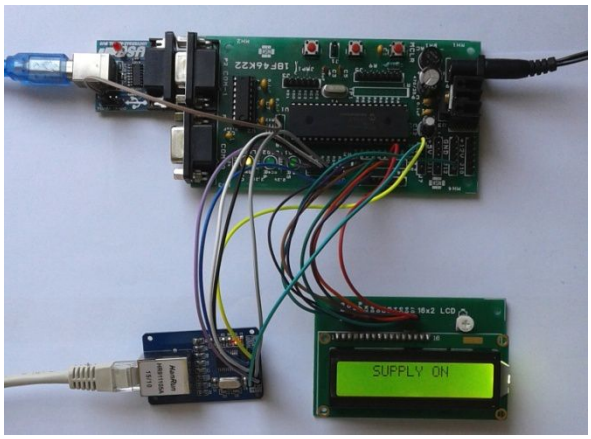

Fig 3: Hardware test setup with LCD display as "SUPPLY ON"

A regulated power supply is an embedded circuit; it converts unregulated AC into a constant DC. With the help of a rectifier it converts AC supply into DC. In this project we have obtained power supply to the PCB through an adapter of 12V, 2A rating, regulator IC LM7805 and bridge rectifier is used to obtain constant 5V.

B. MCU(Master Control Unit)

The master IC used is PIC18F46K22. A 40 Pin DIP(Dual In-line Package), low power, highperformance microcontrollers with XLP technology C compiler optimized architecture having upto 1024 bytes data EEPROM, 64 kilobytes linear program memory addressing, 3896 bytes linear data memory addressing, 16 MPS operation and having EUSART,I2C, SPI Embedded Interface Types.

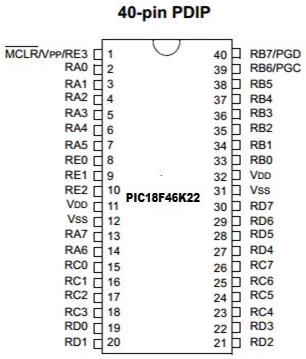

Fig 4: Pin diagram of PIC18F46K22

The single phase energy meter to be tested is connected to PIC microcontroller through RS – 232 port and the testing procedure is carried out.

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C. LCD and LEDs

LCD (Liquid Crystal Display)HD44780 screen is an electronic display module and finds a wide range of applications. In this project we have used 16x2 LCD display which is a basic module. A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The result is displayed using LCD as Test-PASS or FAIL of the single phase energy meter tested.
LEDs(Light Emitting Diode) are used to indicate supply is ON/OFF, and test results as PASS or FAIL by glowing greed or red LED.

D. BARCODE SCANNER

A barcode is an optical machine-readable representation of data relating to the object to which it is attached. Originally barcodes systematically represented data by varying the widths and spacing of parallel lines, and may be referred to as linear or one-dimensional (1D). Later two-dimensional (2D) codes were developed, using rectangles, dots, hexagons and other geometric patterns in two dimensions, usually called barcodes although they do not use bars as such. In this project 1-D barcode of the energy meter is scanned by the scanner which is connected to the Test Setup through USB.

E. MAX232

The MAX232 is an integrated that converts signals from a TIA-232 (RS-232) serial port to signals suitable for use in TTL compatible digital logic circuits. Also convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontrollers with PC. It is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The controller operates at TTL logic level (0-5V) whereas the serial communication in PC works on RS232 standards (-25 V to + 25V). The intermediate link is provided through MAX232

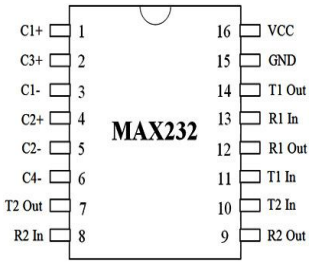

Fig 5: Pin diagram of MAX232

F. COMPUTER

In this project the computer is not continuously connected to the test setup, it is only used build the program and to burn the coding to the IC. Later, after the testing is completed the test results are fetched in the LAN (Local Area Network) by giving the IP address set in the centralized server through Ethernet anytime required.

G. ENERGY METER

In this project we have conducted tests onSingle phase Electronic Energy meters. These are more commonly used, high precession and reliable types of measuring instruments in residential buildingsas compared to conventional mechanical meters. It consumes less power and starts measuring instantaneously when connected to load.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.

H. ETHERNET MODULE

Ethernet is a family of computer networking technologies for local area networks (LANs) and metropolitan area networks (MANs). In this project we have used Microchip's ENC28J60 which is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It is designed to serve as an Ethernet network interface for any controller equipped with SPI which is the method of transferring data one bit at a time sequentially over a communication channel.

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ENC28J60 is a 28-pin, 10BASE-T standalone Ethernet Controller with on board MAC & PHY, 8 Kbytes of Buffer RAM and an SPI serial interface. With a small foot print package size the ENC28J60 minimizes complexity, board space and cost. Target applications include VoIP, Industrial manufacturing of energy meters is in large numbers and require testing of the energy meter continuously with minimizing the errors caused by humans.

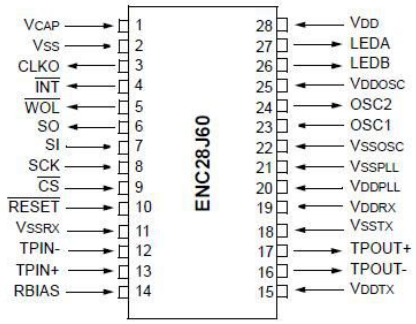

Fig 60:Pin diagram of ENC28J60

RESULTS

The results obtained in this project from the automated test set up is the display as PASS or FAIL of the energy meter tested on LCD and also detailed test results are obtained whenever requiredin the Local Area Network Server using Ethernet by giving the IP address assigned.

Fig 7: Output of Automated testing of Energy Meter showing test is PASS.

Fig 8:Output of Automated testing of Energy Meter showing test is FAIL.

CONCLUSION

To control revenue losses, utilities worldwide need to detect and continue billing accurately when tampering has occurred. This automated test setup will be helpful in our present dynamic life where each second has its

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significant value. Specially it will be helpful for those industries where the process of manufacturing of energy meters is in large numbers and require testing of the energy meter continuously with minimizing the errors caused by humans.

ADVANTAGES

- The test setup developed is automated to eliminate human errors.
- Testing steps are pre-programmed where the setup utilizes company's patent technology, and once the test setup is turned on, the testing is carried out completely thus minimizing human interference during the process of testing.
- The test results are automatically dumped into the server and can be retrieved anytime needed by using an IP address and can be printed out which consumes less time than fetching data manually at the Local Area Network.
- The test setup so built does not have continuous PC connection thus reducing the investment.

FUTURE SCOPE

- The design can be made more compact on a single PCB and further miniaturized.
- Multiple meters can be tested using de-multiplexers.
- Test set up can be developed to carry out various other tests on the meter.
- Test results can be made available in any place by improving the distance of communication

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