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Prepaid Energy Meter with Theft Detection

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Abstract –

In this paper, Improved Short Message Service (SMS) based on Prepayment Energy Meter Monitoring System for Consumers and utility ervices is developed. This is evidenced by the desire of consumers to be able to monitor their meters, especially their use. Also, utility companies need to be able to monitor wireless power meters especially for power assessments and other controls that may be required. The Energy Meter contains PC817 that is used to record pulses in energy meter. Recorded pulses are sent to the Atmega328P, the main controller of the system in its application for updated every second. This controller also controls the unit according to the usage and other functions of the meter. Made with SMS service that is able to connect the Atmega360 with the SIM900 Global System for Mobile Communications (GSM) module. The system also has a server containing the Atmega328P module and a SIM900 GSM that enables the company to access the meter. The server is connected to a PC used by the administrative and administrative platform. The SMS communication command is upgraded to C ++ to achieve metered system monitoring functionality. SMS duration test shows an average time of 32.7s with a standard deviation of 13.71. The SMS Command Reliability Test performed shows a success rate of up to 100% and a high failure rate of 5.88%. The results obtained show that GSM-Based SMS is a good source of energy meter monitoring.

Key Word-- GSM-Based SMS system, Prepayment Energy Meter, Atmega Microcontroller and SMS Command

I. INTRODUCTION

In today's world electricity has become an indispensible part of our everyday life. It is a major driving factor for advances in technology. In a developing country like India with such a large population who wants access to electricity, the metering of electricity usage at household level proves to be a

manpower extensive task where a representative from the electricity company goes door to door and takes readings from meters installed at homes and gives bills to subscribers which is to be paid. Also, electricity theft is quite common which further strains the already burdened electricity grid in our country. It is a menace for the electricity boards/companies. Arduino based Prepaid Electricity which makes the billing of electricity consumption by a user prepaid. The primary application of this project is to calculate the energy consumption based on the number of pulses generated in the electricity meter, and subsequent deduction of money from the balance amount. This makes the user aware of the consumption of electricity but also reduces human effort of door to door billing, as the system would send timely and appropriate messages to the registered user in case of low balance in the system. The system is designed to make it tamper proof and in case of any external human intervention, it would report the electricity board about the same and switch off the power supply. An auto detection system for electricity theft has been employed which allows to tackle the menace of electricity theft faced by electricity boards to make sure that no un-authorized usage of electricity takes place. Tamper proofing of the system makes sure that there is no intentional tampering of the electricity meter to alter or stop the billing of electricity consumption.

II. LITRATURE REVIEW

1.Anti-theft metering for smart electrical distribution system:

A conceptual approach was used to determine both the approximate location of energy theft and estimation of the energy theft at the location using power line

communication as the tool of communication by AMI's. Analog signal being continuous in nature, reflects deterioration that occurs during its transmission from the sender to the receiver end. The signal's signature deterioration is utilized for diagnosis and localization of energy theft. Using Power line carrier (PLC), a carrier frequency is modulated on top of existing 50/60-Hz power line carriers. In this system, meters communicate with each other via PLC such that if meter A sends a signal to meter B, meter A acknowledges and sends to the base station. If no tapping has occurred between the meters, signal will not deteriorate. The Automatic Metering Infrastructure must be equipped with filters as the signal must be filtered before supplying power to the loads. This filtered signal is compared with the base signal or reference signal to determine if deterioration has occurred and to what level. If there is deterioration, which indicates that power has been tapped illegally between the two meters, meter B will identify this corrupt signal and will communicate it to the central station. The degree of deterioration is dependent on the power consumed at the illegal tapings between the meters. In addition, since the metering facility employed here is of Automatic Metering Infrastructure (AMI) type, and communication exists between meters and base stations, electricity theft coordinates could be located within the range of two meters where deterioration occurred. For this system to be effective, all valid meters must be equipped with PLC handshaking capability.

2.Anti-theft automatic metering interface: Abhijeet Das et al. proposed an anti-theft automatic metering interface system that consists of a microcontroller (Arduino) that will continuously monitor and store the energy meter readings in its memory. GSM module was used for monitoring and controlling the energy meter remotely with the help of an interfacing circuitry which counts the pulses with respect to the amount of power the user consumes. The stored energy value is sent to the microcontroller at the utility base on request usually at 30days count interval for the purpose of billing. To detect meter bypassing, they suggested that a comparator be set in parallel to the meter, such that, two inputs are fed into the comparator, one before the supply enters the meter and the other input taken from the point after it passes the meter. In the case of bypassing, there will be a huge difference between the input values to the comparator and hence a large current passes through this comparator which feeds the microcontroller. A tactile sensor which is sensitive to touch, force, pressure was proposed for detection of meter tampering.

3. Intelligent power theft detection model for prepaid energy metering in Nigeria:

The author proposed a power theft detection model made up of three parts, namely: Intelligent Prepaid Meter (IPEM) which is at the consumer's end, Intelligent Power Theft Detection System (IPTDS) at the transformer end or at the electric pole before distributing to consumer, and the Utility Control Server. Unmetered energy consumption is detected by the IPTDS. The communication channel for this implementation is Radio Frequency and GSM communication. A sent SMS is triggered once, and an unmetered consumption is detected. The IPTDS is based on the principle of installing a tree of meters below the IPTDS such that each meter measures the power consumed by the meter directly below it. An intelligent statistical meter is placed at the node of the residential power grid with additional meters placed below it for measuring the consumption of loads beneath it in the branch. A comparison is done by the system between the readings taken by the main Intelligent Statistical Meter and those obtained from the branch intelligent meters. If the values obtained from the main ISM are far greater than those obtained from the sum of the branches, it indicates the usage of illegal power by the consumers and hence the main ISM sends a SMS to the utility.

III. PROPOSED METHODLOGY

This section discusses in detail and the description of the work done, modelling and design of the proposed system. Figure 1 depicts the functional block diagram of the smart prepaid energy meter for energy theft detection. This shows how the various components are interlinked.

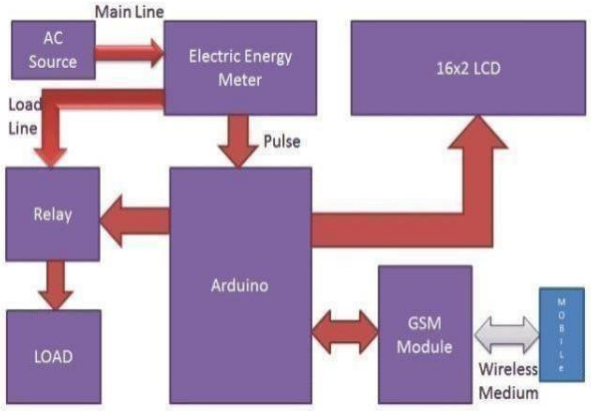


Fig 1: Functional block diagram of proposed model

Here we have interfaced electricity energy meter with Arduino using the pulse LED (Calibration or Cal) of electricity energy meter. We only need to connect this CAL LED to Arduino through an optocoupler IC. When we power up the system then it reads previous values of rupees stored in EEPROM and restores them into the variables then checks the available balance with the predefined value and take action according to them, like if available balance is greater than 15 rupees then Arduino turns On the electricity of home or office by using relay. And if balance is less than 15 rupees then Arduino sends a SMS to user phone regarding low balance alert and requesting to recharge soon. And if balance is less than 5 rupees then Arduino turns Off the electricity connection of home and sends a SMS to user's phone for 'Light Cut' alert and requesting to recharge soon. GSM module has been used to send and receive messages, you can check about GSM module and AT commands here.

IV. WORKINGMODEL

In prepaid energy meter system , arduino is taking electricity usage readings from energy meter. For that , pulse led of meter is connected to arduino via an optocoupler. For each pulse , a unit is deducted from consumers electricity balance. When the number of units reaches zero , arduino auto cuts the power supply of consumer using a relay. When recharged , power supply will automatically be restored by arduino.

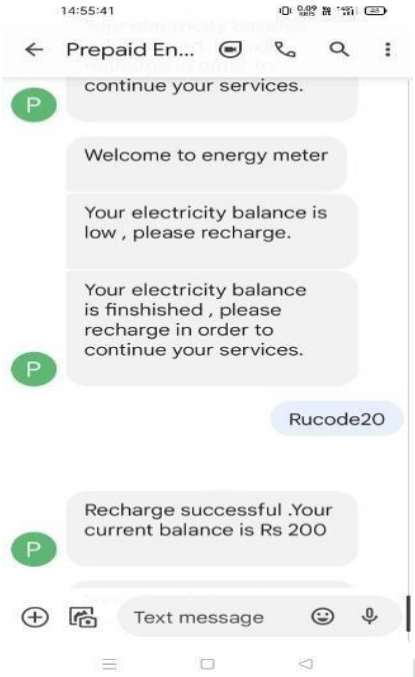


Fig. 2: SMS alerts received by user on the registered Number

For theft detection , we are using a mechanical endstop here . If someone opens the meter , its switch will be pulled and it will signal arduino which will send theft alert message to both company and consumer via GSM module

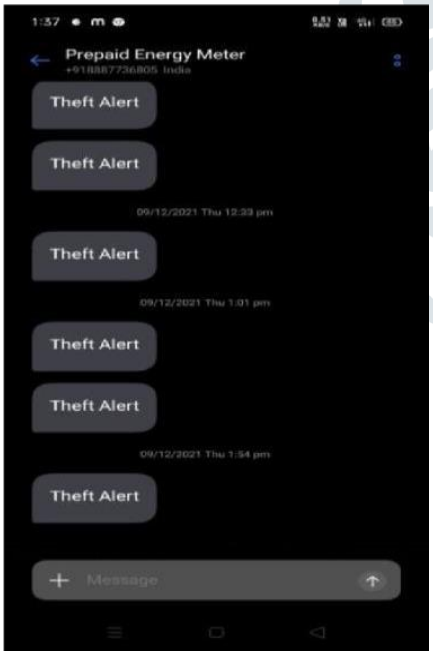


Fig.3 : Alerts received when tampering is detected.

V.SYSTEMREQUIREMET

1. ARDUINO UNO:

1. Arduino UNO is a low-cost, flexible, and easy-touse programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output.
2. Arduino UNO features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output.

3. This board contains a USB interface i.e. USB cable is used to connect the board with the computer and Arduino IDE (Integrated Development Environment) software is used to program the board.
4. The unit comes with 32KB flash memory that is used to store the number of instructions while the SRAM is 2KB and EEPROM is 1KB.
5. The operating voltage of the unit is 5V which projects the microcontroller on the board and its associated circuitry operates at 5V while the input voltage ranges between 6V to 20V and the recommended input voltage ranges from 7V to 12V.

ARDUINO UNO COMPONENTS:

The Arduino UNO board contains
The following components and
specifications:

1. **ATmega328:** This is the brain of the board in which the program is stored.
2. **Ground Pin:**there are several ground pins incorporated on the board.
3. **PWM:** the board contains 6 PWM pins. PWM stands for Pulse Width Modulation, using this process we can control the speed of the servo motor, DC motor, and brightness of the LED.
4. **DigitalI/O Pins:** there are 14 digital (0-13) I/O pins available on the board that can be connected with external electronic components.
5. **Analogue Pins:** there are 6 analogue pins integrated on the board. These pins can read the analogue sensor and can convert it into a digital signal.
6. **AREF:** It is an Analog Reference Pin used to set an external reference voltage.

7. **Reset Button:** This button will reset the code loaded into the board. This button is useful when the board hangs up, pressing this button will take the entire board into an initial state.

8. **USB Interface:** This interface is used to connect the board with the computer and to upload the arduino sketches (Arduino Program is called a Sketch)

9. **DC Power Jack:** This is used to power up the board with a power supply.

10. **Power LED:** This is a power LED that lights up when the board is connected with the power source.

11. **Micro SD Card:**The UNO board supports a micro SD card that allows the board to store more information.

12. **3.3V:** This pin is used to supply 3.3V power to your projects.

13. **5V:**This pin is used to supply 5V power to your projects.

14. **VIN:** It is the input voltage applied to the UNO board.

15. **Voltage Regulator**: The voltage regulator controls the voltage that goes into the board.

16. **SPI:** The SPI stands for Serial Peripheral Interface. Four Pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) are used for this communication.

17. **TX/RX:** Pins TX and RX are used for serial communication. The TX is a transmit pin used to transmit the serial data while RX is a receive pin used to receive serial data.

2. ACTIVE BUZZER:

Active buzzers are called active because they only need a DC voltage to produce sound. Active buzzers are types of magnetic buzzers. Inside the buzzer, there is a coil of wire that's connected to the buzzer's pins. There is also a round magnet that surrounds the wire coil. A thin metal film with a metal weight attached to the top sits above the round magnet and wire coil. When pulses of current are applied to the wire coil, magnetic inductance causes the metal weight and metal film to vibrate up and down. The vibration of the metal film produces sound waves:

Buzzer Features & Specification

1. Operating Voltage: 4-8V DC.
2. Rated current: <30mA.
3. Sound Type: Continuous Beep.
4. Resonant Frequency: ~2300 Hz.
5. Small and neat sealed package.
6. Breadboard performance friendly.

3.MECHANICAL ENDSTOP:

Mechanical End-stop Switch uses a lever switch to detect when it is activated. The switch is wired up so that when activated, it pulls the signal to LOW. There is also an LED on the board that will light up when the switch is activated. It uses a standard 4 pin 100″ pitch header and accepts a standard, old-style CD-ROM audio connector cable. The mechanical end-stop is a simple solution to a simple problem. We want to be able to detect when an X/Y/Z stage has reached its minimum or maximum. Instead of messing with flags or complicated light beam interruption, we use a mechanical switch. If we place the switch in the path of the stage, then the stage itself will simply close the switch when it moves against it. Other than properly positioning the switch, we do not need to modify the stage at all. If you're worried about reliability, you can sleep well at night. The switches we use are rated for 1 million operations before failure. Since we only use the switches once per print, that means you'll be able to do one million prints before having to replace the switch.

Connection Description:

1. Red Line: connecting VCC (ramps of +)
2. Black Line: connecting GND (ramps of -)
3. Green or Yellow Line: connecting SIGNAL (ramps in s)

Specifications:

1. Operating Voltage: 300V DC
2. Max. Operating Current: 2A
3. Temperature Resistance: 80°C
4. Cable Length: 70cm

4. SIM 900A:

The Module SIM900A looks like a single chip but it has a bunch of features that can help to build almost many commercial applications. Although, there are a total of 68 pins on SIM900A and using these pins helps to build the applications. But we will need few pins if you we use a module for interfacing with Arduino. We lists details of pinout diagram in next section.

SIM 900A Pin Configuration:
The GPIO pins help to perform the simple and advance I/O function. All pins give the maximum output equal to the power supply which is useable to control most of the devices like sensors and other modules.

All GPIO pins in SIM900A are:

GPIO1 – Pin40
GPIO2 – Pin41
GPIO3 – Pin42
GPIO4 – Pin43
GPIO5 – Pin44
GPIO6 – Pin47
GPIO7 – Pin48
GPIO8 – Pin49
GPIO9 – Pin50
GPIO10 – Pin51
GPIO11 – Pin67
GPIO12 – Pin68

Status pins:

The module has two status pins which help to indicate two different kinds of status. The first one is the working status of the module and the second for communication status. Net status means either the module is connecting to the network or other network functions, etc. Both these pins can't operate LED directly. They always act with a combination of a transistor.

STATUS – Pin52
NIGHTLIGHT – Pin66

5.RELAY MODULE:

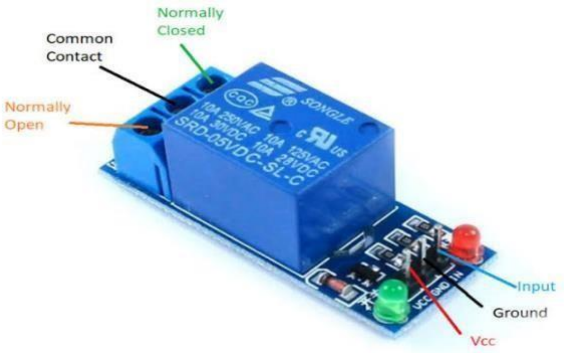
A 5v relay is an automatic switch that is commonly used in an automatic control circuit and to control a high-current using a low-current signal. The input voltage of the relay signal ranges from 0 to 5V.The relay module with a single channel board is used to manage high voltage, current loads like solenoid valves, motor, AC load & lamps. This module is mainly designed to interface through different microcontrollers like PIC, Arduino, etc.

Pins Configuration:

1. **IN:** pin is used to control the relay. It is an active low pin, meaning the relay will be activated when you pull the pin LOW and it will become inactive when you pull the pin HIGH.
2. **GND**: GND is the ground connection.
3. **VCC:**VCC pin supplies power to the module
4. **COM**: COM pin is connected to the signal you are planning to switch.
5. **NC:** NC pin is connected to the COM pin by default, unless you send a signal from the Arduino to the relay module to break the connection.
6. **NO:** NO pin is open by default, unless you send a signal from the Arduino to the relay module to make the connection.

Specifications:

1. Supply voltage – 3.75V to 6V
2. Quiescent current: 2mA
3. Current when the relay is active: ~70mA
4. Relay maximum contact voltage – 250VAC or 30VDC
5. Relay maximum current 10A



6. OPTOCOUPLER:

An Optocoupler, is an electronic component that interconnects two separate electrical circuits by means of a light sensitive optical interface.
There is a is a light emitting diode with a phototransistor inside the optocouplers, both of them are isolated from the external environment of the optocoupler; This means that the internal phototransistor can only receive light emitted by the internal light emitting diode. The phototransistor base is stimulated by light received from a light emitting diode and can pass current according to it.

Opto-couplers are used where two circuits need to be separated and isolated. For example, when we want the control circuit (for example, processors) to be separate from the power circuit (for example, relays, motors, etc.) we use optocoupler to remove the power circuit noise on control circuit.

Pin :
Each optocoupler has 4 pins:

Input pins:
IN: Input – 5 to 30 V
GND: Ground
Output pins:

OUT: Phototransistor collector pin
GND: Phototransistor emitter pin.

7. LCD (Liquid Crystal Display)

A program must interact with the outside world using input and output devices that communicate directly with a

human being. One of the most common devices attached to a controller is an LCD display. Some of the most common LCDs connected to the 8051 are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

The data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

The LCD requires either 8 or 11 I/O lines to communicate with. For the sake of this tutorial, we are going to use an 8bit data bus—so we'll be using 11 of the 8051's I/O pins to interface with the LCD. Let's draw a sample pseudoschematic of how the LCD will be connected to the UNO.

VI.APPLICATIONS

1. Prepaid energy meter is used to provide energy when meter contains balance.
2. Helps in digitalization as it provide online payment facilities.
3. Theft detection is used to prevent meter tampering.

VII. ADVANTAGES

1. Prepaid energy meter gives you control over your energy spend .
2. It enables you to manage your cash flow and allocate cost properly.
3. Designed for considering Human safety operation.
4. You don't have to worry about building up debt as you purchase your energy before you use it making you more aware of your running energy costs
5. You always have an idea of what your remaining balance is as it's displayed clearly on the meter screen which helps you avoid nasty surprise.

VIII. CONCLUSION

By using this techniques the crime of stealing power may be brought to an end and thereby a new bloom may be expected in the economy of ourmotherland and also there will be less scarcity for power utilisation .

IX. REFERENCE

https://www.researchgate.net/publication/336888696_Smart_prepaid_energy_metering_system_to_detect_energy_theft_with_facility_for_real_time_monitoring

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