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PREPAID SMART ENERGY METER

[1]Ms. Ankalgikar S.P.,[2]Ms. Langote G.B., [3] Ms. Kadam Sakshi S.,[4] Ms. Jadhav Pratiksha J.

[1]Lecturer,[2]Lecturer, [3]Student,[4] Student
[1]Electrical Engineering Department,
[1]Shri Siddheshwar Women's Polytechnic, Solapur, India

Abstract: Most of the developing countries are moving in to smart meters equipped with prepayment facility to measure electricity in order to reduce the financial losses faced by power ministry due to consumer reluctance to make bill payments on time. Prepaid smart meters increase awareness in consumer to effectively manage their electricity usage. The prepaid energy meter is a single phase 230Venergy meter which contains of a metering devise designed according to the IEC1036 (1996-09) standard and a prepaid module that uses GSM/GPRS technology to communicate with the utility server. Currently Billing system is monthly and manual reading is taken. it takes lot of time. large human power involved to take reading and circulate bill of electricity.so due to this here we are developed such a system which is fast, accurate and less involvement of human. this system is paperless it means it is ecofriendly.as message about recharge is send directly to customer mobile number. Doing simple modification in Energy meter we can make simple energy meter in SMART ENERGY METER. Use of this type of energy meter can improve the revenue and saving in wastage of electricity.

Index Terms: Electronics Energy Meter, Arduino, GSM Module.

INTRODUCTION

The cost of electrical energy has been increasing over the years. This creates a concern among utilizer's regarding the energy usage efficiency of the electrical appliances that they are using. Thus, there is a need to design and implement a Prepaid Energy meter System to control the amount of energy supply. The purpose is that is to design and implement a Prepaid Energy Meter System to control the amount of energy supply based only on the prepaid amount. This facility can be used in shared environments and the consumer utilized the energy supply based accordingly to its available credit which can be topped-up.

Prepaid Energy Metering System referring to the concept 'First Come First Serve' but for prepaid energy meter the concept is 'First Pay First Serve'. For usage of electricity utilizers need to pay money before use. After a reload, the credit is activated and from that, all of the electricity will start being used. When the credit runs out, electricity will be cut off immediately. To utilization of electricity consumers needs to reload and fill in the credit.

A smart energy metering system can control effectively the amount of electricity consumed by the consumers. Electricity users can buy a required amount of electricity to use it only when they required. So, all consumers will be more carefully utilize and will not waste the electricity and be more responsible about it. The basic prepaid system is used to reload more energy supply and saved it on energy storage for further used, but nowadays it comes with various functions to fulfill consumer needed. However, to own the system, it will be quite pricey.

PROBLEM STETMENT

In conventional energy meter, consumer has to pay electrical bill after the consumption of energy as per the reading of the meter. so extra manpower is needed for taking the reading of the meter every month. Due to consumer reluctance to make bill payments on time, electricity board need to face financial crisis.
Some time consumers not getting clarity regarding units' consumption per month through monthly bills. If we see financial way cost of electricity increasing day by day. So, effective utilization of electricity is the necessary. In prepaid energy meter, consumer has to pay before energy consumption and no need to take a reading of meter every month. so, manpower reduces, which will be beneficial to electricity board.

COMPONENTS

Sr no.	Name of Components	specification
1	Arduino	Arduino Nano
2	GSM	SIM 800L
3	Energy meter	Digital single phase
4	Optocoupler	
5	LED	16*2
6	Bulb Holder	
7	Dc power supply	
8	Bulb	200 Watt
9	Plastic Cabinet	
10	DC power supply	5V, 2A DC

Table No. 1. List of components

COMPONENTS DETAILS

1.1 Arduino

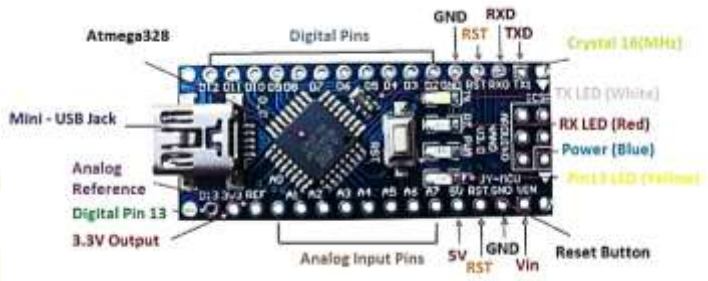

Fig no.1.1 Arduino

Arduino Nano is a small, complete, flexible and breadboard-friendly Microcontroller board, based on **ATmega328p** and contains 30 male I/O headers, configured in a **DIP30 style**. **Arduino Nano Pinout** contains of 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. It is programmed using **Arduino IDE**. Arduino Nano is a smaller version of Arduino UNO, thus, both have almost the same functionalities. It's **operating voltage of 5V** and input voltage can vary from **7 to 12V**. Arduino Nano's **maximum current rating is 40mA**, so the load attached to its pins not should draw current more than **40mA**.

Each of these Digital & Analog Pins main function is to be configured as Input/Output. Arduino Pins are interfaced with sensors acted as Input Pins, but if you are driving some load then we need to use them as an Output Pin. Functions like pin Mode () and digital Write () are used to control the operations of digital pins while analog Read () is used to control analog pins. The analog pins consist of total resolution of 10-bits which measures the value from 0 to 5V. Arduino Nano comes with a crystal oscillator of frequency 16 MHz by using constant voltage it is able produce a clock of precise frequency. There is one drawback of using Arduino Nano i.e., it doesn't come with a DC power jack. This board comes with Type-B Micro USB. Where the size of the electronic components is of great concern that time tiny size and breadboard-friendly nature make this device an ideal choice for most applications. Flash memory is 16KB or 32KB that all depends on the At mega board i.e. Atmega168 comes with 16KB of flash memory. Flash memory is used for storing code. The 2KB of memory is used for a bootloader. In Arduino Nano contains the SRAM memory of 2KB. Arduino Nano has an EEPROM memory of 1KB.

1.2 GSM

Fig no.1.2 GSM

The SIM800L GSM module consist of 12 pins that are used to connect the module to any microcontroller. The Pinout configuration is explained below:

NET: The NET pin is used to attach an For external antenna. Where we can solder Helical Antenna which comes along with the module.

VCC: The VCC pin is used to supply the positive (+) voltage to the module. To work the module finely power supply is required 3.4V to 4.4V with min 2 Amp. Also, It doesn't work on a 3.3 V power supply.

RST: This pin is a hard reset pin. Pulling this pin low for 100 ms to perform hard reset of the module.

RXD(Receiver): RX pin is used for Serial communication

TXD(Transmitter): TX pin is used for Serial communication

GND: This is the Ground Pin. It needs to be connected to the GND pin on the microcontroller.

SPK±: SPK + and SPK – is a differential speaker interface. By these two pins speaker can be connected. The positive pin of the speaker is connected to the SPK+ pin and the negative Pin to the SPK-.

MIC±: MIC+ and MIC- pins are differential microphone inputs. By these two pins microphone can be connected. The positive pin of the micro phone is connected to the MIC+ pin and the negative Pin to the MIC-.

DTR: To activate sleep mode pulling his pin HIGH. In sleep mode, the module disables serial communication. Pulling it LOW to deactivate sleep mode, that is nothing but module wakes up.

RING: The RING pin is acts like Ring Indicator. RING pin is used in detecting calls and SMS. From the module this is the 'interrupt' out pin. It is by-default high. Whenever the call is received it gives a LOW pulse for 120ms. Also, it can be configured to pulse when an SMS is received.

SIM800l GSM Module

The SIM800L GSM/GPRS module contains four key components that are SIM800L GSM cellular chip, LED Status Indicators, Antennas, and Micro-SIM socket. It's very important roles in the work of the module.

SIM800L GSM cellular chip

On the top surface of the GSM module. This is a Quad-band SIM800L GSM/GPRS cellular chip from Samco in SMT type. SIM800L provide a supports Quad-band frequency its works on frequencies 850MHz, 900MHz, 1800MHz, and 1900MHz, also it can able to transmit and receive voice, SMS, and data information with low power consumption. The operating voltage of this chip is from 3.4V to 4.4V which makes it ideal to operate by a LiPo battery supply. This chip supports a baud rate from 1200bps to 115200bps with Auto-Baud detection. For embedding into projects without a lot of space tiny size of 17.6*15.7*2.3mm which makes a good choice.

LED Status Indicators

On the topmost right corner side of the SIM800L Module, we can see an LED that indicates the status of your cellular network. The LED will blink at three different ratios once applying the power supply to the module, which shows three different statuses of your cellular network.

Blink every 1s: When the LED Blinking with a delay of 1s, then it indicates that the GSM module is running but it hasn't made the connection to the cellular network yet.

Blink every 2s: When the LED Blinking with a delay of 2s, then it indicates that The GPRS data connection you requested is active.

Blink every 3s: With a delay of 2s when the LED Blinking, then it indicates that the module has made contact with the cellular network and it is ready to transmit/receive voice and SMS.

Antennas: In the module an antenna is a vital part, it is used for data or voice communications as well as some SIM commands. To connect Antennas SIM800l GSM/GPRS module provides two ways. There are two types of antennas that can connect to the module one is a Helical GSM antenna and another one is PCB Antenna.

Helical GSM Antenna: The Helical GSM antenna is made of wire, which usually comes with the module. It can be soldered directly to the NET pin on PCB.

PCB Antenna: We can see a U. To connect the PCB antenna FL male connector present at the top-left corner of the module. This antenna has better performance and allows you to put your module inside a metal case. the antenna is outside.

Micro-SIM socket: SIM socket is available bn the backside of the module, where we can insert an activated 2G micro-SIM card. When we insert a SIM card into the socket, that time we must sure that the notch point will upwards. On the surface of the SIM socket the symbol of the SIM card is engraved that helps us to identify the correct direction of SIM inserting.

Pinout/Pin Diagram of **SIM800L GSM/GPRS Module**

1.3 Energy meter

Fig no.1.3 GSM

An energy meter is an important as well as essential device that goes with consumption of commercially distributed energy.

Electrical energy meter enables systematic pricing of energy consumed by individual consumer as it measures the amount of electrical energy consumed by a residence/ Commercial load or an electrically powered device. They are typically calibrated in billing units, the most common one being the Kilowatts hour, which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000 joules.

Some meters measured only the length of time for which charge flowed, with no measurement of the magnitude of voltage or current. These were only suited for constant-load applications. Neither type is likely to be used today.

Types of Digital Energy Meters

The meters have two main types i.e. electromechanical and electronic. This paper based on the electronic meter (i.e., the digital meter).

Digital Energy Meters Work

By continuously measuring the instantaneous voltage (volts) and current (amperes) the digital energy meter operates. By finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (Joules, Kilowatt-hours etc.). Meters for smaller services (such as small residential customers) can be connected directly in-line between source and customer. Current transformers are used for larger loads i.e., more than about 200 amps of load, so that the meter can be located other than in line with the service conductors.

1.4 RELAY

Fig no.1.4 Relay

A Soiled state relay is an electronic switching device that switches ON or OFF when a small external voltage is applied across its control terminals lied state relays are semiconductor equivalents of the electromechanical relay and can be used to control electrical load without the use of moving par.

1.5 LCD DISPLAY

Fig no.1.5 LCD Display

LCD display has high quality 16 character by 2-line intelligent display module, with back lighting, this LCD display works with any microcontroller. This is a popular 16x2 LCD display. This LCD display is easy to interface with most micro controllers. This display works of 5v and it has a green back light which can be switched on and off as desired. The contrast of the screen can also be controlled by varying the voltage at the contrast control pin (pin 3).

Features

16 Characters x 2 Lines

5x7 Dot Matrix Character Cursor

HD44780 Equivalent LCD Controller/driver Built-In

4-bit or 8-bit MPU Interface.

1.6 Optocoupler

Fig no.1.6 Optocoupler

An optocoupler (also called opt isolator) is a semiconductor device that allows an electrical signal to be transmitted between two isolated circuits. An optocoupler two parts are used in: LED that emits infrared light and a photosensitive device that detects light from the LED.

BLOCK DIAGRAM

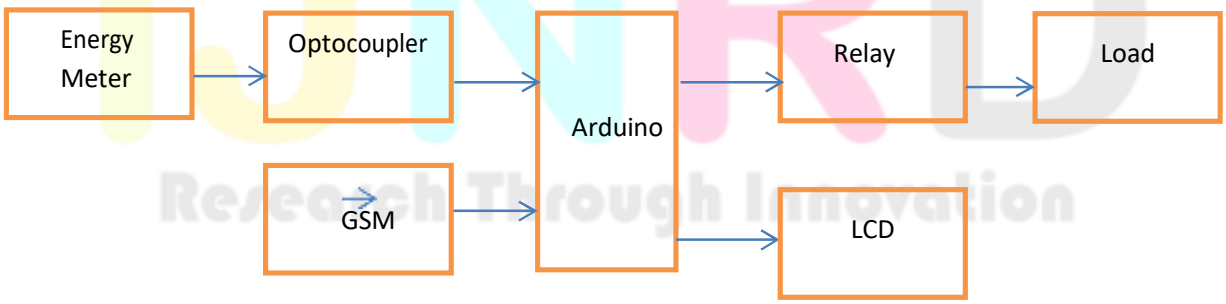

Fig no.1.7 Block diagram

In this Block Diagram Energy meter is connected to Arduino by using Optocoupler. Arduino counts the pulses received from optocoupler. These pulses are indication of power consumption. Consumer has to recharge fist to get electricity on. when it recharges, SMS is received on GSM.it is read by Arduino. Arduino will allow the consumer to use electricity equal to recharge amount. Simple Digital Energy meter is used. GSM module SIM800L is used. Arduino NANO, Relay,16 X 2 LCD display is used in this project. To get fast pulses we are using 200 Watt Lamp as a Load.

CIRCUIT DIAGRAM

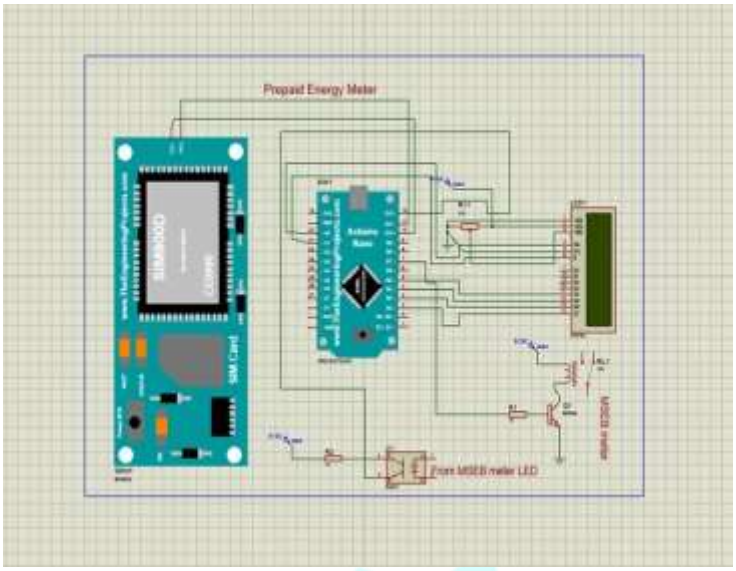

Fig no.1.7 Circuit Diagram

CTRCUIT DIGRAM DISCRIPTION

The circuit diagram for a digital meter. Here, two basic sensors are employed. These are voltage and current sensors. The voltage sensor built around a step-down element. The potential divider network senses both the phase voltage and load voltage. The second sensor is a current sensor; The role of this sensor is to senses the current drawn by the load at any point in time. It is built around a current transformer and other active devices such as voltage comparator. which convert the sensed current to voltage for processing. The output from both sensors is then send to the signal (or voltage) conditioner which ensures matched voltage or signal level to the control circuit, it also contain a signal multiplexer. signal multiplexer enables sequential switching of both signal to the analogue input of the peripheral interface controller (PIC). On a PIC integrated circuit the control circuit centered. The PIC is selected because it contains ten bits analogue to digital converter (ADC), very flexible to program and good for peripheral interfacing.

The analogue to digital converter converts the analogue signals into the its digital equivalent; both signals from the voltage and current sensors are then multiplied by the means of embedded software in the PIC. Here the error correction is taken as the offset correction by determining the value of the input quality with short-circuited input and storing this value in the memory for use as the correction value device calibration. The PIC is programmed in C language. Such that apart from the multiplier circuit peripheral interface controller is simulates, peripheral interface controller is able to use the received data to calculate power consumption per hour, as well as the expected charges.

WORKING

This project is based on Arduino Microcontroller which uses AT Mega 328P. Arduino Nano is used for this purpose. Single phase Digital Energy Meter is used for this purpose We have connected optocoupler to the CAL led of Energy Meter. This led gives pulses to the optocoupler according to the load. Optocoupler is used to provide optical isolation between 230V supply side and 5V Arduino side.so that Arduino circuit is protected from any hazardous condition. there is no direct contact between Arduino and energy meter. Arduino nano is interfaced to the optocoupler and it counts pulses from optocoupler. For 1KW it gives 1000 pulses. Here counting of pulses is measurement of load.

For Recharge we are sending SMS. SMS is read by Arduino Nano. According to Recharge amount Arduino will monitor the Pulses after that, when Recharge amount load consumption is done Arduino nano will disconnect the Energy Meter. Here 16X2 LCD display is used and connected to Arduino pin as-rs = A0, en = A1, d4 = 5, d5 = 4, d6 = 3, d7 = 2; 5V DC supply is given to LCD at Pin 15. 10k Ohm pot is connected in LCD pin 1,2,3. This pot used to adjust the contest of LCD. LCD is used for Local indication

When we start the system first it is essential to get SIN800l in network. SIM 800L start blink very fast until it not connected to network. When it is connected to network then LED will blink after every 3 second. The supply voltage of GSM is 3.7V to 4.4 V dc. The TX & RX pin of GSM is connected to the RX & TX pin (10,11) of Arduino NANO. Arduino will communicate with GSM by using AT commands: - AT+CMGF=1 & AT+CMGS=MobileNo.

At start Welcome to SSWP Smart Energy Meter message is send to registered mobile number. Then after some time message about recharge is send. Upon receiving message we have to send SMS of #9 to GSM. when this message is received to GSM, Arduino read this SMS and consider recharge of 9 Rs. And message of successful recharge is sent to the registered mobile number. And LAMP will glow.

Now Arduino start to count the pulses coming from Energy meter.

Here 1 pulse is considered as 1 unit. when 7 pulses are counted then Arduino will send SMS to registered mobile number that Please Recharge. Your Balance will exhaust soon. & when 9 pulses are received then SMS of Please Recharge. You consumed total recharged amount. Your Balance is exhausted is send to registered mobile number. and supply will off.

SOFTWARE DESCRIPTION

Arduino IDE

In the programming language Java, the Arduino integrated development environment (IDE) is written in. Arduino IDE is used to write and upload programs to Arduino board. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main () into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program argued to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

PROGRAM

```
//Smart Prepaid Energy Meter//
//Womens Polytechnic Solapur 2022-23//
//Completed//
#include <SoftwareSerial.h>
SoftwareSerial mySerial(10, 11); // RX, TX
#include <LiquidCrystal.h>
const int rs = A0, en = A1, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
#include <SoftwareSerial.h>
// constants won't change. They're used here to set pin numbers:
const int buttonPin = 12; // the number of the pushbutton pin
const int ledPin = 13; // the number of the LED pin
const int relayPin = 7;
int i;
char c;
char d;
int e;
int f;
// variables will change:
int buttonState = 0; // variable for reading the pushbutton status
void setup() {
// initialize the LED pin as an output:
pinMode(ledPin, OUTPUT);
pinMode(relayPin, OUTPUT);
// initialize the pushbutton pin as an input:
pinMode(buttonPin, INPUT);
Serial.begin(57600);
digitalWrite(relayPin, HIGH);
disp();
mySerial.begin(9600);
welcome();
```

```
delay(2000);
Recharge();
delay(5000);
}
void loop()
{
Rec();
ReadMessage();
digitalWrite(relayPin, LOW);
i=0;
f=7;
do{
lop1 ();
if(i==f)
{ mySerial.begin(9600);
mySerial.println("AT+CMGF=1");
delay(500);
mySerial.println("AT+CMGS=\"+91----------\"\r");//
delay(500);
mySerial.print("Please Recharge.Your Balance will exaust soon");mySerial.println((char)26);
delay(500);
f=4;
}
}while(i!=e);
digitalWrite(relayPin, HIGH);
mySerial.begin(9600);
mySerial.println("AT+CMGF=1");
delay(500);
mySerial.println("AT+CMGS=\"+91----------\"\r");//
delay(500);
mySerial.print("Please Recharge.You consumed total recharged amount.Your Balance is
exausted");mySerial.println((char)26);
delay(500);
}
void lop1 () {
// read the state of the pushbutton value:
buttonState = digitalRead(buttonPin);
// check if the pushbutton is pressed. If it is, the buttonState is HIGH:
if (buttonState == HIGH)
{
i=i+1;
unit();
do{
buttonState = digitalRead(buttonPin);
}while(buttonState == HIGH) ;
}
```

```
buttonState = digitalRead(buttonPin);
if (buttonState == LOW)
{
do{
buttonState = digitalRead(buttonPin);
}while(buttonState == LOW) ;
}
}
void disp()
{lcd.begin(16, 2);
lcd.print("SSWP Prepaid");
lcd.setCursor(0, 1);
lcd.print(" Energy Meter");
delay(10000);
}
void unit()
{lcd.begin(16, 2);
lcd.print("Unit Consumed=");
lcd.print(i);
lcd.setCursor(0, 1);
lcd.print("Cost of Unit=");
lcd.print(i);
}
void Rec()
{lcd.begin(16, 2);
lcd.print("Please Recharge");
delay (4000);
}
void Recharge()
{lcd.begin(16, 2);
lcd.print("Please Recharge");
delay (4000);
mySerial.begin(9600);
delay(500);
mySerial.println("AT+CMGF=1");
delay(500);
mySerial.println("AT+CMGS=\"+91----------\"\r");//----------
delay(500);
mySerial.print("Please Recharge. No balance in your account.");mySerial.println((char)26);
delay(5000);
}
void welcome()
{
mySerial.println("AT+CMGF=1");
delay(500);
mySerial.println("AT+CMGS=\"+91----------\"\r");//
```

```
delay(500);
mySerial.print("Welcome to SSWP Smart Energy Meter");mySerial.println((char)26);
delay(5000);
}
void Rechsucc()
{
mySerial.println("AT+CMGF=1");
delay(500);
mySerial.println("AT+CMGS=\"+91----------\"\r");//
delay(500);
mySerial.print("Recharge is successful of Rupees=");mySerial.print(d);mySerial.println((char)26);
delay(5000);
}
void ReadMessage()
{mySerial.begin(9600);
mySerial.println("AT+CMGF=1");
delay(2000);
mySerial.println("AT+CMGD=1");
delay(2000);
do{
if(mySerial.available())
{
c=mySerial.read();
// Serial.print(c);
}} while(c!='I');
delay(2000);
i=0;
//Serial.println("Message is Received");
mySerial.begin(9600);
delay(2000);
mySerial.println("AT+CMGF=1");
delay(2000);
mySerial.println("AT+CMGR=1");
do{
if(mySerial.available())
{
c=mySerial.read();
}
}while(c!='#');
do{if(mySerial.available())
{d=mySerial.read();
// Serial.print(d);
i=1;
}}while(i!=1);
e=d-48;
lcd.begin(16, 2);
```

```
lcd.print(" Recharge =");
lcd.print(e);
lcd.setCursor(0, 1);
lcd.print(" Successful");
Rechsucc();
digitalWrite(relayPin, LOW);
delay(10000);
}
```

ADVANTAGES

1. Timely collection of bills.
2. Less enrollment of man power
3. Most efficient system
4. It is fast system.so that time to time recharge will be done
5. If there is a Delay of recharge, then meter will automatically disconnect supply
6. Less energy consumption

APPLICATION

1. Industrial Customer
2. Domestic Consumers.
3. Commercial consumers like: school, Hospitals, Offices etc.

CONCLUSION

Billing error and reduces the maintenance cost. On LCD It displays the corresponding information for user notification. The main advantages of Smart Energy Meter are it requires less manpower, there is no need to chase payments, bill is sent to the consumer with due date, the meter can act as either prepaid or postpaid meter it's minimize the power consumption in a house. The progress in electrical technology about electrical distribution network is a non-stop process. In the present work wireless meter reading system is designed to continuously monitor the meter reading and to shut down the power supply automatically whenever the consumer fails to pay the bill. It avoids the human intervention and also provides efficient meter reading

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HARDWARE: