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Study of Various Prepaid Energy Metering System in India

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Abstract: The prepaid meter is important in making the consumer having sense about his/her energy consumption which is important in eliminating the difficulties facing the electrical utility employee in getting the reading of the conventional electromechanical meter and eliminating any error incurred in bill issuing .There were so many issues coming in the process of conventional energy resources (Electromechanical Induction and Electronic Energy Meter) like-consumes considerable amount of power, incorrect magnitude of fluxes and phase angles etc. To overcome these drawbacks we proposing a smart IOT- Internet of things based energy meter using Arduino and GSM Module. This system not only solves the problem of manual meter reading but also provide additional features such as power disconnection due to outstanding dues, power reconnection after making the necessary payments, power cut alert, tampering alert etc. instantly.
Keywords: IOT, Arduino, GSM, Energy Meter.

I. INTRODUCTION

Prepaid Electricity Energy Meter is a good concept in which we can recharge its balance, like we do in our mobile phones. In this project we are building an automated system by using Arduino and GSM module. we can recharge the electricity balance through this system, just by sending a SMS. It can also disconnect the home power supply connection, if there is low or zero balance in the system. And this system will reads the energy meter readings and automatically send some updates to user's mobile phone like low balance alert, cut off alert, resume alert and recharge alert. The term prepaid has been very much in news since the mobile revolution began in India a decade ago. Various factors have led to the genesis of Prepayment Metering concept in India keeping in view the benefits that's going to accrue to all involved in the concept and its acceptance. Prepayment or pay as you go system is receiving more and more attention worldwide as utilities are looking at ways to improve customer service, improve their cash flow and minimize their risks. The concept of prepaid remains the same but there is going to be a paradigm shift in the application. It's altogether a new arena in Metering India which is likely to be important to revenue and energy management. This will in the days to come, open up new vistas for investment and deployment of infrastructure for better customer services. There will be immense benefits, which will be reaped by the State Electricity Boards (SEBs), private utilities and citizens of India.
The objective of the paper is to share the details of Prepayment Metering system as a concept and highlight the role to be played by all stakeholders in getting the concept effectively implemented for the overall benefit of the Indian Power Section. Prepayment metering system is very simple. The consumer has a new kind of meter installed in his house which has an inbuilt disconnecting device. The customer buys electricity in advance by paying at any of the Vending office. Once the amount is exhausted the meter automatically disconnects the supply after providing an alarm. The consumer can reconnect himself by buying more electricity and recharging the meter.

II. TYPES OF ENERGY METER

These may be single phase or three phase meters depending upon the supply utilized by domestic or commercial installation. For small service measurements like domestic customers, these can be directly connected between load. But for larger loads, step down current transformers must be placed to isolate energy meters from high currents. Basically three types of energy meters are present.

1. Electro Mechanical Induction Type Energy Meter

It consists of rotating aluminium disc mounted on a spindle between two electro magnets. Speed of rotation of disc is proportional to the power and this power is integrated by the use of counter mechanism and gear trains.

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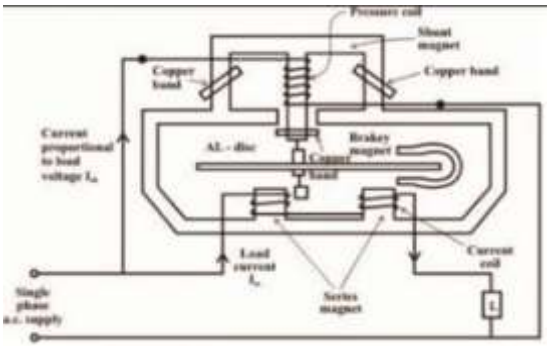

Figure 1: Electro mechanical induction type energy meter

It comprises of two silicon steel laminated electromagnets that are shunt and series magnets. Series magnet carries a coil which is few turns of thick wire connected in series with line. Series magnet produces the flux which is proportional to the current flowing. Whereas shunt magnet carries coil with many turns of thin wire connected across the supply and produces the flux proportional to the voltage. These two fluxes lag by 90 degree due to inductive nature. The interaction of these two fields produce eddy current in the disk, exerting a force, which is proportional to product of instantaneous voltage, current and phase angle between them.
Breaking magnet is a permanent magnet which applies the force opposite to normal disc rotation to move the disc at balanced position and to stop the disc while power is off.
Vertical spindle of the aluminium disc is connected to gear arrangement which records a number, proportional to the number of revolutions of the disc, this gear arrangement sets the number in a series of dials and indicates energy consumption over a time. This type of meter is simple in construction and accuracy is somewhat less due to creeping and other external fields. A major problem with these type of meters is their easy prone to tempering, leading to a requirement of an electrical energy monitoring system. These are very common used in domestic and industrial applications.

1. **Advantages of Electro Mechanical Induction type Energy meter**

a. No moving iron.
b. High torque is to weight ratio.
c. The moving element has no electrical contact with the circuit.
d. Less affected by stray magnetic field.
e. Good Damping.

2. **Disadvantages of Electro Mechanical Induction type Energy Meter**

a. Induction meters can be used only for AC measurements.
b. They consume a considerable amount of power.
c. They have nonlinear scales.

3. **Application of Electro Mechanical Induction type Energy Meter**

• Electromechanical induction type energy meters are universally used for energy measurements in homes and industries. Government and energy companies charge customers according to these readings. They are cheap to manufacture and very accurate. With some modification they are being used in measuring electricity going to machines in factories.

2. Electronic Energy Meter

Electronic Energy Meter is based on Digital Micro technology (DMT) and uses no moving parts. So the electronic energy meter is known as Static Energy meter. In Electronic energy meter the accurate functioning is controlled by a specially designed IC Called Application specified integrated circuit (ASIC). ASIC is constructed only for specific applications using embedded system technology.

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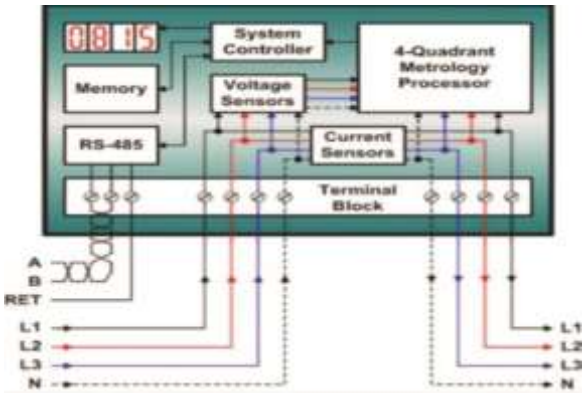

Figure 2: Electro energy meter

In addition to ASIC, analogue circuits, voltage transformer, current transformer etc. are also present in Electronic energy meter to sample current and voltage. The input data (voltage) is compared with a programmed Reference Data (voltage) and finally a "voltage rate" will be given to the output. This output is then converted into digital data by the Analogue-Digital converter presented in the ASIC.
The Digital Data is then converted into an Average Value. Average value\mean value is the measuring unit of power. The output of Analogue-Digital Converter is available in pulses indicated by the Light Emitting Diode (LED) placed on the front panel of Electronic energy meter. These pulses are equal to average Kilo Watt Hour (kwh\unit). Different ASICs with various Kwh are used in different makes of EEMs. The output pulses are indicated through LED. The ASIC are manufactured by Analogue Device company. ADE 7757 IC is generally used in many countries to make EEMs.

1 .Advantages of Electronic Energy Meter

a. Better accuracy.
b. Low current performance.
c. Low voltage performance.
d. Difficult to temper.
e. Digital display.

2 .Disadvantage of Electronic Energy Meter

a. Incorrect magnitudes of fluxes.
b. Incorrect phase angles.
c. Change in strength of brake magnet
d. Change in disc resistance• Abnormal friction of moving parts

3. Application of Electronic Energy Meter

Modern solid state electronic energy meters are recently developed electronic components to measure electrical energy. Measurement accuracy of the electronic meter is about an order of magnitude better than that of a mechanical meter, while power consumption is lower by about two orders of magnitude. The electronic energy meter is also better protection against tampering than its mechanical predecessor, and units for prepaid operation (e.g., card readers) and remote meter reading (e.g., wireless, telephone line, or internet) can easily be included.

3. Smart Energy Meters

It is an advanced metering technology involving placing intelligent Meyers to read, process and feedback the data to customers. It measures energy consumption, remotely switches the supply to customers and remotely controls the maximum electricity consumption. Smart metering system uses the advanced metering infrastructure system technology for better performance. These are capable of communicating in both directions. They can transmit the data to the utilities like energy consumption, parameter values, alarms, etc. and also can receive information from utilities such as automatic meter reading system, reconnected\disconnected instructions, upgrading of meter software's and other important message. These meters reduces the need to visit while taking or reading monthly bill. Modems are use
in these smart meters to facilitate com power in an illegal way.

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Figure 3: Smart Energy Meter

1 .Advantages of Smart Energy Meters

a. Eliminating manual meter readings.
b. Monitoring the electrical system more quickly.
c. Providing real time data useful for balancing electrical load and reducing power outages.
d. Making it possible to use power resources more efficient.
e. Avoiding the capital expense of building new power plants.
f.

2 .Disadvantages of Smart Energy Meters

a. Transitioning to new technology and processed.
b. Managing public reaction and customer acceptance of the new meters.
c. Managing and storing vast quantities of metering data.
d. Ensuring the security of metering data.

3 .Applications of Smart Energy Meters

Smart energy meter is an important device to manage electricity usage. It collects information of power outage from the appliances and communicates this information to the utility center.

A. **Construction of IOT based Smart Energy Meter**

1. Component:

- Power supply, 220V
- Potential Transformer
- Current Transformer
- Rectifier
- Filter capacitor
- Voltage regulator
- Relay Board
- Energy Meter Module(PZEM-004T V3)
- Arduino Mega
- GSM Module SIM800C
- LCD Module 16*2 or 20*4

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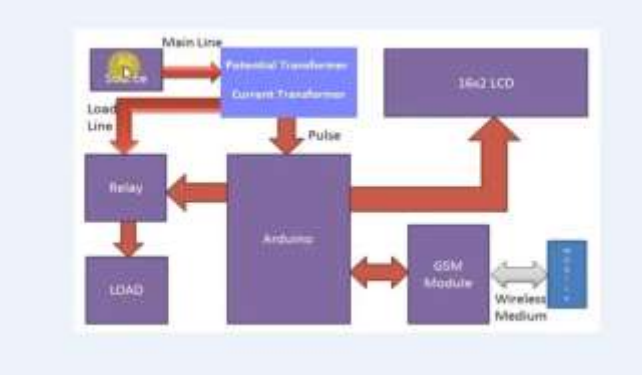
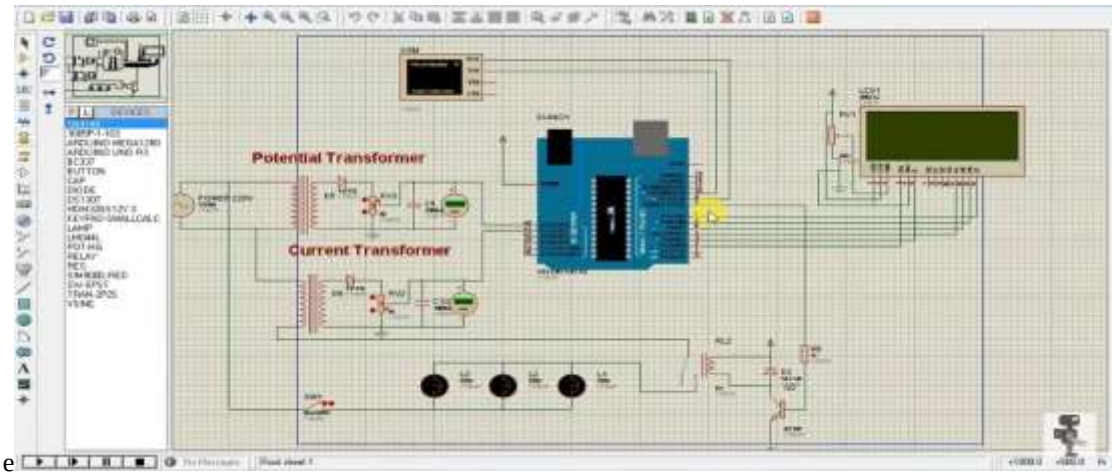


3. Circuit: there is AC source 220V Power Supply and then a pressure transformer(PT) connected to current transformer(CT) . PT is connected in parallel and CT is connected in series ie. One wire going directly to the load and one from the CT to the relay in series when it get on bulb on. Divider circuit is used to read the voltage and current. Voltage signal is going to analogue 0 and current signal to analogue 1. GSM is attached with 10 no. pin and relay on 8no. pin to turn off/on to the load. LCD is attached to 2-7 pin .



e

4. Arduino code: First of all we include required library and Define pins & variables that are required in our project. This can be seen in first few lines of our program code below. After it we initialize the LCD, serial communication, GSM and display some message. After this in loop function we read serial received data if any. And reads pulse from energy meter and show units and balance on LCD.

```
void setup()
{
  lcd.begin(16,2);
  Serial.begin(9600);
  pinMode(led, OUTPUT);
  .. ...
  ... ....

lcd.print("Circuit Digest");
  lcd.setCursor(0,1);
  delay(2000);
  lcd.print("GSM Initilizing...");
  gsm_init();
  .. ..
```

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After this in loop function we read serial received data if any. And reads pulse from energy meter and show units and balance on LCD.

```
void loop()
{
 serialEvent();
 rupees=EEPROM.read(1) ;
 units=rupees/5.0;
 lcd.setCursor(0,0);
 lcd.print("Units:");
 .. ...
```

void init_sms(),void send_data(String message), and void send_sms() functions have been used to send SMS.

gsm_init() function is used for initializing the GSM module for get ready to operate with the system. In this we first sends AT command to know whether GSM module is connected or not. After it we turned off the echo and then check the network.

```
void gsm_init()
{
 lcd.clear();
 lcd.print("Finding Module..");
 boolean at_flag=1;
 while(at_flag)
 .. ...
```

void init_sms(),void send_data(String message), and void send_sms() functions have been used to send SMS.

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```
void gsm_init()
{
 lcd.clear();
 lcd.print("Finding Module..");
 boolean at_flag=1;
 while(at_flag)
 .. ...
```

In check_status() function system reads connection and Balance conditions; like whether electricity balance is greater than the defined limit. If balance is less than 15 , then it alerts the user by sending the SMS alert of 'Low Balance' and if balance is less than 5 rupees then system will cut the electricity and inform the user by sending SMS using GSM module.

```
void check_status()
{
if(rupees>15)
{
digitalWrite(relay, HIGH);
flag1=0;
.. ...
```

send_confirmaiton_sms() function is used for sending confirmation message to the user if recharge has been done and it also update the balance in the system.

decode_message() function is used for decoding the amount figure from the SMS message, by using the # and * as starting and ending character.

read_pulse() function is used for reading pulse from the Energy meter through optocoupler IC. And update the unit and balance.

```
void read_pulse()
{
  if(!digitalRead(pulsein))
   {
    digitalWrite(led, HIGH);
    if(units<1){}
    .. ...
    ... ....
```

serialEvent() function is used for serial communication and receiving the message.

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CODE:

```
#include<EEPROM.h>
#include <LiquidCrystal.h>
LiquidCrystal lcd(7,6,5,4,3,2);
int led=13;
#define pulsein 8
#define relay 12
unsigned int pusle_count=0;
float units=0;
0,i=0,x=0,k=0;
char str[70],flag1=0,flag2=0;
String bal=""; unsigned int rupees=0;
float watt_factor=0.3125;
unsigned int temp=
void setup()
{
lcd.begin(16,2);
Serial.begin(9600);
pinMode(led, OUTPUT);
pinMode(pulsein, INPUT);
pinMode(relay, OUTPUT);
digitalWrite(pulsein, HIGH);
lcd.setCursor(0,0);
lcd.print("Automatic Energy");
lcd.setCursor(0,1);
lcd.print("      Meter     ");
delay(2000);
lcd.clear();
lcd.print("Circuit Digest");
delay(2000);
lcd.clear();
lcd.print("GSM Initilizing...");
gsm_init();
lcd.clear();
lcd.print("System Ready");
Serial.println("AT+CNMI=2,2,0,0,0");
init_sms();
send_data("System Ready");
send_sms();
delay(1000);
\digitalWrite(led, LOW)
lcd.clear();
//  EEPROM.write(1,0);
// rupees=EEPROM.read(1);
}
void loop()
if(temp==1) {
serialEvent();
rupees=EEPROM.read(1);
units=rupees/5.0;
lcd.setCursor(0,0);
lcd.print("Units:");
lcd.print(units);
lcd.print("      ");
lcd.setCursor(0,1);
if(rupees<15)
lcd.print("LOW Balance:");
else
lcd.print("Balance:");
lcd.print(rupees);
lcd.print("      ");
read_pulse();
check_status();
{
decode_message();
send_confirmation_sms();
}
}
void serialEvent()
{
while(Serial.available())
```

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```
{
char ch=(char)Serial.read();
str[i++]=ch;
if(ch == '*')
{
temp=1;
lcd.clear();
lcd.print("Message Received");
delay(500);
break;
} } }
void init_sms()
{
Serial.println("AT+CMGF=1");
delay(200);
Serial.println("AT+CMGS=\"+918287114222\"");
delay(200);
}
void send_data(String message)
{
Serial.println(message);
delay(200);
}
void send_sms()
{
Serial.write(26);
}
void read_pulse()
{
if(!digitalRead(pulsein))
{
digitalWrite(led, HIGH);
//count++;
//units=watt_factor*count/1000;
if(units<1){}
else
units--;
rupees=units*5;
EEPROM.write(1,rupees);
while(!digitalRead(pulsein));
digitalWrite(led,LOW);
// delay(2000);
}
}
void check_status()
{
if(rupees>15)
{
digitalWrite(relay, HIGH);
flag1=0;
flag2=0;
}
if(rupees<15 && flag1==0)
{
lcd.setCursor(0,1);
lcd.print("LOW Balance      ");
init_sms();
send_data("Energy Meter Balance Alert:");
send_data("Low Balance\n");
Serial.println(rupees);
delay(200);
send_data("Please recharge your energy meter soon.\n Thank you");
send_sms();
message_sent();
flag1=1;
}
if(rupees<5 && flag2==0)
{
digitalWrite(relay, LOW);
lcd.clear();
lcd.print("Light Cut Due to");
lcd.setCursor(0,1);
```

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```
lcd.print("Low Balance");
delay(2000);
lcd.clear();
lcd.print("Please Recharge ");
lcd.setCursor(0,1);
lcd.print("UR Energy Meter ");
init_sms();
send_data("Energy Meter Balance Alert:\nLight cut due to low Balance\nPlease recharge your energy meter soon.\n Thank you");
send_sms();
message_sent();
flag2=1;
} }
void decode_message()
{
x=0,k=0,temp=0;
while(x<i)
{
while(str[x]=='#')
{
x++;
bal="";
while(str[x]!='*')
{
bal+=str[x++];
}    }
x++;
}
bal+='\0';
}
void send_confirmation_sms()
{
int recharge_amount=bal.toInt();
rupees+=recharge_amount;
EEPROM.write(1, rupees);
lcd.clear();
lcd.print("Energy Meter ");
lcd.setCursor(0,1);
lcd.print("Recharged:");
lcd.print(recharge_amount);
init_sms();
send_data("Energy Meter Balance Alert:\nYour energy meter has been recharged Rs:");
send_data(bal);
send_data("Total Balance:");
Serial.println(rupees);
delay(200);
send_data("Eelctricity Has Been Connected\nThank you");
send_sms();
temp=0;
i=0;
x=0;
k=0;
delay(1000);
message_sent();
}
void message_sent()
{
lcd.clear();
lcd.print("Message Sent.");
delay(1000);
}
void gsm_init()
{
lcd.clear();
lcd.print("Finding Module..");
boolean at_flag=1;
while(at_flag)
{
Serial.println("AT");
while(Serial.available()>0)
{
if(Serial.find("OK"))
at_flag=0;
```

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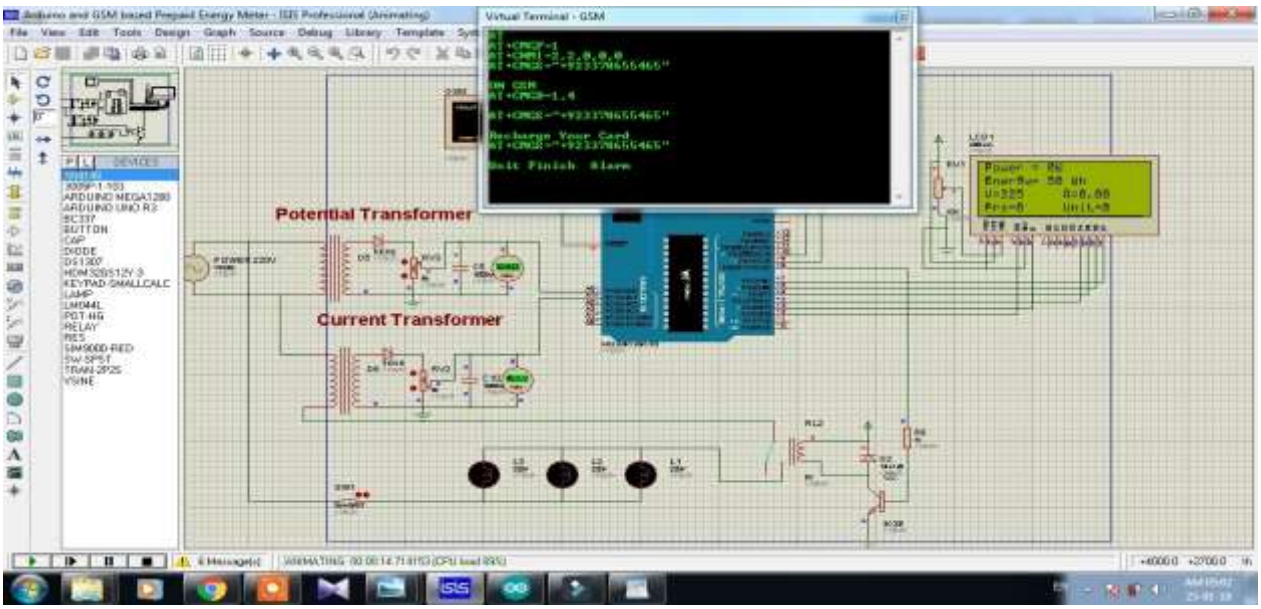
```
}
delay(1000);
}
lcd.clear();
lcd.print("Module Connected..");
delay(1000);
lcd.clear();
lcd.print("Disabling ECHO");
boolean echo_flag=1;
while(echo_flag)
{
Serial.println("ATE0");
while(Serial.available()>0)
{
if(Serial.find("OK"))
echo_flag=0;
}
delay(1000);
}

lcd.clear();
lcd.print("Echo OFF");
delay(1000);
lcd.clear();
lcd.print("Finding Network..");
boolean net_flag=1;
while(net_flag)
{
Serial.println("AT+CPIN?");
while(Serial.available()>0)
{
if(Serial.find("+CPIN: READY"))
net_flag=0;
}
delay(1000);
}
lcd.clear();
lcd.print("Network Found..");
delay(1000);
lcd.clear();
}
```

Results: it will display the message on the screen after running the code on the registered mobile number and according to the load amount will be displayed . If amount becomes zero it will automatically switch off the Power.



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Advantages to utility:

- No more bills will be unpaid
- No error in the meter reading
- Drastically lower the overheads
- Payment will be upfront
- Tamper and fault detection

Advantages to Consumers:

- Allows the consumer to budget
- It will display the remaining credit
- As much as we pay as power go on
- Help become energy conscious

III.CONCLUSION

This smart prepaid energy meter proves to be a boon in the power sector that control the usage of electricity on consumer side to avoid wastage of power and helps to the country revenue by stopping current theft and punishing the dishonest customers. This project is performing satisfactory function in laboratory condition. The device designed is used in conjunction with an induction energy meter. With minor modification in the software and hardware this system can be used for field applications.

FUTURE SCOPE

This software can be modified to view the balance on request and a mini printer can be interfaced to get a printed bill or details of billing. Remote recharging can be implemented through telephone line or wireless network.

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