Design of a Prepaid EB Meter with Power Theft Detector

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Abstract - Post-paid EB payment is very common in recent days. But the user will not be able to predict the amount to be paid once in two months. Thus a prepaid system will suffice the user by predetermining the budget for power consumption and plan their usage accordingly. Secondly the proposed system will also help detection of electric power being used by an intruder. This phenomenon is called as power theft and the proposed project is capable of finding any power theft in the power line. Once power theft is found, the power supply to that user is cut. The user information is sent to the power supply unit through Zig-Bee protocol.

***Keywords** - post-paid, prepaid, power theft, Zig-Bee*

I. INTRODUCTION

With the increased inflation, it's very difficult for anyone to lead a financially unplanned life. Every family will have plans for their monthly expense exceeding which they will have to face significant consequence. On the other hand, the power usage should also be limited since the production of power is not in enormous amount so that all users can use power extensively. Since power production is limited, the usage of power must also be limited. This can also be done by using this system. The main objective of this project is to use prepaid system that is analogous to ATM card and mobile recharge in certain aspects. The first part of the proposed work is a prepaid EB meter wherein we can recharge the meter once in a while and use the power until the amount is available in the prepaid card account provided to each user. Once the amount is over, the power will be cut by the distribution center. Thus the user will be tempted to use power within their recharge amount as far as possible. This will limit the power usage on the user side. Money can be deposited in the card similar to depositing money in bank account. Money can be paid to the EB office as and when required by using the payment option. The second part of this system deals with identifying the power theft done in the power line provided to every user. If power theft is present then the proposed system can find them by calculating the difference between the power sent and the power received at the user. All user information is stored in the prepaid card. Once the card is inserted the user information is sent to the office using Zig Bee protocol.

II. METHODOLOGY

The basic block diagram of the proposed system is given in Fig. 1. For the purpose of demonstration only two EB meters are considered to be connected to the centre node and are monitored continuously to check for power theft and record the power usage.

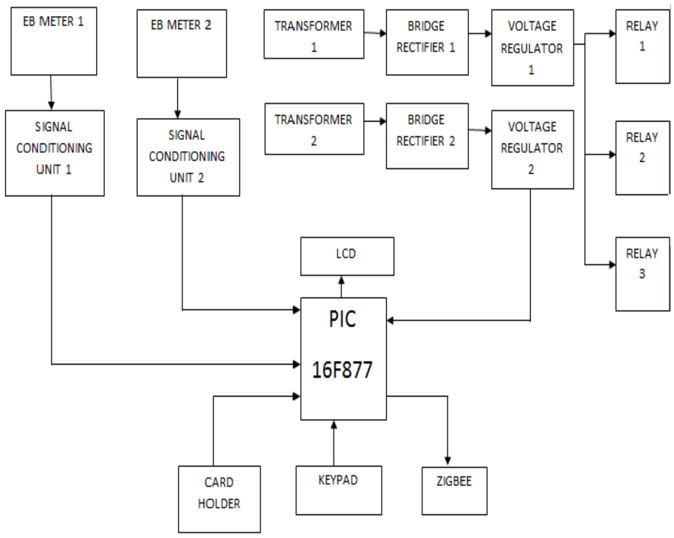


Fig.1-Block diagram of the project

The power enters the signal conditioning unit or the driver circuit performs the switching operation. The output from the signal conditioning unit is given to the transformer. It steps down the voltage to 9V for the microcontroller and another transformer steps down the voltage to 15V for the relay. The output of both the transformers is given to the bridge rectifier that gives a fully rectified voltage. It is then passed through a voltage regulator which produces a ripple free 12V for relay and 5V for the microcontroller. When the card-balance is low, the LCD displays insufficient balance after which the user must recharge his account. Simultaneously the power in the relay is also cut down manually by the operator. When the relay is cut down, the power shuts for all the users belonging to the substation. After shutting down the power, the user should first fill balance in the card and then pay the necessary amount in accordance with the usage.

Power theft is another important problem faced by many users. They unnecessarily pay the bill for the power not used by them. The main measure to be taken is to find if power theft has occurred or not. Power theft is found by calculating the difference between the units in both the energy meter. When the difference is at least 5 units the monitor in the operator side displays Power Theft after which the relay should be manually cut and necessary actions must be taken. Once power theft message is displayed, action must be taken and system must be restarted again. After restarting the system the operator must keenly watch if the power theft was properly identified and completely eliminated. If not, then again power theft message will be displayed.

III. HARDWARE IMPLEMENTATION

A. Digital energy meter

The digital energy meter is used as a prototype for the transformer and substation. Two digital meters are used. One digital meter is used to denote the power sent by the distribution centre and the other meter is used to indicate the power consumed by the user. The schematic diagram of this energy meter is shown in fig.2.

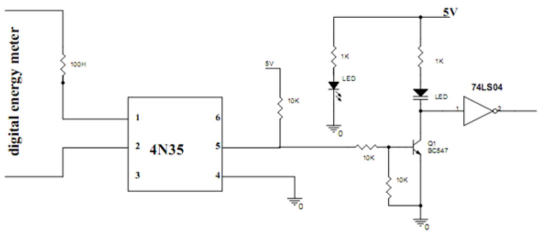


Fig.2: Schematic diagram of energy meter

This circuit measures the energy consumption through Digital energy meter. Here the output from the energy meter is given to the 4N35 opto-coupler IC input. The opto-coupler is nothing but an isolation circuit i.e., AC Line Digital logic isolator, which useful in AC line detection over short circuit prevention. 4N37 (short) consists of a gallium arsenide infrared emitting diode coupled with a silicon phototransistor in a dual in−line package. In that IC output will be always low. When input comes from energy meter, output is logic high. If this IC output is low, then it means that the output of BC547 is high, so the LED behind that operation is in OFF condition. The input given to the controller is also low. When the output of 4N37 is high, it means that the output of BC547 is Low, so the LED behind that operation is in ON condition. Also, the input given to the controller is high. Like this, whenever the input comes from digital energy meter, the LED on the board will glow. Also, the input to controller changes their logic from high to low. Otherwise the output of circuit remains high condition. The output logic is inverted through 74LS04 which is placed on the circuit at final point. So, through the logic changes we can measure the unit of consumption

B. Power Supply

The power supply unit is used to provide a constant 5V DC supply from a 230V of AC supply. These 5V DC will acts as power to different standard circuits. It mainly uses three devices

1. Transformers.
2. Bridge rectifier.
3. Voltage regulator.

The basic block diagram of a power supply is shown in fig.3

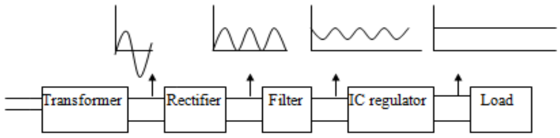


Fig.3: Block diagram of power supply

1. Transformer:

The potential transformers will step down the power supply voltage (0-230V) to (0-9V) and (0-12V) level for microcontroller and relays respectively. Same transformers cannot be used because more heat will be generated while converting the (0-230V) input to 5V. This will cause oscillation and the microcontroller will be reset frequently. The secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantage of using precision rectifier is that it will give peak voltage output as DC while rest of the circuits will give only RMS output.

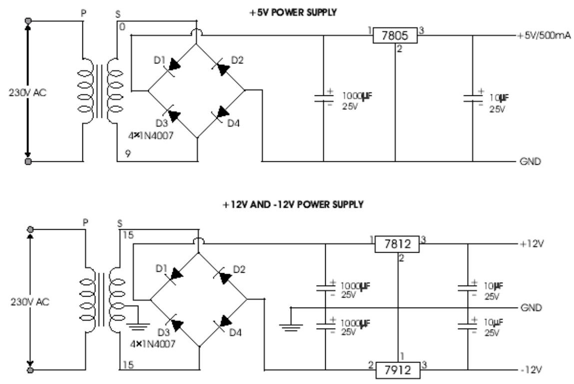


Fig.4: Circuit diagram of bridge rectifier

2. Bridge rectifier:

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit. The circuit diagram of a bridge rectifier is shown in fig.4.

This may be shown by assigning values to some of the components shown in views A and B. Assume that the same transformer is used in both circuits. The peak voltage developed between points X and Y is 1000V in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the centre tap to either X or Y is 500V. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500V.

The maximum voltage that appears across the load resistor is nearly-but never exceeds-500V, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000V. Therefore, the peak output voltage across the load resistor is nearly 1000V. With both the circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

3. Three terminal voltage regulator:

The fixed voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated output dc voltage, Vo, from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation). The schematic of voltage regulator is given in fig.5.

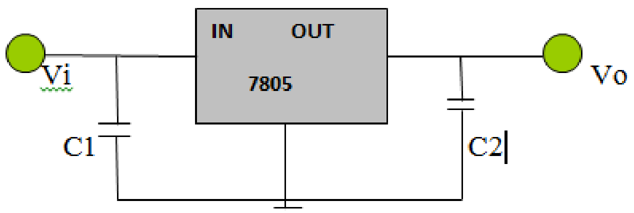


Fig.5: Schematic of Voltage regulator

An unregulated input voltage Vi is filtered by capacitor C1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). While the input voltage may vary over some permissible voltage range and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer's specification sheets.

4. PIC microcontroller:

The microcontroller that has been used is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The Pin diagram of PIC microcontroller is given in fig.6

The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques. Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in PIC16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877. Develop a uniquely decoded 'E' strobe pulse, active high, to accompany each module transaction. Address or control lines can be assigned to drive the RS and R/W inputs. Utilize the host's extended timing mode, if available, when transacting with the module. Use instructions, which prolong the Read and Write or other appropriate data strobes, so as to realize the interface timing requirements. If a parallel port is used to drive the RS, R/W and 'E' control lines, setting the 'E' bit simultaneously with RS and R/W would violate the module's set up time. A separate instruction should be used to achieve proper interfacing timing requirements.

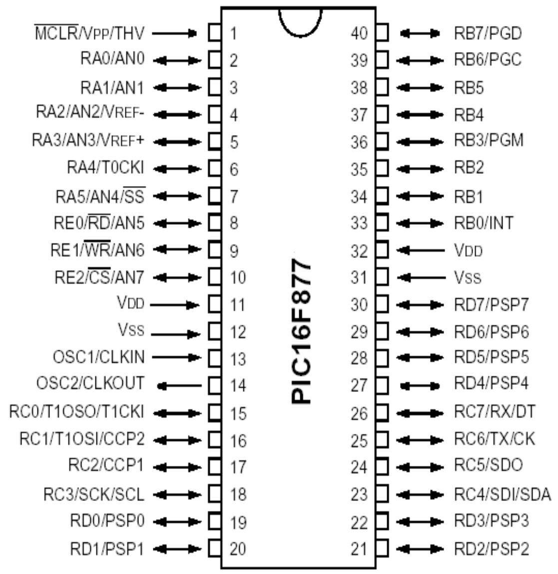


Fig.6: Pin diagram of PIC16F887 microcontroller.

5. Zig-Bee

The transmitter module of Zig-Bee is shown in fig.7. The Zig-bee module is a flex sensor patented technology.

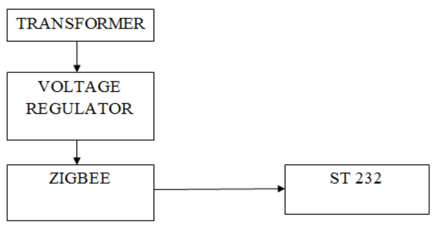


Fig.7 Transmitter module of Zig-Bee

The Flex Sensor patented technology is based on resistive carbon elements. As a variable printed resistor, the Flex Sensor achieves great form factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius. The smaller the radius, the higher is the resistance value. The pin diagram of Zig-Bee is shown in fig.8.

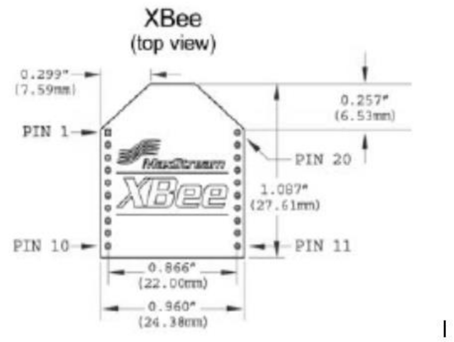


Fig.8 Pin diagram of Zig-Bee module

6. Smart card and smart card reader:

The smart card is the unique identity of the user. This card is used for recharging every once and then. The smart card is shown in fig.9.

Fig.9: Smart card

When the power is switched on it will display SMART CARD on the terminal (hyper terminal). This indicates that the smartcard reader is ready to work. The smart card reader module is shown in fig.10. After getting this display message on the terminal if you insert a smartcard green LED (ln2) will be glowing .It will check whether it is inserted properly or not. If not, it will display the error message like "Please insert the card properly". If you have inserted the card properly it will prompt you to enter password which is called as security code.

Fig.10: Smart card reader module

IV. MOUNTING CHALLENGES

a) Cover the display surface with a transparent protective plate, to protect the polarizer.

b) Don't touch the display surface with bare hands or any hard materials. This will stain the display area and degrade the insulation between terminals.

c) Do not use organic solvents to clean the display panel as these may adversely affect tape or with absorbent cotton and petroleum benzene.

d) The processing or even a slight deformation of the claws of the metal frame will have effect on the connection of the output signal and cause an abnormal display.

e) Do not damage or modify the pattern wiring, or drill attachment holes in the PCB. When assembling the module into another equipment, the space between the module and the fitting plate should have enough height, to avoid causing stress to the module surface.

f) Make sure that there is enough space behind the module, to dissipate the heat generated by the ICs while functioning for longer durations.

g) When an electrically powered screwdriver is used to install the module, ground it properly.

h) While cleaning by a vacuum cleaner, do not bring the sucking mouth near the module. Static electricity of the electrically powered driver or the vacuum cleaner may destroy the module.

i) When an electrically powered screwdriver is used to install the module, ground it properly.

j) While cleaning by a vacuum cleaner, do not bring the sucking mouth near the module. Static electricity of the electrically powered driver or the vacuum cleaner may destroy the module.

V. ENVIRONMENTAL PRECAUTIONS

a) Operate the LCD module under the relative condition of 40°C and 50% relative humidity. Lower temperature can cause retardation of the blinking speed of the display, while higher temperature makes the overall display discolour.

b) When the temperature gets to be within the normal limits, the display will be normal. Polarization degradation, bubble generation or polarizer peel-off may occur with high temperature and humidity.

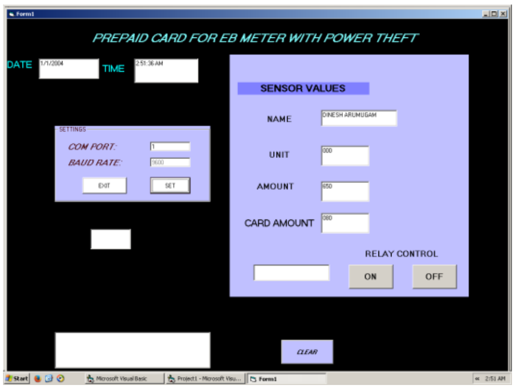
c) Contact with water or oil over a long period of time may cause deformation or colour fading of the display. Condensation on the terminals can cause electro-chemical reaction disrupting the terminal circuit.

VI. RESULTS AND DISCUSSIONS

The hardware setup has two parts, a transmitter and a receiver along with PIC microcontroller. The hardware setup of the system is shown in fig.11.

Fig.11: Hardware setup

The visual basic software is used to create a form for displaying the results. The VB software is started and the form is run. The port number is set as the port of the system. The amount is added to the card and the necessary amount is paid. All these details are processed and the form appears as in fig.12.



After the first form page appears, the operator starts the relay for that specific user. The balance is reduced while using the relay at the rate of Rs20 per unit (set for demonstration). When the card balance reaches Rs.20, 'Insufficient balance' message gets displayed both in the LCD and in the form page as shown below. The form is shown in fig.13.

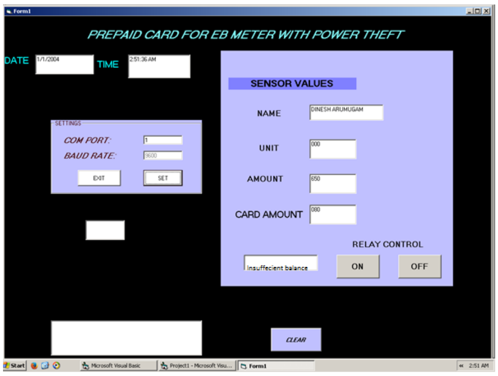


Fig.13 Form with insufficient balance message.

Power theft is identified by finding the difference in power between the power used by the users and the power sent from the substation. When the difference is more than 5 units, 'Power Theft' message is displayed. This form is shown in fig.14.

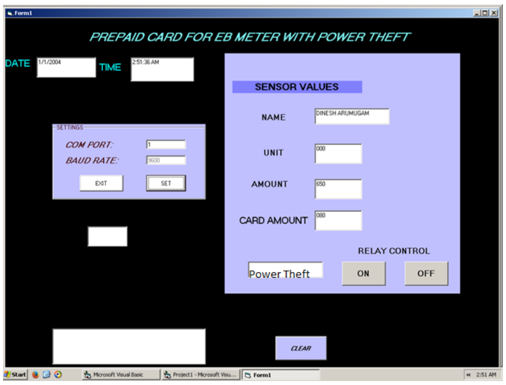


Fig.14 Form with power theft message.

VII. CONCLUSION

Thus the prepaid card for EB meter is designed successfully and the power theft is also found by calculating the difference between the units of power used by the consumer and the power sent by the transformer. This system has so many advantages such as planned use of power by the user, easy and simple identification of power theft and knowing the balance in the prepaid card so that power can be used accordingly or card can be recharged.

VIII. FUTURE ENHANCEMENT

When the amount is entered the card should automatically get connected to the user's bank account from which amount can be credited. The relay can be made to automatically switch on and switch off when the corresponding message is received. The same set up can be made for a number of users in a street and a substation and power theft can be tested. The system may be made capable of finding power theft in multiple parts of the same place.

IX. REFERENCES

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