Low Cost High Precision Accuracy Energy Meter

Major Project Report

Submitted in fulfillment of the requirements
for the degree of

Master of Technology
in
Electronics & Communication Engineering
(Embedded Systems)

By

Bhatt Kirtankumar Sanjaykumar

(15MECE02)

Electronics & Communication Engineering Department
Institute of Technology
Nirma University
Ahmedabad-382 481

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Ahmedabad-382 481

Declaration

This is to certify that

a. The thesis comprises my original work towards the degree of Master of Technology in Embedded Systems at Nirma University and has not been submitted elsewhere for a degree.

b. Due acknowledgment has been made in the text to all other material used.

- Bhatt Kirtankumar Sanjaykumar
15MECE02

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NIRMA UNIVERSITY
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Certificate

This is to certify that the Major Project entitled **"Low Cost High Precision Accuracy Energy Meter"** submitted by **Bhatt Kirtankumar Sanjaykumar (15MECE02)**, towards the partial fulfillment of the requirements for the degree of Master of Technology in Embedded Systems, Nirma University, Ahmedabad is the record of work carried out by him under our supervision and guidance. In our opinion, the submitted work has reached a level required for being accepted for examination.The results embodied in this major project, to the best of our knowledge,haven't been submitted to any other university or institution for award of any degree or diploma.

Date: Place: Ahmedabad

Dr. Y. N. Trivedi

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Program Coordinator

Dr. D.K.Kothari

HOD, EC

Dr. Alka Mahajan

Director, IT

Certificate

This is to certify that the Major Project (Phase- I) entitled **"Low Cost High Precision Accuracy Energy Meter"** submitted by **Bhatt Kirtankumar Sanjaykumar(15MECE02)**, towards the partial fulfillment of the requirements for the degree of Master of Technology in Embedded Systems, Nirma University, Ahmedabad is the record of work carried out by him under our supervision and guidance. In our opinion, the submitted work has reached a level required for being accepted for examination.

Chintan Chauhan
Manager R and D
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- Bhatt Kirtankumar Sanjaykumar
15MECE02

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Abstract

Today to be able to be competent in the market, the control over each and every minimal cost is required. In the industries, the electricity consumption charges is one of the huge expense and it takes away a high percentage of revenues. Most of the machines nowadays run on electricity and their life span is very much dependent on the quality of power fed to it. So it is an immediate requirement of todays era to measure the power quantitatively as well as qualitatively. The system proposed here consists of an micro controller, a display and serial communication protocol (RS - 485) for the data to be viewed on laptop. The micro controller takes the line current and line voltage as an input in order to measure the power and energy and other parameters related to quality of power. First of all the intensity of current and voltage are converted in the range of the ADCs input by using voltage divider circuitry and Current Transformer. The energy is calculated by digitally integrating the instantaneous power with a delta time of about 1us. The on chip ADC is capable of simultaneously dual sampling, allowing current and voltage to be sampled together in each phase. We have tried to use the mechanical and electrical components that are available in our inventory to make it a low cost system. Intensive research was carried out while choosing components related to display, RS 485 section and micro controller section to make it available at lowest possible cost. The precision of the system plays role when the parameters are measured several times under robust conditions and it shows the same value. The system proposed here is in compliance with IEC standard IEC62052-11 and applicable for class 1S and class 0.5S.

Chapter 1

Introduction

1.1 Motivation

There is a huge difference between the amount of electric energy produced and electric energy consumed and this is because of the difference in quality of power delivered. If we can measure the quality and quantity of the power, then we can devise certain strategies to increase the efficiency of the power consumed.[3]

1.2 Objective

The main objective behind this project is to introduce a low cost energy meter for consumer as well as industrial applications which can work in robust environment. Based on the results given by the energy meter, necessary steps should be taken so that efficient use of power is possible.

1.3 Scope

The system proposed here can be easily used in consumer market as well as industrial applications. In future it will be compulsion to have a sub energy meter system in each and every household so that every individual can have a check at how he is consuming electric energy.

1.4 Requirements

To complete this project at Masibus, I required knowledge of serial communication protocol - SPI that is Serial Peripheral Interface for the communication between energy metering chip and Micro controller. Also knowledge of I2C protocol is necessary to throw the data from micro controller to display. In depth knowledge of RS-485 protocol is required for the data to be viewed at remote place on the laptop. Knowledge of designing schematic as well as PCB is also required.

Chapter 2

Literature review

2.1 Evolution of Digital Energy Meter

Traditionally energy meter were based on electromagnetic induction phenomenon. But the main disadvantage of the traditionally available energy meter is their enormous size and bulkiness. The load range available was not dynamic. There was no feature of compensation when power factor, voltage and current changes.[3]
Nowadays there is future of digital energy meter which is compact in size and highly accurate within a long dynamic range. The size of today's energy meter is highly compact and can be installed anywhere. In the system proposed here RENESAS micro controller is used which has unique features such as Sag detection control, Over voltage detection control, Phase loss detection and Over current detection, and Reverse V/I phase sequence detection.[3]

2.2 Types of Metering Devices available

There are different types of metering devices available in the market. Namely energy meter, multi function energy meter, voltage-ampere-frequency meter, power meter, etc. As per the application different measuring devices can be used. There are various accuracy classes available for all this devices and all the devices has to be passed through certain tests before it comes into the market.[3]

2.3 Cost Comparison of Energy Meters

SR NO.	COMPANY	COST (INR)
1	SCHNEIDER	4000
2	RISHABH	3000
3	SELEC	2000
4	ELMEASURE	2000
5	CONZERV	4000
6	EAPL	4000
7	SECURE METER	3500
8	MASIBUS	1500*

Table 2.1: Cost Comparison of Energy Meters

2.4 Different Electric Parameters

As noted in the above section prices of Energy Meters from different companies vary a lot. The main reason behind this is the range of parameters on the display they provide. It also depends on the certain features such as communication supported by it, the accuracy provided by it, and the type of display provided by the vendors. Here certain attractive features are mentioned below with which the customer can thoroughly check the quality of power as well as quantity of power and ultimately it will help in taking them necessary action based on the results provided by the proposed system.

- **Pulse output OR Relay output:**
  In the case of Energy Meter, a pulse output is a very important parameter as based on the pulse count the energy consumed is calculated. In the system proposed here, there are 4 pulse outputs provided, namely for Active energy,

Apparent energy, Fundamental energy and Reactive energy. Here relay output is also provided for the alarming purpose.

- **EB/DG input**

  In the proposed system we have provided EB/DG input which is used to calculate the energy when the supply from the main is OFF and load is on Diesel Generator. Basically it is circuit which will give signal to micro controller when mains is OFF and will give the count of KWH consumed from the Diesel Generator.

- **RS-485 communication**

  RS-485 communication is very much necessary in nowadays energy meter so that customer seating remotely can monitor how he is consuming his power as because of RS-485 data measured by the system can be displayed on laptop.

2.5 Exercise for Making Energy Meter Cheaper

2.5.1 Choosing of Components

Traditionally, energy meters has single high end controller which does task of taking voltage and current as input and then based on it it measures power and energy and other related parameters. This act was a bit costly. In the system proposed here, we have used an energy metering chip and a cheap controller whose role is only to read the data from the chip and throw it on the display. This way we were able to reduce cost in the proposed system.

The second step which we had taken to reduce cost is to use only those components which are already available in the inventory of the industry as far as possible. The Current Transformer we had used are cheaper with same accuracy.

There were many problems which we had faced while designing this system. The primary task was to implement energy meter in the enclosure of voltage ampere frequency meter which was actually a big task. This was done to reduce cost as the enclosure was already available in the inventory. Mechanically there were certain issues in the primary stage but after rigorous efforts we were able to mechanically fit the proposed system in the given enclosure.

The dimensions of PCB were fixed for us before the system was in design phase. It was also a challenging task for us because components to be mounted on the PCB of proposed system were 30 percent more than previously components mounted on same PCB. But by making certain components surface mount from through hole helped us and we were able to mount all the components in the same PCB.

2.5.2 Digital Outputs and Inputs

Thereafter the challenge was to provide maximum possible digital outputs and inputs so that customer can take action and can efficiently devise a strategy of how to save power and quality of power can be improved. The challenge was to provide this many features at lowest possible cost. For example in the proposed system we have provided relay output, which has its own application. Suppose customer wants that if the consumption is more than 1000 KWh than to switch OFF certain equipment's or to get an alarm for that, then with the help of relay output it can be easily done.

In the proposed system we have provided pulse output which has application of counting how much KWh consumed and it measures this on the basis of pulses generated of constant frequencies.

Here EB/DG input is provided, which has application when suppose the supply from the mains is OFF and the full load is running on Diesel Generator and customer wants to have a record of how much KWh consumed from the DG. Then this input is very much helpful. As soon as the mains is OFF the signal from the EB/DG circuit through optocoupler goes to the micro controller giving a notification to it to count KWh that are consumed from the DG set.

2.6 Different Accuracy Standards

2.6.1 IEC 62052-11 Accuracy Standard for Metering Equipment

The IEC - International Electrotechnical Commission is a worldwide organization for standardization comprising all national electrotechnical committees. It provides standards in different fields related to electrical and electronics. IEC 62052-11 is for the electrical energy measurement and load control. IEC 62052-11 gives the basic different between the energy meters that are going to be installed in outdoors or indoors as well as it also defines the protective class such as class I or class II. This standard is applicable only for the load equipment's running at 50 or 60 Hz at maximum of 600 volts. This is not applicable to the portable energy meters.[2]

2.6.2 IEC 62053-22 Accuracy Standard for Static Meters for Active Energy

The IEC - International Electrotechnical Commission is a worldwide organization for standardization comprising all national electrotechnical committees. This standard is particularly for meters that are being used indoors. This standard is not applicable to the special implementations such as metering part and displays in separate housings. This standard provides the basic difference between the accuracy class index 0.5S and accuracy class 0.2S meters. It also defines the protective class such as class I or class II. This standard also provides difference in the meters for use in networks equipped with or without earth fault neutralizers.[2]

2.6.3 IEC 62053-23 Accuracy Standard for Static Meters for Reactive Energy

The IEC - International Electrotechnical Commission is a worldwide organization for standardization comprising all national electrotechnical committees. This standard is particularly for meters that are being used indoors and outdoors. This standard is not applicable to the special implementations such as metering part and displays in separate housings. This standard provides the basic difference between the accuracy class index 2 and accuracy class 3 meters. It also defines the protective class such as class I or class II. This standard also provides difference in the meters for use in networks equipped with or without earth fault neutralizers.[2]

2.7 Comparative Analysis

In the below section, I have mentioned the comparison analysis of the Energy Meter provided by different companies. Here it is mentioned that which are the features provided by the different companies in their system and accordingly we have tried to provide maximum features in the proposed system.

Make	Masibus
Model	EM 2140
Display	1 line 8 digit LED display
	
Display Parameter	Active Energy
	Reactive Energy [Selective]
	Apparent Energy [Selective]
Indication LEDs	x1000
	Phase_R V & I Status
	Phase_Y V & I Status
	Phase_B V & I Status
	3600 imp/KWh
	KWh
	KVARh
	RX
	TX
	DG - EB/DG
	Alarm
Selection in Ordering Code	**Optional:** EB/DG Option
	Optional: MODBUS (RS485) outpu
	Optional: Pulse Output / Relay O/P

Figure 2.1: MASIBUS EM 2140

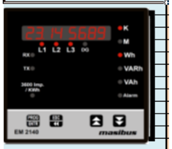
Make	**RISHABH**
Model	EM 3490
Display	1 line 8 digit LED display
	
Display Parameter	Active Energy (8 digit counter)
Indication LEDs	x1000
	Von_R
	Von_Y
	Von_B
	Irev_R
	Irev_Y
	Irev_B
	3600 imp/kwh
Selection in Ordering Code	**Input Voltage**
	110V L-L (63.5V L-N)
	230V L-L (133V L-N)
	415V L-L (239.6V L-N)
	440V L-L (254V L-N)
	Input Current
	5 Amps
	1 Amps
	Optional: MODBUS (RS485) outp
	Optional: Pulse Output for energ

Figure 2.2: RISHABH EM 3490

Make	**Schneider**
Model	EM 1000 /EM 1200
Display	Single row LCD backlit display 
Display Parameter	PF - PF1 PF2 PF3 W W1 W2 W3 VA VA1 VA2 VA3 VAR VAR1 VAR2 kWh / kVAh / kVARh Run.h On.h INTR
Indication LEDs	L1 L2 L3 Von_B Irev_R Irev_Y Irev_B 3600 imp/kwh
Selection in Ordering Code	**Input Voltage** 110V L-L (63.5V L-N) 230V L-L (133V L-N) 415V L-L (239.6V L-N) 440V L-L (254V L-N) **Input Current** 5 Amps **Optional:** Accuracy 0.5/1.0 **Optional:** MODBUS (RS485) output **Optional:** Pulse Output for energy measurement

Figure 2.3: SCHNEIDER EM 1000

Make	**ELMEASURE**
Model	LG+ 3100
Display	Single line 6 digit display
	
Display Parameter	W
	PF
	VA
	KWH
Indication LEDs	K
	M
	NEGATIVE
	OLD
	OUT OF RANGE
	PULSE Op
	COMMUNICATION
	3600 imp/kwh
Selection in Ordering Code	**Input Voltage**
	110V L-L (63.5V L-N)
	230V L-L (133V L-N)
	415V L-L (239.6V L-N)
	440V L-L (254V L-N)
	Input Current
	5 Amps
	1 Amps
	Optional: MODBUS (RS485) output
	Optional: RS232 output
	Optional: Pulse Output
	Optional: 1 digital o/p

Figure 2.4: ELMEASURE LG+ 3100

Make	**SELEC**
Model	EM 306A
Display	6 digit LED display
	
Display Parameter	Active Energy 6 Digit
	PF
	VA
	KWH
Indication LEDs	INT
	x10
	REV
	OLD
	OUT OF RANGE
	PULSE Op
	COMMUNICATION
	3600 imp/kwh
Selection in Ordering Code	**Input Voltage**
	110V L-L (63.5V L-N)
	230V L-L (133V L-N)
	415V L-L (239.6V L-N)
	440V L-L (254V L-N)
	Input Current
	5 Amps
	1 Amps
	No RS485 option
	Optional: RS232 output
	Pulse O/P available always
	Optional: 1 digital o/p

Figure 2.5: SELEC EM 306A

Make	**SELEC**
Model	EM 368 / 368-C
Display	8 digit LCD Panel
	
Display Parameter	PF
	KW
	KVAR
	KWH
	KVARH
	KVAH
Indication LEDs	NO LED'S
	x10
	REV
	OLD
	OUT OF RANGE
	PULSE Op
	COMMUNICATION
	3600 imp/kwh
Selection in Ordering Code	**Input Voltage**
	110V L-L (63.5V L-N)
	230V L-L (133V L-N)
	415V L-L (239.6V L-N)
	440V L-L (254V L-N)
	Input Current
	5 Amps
	1 Amps
	Optional: MODBUS (RS485) outp
	Optional: RS232 output
	Pulse O/P available always
	Optional: 1 digital o/p

Figure 2.6: SELEC EM 368C

Make	**VERITEK**
Model	VIPS 84P
Display	1 line 8 digit LED display for energy 1 line 4 digit LED display for other parameters 
Display Parameter	Active Energy RY, YB, BR, RN, YN, BN AR, AY, AB PFR, PFY, PFB KWR, KWY, KWB KVA - R, KVA - Y, KVA - B KVAR - R, KVAR - Y, KVAR - B FREQUENCY HARMONICS VOLTS TOTAL HARMONICs AMPS TOTAL LOAD HOUR
Indication LEDs	K M L1 L2 L3 V A Hz PF W VA VAR
Selection in Ordering Code	**Input Voltage** 110V L-L (63.5V L-N) 230V L-L (133V L-N) 415V L-L (239.6V L-N) 440V L-L (254V L-N) **Input Current** 5 Amps 1 Amps **Optional:** MODBUS (RS485) output **Optional:** RS232 output **Optional:** Pulse Output **Optional:** 1 digital o/p

Figure 2.7: VERITEL VIPS 84P

Chapter 3

Introduction to RENESAS Micro Controller

3.1 Introduction

RENESAS R5F521A6BDFP is a 100 pin micro controller is used which is brain of the proposed system and the main advantage of it is that it has 7 channels of 24-bit Sigma-Delta ADC which provides high accuracy at lowest possible cost.[1] The main task of this controller is to take samples of line current and line voltage as an input and then from that other electrical parameters such as Power, Energy, Power Factor, Frequency etc. are calculated. Here we use three channels for current sampling and three channels for voltage sampling of the 24-bit Sigma Delta ADC.[1] After the calculation of electrical parameters, this controller communicates with seven segment display with the help of I2C protocol and floats the data on the display which is present on the energy meter for the monitoring purpose.[1] Also with the help of RS-485 communication these data are floated on MODBUS which can be monitored remotely on customer's laptop. There is also FRAM provided for the storage of calibration data as well as configuration data which communicates with micro controller with the help of SPI communication. This controller works on power supply of 3.3V. The RX21A group of micro controllers of RENESAS are specifically designed for energy metering purpose and have feature of high speed and high performance. There are two type of operating modes of this micro controller which is selected by the logic level at dedicated pins and namely those modes are single chip mode and user boot mode. This micro controller can be used in both condition namely 3 phase 4wire and 3 phase 3wire combination.[1]

The 24-bit Sigma Delta ADC has gain up to 64 times which can amplify the small current or voltage signals which ultimately improves the accuracy of proposed system. The resolution of the sigma delta ADC is 24 bit.[1]

3.2 JTAG Circuit of R5F521A6BDFP

The JTAG connection between RENESAS micro controller and E1 Emulator to dump the code involves eight connections.[1] The SCK pin of 14 pin debugger provides the clock for the JTAG communication. The RXD and TXD pin are for the receive and transmit of data between controller and emulator. The RESET pin is provided for the reset of micro controller when it is in debug mode. The Vcc and Vss pin are for supply and Ground. When the MODE pin of the debugger is at logic level 1 means controller is in single chip mode and it is the mode in which controller has to be programmed. When UB pin is at logic level 1, the controller enters user boot mo1de which is useful when internal memory stack is required to be changed.[1]

3.3 24-bit Sigma Delta ADC

3.3.1 Overview

This LSI has an internal 24-bit A/D converter using a Sigma Delta modulation scheme for power measurement. The PGA (Programmable Gain Amplifier) is also included for signal amplification in the previous stage of A/D conversion.[1] Analog inputs from up to seven channels are converted to digital values.Four channels out of seven use differential inputs with gains up to 64 times and the remaining three channels use single-ended inputs with gains up to four times. One unit of PGA and A/D converter is allocated to one channel, so each channel is independent and controlled at a separate timing. In addition, an interrupt request can be generated for each channel at the completion of conversion. This converter incorporates the BGR (Band Gap Reference) circuit, and the reference voltage is generated based on either output voltage from this BGR or BGR BO pin voltage externally applied.[1]

3.3.2 Pin Configuration of 24-bit ADC

Pin number 74, 75, 76, 77, 78, 79, 80 and 81 are for positive and negative voltage and current channels from where input is provided to the controller and this channels are differential.[1] VREFDSH pin is high reference voltage which is connected to analog ground through 1uF capacitor.[1] VREFDSL pin is low reference voltage which connects to the analog ground. VCOMDS pin is common mode voltage pin which is connected to analog ground through 0.1 uF capacitor. BGR B0 is externally applied pin for reference voltage to be provided externally and if on chip reference voltage is used than it goes high impedance.[1]

3.3.3 Operation

The A/D converter uses a voltage between the VREFDSH pin and the VREFDSL pin as the reference voltage and converts analog input voltages to up to 26-bit digital values.[1] This converter consists of modulators, decimation filters and a control circuit for them. Up to seven channels are available for A/D conversion.[1] The activation, trigger, gain, conversion timing, and the A/D conversion end interrupt (DSADI), and the data registers corresponding to channels are independent, thus allowing them to be set for each channel. However, the clock supplied to modules are common to all the channels.[1] The data register overwrite interrupt (DSADORI) functions as a single interrupt request with the requests from all the channels being handled collectively. When analog signals are input, they are sampled with an oversampling clock (DSADCLK divided by 8) and converted to digital signals by the modulator. These digital signals are filtered by the decimation filter at the next stage and the resultant filter output is stored in the A/D data register. During A/D conversion, the analog input signals are amplified with a gain set in the gain select register.[1]

3.4 Specifications of proposed system

PARAMETERS	**VALUE**
Voltage	20 to 350 L-N
Burden	0.5 VA
Current	1A/5A
Accuracy	Class 1.0
Frequency	45 to 65 Hz
Aux Power Supply	85 to 265 VAC
Working Temperature	0 to 55 deg C
Relative Humidity	30-95

Table 3.1: Specifications of proposed system

Chapter 4

System Architecture

4.1 Block Diagram of Proposed System

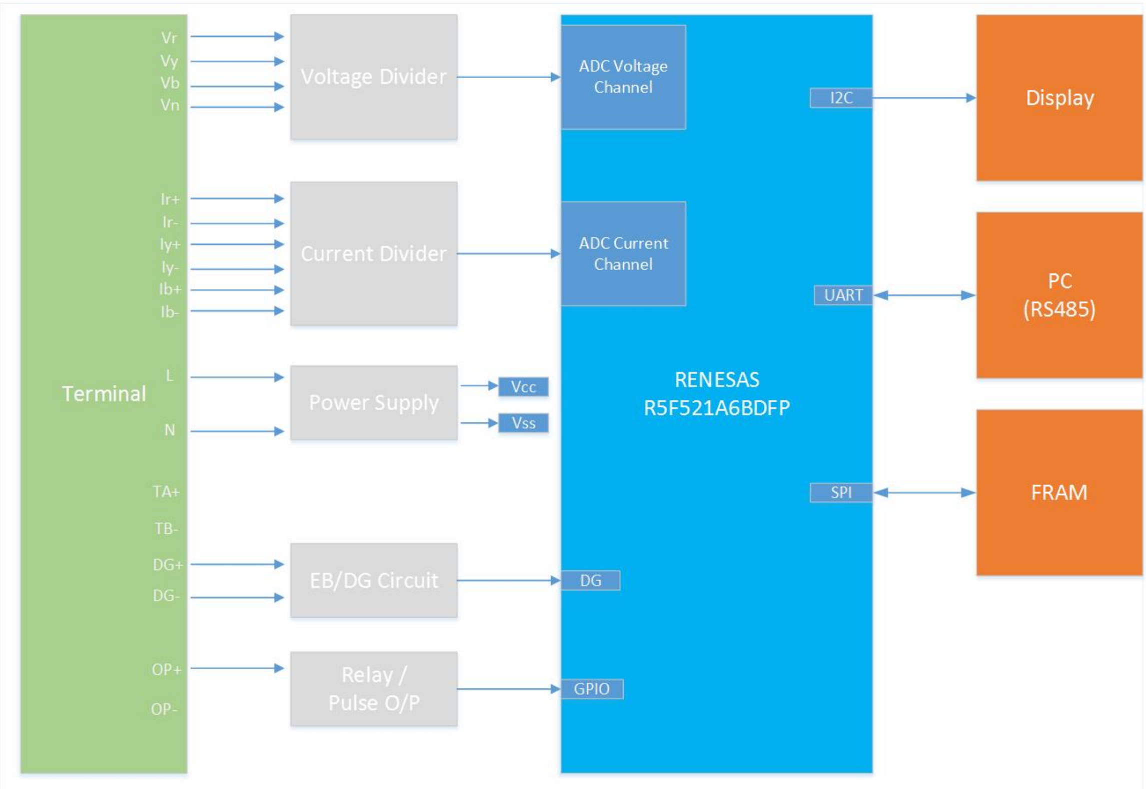


Figure 4.1: Block diagram

4.2 Working of Energy Meter

To understand the working of the Energy Meter it has been divided into blocks such as SMPS section, current and voltage sampling section, micro controller section RENESAS R5F521BDFP, memory and at last display section. We will understand each section in detail in the following sections.[3]

4.2.1 SMPS Section

In the SMPS section, the power supply to the energy meter is provided and that is 230V 50Hz AC supply. It is then converted to +5V DC, Isolated +5V DC and +3.3V DC as per the requirement. Isolated supply is generated for RS-485 communication protocol. The energy metering controller works on +3.3V. In the proposed system to convert 230V AC to 5V DC Prismatic transformer is used. To convert +5V to +3.3V we have used LM317 voltage regulator. The +5V is generated in the PS card and isolated +5V is also generated at PS card and then send it to the CP card. The +3.3V is generated on CP card with the help of LM 317.[3]

4.2.2 Current and Voltage Sampling Section

In the proposed system, there are 4 inputs for the voltage namely R, Y, B, N and 6 current inputs namely Ir+, Ir-, Iy+, Iy-, Ib+, Ib-. The voltage sampling section consists of voltage divider section which scales down the voltage in the range of 120uA to 720mA which is range of ADC present in the energy metering controller. The This voltage after sampling are fed to the chip which it takes to calculate other electrical parameters.

Current sampling is done with the use of CT that is current transformer which scales down the current in the range of ADC and it is directly fed to the energy metering chip. Using this voltage and current the energy metering IC calculates power and energy. The selection of CT in the current sampling section is also very much important because it had a very handy role to play with the overall accuracy of the proposed system.[3]

4.2.3 CPU Section

The CPU section has Renesas micro controller which is the brain of the system. The controller takes the RMS value of current and voltage as an input and DSP which is embedded in it calculates all other parameters related to power and energy. Micro controller reads the appropriate registers to get the desired parameter with the help of SPI protocol. Then with the help of I2C protocol the control throws the data on the display which is seven segment display. In the proposed system for the RS 485 communication we have used ISO3082 IC for throwing data on the PC so that customer can monitor his data from remote place. For storing of data we have used FRAM FM25L04B which has storing capacity of 4 KB and the main advantage of this FRAM is that it has infinite read write cycles. The communication between FRAM and micro controller is also done using SPI protocol.

4.2.4 Software for Energy Meter

The software for the proposed system is written in embedded C. The compiler and debugger used for the proposed system is E2studio. The steps we have followed to develop software for the energy meter includes, first of all we had written code for 24 bit sigma delta ADC to calculate the number of samples of current and voltage. After the successful execution of this we had written code for measurement parameters such as voltage, current, power, energy, power factor and frequency. After that the code was written for the calibration of the energy meter. The flow chart for the calibration is shown in the following diagram. In the proposed system, the calibration of voltage, current, power, and energy is required and there are two calibrations required which is namely offset calibration and gain calibration which are mentioned in the flow chart given below.

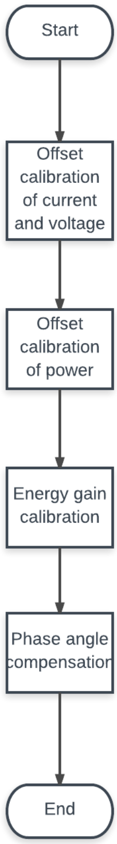


Figure 4.2: Calibration flow chart

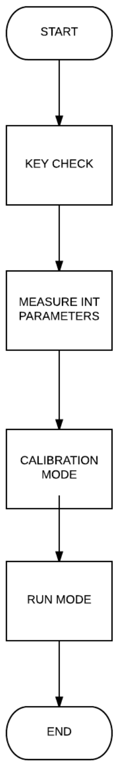


Figure 4.3: Calibration flow chart

Chapter 5

Schematic design of Energy Meter

5.1 Description

As shown in the below figure, the schematic design of PS card, CP card and Display card. The PS card consist of power supply section and current and voltage sampling section. There are three connectors which are used to transfer the signal from PS card to CP card. The CP card contains micro controller section, RS 485 section, EB/DG section, Relay output section and Pulse output section. It also contains 9mm bright LED seven segment display up to 8 digit resolution. There are thirteen (13) LED's for indication purpose and 4 keys for navigation purpose. Generally the proposed system will work in Run mode, Configuration mode and Calibration mode.

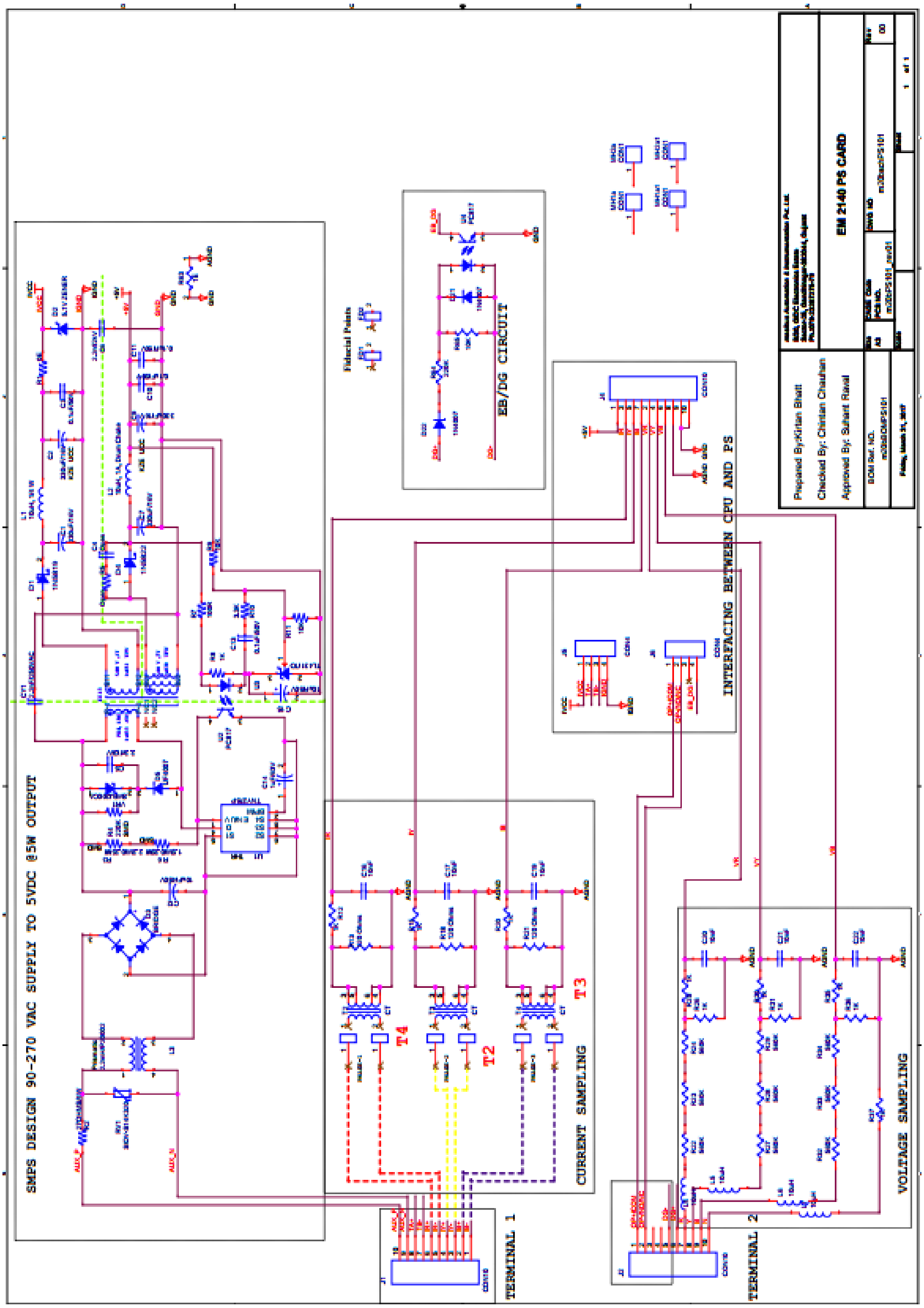


Figure 5.1: Power Supply Schematic

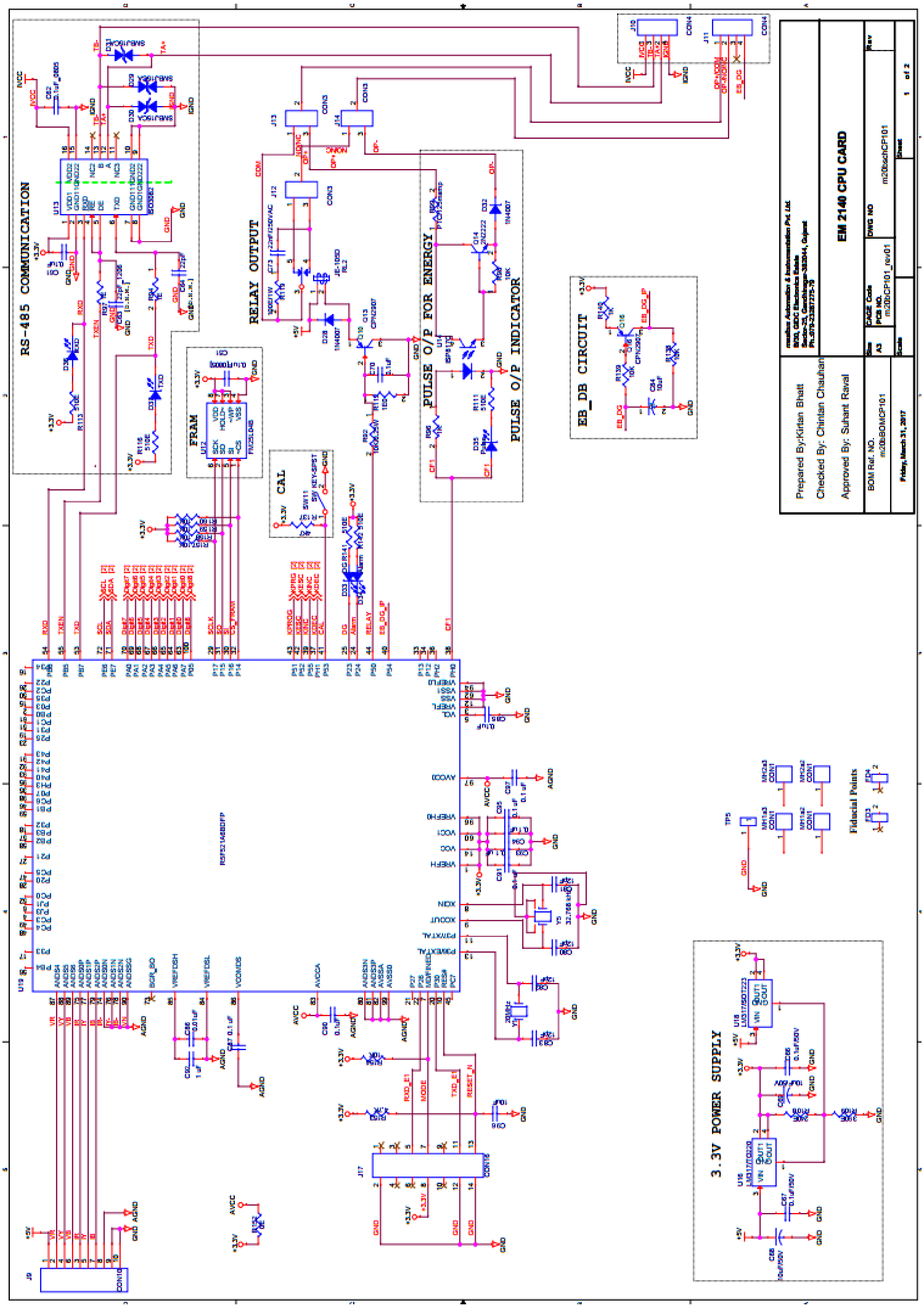


Figure 5.2: CPU schematic

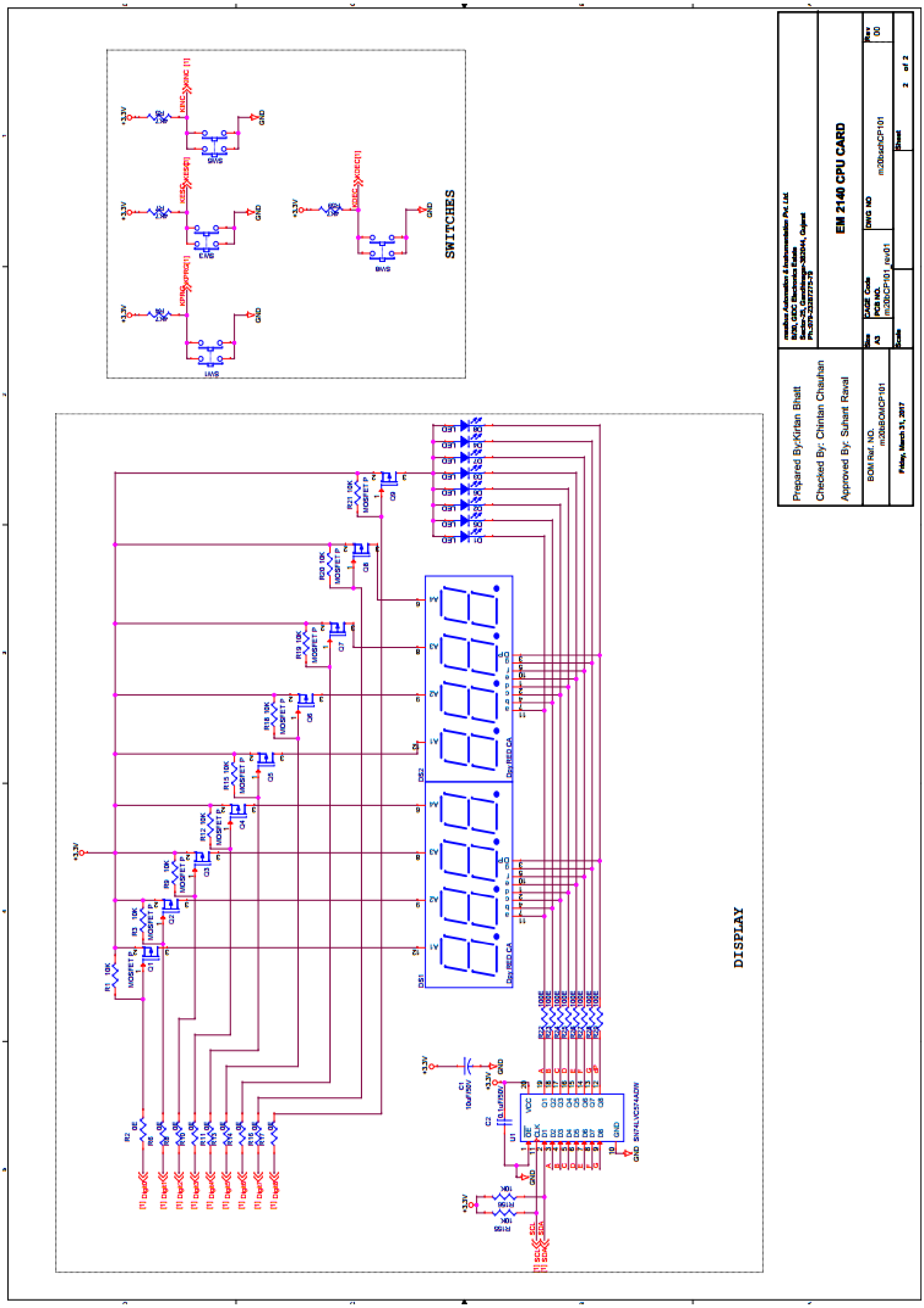


Figure 5.3: Display Schematic

Chapter 6

PCB Design of Energy Meter

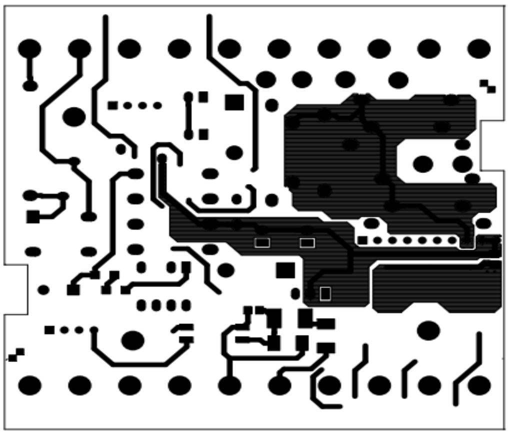


Figure 6.1: PCB PS TOP

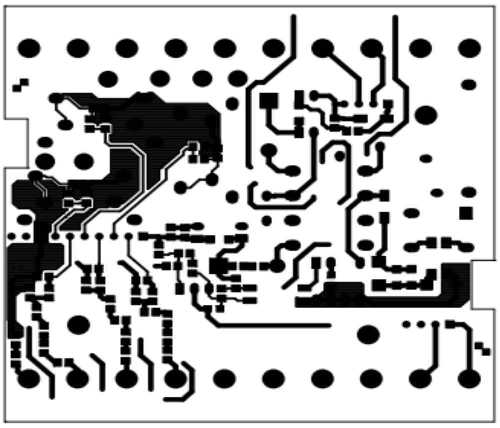


Figure 6.2: PCB PS BOTTOM

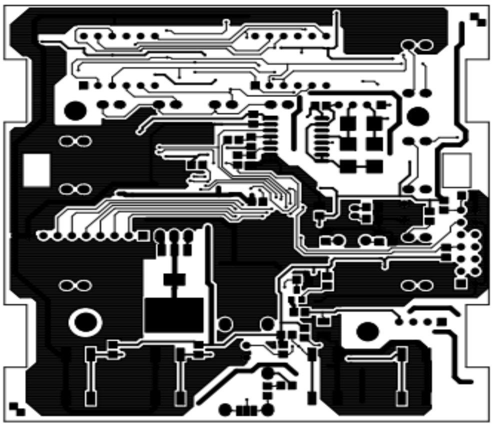


Figure 6.3: PCB CPU TOP

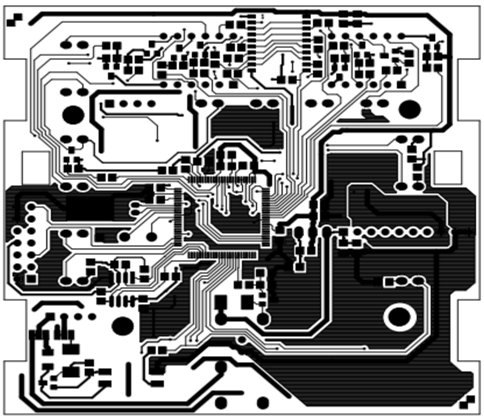


Figure 6.4: PCB CPU BOTTOM

Chapter 7

Conclusion

Instead of using a combination of high end micro controller and energy metering chip, if only dedicated micro controller is used in design of energy meter, cost of system can be reduced greatly to a certain extent without sacrificing accuracy which is very considerable parameter. We have attained accuracy of class 1.0 in the proposed system. In the proposed system the customer can monitor electrical parameters from remote place also which is very helpful for devising strategy for efficiently using electric energy. The front panel of the proposed system is very intuitive and user friendly. To be competent in the market the main trade off is provide more functionality at lowest possible cost. The proposed system here offers low cost system with numerous functionality. This can be an alternative for the sub meter system in each and every field. The proposed system will provide automation in the energy metering sector and it will be very helpful in saving revenues spent in billing by the industries as well as in residencies.

Chapter 8

Future Scope

In the proposed system if wi-fi functionality and if GSM cellular technology is added then the system can communicate with customer's PC wireless. In this system we can also add billing calculation feature in which customer can pay the bill amount which is displayed on the display.

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