Cloud Based Smart Energy Meter

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Abstract:- LPC2148 is a very powerful system-on-chip device belonging to the generation of the ARM 32-bit platform devices providing a lot new features and flexibility to support single, two and three-phase metering solutions. Intercepting 2 terminals of the supply are connected 2 terminals to the Energy Meter where the other two terminals are connected to the load for tapping the energy consumed by the load. The tapping of the meter readings are being done with the help of the Voltage Sensor and a Current sensor. The two results are combined for the calculation of the energy consumption. The bill generated and units consumed for a particular period is being intimated to the particular user and PC via a GSM module. The bill is calculated according to the tariff plan charges and updated. The payment is being facilitated via a Web Payment Portal using an A/c No and password. On a payment being made, a message is being triggered to the meter indicating bill paid and metering to be continued else a disconnection of the supply will result.

Keywords:-ARM 7 (LPC 2148), Step Down Transformer, Voltage Sensor, Current Sensor, Opamp, Hall Effect Sensor, ADC

I. INTRODUCTION

The very specific application of this embedded system describes a single phase energy meter. The components designed measures the active energy, current and potential in a single-phase distributed environment. The main core component of the energy meter is an ARM processor.

Power meters are most of the times to be mentioned as Energy Meters. Power may be defined as a product of voltage and current which is usually required in order to perform a useful task.

A. Objectives

There are various objectives to be met. Some of them involves in determining the following below.

- Determining the load. I.e. 1-phase/3-phase.
- Energy Consumption per unit time.
- Generate bill as per tariff charges of the particular circle and update it in the database.
- Intimate the customer by forwarding the bill generated via SMS.
- Auto-Disconnection on non-payment of bills within the stipulated due time and reconnection after payment if done after the stipulated due time.
- Authentication to a particular account via the user's Account No and a password.

B. Scope of the Work

Since the energy meter determines the energy consumption of the domestic household appliances, it definitely has a scope in the following sectors:

- The individual energy utilization of a particular appliance can be calculated.
- Energy savings based on the utilization by the particular individual and diverting it as needed.
- Forecasting the future energy desire based on the statistics of prior utilization for the same purpose.
- Statistical modeling of the data based on the energy consumed by the specific individual.
- Approximation of the usage of energy by an individual over various intervals of time and averaging it.
- Recording the statistics of energy utilization on a day to day basis and notifying.

C. Purpose of the Work

The purpose of this project is to understand the statistics of the energy utilization by an individual or an organization such as to reduce the wastage or unnecessary utilization of electricity in situations like non-payment of bills, power theft, etc. Also the very purpose of this project is that to reduce the manpower in case of disconnection and reconnection of supply in case of non-payment of bills by the consumer and also during the bill generation. The statistics provide huge information regarding the usage of the energy. Also provides an alternate for the electromechanical analog or digital meters which provide approximate readings by providing more near-accurate readings. Also the web portal interfacing provides an accurate method in generation of bills based on the energy units received wirelessly. The online payment also facilitates the auto continuation and discontinuation of the supply based on the bill payment within a stipulated amount of time duration.

II. LITERATURE SURVEY

Various methods have been implemented for the Energy Utilization and in most methods, there has been a way to eliminate the magnetic induced rotational motion and replace the same using various sensors and Developmental boards by calibrating it via some programming language used for coding purpose. Various papers propose the automatic billing as per the energy consumed according to the tariff plans of the particular circle. Automatic Energy metering system with RFID limited range connectivity[1], wireless sensor networks[2], GSM[3][7][8][11][13][17], Android Application[4], IoT with PLC modem and android application[5][20], Theft Detection using ATMega[6][15], Zigbee [9][16][18], Wireless ARM board[10][12], Prepaid meter[14], Power factor meter and Instrument Transformer[19], along with billing is being discussed. The implemented work makes used of various development boards such as ARM, Arduino, ATmega, 8051, etc. All of the implemented work mainly aim at saving power.

III. BLOCK DIAGRAM

The Energy meter is being installed on the customer end. The power calculations and the energy calculations are being done only at the customer side. The block diagram depicting the energy meter is being shown in the figure below.

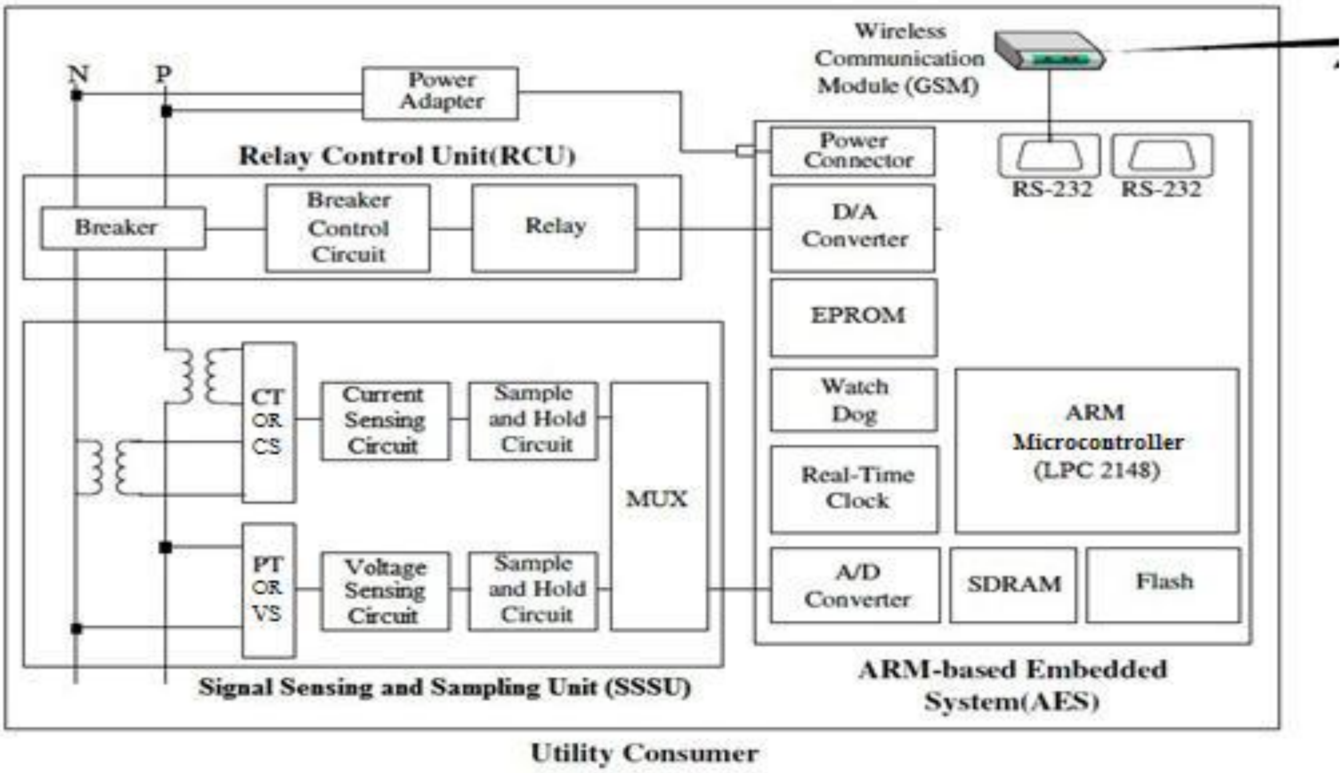

Fig 1: Block Diagram at the Customer End

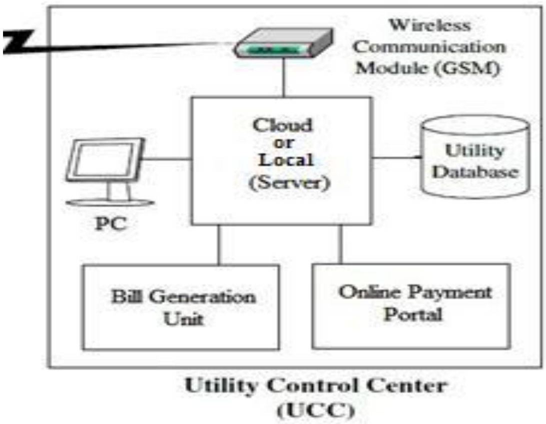

Fig 2: Utility Control Center (UCC)

The functioning of each of the component of a block diagram is as follows:

Initially the power lines are intercepted and are joined according to the block diagram. The Current and the Voltage are being sensed with respective transformers / sensors. The signal obtained is conditioned and is being given to the Analog to Digital Converter of ARM7. The power calculation is being done based on the voltage and current that is measured in the circuit due to variable load connected. The energy calculation is done with respect to the time for how much the electricity is being consumed by the load. The power calculations and the energy calculations are being done in the Microcontroller LPC2148. The EEPROM keeps a backup of the energy when there is a power cut such that the counting of the units can be resumed from where it stopped after the power resumes. The Real Time clock facilitates the calculation of the energy with respect to real time. The stored energy in units is then sent to the Utility Billing Center or the Server via a GSM Module for the Bill Generation and the Payment Purpose. The circuit breaker here is the relay circuit which facilitates disconnection/ reconnection of supply based on the payment made.The utility center lies at the electricity board end. The energy computed at the customer end is being sent to the UCC via a GSM module. This energy received is stored in a database maintained. Block diagram depicting the UCC may be as shown in the Fig 2 above. The working of each of the component of the block diagram is as follows: The information is being fetched from the table in the database. The bill is being generated as per the existing tariff plans of the particular circle. The notification of the bill generation is being intimated to the user via a GSM Module. The payment facilitation is being done via the Web Portal itself where the customer needs to login for making a payment. The head of the board can also analyze the usage statistics of the user based on the energy readings.

IV. DESIGN

Before implementation of any circuit for the practical purpose, the design of it is necessary. The design can be broadly categorized into 2 parts: Hardware and Software Design.

A. Hardware Design

The hardware design involves the design of the voltage regulation circuit, voltage sensing circuit, current sensing circuit and relay.

a) Voltage Regulation Circuit

One method is a 12-0-12 1A Transformer can be used for stepping down the voltage directly from 230V/50Hz to about 12V/50Hz/1A. The output is rectified using bridge-wave rectifier using 1N4007 diodes and 10µF capacitor for the usage of it in electronic components. The figure below depicts the voltage regulation circuit being connected to 7805 and 7812 voltage regulators respectively.

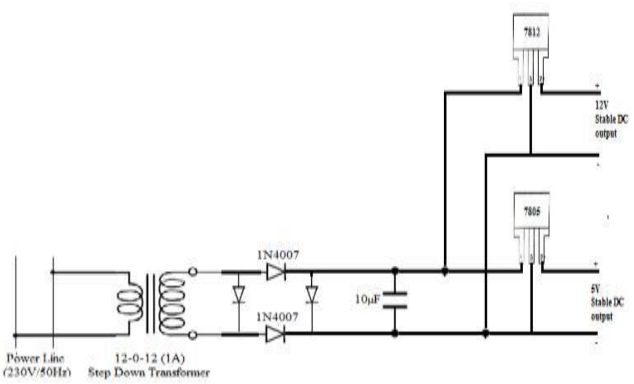

Fig 3.Voltage Regulation Circuit

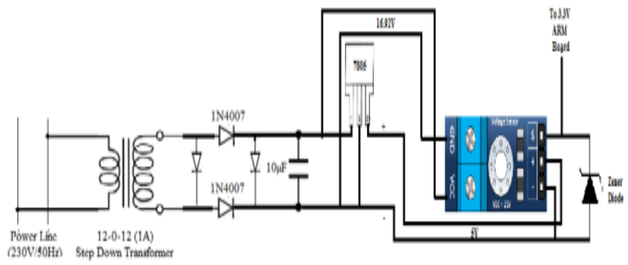

Fig 4. Voltage Sensing

b) Voltage Sensing Circuit

A Voltage detection sensor is being used for the voltage sensing purpose. The voltage sensor has the input voltage less than 16.5V +/- 0.5V whenever it is used with a maximum output voltage of 3.3V. The voltage detection sensor works on the 5V DC supply which can be taken from the 5V stable output of the 7805 Regulator. The Bridge Wave Rectifier output can be given as follows:

VRMS = VIN. * 1.41

Given VIN = 12V, we get

VRMS = 12 * 1.41 = 16.92V

Fig 4 depicts the diagram of a voltage sensing circuit. The voltage available at the output is 2.4V from the voltage sensing circuit.

c) Current Sensing Circuit

A Current sensor (ACS712 – 20A) is being used for the current sensing purpose. The current sensor has the sensitivity of varying about 100mV/A. This is being connected in series with the load which is in-turn connected directly with the main line in series. The current sensor works on the 5V DC supply which can be taken from the 5V stable output of the 7805 Regulator. Figure 5 depicts the connections to a current sensor.

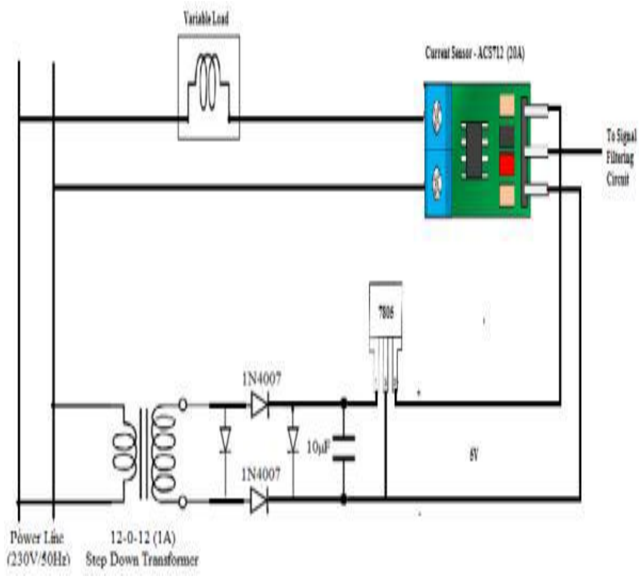

Fig 5.Current Sensing Circuit

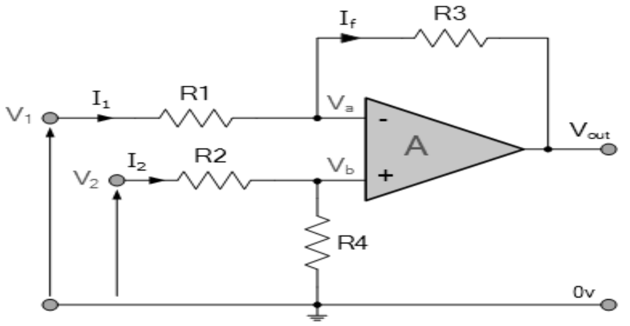

Fig 6. Differential Amplifier Circuit

When the current sensor ACS712 is being used with the DC load, the readings can be directly measured from the output pin. Whatever may be the input, the output always varies in the range 0 to 5V. But when this current sensor is used with AC load, the output needs to be filtered, conditioned and amplified. Thus the conditioning or differential amplifying circuit is being used. Fig 6 below depicts the differential amplifier circuit whose design is as mentioned above. Connecting each input to the 0V or ground and using the superposition to solve for the output voltage. The transfer function for the differential amplifier circuit is as following:

$$I_1 = \frac{V_1 - V_a}{R_1}, \quad I_2 = \frac{V_2 - V_b}{R_2}, \quad I_f = \frac{V_a - (V_{out})}{R_3} \qquad (1)$$

Summing point $V_a = V_b$

$$\text{and} \quad V_b = V_2\left(\frac{R_4}{R_2 + R_4}\right) \qquad (2)$$

$$\text{If } V_2 = 0, \text{ then: } V_{out(a)} = -V_1\left(\frac{R_3}{R_1}\right) \qquad (3)$$

$$\text{If } V_1 = 0, \text{ then: } V_{out(b)} = V_2\left(\frac{R_4}{R_2 + R_4}\right)\left(\frac{R_1 + R_3}{R_1}\right) \qquad (4)$$

$$V_{out} = -V_{out(a)} + V_{out(b)} \qquad (5)$$

$$V_{out} = -V_1\left(\frac{R_3}{R_1}\right) + V_2\left(\frac{R_4}{R_2 + R_4}\right)\left(\frac{R_1 + R_3}{R_1}\right) \qquad (6)$$

Considering the following values: R1 = R2 = R4 = 10KΩ and R3 = 47KΩ. A 10KΩ potentiometer is being used at the non-inverting terminal to adjust the voltage difference available at the output. The input voltage at the potentiometer is 5V. The voltage V2 is the input being received from the current sensor output. A resistor 4.7KΩ is used at the output to step down the voltage. A 100nF capacitor is being used for the removal of any ripples present in the output. This output is then given to the ARM. Voltage V1 is set to 1.4V for proportional amplification of the input.The obtained output from the differential amplifier isthen given to the ARM Board. Figure 7 below depicts the differential amplifier circuit designed.

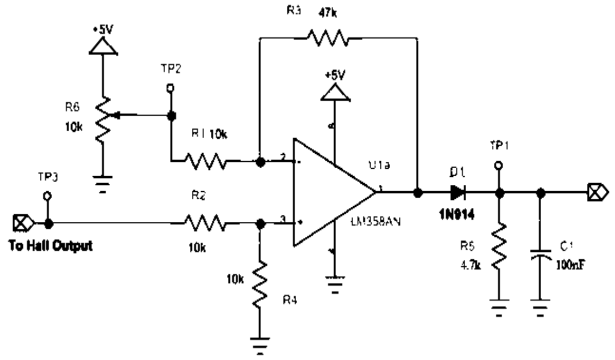

Fig 7.Differential Amplifier Circuit

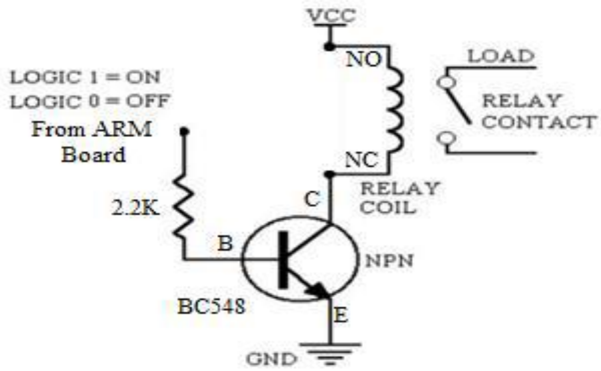

Fig 8. Relay Circuit

d) The Relay

Figure 8 shows the general diagram of interfacing the relay with any microcontroller. There are 2 input channels to the relay. Each input of the relay is connected to their respective triggering coil. Corresponding to the 2 inputs of the relays are the 2 outputs. Energizing the input turns the relay ON which in turn connects the "+" terminal to the Vcc and de-energizing the input connects the "+" terminal to the ground turning the relay OFF. The "-" terminal is permanently grounded.

B. Software Design

The system needs software to be designed for the working of the complete project. The software is categorized into 2 separate parts:

- Code for the ARM Development board for the purpose of Interfacing
- Code for the Database Management System.

a) Code for ARM Board

The source code development for the ARM board needs to be separately designed for each of the interfacing modules.

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- *Analog to Digital Conversion*

The ADC of LPC 2148 is a 10-bit successive approximated ADC. There are 2 ADC's onboard ADC0 and ADC1. ADC0 has 6-Channels and ADC1 has 8 channels. The maximum frequency supported by each ADC is 4.5MHz. ADC related pins are as mentioned below.

ADC 0		ADC 1	
ADC Channel 0	LPC2148 Pins	ADC Channel 1	LPC2148 Pins
AD0.1	P0.28	AD1.0	P0.6
AD0.2	P0.29	AD1.1	P0.8
AD0.3	P0.30	AD1.2	P0.10
AD0.4	P0.25	AD1.3	P0.12
AD0.6	P0.4	AD1.4	P0.13
AD0.7	P0.5	AD1.5	P0.15
		AD1.6	P0.21
		AD1.7	P0.22

Table 1. ADC Related Pins in LPC2148

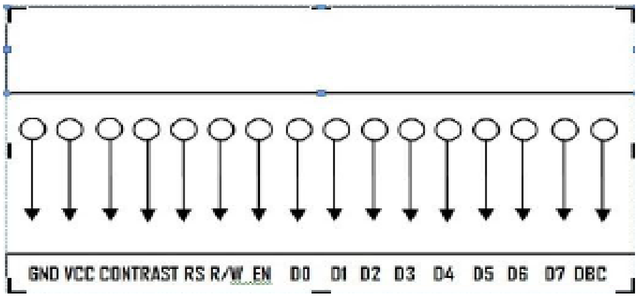

Fig 9. LCD Module

ADCR is the control register used for controlling the Analog to digital conversion. ADGDR is the Global Data register used for storing the converted Data. The bits that are set as follows:

- ADCR (Control Register) : For controlling the ADC
- ADGDR (Global Data Register): For storing the data after conversion as it contains DONE bit.
- ADGSR (Global Start Register): For starting both the ADC's simultaneously.

- *Real Time Clock*

Design of a RTC is a very important task since the bills and the payments are to be generated and received within the stipulated time. The real time clock can be designed with the help the timer registers which is inturn based on the 38.92MHz click frequency. This clock period is very much close to that of the real time normal clock. The registers programmed are as follows: CTIME0, MASKHR, MASKMIN and MASKSEC. The Time is automatically set and then triggered and updated time to time. This RTC is being backup by a 3.3V battery.

- *Relay*

The hardware design for the relay is being discussed in the previous section. The triggering part is being done by developing a source code. The source code for relay is very simple. It can be either triggered by setting any one of the LED on as LED_ON() and off by LED_OFF() where LED ON() and LED_OFF() are 2 functions written to turn on and off the LEDs. The relay trigger switch is being connected to the extended bus of the LED pins.

- *Serial Interfacing of the GSM SIM300 Modem*

The SIM 300 module is interfaced using a serial port. Thus the sending and receiving the data from the modem is via AT commands. The serial registers such as U0THR (Transmit Hold Register of UART 0) and U0RBR (Receive Buffer Register of UART0) are being used for sending and receiving the data from the GSM Module. TX and RX of the port 0 are being used.

- *LCD Interfacing*

The LCD module is interfaced only to display the results after the completion of the operation. The LCD module is as shown in the fig 9. D0-D7 are data lines through which data to be displayed can be sent. It can be written only when EN is low. Based on Read or Write, R/W is set. Gnd and Vcc are connected.

b) Code for DBMS

The DBMS involves the creation of the database, tables and then the code for it. The DBMS is created using PhPMyAdmin. The creation of the DB simply involves a clicking on new, giving and name and clicking on Create. Tables have to be created within the database. Click on New and set the parameters. The parameters can be set using different datatypes such as Int, Bigint, Char, Varchar, etc. The data to be loaded or fetched from the database is done using php language. The calculations are also done by embedding the mathematical calculations into the php coding script. The designs for the HTML pages are done as per the requirement.

V. WORKING

A. Energy Consumption

An Introduction message is being displayed initially and the a message is being displayedindicating to press the switch. Pressing a switch initializes the Energy calculation. The voltage and current sensor's differential amplifier's output is being given to the ADC's of the ARM board. The voltage sensor's output is being provided to the P0.29/AD0.1 of the ADC and the differential amplifier's output (Current Sensor's output) is being given to the P0.28/AD0.2 of ADC 1. The 2 ADC's are being used simultaneously since its very much needed for the power calculation. The power calculation is done as shown below:

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Power = Current x Voltage x Power Factor

The power calculation is current driven and thus changing the load always changes the current value. The voltage is always constant with a value of 2.4V. The value of voltage is less than 3.2V which is the threshold value for the ADC's of the ARM board. Increase in the value of either current or voltage will lead to the damage of the ADC channels. The time period is set for about 2 minutes. Now Energy is defined as the power calculated with respect to time. The figure 10 below depicts a diagram of the calculation of energy.

B. Calibration

Calibration plays a very important role here, since the voltage and the current are being stepped down to their proportional, they have to be again stepped up during the calculations of the energy in units. The calibration can be done as follows:

a) Voltage Calibration

Voltage in the circuit is being stepped down to 2.4V. The actual voltage lies in the range of 230-240V. Assuming the maximum voltage flows in for the domestic use, multiplying the voltage by 100. Thus we get the original value of 240V.

b) Current Calibration

ARM board doesn't understand the value of current when measuring it, It instead measures the proportional voltage generated for the current. Multiplying the voltage by some constant value, the equivalent original current value is obtained.

c) Energy Calculations

Energy is defined as the amount of the power utilized with respect to time. Power is calculated by

Power = Voltage x Current x Power Factor
Energy = Power x Time
i.e. E = [P.T (in hours) / 1000] KWh or units

Thus at the end of the time, the readings fetched and stored in the ADGDR is being fetched, calculations are being done, calibrated as per the original readings and are sent via GSM which is being interfaced via a UART0. Also the Energy consumption in units and the successful message sent is being displayed on the LCD for the user notification.

C. Serial Communication

The calculated energy is being transmitted wirelessly using GSM modem SIM 300. SIM300 module works on 12V/2A but ARM LPC 2148 works on 3.3V, hence there is a need for the logical conversion of the voltages between the 2 devices. This logical conversion of voltages is done by MAX232 IC present onboard of GSM modem. Communication in between the GSM module with other mobile phones occurs with the help of UART present on the microcontroller board. Communication over UART or USART requires 3 basic communication signals namely: RXD (Receive), TXD (Transmit) and GND (Common Ground). Here, in this scheme, CTS and RTS signals of the serial port interface of GSM Modem are connected to each other. Fig 11 depicts the transmission of the message containing the energy consumed by the customer.

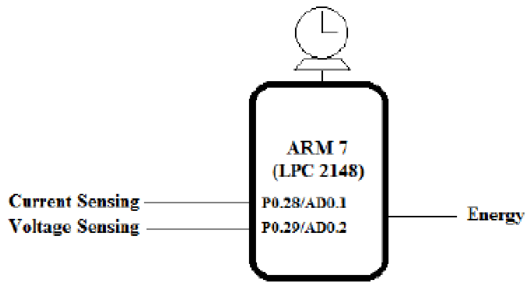

Fig 10.Energy Calculation

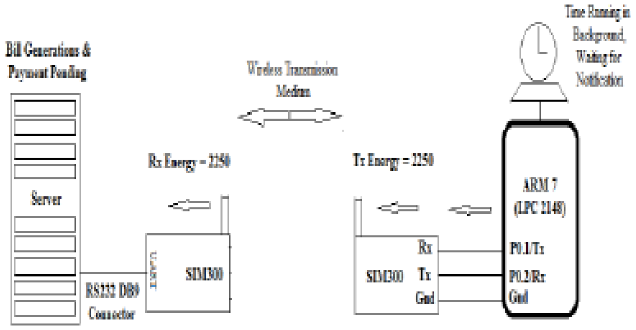

Fig 11.Tx of Message to the Server

The transmission is scheduled only after specified time duration. After the transmission of the energy consumed to the server, the meter continues its metering and simultaneously waits for the bill payment notification from the server. The connection of the GSM Modem on the server side is being done via a RS232 DB9 cable. A timer runs in the background waiting for the bill payment within specific duration. Upon the completion of timer, a disconnection in the supply occurs. Once the message is being successfully delivered, a message is being displayed on the LCD indicating the Message sent successfully. Also since the energy meter is waiting for the SMS, a message indicating "Waiting for Payment" is being displayed on the LCD. This is being displayed until the timer running in the background elapses.

D. Bill Generation

The energy consumed by the customer is being received on the server side. The data received on the server side is directly stored into the local database built for receiving the data directly from the interfaced GSM Modem.The data received via GSM module is directly sored into the database. The energy utilization is stored in the database for the analysis purpose. The data stored is fetched and the first term in the Energy Consumed is separated from the other terms since the 1st character is an Account number and the rest are the units consumed.

sms_text	sender_number	sent_dt
2250		2017-03-04 06:25:40.000000
3250		0000-00-00 00:00:00.000000
4350		0000-00-00 00:00:00.000000

Fig 12. Storing in the Database

From the above figure 12, consider the units used are 2250. Here 2 is the customer account number and 250 are the energy units consumed by the customer. The separation is done in order to facilitate the updation of the bills to the particular user's account since the account number is unique. Whenever bill generation occurs, the current meter reading is being replaced with the new units consumed, the old meter reading is being replaced by the prior meter readings in addition to prior month's meter readings. The billing is done every stipulated time, according to the tariff plan of the particular circle. Once the bill generation is complete, a message is being triggered to the user intimating him of the bill generated, cost and the due date. Simultaneously the bill generated is being updated into the database with respect to the user's account number. Bill updation in the user's account may be as shown in the fig 13 below.

Fig 13. Bill Updation in the User's Account

Fig 14. Payment Portal

E. Payment Portal

The online payment is being facilitated on the local server. The user logs in with his account number and a password, proceeds for payment, enters all the banking details and then submits the information. Based on the details entered by the customer in the form, the details are validated and then the payment transactions is completed. Once the Payment is being completed, a message is being triggered to the user as well as to the modem connected to the energy meter. The bank details are updated simultaneously. Figure 14 depicts the Payment Portal for the customer.

F. Relay (Connection and Disconnection)

Once the payment is done by the customer, a message is being triggered by the portal to the ARM Board. This message is being sensed and based on the time elapsed, a specified action is being taken. If the time duration for the waiting of the payment has elapsed, the supply is reconnected or else if the time duration has not elapsed, it continues metering for the next stipulated amount of time. Fig 15 depicts the reception of the message containing the payment notification.

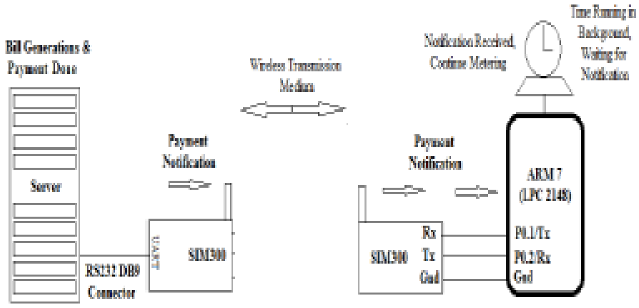

Fig 15.Reception of Payment Notification

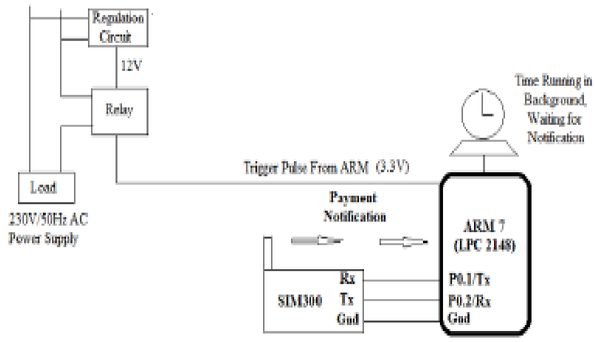

Fig 16. Relay Interfaced with ARM Board

Based on the condition whether the payment notification is received or no, there occurs a connection or disconnection of the supply with the help of the relay circuit. If the bill payment is done within the stipulated amount of time, the metering continues for the next cycle of energy calculation and if the bill is not paid within the stipulated time, there occurs a disconnection in the supply and the energy metering stops. If the payment notification is received after the disconnection of the supply, the connection restarts. Once the timer waiting for the payment notification elapses, a message is being displayed on the LCD indicating "Bill Not Paid, Power Cut" is being displayed and then the supply is disconnected. If the payment notification is received within time, then it continues metering for the next specified duration.

G. Load Determination

Load determination is done by classifying the load into single phase and three phase. Since the voltage fed to the ARM board is 2.4V from the voltage sensor, the voltage upto 2.4V is assumed as single phase and the voltage exceeding 2.4V is considered as 3 phase. This adjustment is done since the actual single phase voltage lies in the range of 230V to 240V. Exceeding the 240V upto 440V is considered as three phase. So the load determination is based on the threshold basis and the threshold is set as 2.4V. Fig 17 below shows a picture depicting load determination.

Fig 17. Load Determination

VI. MERITS AND DEMERITS

A. Merits

There are lot advantages of the implemented work. Some of the advantages are as mentioned below:

- Highly Reliable.
- Portable.
- Compatible.
- Reduces manpower for billing delivery and payment reception purpose.
- User account details viewing and payment accessible at the users place via Authentication.
- Automatic updation of bills and intimating the user at specific time every month via GSM.
- User Energy Consumption can be easily analyzed.
- Specific discrete components can be easily replaced in case of failure.
- Reset of the energy meter is possible in case of failure.

B. Demerits

The lesser the disadvantages, the efficient is the system. Some of the disadvantages are:

- Though GSM is reliable for its network, sometimes unavailability of the network poses a problem.
- Current sensor is magnetically isolated from other components. Flow of electric current around it within few mm distances gives erroneous results.
- Inputs to the ARM board always need to be < 3.2V else there occurs a burnout of the ADC channels.
- Maintenance charges for the billing portal such as Bill Desk are expensive.
- Cloud purchase and maintenance charges are high.

VII. RESULTS AND CONCLUSION

A. Results

Some measurements are being observed with the implemented Energy Meter. These experiments are being conducted to evaluate the correctness and working ability of the system. The system designed was tested for various load and it was observed that it withstands upto wattage of about 1.2KW which corresponds to about a proportional voltage less than 3.2V of the as is also suitable to be used for the ARM Controller.

a) Tests on Voltage Measurement

The performance of the implemented prototype is being measured or evaluated by comparing the actual voltage readings obtained from the prototype with the standard digital multimeter. Table 2 shows the voltage readings on actual DMM and the readings obtained from the prototype. Relative error % is also being calculated.

Measurement No	Actual Voltage Readings	Voltage Reading from the Prototype	Relative Error (%)
1	235.4	240.0	-0.019
2	232.1	240.0	-0.034
3	239.2	240.0	-0.003
4	241.6	240.0	0.006
5	238.5	240.0	-0.006
6	237.0	240.0	-0.012
7	238.2	240.0	-0.007
8	242.1	240.0	0.008
9	239.3	240.0	-0.002
10	240.2	240.0	0.0008

Table 2.Comparison of Actual and Prototype V Readings

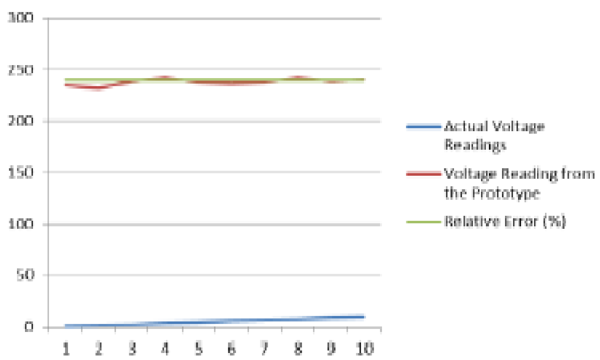

Fig 18. Graphical Representation of Voltage

b) Tests on Current Measurement

The performance of the implemented prototype is evaluated by comparing the actual current readings obtained from the prototype with the standard digital multimeter. Table 3 shows the current readings on actual DMM and the readings obtained from the prototype. Relative error % is also being calculated.

Measurement No	Actual Current Readings	Current Reading from the Prototype	Relative Error (%)
1	0.7984	0.7785	0.0249
2	0.8015	0.7742	0.0340
3	0.7994	0.7810	0.0230
4	0.8034	0.7764	0.0336
5	0.8042	0.7712	0.0410
6	0.7974	0.7694	0.0351
7	0.8021	0.7719	0.0376
8	0.8057	0.7786	0.0336
9	0.7998	0.7684	0.0392
10	0.8010	0.7795	0.0268

Table 3.Comparison of Actual and Prototype I Readings

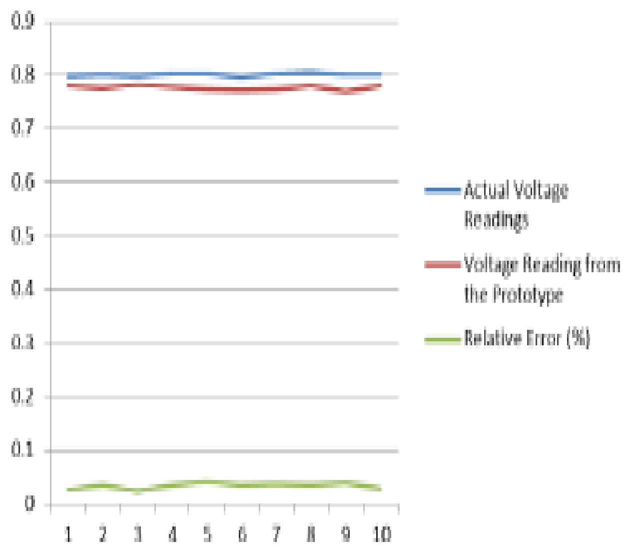

Fig 19. Graphical Representation of Current

c) Tests on Energy Measurement

The consumed power with respect to time is called energy. The performance evaluation of the prototype is being done by comparing the readings obtained from the prototype to the actual readings obtained from the standard meters. The Energy measurements with different loads are being done. Relative error (%) is also being measured.

Load	Actual Energy Consumed (in Units)	Energy obtained from the Prototype (In Units)	Relative Error (%)
25W, 240V	0.009	0.006	0.330
40W, 240V	0.019	0.009	0.520
100W, 240V	0.057	0.026	0.540
200W, 240V	0.155	0.147	0.051

Table 4.Comparison of Actual and Prototype E Readings

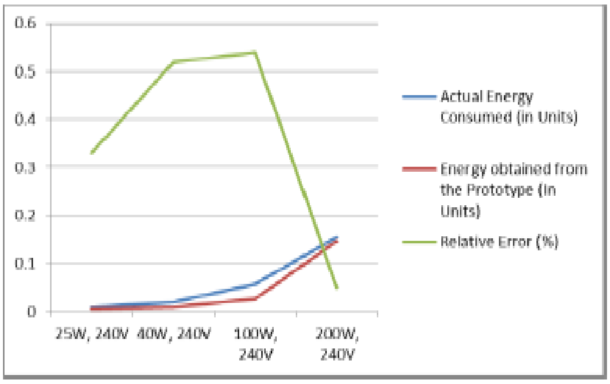

Fig 20. Graphical Diagram of Energy Comparison

d) Bill Generation and Analysis

Based on the energy meter readings, the bill generation is initiated whose accuracy is close to the actual meter readings since the relative error in the measurement of the energy, voltage and current is less than 1%. Also measurements can be saved for the analysis purpose of the amount of energy consumed by each customer with respect to the billing period.

VIII. CONCLUSION

The design and the implementation of the desired energy meter have been achieved. Each part and the section is being carefully designed to meet the necessary requirements of accuracy and bandwidth. The features included are

- Load Determination
- Energy Measurement
- Disconnection and Connection using relay based on bill payment.
- Payment facilitation via online web portal.
- Online Bill Generation
- User access via authentication module.
- Energy Usage Analysis based on the user data in the database.

The code development for the ARM 7 (LPC2148) done in C language provides more flexibility such that any changes necessary can be made or any new feature required can be added without tampering the current code since the code is being developed in modules. The interfacing of the sensors with the ARM board provide much flexibility for design as such if a current sensor of higher range is to be replaced, it can be done easily. Similarly with the other components.The new energy measurement system will certainly decrease the wastage of time as compared to the conventional method of getting the same results for the same time. Observing the results obtained, it can be concluded that the accuracy of the voltage and current measurement is very high since the relative error between the actual readings and the readings obtained from the prototype is very less (Less than 1%).

The usage of the energy by a customer can be analyzed so that electricity wastage can be avoided. Billing at the right time and intimating the user and the time monitoring for the payment of the bills facilitates the in-time connection and disconnection of the supply eliminating the manpower. The maintenance of the user data is being done automatically on the server. The complete view of all the details of all the users to the admin facilitates the triggering of an SMS to the user regarding the payment which is highly advantageous. The implemented work is highly compatible, accurate, portable, reliable and can be used as a substitute or an equivalent for the conventional meters.

IX. FUTURE SCOPE

Future Scope of the work involves

- Introduction of the IoT concept within the system instead of GSM modules.
- Automatic diversion of the extra power to elsewhere needed based on the analysis obtained.
- Introducing a prepaid way of recharging via SMS and authentication by the bank module.
- Theft and malfunction detection.

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