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Full Length Paper

Design and Construction of an Arm Cortex Based Prepaid Meter

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Abstract

This research is a demonstration of the development of an Arm Cortex Based energy Prepaid Meter. The prepaid meter was designed to operate in both prepaid and postpaid mode using key pad to input the subscription code by default the meter operates in prepaid mode unless changed by pressing postpaid button. The system has Arduino Due Microcontroller (Atmel SAM3x8E), Current Transformer (TA1309-200), Voltage Regulator (LM7805), 16x2 LCD Screen (LM041L) and GSM Module (SIM900A). The GSM Module serves as a communication medium between the system and the mobile phone which sent text message to the user with detailed information on low subscription and exhausted subscription. The GSM Module has a SIM Card Number and the system was designed to display on the LCD the wattage consumed and the wattage remaining and also to send text message to the user when the meter have consumed 90% of the subscription loaded. Open circuit and short circuit test were carried out on the project to ensure that there is no open circuit and short circuit fault and operation test was carried out to ensure the functionality of the system.

Keywords: Energy Prepaid Meter, Microcontroller, GSM Module

1. INTRODUCTION

Microcontroller is used for selecting prepaid and post-paid mode. In prepaid mode balance can be filed by user as per requirement. The proposed system works very fast and it sends "low Balance" when operated in prepaid mode to the user to notify him of low balance. For post-paid mode, power used is measured and sent to the distribution company in form of message [1]. This energy prepaid meter will help to reduce the level of stress and loss in the analog energy meter. Ability of the meter to operate in both prepaid and post-paid mode makes it flexible since customers can switch to the mode supported by their distribution company. Implementation of microcontroller with arm cortex 32 bit microprocessor makes the energy meter supersonic in terms of its speed of processing instructions. The aim of this study is to design and construct an arm cortex based energy prepaid meter. It is specifically narrowed to designing and constructing a kind of energy meter capable of operating in both prepaid and post-paid mode.[2]

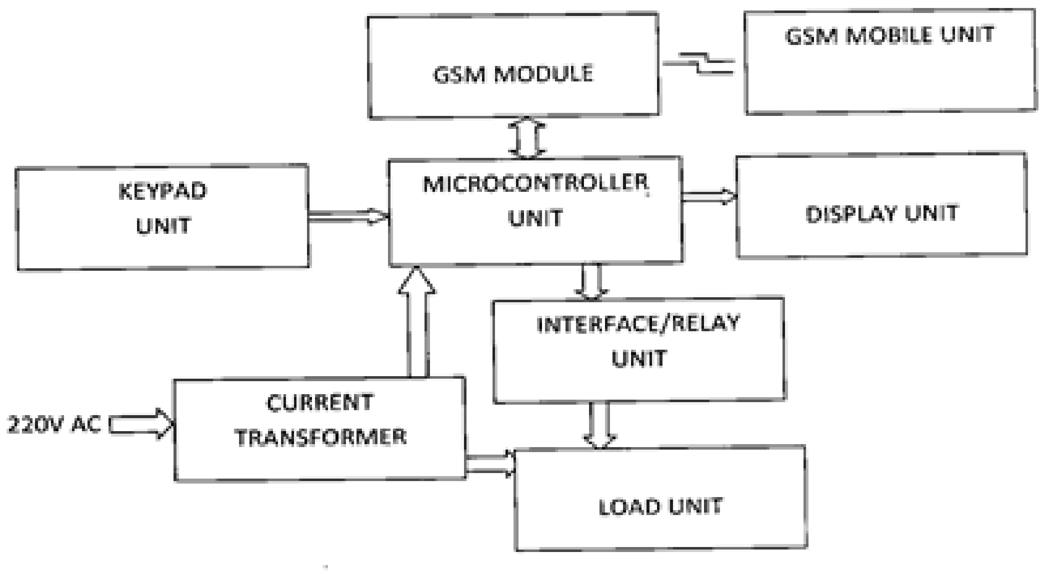

Figure 1: Block diagram of an arm-cortex based energy prepaid meter

GSM Module: This transmits the consumption amount to office modem.
L.C.D Display Unit: This displays the status of the device.

Arduino Microcontroller: All logical decisions such as sending, reception and processing of SMS, switching on and off of load through switch as well the message displayed on the L.C.D are performed by microcontroller unit. Interface/Relay Unit: This unit consists the interfacing components such as transistors and relays. Keypad Unit: The keypad unit is very important unit in the system which helps inputting the prepaid pin into the system [3].

G.S.M: The G.S.M is a global system of mobile network, which is in charge of receiving the alerts of low balances from the system as well as other communications with the system. Load Unit: The load unit shows the entire consumption of electrical appliances.

Applications can be used in Industries, residential buildings, schools and others.

2. RELATED WORKS

The importance of electricity in both homes and industries creates ever increasing demand for it. Present billing methods have made life easy for both customers and the electricity distribution companies and has increased accuracy and reliability by integrating advanced technologies especially in terms of communication and remote subscription [4]

Various approaches have been proposed using Power Line Carrier (PLC) communication, Bluetooth, ZigBee and Wi-Fi and established to provide the reliable and effective solution to the remote metering system. The above methods are too expensive to implement and require complex infrastructure and operate in short distance.GSM and Arduino" where he uses ArduinoUno as microcontroller and GSM module sim900A for remote access and recharging. In his work, the meter can only operate in prepaid mode and recharging is done through SMS thereby allowing remote subscription. In this version of prepaid meter [5], consumer makes payment to the billing company in order to obtain their Personal Identification Number (PIN), and as soon as the PIN is obtained, it is sentas text message to the phone number on the GSM module in the system where it is loaded to update customer’s subscription status. Another related work done is by Ananth C Jayan et al where they used smartcard for recharging of the meter andpic16f887A as microcontroller for control purposes. In their work, recharging is done by a separate unit made of smartcard reader where the card is placed. Customer goes to the distribution where he makes payment in cash and the subscription detail is stored on the smartcard. Use of smartcard eliminates the keying in the PIN number in the other versions of meter. The system is represented by a block diagram as shown below:

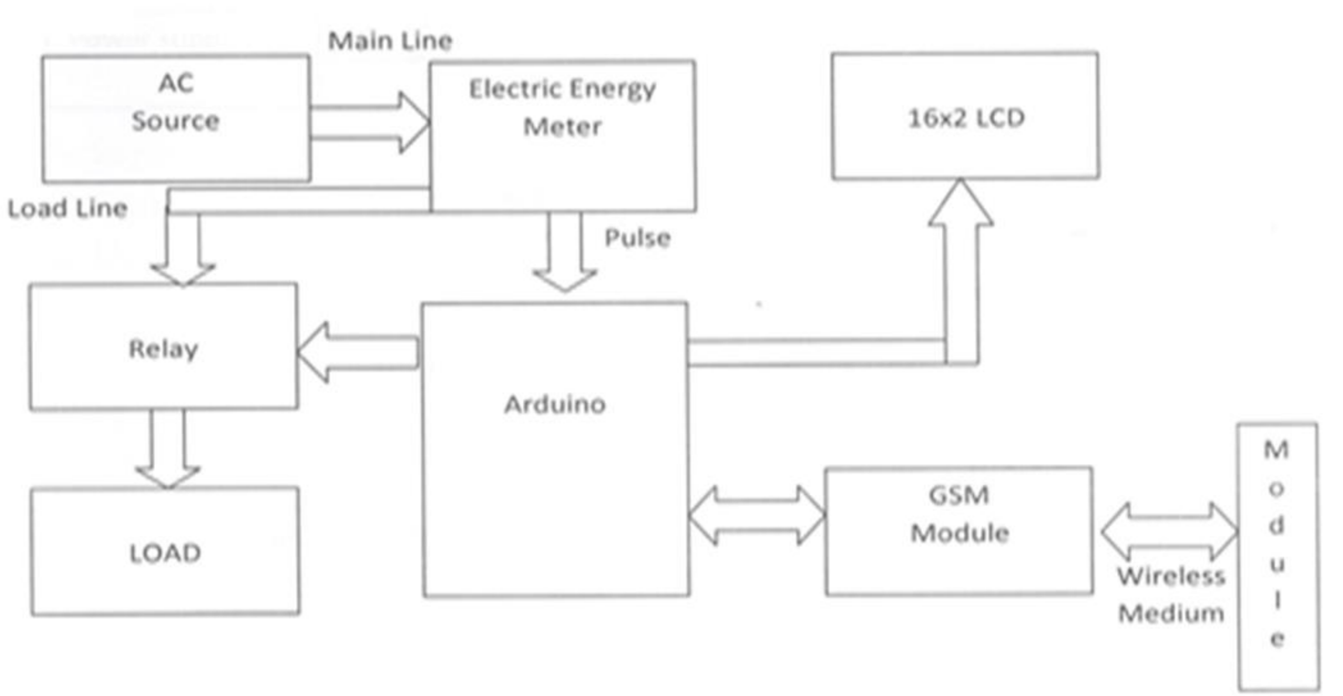

Figure 2: Block diagram of energy prepaid meter using GSM and Arduino

2.1. Prepaid and Post Paid Energy Meter

Prepaid energy meter is a device that allows customers to enjoy energy services based on their subscription after which the services will be disconnected until another subscription. A prepaid meter is an electricity meter which only provides the subscriber with power after payment has been made and this can be in the form of a meter token or credit purchased prior to use. Energy and water so as to ensure that such services are only enjoyed by subscribers thereby reducing chances of customers refusing to pay for services rendered to them. On the other hand, postpaid meter is one that immediately provides electric power to the consumer once it has been installed and allows the consumer to only make pay for his power bills after hehas used the service and this is normally on a monthly or periodic basis but it's always after use [6].Components used to build arm cortex based energy meter are briefly described here. The following components are used :Arduino Due, liquid crystal display, GSM module, relay, current transformer, voltage transformer, bridge rectifier, voltage regulator, transistor and Capacitor.

2.2. Arduino Due (Arm Cortex Processor Based)

Arduino is an open source microcontroller which can be easily programmed, erased and reprogrammed at any instant of time. Based on simple microcontroller boards, it is an open source computing platform that is used for constructing and programming electronic devices. It is also capable of acting as a mini computer just like other microcontrollers by taking inputs and controlling the outputs for a variety of electronics devices. It is also capable of receiving and sending information over the internet with the help of various Arduino shields, which are discussed in this paper. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment). Built up with the 8-bit Atmel AV Rmicro controller's that are manufactured by Atmel or a 32-bitAtmel ARM, these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE. The Arduino Due is a microcontroller board based on the AtmnelSAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs),12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button..

2.3. 16x4 LIQUID CRYSTAL DISPLAY (LCD)

A Liquid-Crystal Display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in colour or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7- segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including LCD televisions, computer monitors, instrument panels, aircraft Cockpit displays, and indoor and outdoor signage. Small LCD Screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smart phones. LCD screens are also used on consumer electronics products such as DVD players, videogame devices and clocks. LCD screens have replaced heavy, bulky cathode ray tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD screens available in sizes ranging from tiny digital watches to huge, big-screen television sets.

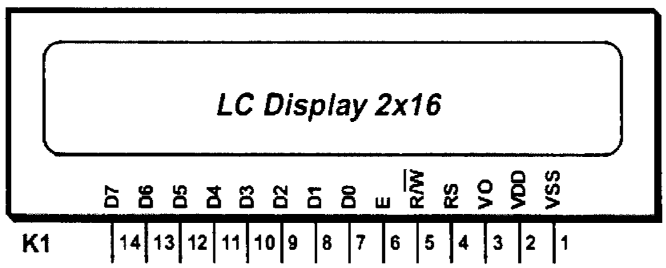

Figure 3: 16x4 LCD

2.4. GSM MODULE

This is a GSM/GPRS-compatible Quad-band cell phone, which works on a frequency of 850/900/1800/1900MHz and which can be used not only to access the Internet, but also for oral communication (provided that it is connected to a microphone and a small loud speaker) and for SMSs .Externally, it looks like a big package (0.94 inches x 0.94inches x 0.12 inches) with L-shaped contacts on four sides so that they can be soldered both on the side and at the bottom. Internally, the module is managed by an AMR926EJ –S processor, which controls phone communication, data communication (through an integrated TCP/IP stack),(through an UART and a TTL serial interface) the communication with the circuit interfaced with the cell phone itself. The processor is also in charge of a SIM card (3 or 1,8 V)which needs to be attached to the outer wall of the module. In addition, the GSM900 device integrates an analog interface, an A/D converter, an RTC, an SPI bus, an I2C, and a PWM module. The radio section is GSM phase 2/2+ compatible and is either class 4 (2 W) at 850/ 900 MHz or class 1 (1 W) at 1800/1900 MHz..

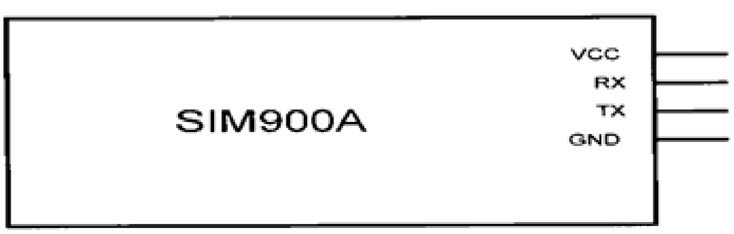

Figure 4: SIM900 GSM Module. SEE APPENDIX 2

2.5 RELAY

Relay is a switch that opens and closes a circuit electromagnetically or electronically. Relays controls one electrical circuit by opening and closing contacts in another circuit. A relay is a three terminal device which are normally closed (NC), normally open (NO) and common (C). The relay is energized when the armature stays on the normally closed terminal, but the armature deflects to the normally open terminal when there is no current flowing in the relay coil. There are different types of relay. These include: Electromagnetic relay, machine tools relay, solid state relay, overload protection relay, latching relay.

2.6. Transformer

Transformer is a passive electrical device that transfer electrical energy between two or more circuits through electromagnetic induction. Two types of transformer used:

Current Transformer - We have used current transformer TA1309-200. It gives output voltage corresponding to the input voltage. There is no connection between high voltage side and low voltage side; high current passes through the primary winding of the current transformer. Maximum measuring Current as about 5A, we have used two current transformers for measuring line current and feedback current. For 30 A current measurement, we have just used one current transformer of 5 An along with five shunt wires of the same length. By measuring current in one wire then multiply with five, we get actual line current. The second current transformer is connected to a neutral line for authenticating meter tampering.

2.7. Voltage Transformer - Transformers are electrical devices consisting of two or more coils of wire used to transfer electrical energy by means of changing magnetic field.

Voltage Transformer can be thought of as an electrical Component rather than an electronic component. Transformer basically is very simple static (or stationary)electro-magnetic passive electrical device that works on the principle of Faraday's law of induction by converting electrical energy from one value to another. The transformer does this by linking together two or more electrical circuits using a common oscillating magnetic circuit which is produced by the transformer itself. A transformer operates on the principals of "electromagnetic induction", in the form of Mutual Induction.

Mutual induction is the process by which a coil of wire magnetically induces a voltage into another coil located in close proximity to it. Then we can say that transformers working the "magnetic domain", and transformers get their name from the fact that they transform" one voltage or current level into another. Transformers are capable of either increasing or decreasing the voltage and current levels of their supply, Without modifying its frequency, or the amount of electrical power being transferred from one winding to another via the magnetic circuit.

2.8. Bridge Rectifier

Bridge Rectifiers are the circuits which convert Alternating Current (AC)into direct current (DC) using the diodes arranged in the bridge circuit configuration. They usually comprise of four or more number of diodes which cause the output generated to be of the same polarity irrespective of the polarity at the input, Figure 1 show such a bridge rectifier composed of four diodes D1, D2, D3 and D4 in which the input is supplied across two terminals A and B in the figure while the output is collected across the load resistor RL connected between the terminals C and D.

Now consider the case wherein the positive pulse appears at the AC input i.e. the terminal A is positive while the terminal B is negative. This causes the diodes D1 and D3 to get forward biased and at the same time, the diodes D2 and D4 Will be reverse biased.

As a result, the current flows along the short-circuited path created by the diodes D1 and D3 (considering the diodes to beideal), as shown in Figure 4.

Thus the voltage developed across the load resistor RL will be positive towards the end connected to terminal D and negative at the end connected to the terminal C

2.9. Regulator

A voltage regulator is one of the most widely used electronic circuitry in any device. A regulated voltage (without fluctuations & noise levels) is very important for the smooth functioning of many digital electronic devices. A common case is with micro controllers, where a smooth regulated input voltage must be supplied for the micro controller to function smoothly. Voltage regulators are of different types. In this article, our interest is only with IC based voltage regulator.

An example of IC based voltage regulator available in market is the popular 7805 IC which regulates the output voltage at 5volts. Now lets come to the basic definition of an IC voltage regulator. It is an integrated circuit whose basic purpose is to regulate the unregulated input voltage (definitely over a

predefined range) and provide with a constant, regulated output voltage.
An IC based voltage regulator can be classified in different ways. A common type of classification is 3 terminal voltage regulator and 5 or multi terminal voltage regulator. Another popular way of classifying IC voltage regulators is by identifying them as linear voltage regulator & switching voltage regulator.

2.10. BIPOLA Transistor

Transistor was invented by a team of three scientists at bell laboratories, USA in 1947. Although the first transistor was not a bipolar junction device, yet it was the beginning of a technological revolution that is still continuing in the first century.

2.11. The Bipolar Junction Transistor (BJT)

The bipolar junction transistor (BJT), referred to as a transistor, is a three-terminal solid-state device that operates on electric current much like a valve does on water in a pipe.
There are two basic types of BJT transistor: NPN and PNP both of which are made from three layers of semiconductor material. The only functional difference between the two types is the direction of current flow. The arrow head of the emitter indicates the (conventional) current direction. The NPN type is more common and will be the type used in the following discussions. In each of the BJTs, there are three layers called Base, Collector and Emitter.

2.12. Resistor

Resistance is the property of a resistor to restrict the flow or electric current. During this process energy is used up as the voltage across the component drives the current through it and this energy appears as heat in the component. Resistance is measured in ohms and thesymbol for ohms is an Omega (Ώ). The resistance R offered by a conductor depends on the following factors: It varies directly as its length L, it varies inversely as the cross sectional area A of the conductor, it depends on the nature of the material, it also depends on the temperature of the conductor. Resistor is manufactured in a wide range of resistance values from less than 12 to more than 100MΩ.

Resistor Color Coding

Resistance value is marked on the resistor body. The first three bands provide the value of the resistor in ohms and the fourth band indicates the tolerance. Tolerance values of 5%,2%, and 1% are most commonly available.

Table 2.1: Resistor color codes

COLOUR	DIGIT	MULTIPLIER	TOLERANCE	TC
Silver		x 0.01Ω	±10%	
Gold		x 0.1Ω	±5%	
Black	0	x 0.10Ω		
Brown	1	x 0.100Ω	±1%	±100* 10^{-6}/K
Red	2	x 0.1kΩ	±2%	±50* 10^{-6}/K
Orange	3	x 0.10kΩ		±15* 10^{-6}/K
Yellow	4	x 0.100kΩ		±25* 10^{-6}/K
Green	5	x 0.1MΩ	±0.5%	
Blue	6	x 0.10MΩ	±0.25%	±10* 10^{-6}/K
Violet	7	x 0.100MΩ	±0.1%	±5* 10^{-6}/K
Grey	8	x 0.1GΩ		
White	9			±1* 10^{-6}/K

2.13. Capacitor

Capacitors are passive elements which are capable of storing charges and discharging energy. It consists of two plates placed in parallel to each other. The distance between the two plates (electrode) is filled with dielectric (insulator). These are polarized (electrolyte) capacitors and the non – polarized (ceramic) capacitors. Other types are paper, polyester, polycarbonates etc. the symbol of the types of capacitor.

The circuit consists of different sections each performing its own task. The explanation starts with the power supply where both ac and dc are supplied to the load as well as the electronic circuitry. At 220V the main is applied to the primary of the transformer which transforms it to 24V and applies it to bridge rectifier for conversion from ac to dc. Capacitor C_1 filter removes the ripples in the dc and applies it to both LM7805 and LM7812 voltage regulators where it regulated to both 5V and 12V respectively. Biasing of transistor Q_1 is done using 12V from LM 78 12 while 5V is used to power sim900 module, Arduino Due as well as LCD LM041L respectively.

By default, the meter operates in prepaid mode unless changed by pressing POSTPAID button. Current drawn by LOAD passes through current transformer TR_2 which induces current in the winding. The induced current is converted to voltage using a burden resistor R_1 and capacitor C4 so that it will suit the analog input pins of the Arduino Due microcontroller. The converted voltage is now applied to analog input pin A5 for microcontroller to calculate the power consumed by the load. The calculated power consumed is displayed on the LCD. The balance of the subscription, mode of operation (either post-paid or prepaid) are also displayed. When the subscription is exhausted, microcontroller sets it digital output pin 15 to HIGH state (to forward bias the emitter-base junction of Qi so as to cause current to flow through the coil of relay and as a consequence makes its armature moves to the normally open terminal to disconnect LOAD from the main supply) prepares the content of the message and triggers GSM module to send it to the user cell phone. User can subscribe by typing the subscription code or send it to the meter through SMS service of the GSM mobile phone. When the code is successfully typed or sent. Arduino Due receives it, decode it and updates the subscription status displayed on LCD and in addition, it sends a success message to the registered phone numbers.

3. MATERIALS AND METHODS

Design of prepaid energy meter is based on the following specifications given GSM Communication, Rechargeable remote, single phase, Load cut off, Arm-cortex based processor controller. The design was sectioned into power supply, microcontroller selection, display unit selection, voltage regulator selection, current regulator selection, capacitor filter selection and G.S.M module.

3.1. Design of Power Supply

Selection of transformer is guided by two major factors, namely; current and voltage. Voltage from the secondary of chosen transformer should be within range of specified input voltage of voltage regulators to use in the design. Since the required input voltage by both regulator (LM7805 and LM7812) is between 7 to 35 volt, and total current consume by circuit components and module is less than 1A, it was decided to go for 12x2 volts, 1A centre-tap transformer. The transformer has the following specifications:

3.2. Selection of Voltage Regulator

Selection of voltage regulators is also guided by same factors guiding the selection of transformer. Each of the selected regulators is capable of supply maximum of 1A. LM7805 outputs 5V while LM7812 supplies 12V, Based on the current consumption of the circuit (i.e. 683mA), both LM7805 and LM7812 were good choice.

3.3. Selection of Bridge Rectifier

The best is using a full wave rectifier, Its advantage is DC saturation is less as in both cycle diode conduct. Higher Transformer Utilization Factor (TUF). 1N4007 diodes are used as it is capable of withstanding a higher reverse voltage of 1000V whereas 1N4001 is 50V. Center Tap Full Wave Rectifier. The bridge rectifier converts the ac voltage input to dc voltage output.
The choice of the bridge rectifier depends on: Peak inverse voltage and the forward current rating.

3.4. Capacitor Filter Selection.

The filter used in this power supply is a single shunt capacitor. The choice of the filter capacitor depends on: **T**he ripple factor allowed
and the capacitor breakdown voltage

3.5. The Ripple Factor Allowed

The output of a rectifier consists of a dc component and an ac component (also called ripple). The ripple is undesirable and causes pulsations in the rectified output the effectiveness of a rectifier depends on the amount of ripple in its output, the smaller this is, the more effective is the rectifier. The ripple factor is an indication of the effectiveness of the filter capacitor and is defined as:

Ripple factor = $\frac{\text{rms value of ac component}}{\text{value of dc component}} = \frac{V_{rms}}{V_{dc}} = \frac{ac}{dc} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

The smaller the ripple factor the lesser the amount of ripples and hence more effective is the rectified output signal. These ripples have a frequency of twice the input supply frequency. The ripple factor for full-wave rectifiers and thus allowed for this project is given as:

$I_{RMS} = \frac{I_m}{\sqrt{2}}$

$I_{DC} = \frac{2I_m}{\pi}$

$$\therefore y = \sqrt{\left(\frac{I_m}{\sqrt{2}} \text{ x } \frac{\pi}{2I_m}\right)^2 - 1} = 0.48$$

This shows that the dc component of the full-wave rectifier output is more than the ripples, making full wave rectifiers more suitable for rectifying ac to dc.

3.6. The Capacitor Breakdown Voltage

The fixed positive IC voltage regulator was chosen from the 78xx family of fixed positive voltage as they are more efficient in providing the much needed constant voltages for the interconnected circuitries of the design. The capacitor breakdown voltage can be determined by applying Kirchhoff's voltage law at the output of the rectifier to the terminal of the filter capacitor. The capacitance of the capacitor used is gotten using the relationship:

$\Delta V = \frac{I_L}{2fC}$

Where:

ΔV = Change in maximum minimum peak values of the capacitor voltage

I_L = load current

F = frequency (Hz)

C = capacitance

Taking

ΔV = maximum peak - minimum peak

Maximum peak = 22.16V (calculated)

Change peak voltage (AV) = maximum peak minimum peak =2.2v

A standard value of 2200uF capacitor was selected

3.7. Selection of Microcontroller

A high speed of ARM CORTEX ARDUINO microcontroller of 20 pins are required.

Hence, the Arduino due microcontroller ARM-CORTEX A55 was selected.

Features of ARM CORTEX microcontroller; For its powerful 84M; Hz, 32 bits processor for speed, low rate of heat loss and its efficiency

3.8. Selection of a Current Transformer

A current transformer is a type of transformer that is used to measure alternating current AC. It produces a current in its secondary which is proportional to the current in its primary. The selection of the current transformer was done based on its following Factors in selection of a current transformer, Burden, Rating factor, Load, Burden class/saturation class, Temperature.

3.9. Selection of GSM Module (SIM 900)

GSM module does not need much considering in terms of selection apart from just two or more factors. There are a lot GSM module with different designs and specifications but to be able to select good one among at affordable price, the following points were considered. Features of a GSM module, GPRS class 10: max. 85.6 kbps (downlink), PBCCH Support, Coding schemes CS 1,2,3,4.

3.10. Selection of Display (16 X 2 LCD MODULE)

Quantity and nature of information to be conveyed to the user are the determining factor of how big a display should be and whether it should be a graphical or textual display only. In our project, the interest is to display Energy consumed, energy balance and total energy paid for. So three rows are required for the three different information, but since the displays available in the markets are having either 2 or 4 rows, 4 rows display becomes the best option. Since graphical information is out of context, having a display that will display texts properly is enough as it will to reduce cost. Hence, LCD LMO16L was selected.

3.11. Design of Load Switching Circuit

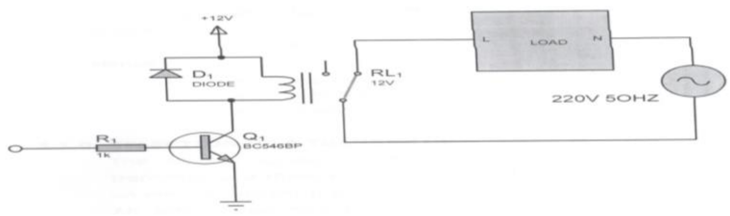

Figure 6: Load Switching Circuit

Applying KVL to the input of Q1 in Fig. 6;
Output loop equation

$V_{CC} = V_C$

$V_C = I_C R_C$

Where

R_C = relay coil (400Ω)

I_C = 12/400

= 30mA, relay coil current

From

$I_B > I_C/\beta$

From the data sheet β = 100

I_b = 320 vA

From input loop equation

$V_{bb} - I_b R_b - V_{be} = 0$

Where

V_{bb} = 5

Hence

$R_b = V_{bb} - V_{be} / I_b =$ 4.99Ω

3.12. Selection of a Transistor

The bipolar junction transistor (BJT), referred to as a transistor is a three terminal solid state device that operates on electric current much like a valve does on water in a pipe. An NPN silicon BC546, was selected. Features of an NPN transistor. Collector-emitter breakdown voltage BC546 (I_C = 1.0mA, I_b = 0). The base is more positive than the emitter and the collector. The emitter is more negative than the collector.

3.13. Installation of Arm Cortex Based Energy Prepaid Meter

The energy prepaid meter can be installed on the wall from 6fit above the grand where water or any fluid will not affect it to avoid danger of electric shock or damage of the meter. It is also important to install the meter where it can be protected from been stolen or manipulated by on authorized personnel.

4. CONSTRUCTION OF AN ARM CORTEX BASED PREPAID METER

After designing the circuit in the previous chapter, in this present chapter, there in is the construction of the designed work performed. It involves: Fabrication circuit board (PCB) layout, Soldering of components, testing, preparation of casing. Tools and Equipment used to perform construction are: Multimeter, cutter, hand drilling machine, screw drivers, sand paper, meter rule, laserJet printer, pressing iron, soldering iron.

4.1. Fabrication of Printed Circuit Board (PCB)

Fabrication of Printed Circuit Board (PCB) took numbers of sequential steps as listed : Preparing the layout, printing and Transferring the layout to copper clad board, etching and drilling the printed circuit board, inserting the component into the holes on the board, soldering of components to printed circuit board, testing the circuit.

4.2. Making the Layout of the Circuit

To prepare the PCB layout, Proteus software was used. It involves the following steps: Selecting the components from the components library; wiring the components; opening the PCB design window and routing all the connections; placing Via around the components pins; printing the layout on a glossy paper using a laser jet printer.

4.3. Printing and Transferring the Layout

After successful completion of the layout, next is to print it on a glassy paper using a laser jet printer. To transfer the layout to the copper clad board, the paper is wrapped around the board and hot pressing iron is used to press the board for about four minutes until the layout is visible on the board.

4.4. Etching and Perforation of the Board

After successful transfer of the layout on to the board, the board was immersed into a solution of ferric chloride for etching. The solution was shook and after about 8 to 13 minutes, the board was etched. The board was removed from the solution and cleaned with water. Thinner was used to remove the toner covering the unexposed part of the layout. Finally, the board was perforated using a mini hand drilling machine.

4.5. Placing the Component on the Vero-board

After the identification of the required components, the layout diagram was followed to place each component in their proper positions while paying serious attention to the terminals of the components. To secure each component in its position before soldering, their terminals were bent around the holes of the board.

4.6. Soldering of the Components to Vero-board

After placing the components in their proper positions and bending their terminals, the other side of the Vero- board was turned to solder the terminals of the components to the copper strips. To solder, the tip of the soldering iron bit was placed between the terminals of the components and copper strip and allowed to heat up for some few seconds, and afterwards soldering lead was applied. The soldering lead melted and flowed freely between the terminals of the components and the copper plate. Afterwards, the soldering iron was removed allowing the molten lead to cool down and solidify. To ensure good bond, the tip of the soldering iron was cleaned to free it from dirt.

4.7. Preparation of casing

The casing here refers to package that houses the circuit board and all the components mounted on it. In this section, two considerations are important. The casing is to serve two purposes to protect circuitry from environmental exposure and gives the project good look. The casing is plastic and rectangular in shape. The following steps were taken to prepare the casing: For the lcd used to be attached to the casing, rectangular hole was made using electrical drilling machine and flat file. More perforations were made on the rear side for power supply from the main.

4.8. Challenges Encountered/Solution Procedure

Problems or challenges faced while designing or constructing this project are: It was a tough task to develop an algorithm for interacting with user's input and reading energy consumption simultaneously; there was short-circuit fault in the circuit that was traced but not found immediately until after serious troubleshooting with continuity tester; Although the highlighted problems/challenges are obviously a cause of time wasting and little bit of frustration, they are also sources or knowledge. Experience gained in the design and construction of energy meter with multiple functionality are numerous and may not be easy to be mentioned because some are so minimal that one cannot recollect easily: Deeper knowledge and understanding of C programming language; ability to solder component; how to integrate GSM technology into a research project; Understanding of preparation of printed circuit board; Use microcontroller to automate devices or systems.

5. Conclusion

After completing the design, the construction of the system was implemented and finally testing takes place. The result obtained was in line with the aim and objective of building a prepaid/post-paid energy meter that user can operate in both modes depending on the one suitable while considering the financial status or location of the system. It was concluded that the aims and objectives of the project were achieved. It was observed that using PCB for the construction reduces the number of errors, increases the speed and makes work more beautiful. Also, a little intelligence was added to the energy meter which will not help a user manage his power effectively. It was recommended that subsequent designs should include power management capability so that it will be user friendly by helping user to use power when needed and disconnected any undesired load s as to conserve energy and save subscription.

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