NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 10, ISSUE 6, June -2023

PREPAID ENERGY METER USING GSM/GPRS

Mr. Rushikesh J. Admane[1]
Mr. Shubham P. Chavan[2]
[1,2] Undergraduate Students, Department of Electrical Engineering/VVPIET, Solapur/
Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad, Maharashtra

Prof. Dhavale A. A.
Asst. Prof., Department of Electrical Engineering/VVPIET, Solapur/
Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad, Maharashtra

ABSTRACT
The work carried out here in this paper represents designing and implementing a digital prepaid energy meter which this affordable for domestic consumers in a developing countries. The prepaid energy meter is a single phase 230V/40A energy meter which consist of a metering devise designed according to the IEC1036 (1996-09) standard and a prepaid module that uses GSM/GPRS technology to communicate with the utility server. In this project researchers have proposed prepaid energy meter by using Arduino nano, GSM SIM800L. The main advantage of this work is fast collection of electricity bill, less involvement of human in the process, increased speed of operation. And along with it the work will make the system paperless.

INTRODUCTION
The cost of electrical energy has been increasing over the years. This creates a concern among home users regarding the energy usage efficiency of the electrical appliances that they are using. Thus, there is a need to design and implement a Prepaid Energy meter System to control the amount of energy supply. The purpose of this project is to design and implement a Prepaid Energy Meter System to control the amount of energy supply based only on the prepaid amount. This facility can be used in shared environments and the consumer utilized the energy supply based accordingly to its available credit which can be topped-up. Prepaid Energy Metering System referring to the concept 'First Come First Serve' but for this project the concept is 'First Pay First Serve'. All electricity can be only generated once people pay money or reload fist before use. After a reload, the credit is activated and from that, all of the electricity will start being used. When the credit runs out, electricity will be cut off immediately. To use the electricity consumers needs to reload and fill in the credit. An energy metering system can efficiently control the amount of electricity consumed by the user. Electricity users can buy a specific amount of energy to use it only when they need. So, all consumers will be more careful and will not waste the electricity and be more responsible. Because of the fast growing of technology, prepaid energy system is faced with very fast accommodation. The basic prepaid system is used to reload more energy supply and saved it on energy storage for further used, but nowadays it comes with various functions to fulfill consumer needed. However, to own the system, it will be quite pricey.

Comparison between Postpaid Metering System & Prepaid Metering System

Sr. No.	Postpaid Metering System	Prepaid Metering System
1	Make a payment after use	Make a payment before use
2	The process is under office management,which have invoicing, feedback and response and consumer monitoring	The process is self-administered whichalready cut down the worker costs
3	To end up payments, staff in charge willcome to read the meter reading	To end up payments, no need staff to readthe meter reading
4	There have lots of time loss and resourcesfor clients and distributor due to connection disconnection of the system	There are use concept of self- connection and self-disconnection ofthe system whichsave money and there no customer complaints
5	Low-income households which uselow energy consumption need to pay the samerates of maintenance and management costs every month	Just only once off installation,maintenance and management costs

BLOCK DIAGRAM

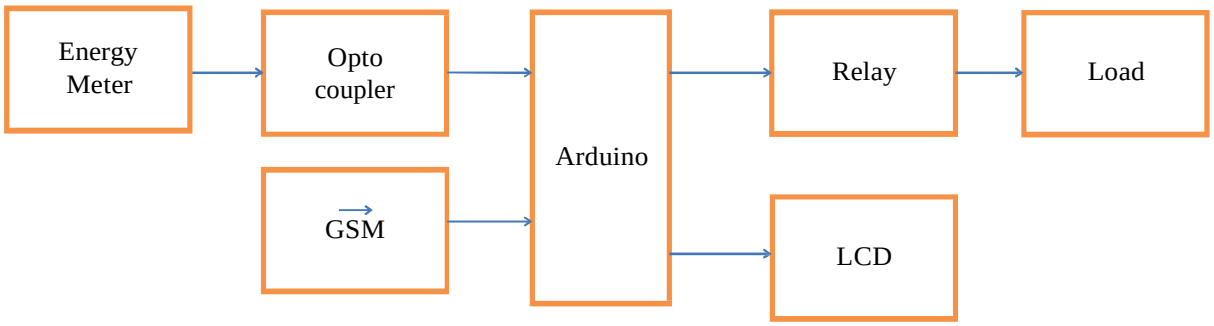


Fig 1

CIRCUIT DESIGN

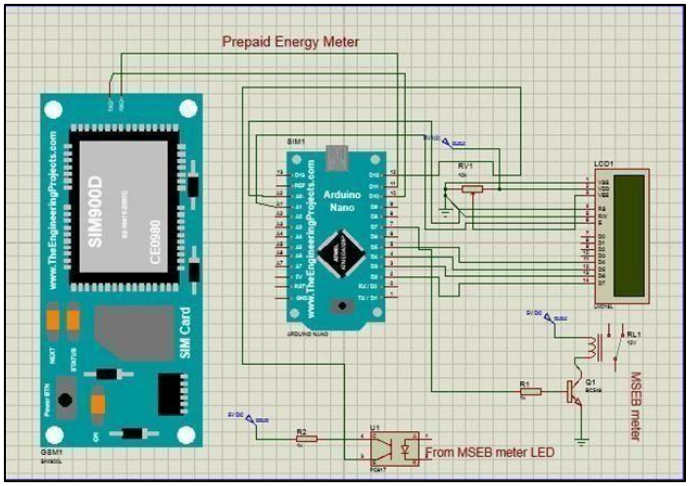


Fig 2

ANALYSIS OF HARDWARE COMPONENTS:

1. Regulated Power Supply:

The microcontroller and the circuit associated with it requires 5V supply where as the relay used requires 12V supply for its operation. Usage of two separate power supplies for Arduino and relay will increase the size and cost of the project. Hence, a single 12V adapter is connected to the mains, which produces 12V output usable for the relay and then this voltageis passed through a LM7805 voltage regulator resulting in a 5V DC output usable for the Arduino and the associated circuitry. The adaptor works as a filter and rectifier. Load is connected across 220V AC supply.

2. Arduino:

Arduino is a programmable device which consists of a processor RAM, ROM, I/O ports, and a timer all on a single chip. ATmega 328P Arduino is used in this project. It is highly reliable and virtually low cost. The software used to program the ATmega 328P to do specific tasks is Arduino IDE. It has a total of 28 pins out of which 23 are multifunctional. The device operates between 1.8-5.5 volts International Journal of Management, Technology And Engineering Volume 8, Issue XII, DECEMBER/2018 ISSN NO : 2249-7455 Page No:4401

3. GSM:

GSM in this project is used for the communication between the device and the user. We used SIM800L module. This module supports quad-band GSM/GPRS network, available for GPRS and SMS message data remote transmission. The SIM800L communicates with microcontroller via UART port, supports command including 3GPP TS 27.007, 27.005 and SIMCOM enhanced AT Commands. SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. After connecting power module boots up, searches for cellular network and logins automatically. On board LED displays connection state (no network coverage-fast blinking, logged in-slow

blinking).

4. Energy Meter:

In this project Digital Energy Meters. These meters have microprocessors which are used to calculate phase angle between voltage and current, so that it also measures and indicates reactive power. It is programmed in such a way that it calculates energy according to the tariff and other parameters like power factor, maximum demand, etc. and stores them in EEPROM. It also contains real time clock (RTC) for calculating time for power integration, maximum demand calculations and also time and date stamps for particular parameters.

5. Optocoupler:

An Optocoupler is an electronic device that interconnects two separate electrical circuits by means of a light sensitive optical interface. It acts to break ground loops used in eliminating common-mode noise, especially for systems working at the higher operating voltages. Here we are using PC817 Optocoupler.

6. Relay:

A relay is an electrically operated switch. In this project relay is used to control the power to the en energy meter. The relays are controlled using a low-power signal. All relays contain a sensing unit, the electric coil, which is powered by AC or DC current. When the applied current or voltage exceeds a threshold value, the coil activates the armature, which operates either to close the open contacts or to open the closed contacts. When a power is supplied to the coil, it generates a magnetic force that actuates the switch mechanism. The magnetic force is, in effect, relaying the action from one circuit to another. The first circuit is called the control circuit; the second is called the load circuit.

WORKING:

The 230V AC power supply is given to operate the loads. A 20V adapter is used to provide 5V to the Arduino board and from here it is interfaced with relay, GSM and LCD. The transmitter and receiver pins of GSM are connected to the receiver (Rx 0) and transmitter (Tx 1) pins of Arduino board. The Optocoupler is given to the 8 pin of Arduino Uno and the other end is given to the energy meter. The relay is connected to the 12 pin of the Arduino board and to the energy meter as well as the load. The load in turn is connected to the energy meter. The LCD 6 pins i.e. RS, Rw, E, D0-D2 are given to the 2, 3, 4,5,6,7 pins and the switch is connected to the 13 pin of the Arduino board. Here we are representing the switch outside of the energy meter just to represent the power theft in real life.

COMPONENT DETAILS

Arduino Nano:-

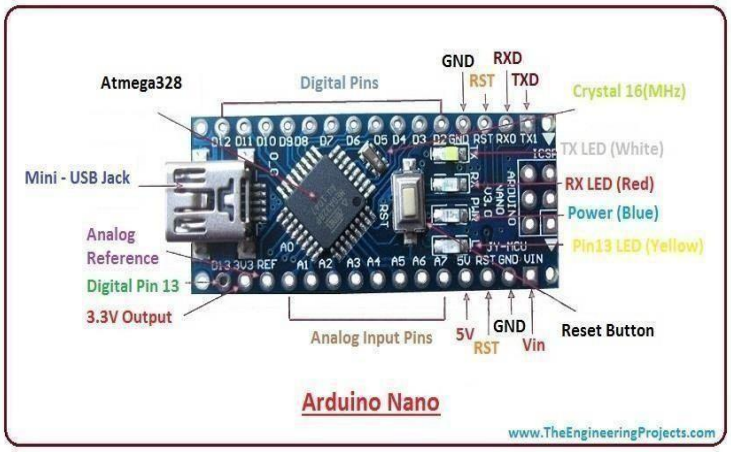


Fig 3

Arduino Nano is a small, complete, flexible and breadboard-friendly Microcontroller board, based on ATmega328p, developed by Arduino.cc in Italy in 2008 and contains 30 male I/O headers,configured in a DIP30style. Arduino Nano Pinout contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. It is programmed using Arduino IDE, which can be downloaded from Arduino Official site. Arduino Nano is simply a smaller version of Arduino UNO, thus both have almost the same functionalities. Itcomes with an operating voltage of 5V; however, the input voltage can vary from 7 to 12V. Arduino Nano's maximum current rating is 40mA, so the load attached to its pins shouldn't draw current more than that. Each of these Digital & Analog Pins is assigned with multiple functions but their main function is to be configured as Input/output. Arduino Pins are acted as Input Pins when they are interfaced with sensors, but if you are driving some load then we need to use them as an Output Pin. Functions like pin Mode () and digital Write () are used to control the operations of digital pins while analog Read () is used to control analog pins. The analog pins come with a total resolution of 10-bits which measures the value from 0 to 5V Arduino Nano comes with a crystal oscillator of frequency 16 MHz it is used to produce a clock of precise frequency using constant voltage. There is one limitation of using Arduino Nano i.e. it doesn't come with a DC power jack, which means you cannot supply an external power source through a battery. This board doesn't use standard USB for connection with a computer; instead, it comes with Type-B Micro USB. The tiny size and breadboard-friendly nature make this device an ideal choice for most applications where the size of the electronic components is of great concern. Flash memory is 16KB or 32KB that all depends on the Atmega board i.e. Atmega168 comes with 16KBof flash memory while Atmega328 comes with a flash memory of 32KB. Flash memory is used for storing code. The 2KB of memory out of total flash memory is used for a boot loader. The SRAM memory of 2KB is present in Arduino Nano. Arduino Nano has an EEPROM memory of 1KB.

SIM800l GSM Module

The SIM800L GSM/GPRS module consists of four key components, which take important roles in the work of the module. These key components are SIM800L GSM cellular chip, LED Status Indicators, Antennas, and Micro-SIM socket.

SIM800L GSM cellular chip

On the top surface of the GSM module, we can see a chip is mounted on the module board. This is a Quad- band SIM800L GSM/GPRS cellular chip from SimCom in SMT type. SIM800L supports Quad-band frequency its works on frequencies 850MHz, 900MHz, 1800MHz, and 1900MHz, it can transmit and receive voice, SMS, and data information with low power consumption. The operating voltage of this chip is from 3.4V to 4.4V which makes it ideal to operate by a LiPo battery supply. This chip supports a baud rate from 1200bps to 115200bps with Auto-Baud detection. It has a tiny size of 17.6*15.7*2.3mm which makes it a good choice for embedding into projects without a lotof space.

LED Status Indicators

On the topmost right corner side of the SIM800L Module, we can see an LED that indicates the status of your cellular network. After applying the power supply to the module the LED will blink at three different ratios, which shows three different statuses of your cellular network.

- **Blink every 1s:**

When the LED Blinking with a delay of 1s, then it indicates that the GSM module isrunning but it hasn’t made the connection to the cellular network yet.

- **Blink every 2s:**

When the LED Blinking with a delay of 2s, then it indicates that The GPRS dataconnection you requested is active.

- **Blink every 3s:**

When the LED Blinking with a delay of 2s, then it indicates that the module has made contact with the cellular network and it is ready to transmit/receive voice and SMS.

ANTENNAS:

An antenna is a vital part of the module; it is used for voice or data communications as well as some SIM commands. SIM800l GSM/GPRS module provides two ways to connect Antennas. There are two types of antennas that can connect to the module one is a Helical GSM antenna and another one is PCB Antenna.

- **Helical GSM Antenna:**
- **PCB Antenna:**

Micro-SIM socket:

On the backside of the module, a SIM socket is available, where we can insert an activated 2G micro-SIM card that would work perfectly. When we insert a SIM card intothe socket we must ensure that the notch point will upwards. Normally the symbol of the SIM card is engraved on the surface of the SIM socket that helps us to identify the correct direction of SIM inserting.

Pinout/Pin Diagram of SIM800L GSM/GPRS Module:

The SIM800L GSM module has 12 pins that are used to connect the module to any microcontroller. The Pinout configuration is explained below:

NET:

The NET pin is used to attach an external antenna. Here we can solder Helical Antenna which comes along with the module.

VCC:

The VCC pin is used to supply the positive (+) voltage to the module. Power supply 3.4Vto4.4V within 2 Amp required working the module finely. We need to remember; never connect it to a 5Vpower supply, which can destroy module. Also, it doesn't work on a 3.3 V power supply.

R S T:

This pin is a hard reset pin. Pulling this pin low for 100 ms to perform hard reset of the module

RXD (Receiver):

RX pin is used for Serial communication

TXD (Transmitter):

TX pin is used for Serial communication

GND:

This is the Ground Pin of the module that needs to be connected to the GND pinon the microcontroller.

SPK+:

SPK + and SPK – is a differential speaker interface. The two pins of a speaker can be connected to these two pins. The positive pin of the speaker is connected to the SPK+ pin and the negative Pin to the SPK-.

MIC+:

MIC+ and MIC- pins are differential microphone inputs. The two pins of the microphone can be connected to these pins. The positive pin of the microphone is connected to the MIC+ pin and the negative Pin to the MIC-.

DTR:
Pulling this pin HIGH to activate sleep mode. In sleep mode, the module disables serial communication. Pulling it LOW to deactivate sleep mode, means the module wakes up.

RING:
The RING pin acts as a Ring Indicator, which is used in detecting calls and SMS. Basically this is the 'interrupt' out pin from the module. It is by-default high, but when a call is received it gives a LOW pulse for 120ms. Also, it can be configured to pulse whenan SMS is received

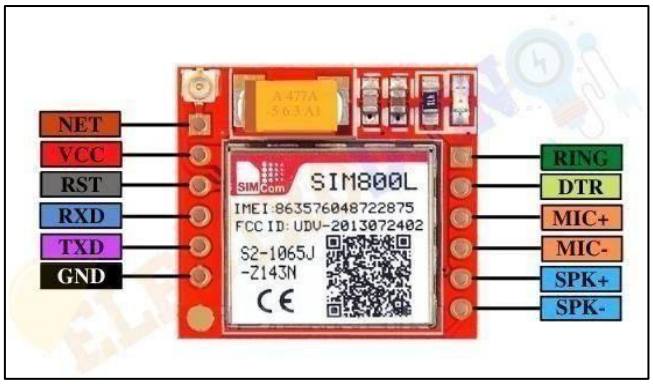


Fig 4

Features
- Receive and make calls using the external speaker and electric microphone
- Receive and send SMS/ Text messages
- Send and receive GPRS data (TCP/IP, HTTP, etc.)
- Scan and receive FM radio broadcasts
- GPRS multi-slot class12 connectivity: max. 85.6kbps(download/upload)
- GPRS mobile station class B
- Controlled by AT Command (3GPP TS27.007, 27.005 and SIMCOM enhanced ATcommands)
- Supports Real-Time Clock
- Supports A-GPS

POWER SUPPLY FOR SIM800L GSM MODULE
One of the biggest issues with the SIM800L GSM module is the power supply to the module. If the power supply can't fulfill the required current well, then the module can't make the connection to the cellular network or it will shut down/reset in the middle of the action. The operating voltage range of the module is 3.4- to 4.4-V. But another problem is the SIM800L module doesn't have an integrated voltage regulator. So, we need an external power supply between 3.4V to 4.4V (Ideal 4.1V). Also we need to remember that this module is a bit power- hungry and the current consumption can be up to 2A in peaks. So, the power supply should be able to source 2A.

APPLICATIONS
- Home automation
- Emergency systems
- Remote sensing
- Communication

SPECIFICATIONS OF GSM

Sr. No.	IC Chip	SIM800L GSM cellular chip
1	Operating Voltage range	3.4V ~ 4.4V
2	Recommended supply voltage	4V
3	Peak Current	2 A
4	Power consumption	Sleep mode < 2.0mAIdle mode < 7.0mA GSM transmission (avg): 350 mAGSM transmission (peek): 2000mA
5	Supported frequencies	2G Quad Band (850 / 950 / 1800 /1900MHz)
6	Transmit Power	Class 4 (2W) forGSM850 Class 1(1W) forDCS1800
7	Interface	UART (max. 2.8V) and AT commands
8	SIM card socket	Micro SIM card socket
9	Network Status Indicator	LED
10	Antenna connector	U.FL connector and Header Pin
11	Working temperature range	-40 to + 85 ° C
12	Module size	25 x 23 mm

LCD DISPLAY

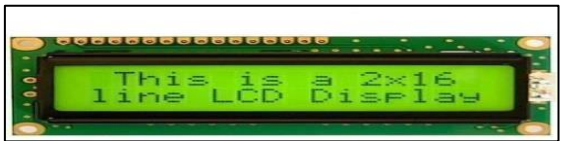


Fig 5

This is a high quality 16 character by 2 line intelligent display module, with back lighting, Works with almost any microcontroller. This is a popular 16x2 LCD display. It is easy to interface with most micro controllers. It works of 5v and has a green back light which can be switched on and off as desired. The contrast of the screen can also be controlled by varying the voltage at the contrast control pin (pin 3).

Features

- 16 Characters x 2 Lines
- 5x7 Dot Matrix Character Cursor
- HD44780 Equivalent LCD Controller/driver Built-In
- 4-bit or 8-bit MPU Interface.

SINGLE PHASE ENERGY METER

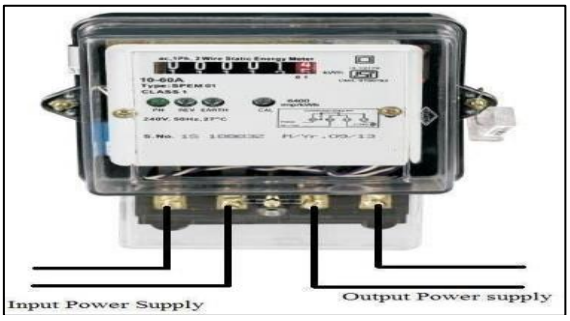


Fig 6

An electric meter or energy meter is an essential device that goes with consumption of commercially distributed energy. It enables systematic pricing of energy consumed by individual consumer as it measures the amount of electrical energy consumed by a residence, business, or an electrically powered device .They are typically calibrated in billing units, the most common one being the Kilowatts hour, which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000joules. Some meters measured only the length of time for which charge flowed, with no measurement of the magnitude of voltage or current. These were only suited for constant- load applications. Neither type is likely to be used today. In addition to metering based on the amount of energy used, other types of metering are available. Meters which measured the amount of charge (coulombs) used, known as ampere-hour meters, were used in the early days of electrification. These were dependent upon the supply voltage remaining constant for accurate measurement of energy usage, which was not a likely circumstance with most supplies.

Digital Energy Meters Working:

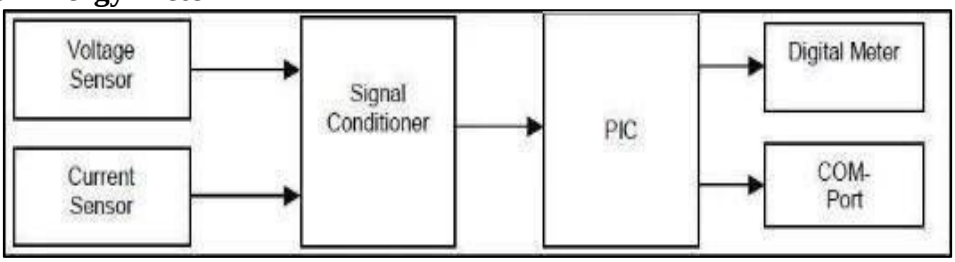
The digital energy meter working principal operates by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (Joules, Kilowatt-hours etc.). Meters for smaller services (such as small residential customers) can be connected directly in-line between source and customer. For larger loads, more than about 200 amps of load, current transformers are used, so that the meter can be located other than in line with the service conductors.

Types of Digital Energy Meters

The meters fall into two basic categories, electromechanical and electronic. This paper dwells on the electronic meter (i.e. the digital meter)

- **Electromechanical Meters**
- **Electronic Meters**

Block Diagram of Energy Meter



In the block diagram for a digital meter above two basic sensors are employed. These are voltage and current sensors. The voltage sensor built around a step down element and potential divider network senses both the phase voltage and load voltage. The second sensor is a current sensor; this senses the current drawn by the load at any point in time. It is built around a current transformer and other active devices (such as voltage comparator) which convert the sensed current to voltage for processing. The output from both sensors is then fed into a signal (or voltage) conditioner which ensures matched voltage or signal level to the control circuit, it also contain a signal multiplexer which enable sequential switching of both signal to the analogue input of the peripheral interface controller (PIC). The control circuit centered on a PIC integrated circuit. The PIC is selected because it contain ten bit analogue to digital converter (ADC), very flexible to program and good for peripheral interfacing. The ADC converts the analogue signals to its digital equivalent; both signals from the voltage and current sensors are then multiplied by the means of embedded software in the PIC. Here the error correction is taken as the offset correction by determining the value of the input quality with short- circuited input and storing this value in the memory for use as the correction value device calibration. The PIC is programmed in C language. Such that apart from the multiplier circuit it simulates, it is able to use the received data to calculate power consumption per hour, as well as the expected charges. These are displayed on the liquid crystal display attached to the circuit.

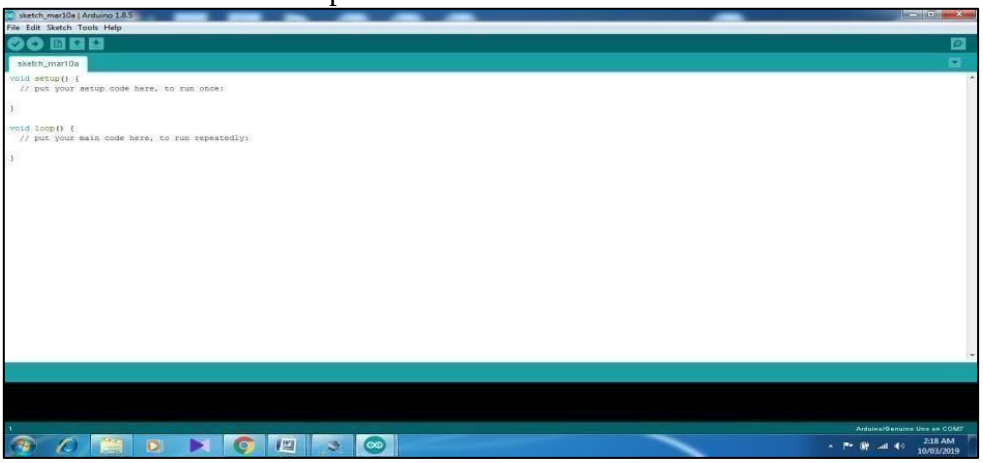
WORKING

This project is based on Arduino Microcontroller which uses ATMega 328P. Arduino Nano is used for this purpose. Single phase Digital Energy Meter is used for this purpose .We have connected Optocoupler to the CAL led of Energy Meter. This led gives pulses to the Optocoupler according to the load. Arduino nano is interfaced to the Optocoupler and it counts pulses from Optocoupler. For 1KW it gives 1000 pulses. Here counting of pulses is measurement of load. For Recharge we are sending SMS. SMS is read by Arduino Nano. According to Recharge amount Arduino will monitor the Pulses after that, when Recharge amount load consumption is done Arduino nano will disconnect the Energy Meter.

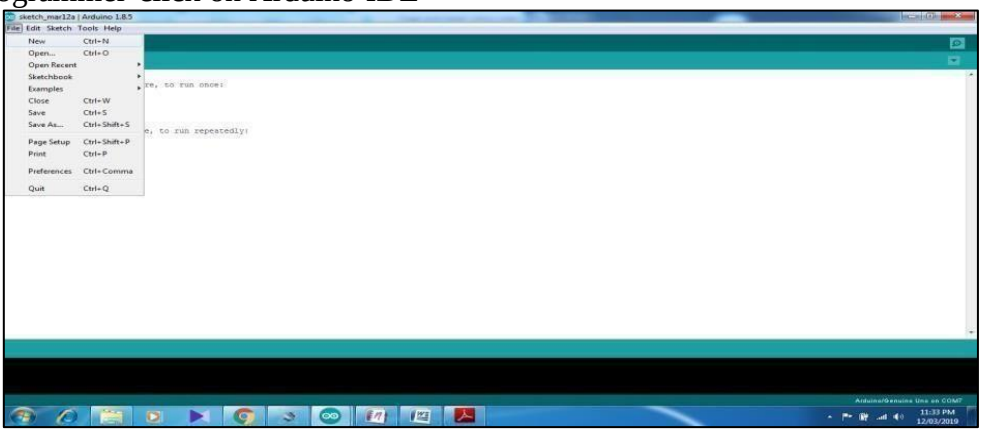
ARDUINO IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino board. The source code for the IDE is released under the GNU General Public License, version. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program argued to convert the executable code into a text file in hexadecimal encoding thatis loaded into the Arduino board by a loader program in the board's firmware.

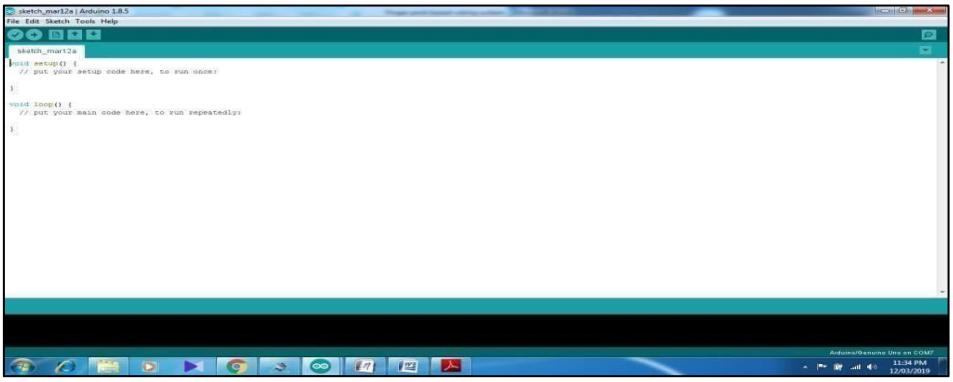
Arduino 1.8.5 software is used which is open source.



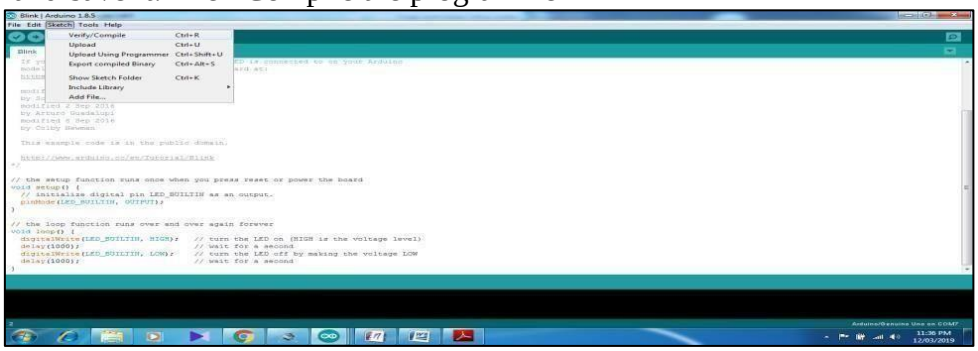
To develop a programmer click on Arduino IDE



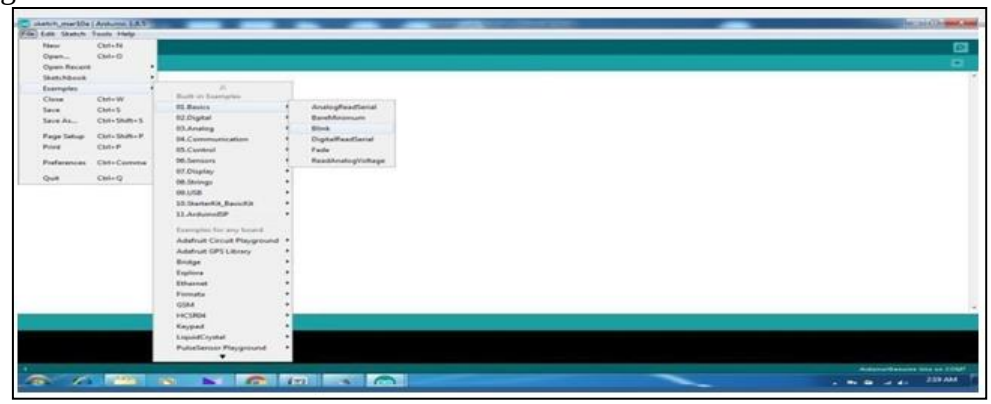
Go to file, click on new



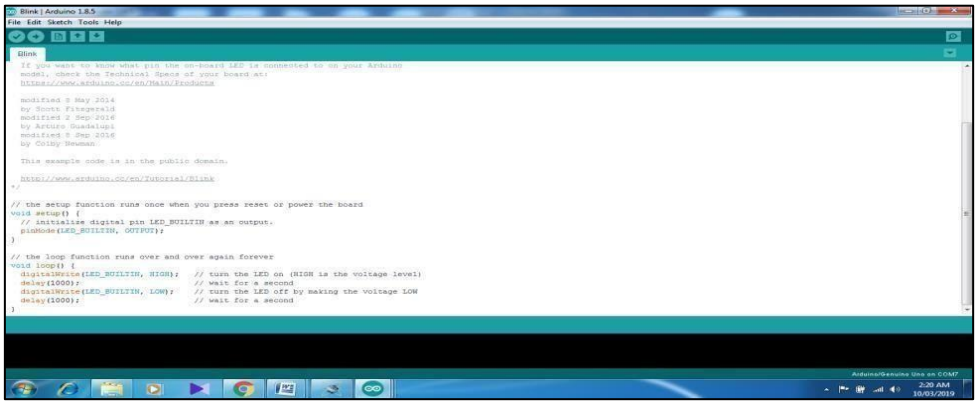
Write a program and save it. Then Compile the programmer



To load the program in Arduino click on UPLOAD.



Example blink LED



ADVANTAGES & DISADVANTAGES

ADVANTAGES:-

1. Timely collection of bill.
2. Less involvement of man power
3. Most efficient system
4. It is fast system. so that time to time recharge will be done
5. If there is a Delay of recharge ,then meter will automatically disconnectsupply

DISADVANTAGES:-

1. GSM network may create problem so that this system is suitable where GSMnetwork is available.
2. Spike in supply may damage system because it uses Electronic Energy Meter.

APPLICATIONS

1. Improved cash flow management: Prepaid energy meters allow utility companies to collect payments upfront, which can help them manage their cash flow more effectively.
2. Reduced energy theft: Prepaid energy meters can help reduce energy theft and tampering, as customers are required to pay for the electricity they use before they can access it.
3. Increased customer control: Prepaid energy meters provide customers with greater control over their electricity usage and spending, as they can monitor their energy consumption in real-time and adjust their usage accordingly.
4. Reduced billing disputes: Prepaid energy meters can help reduce billing disputes between customers and utility companies, as customers can see exactly how much electricity they are using and paying for.
5. Remote monitoring and control: Prepaid energy meters can be remotely monitored and controlled by utility companies, which can help them quickly detect and resolve any issues with the meter or the customer's energy supply.

FUTURE SCOPE

- Integration with renewable energy sources: Prepaid energy meters can be integrated with renewable energy sources such as solar and wind power to provide customers with more sustainable and cost- effective energy options.
- Smart grid integration: Prepaid energy meters can be integrated with smart grid technology to enable real-time communication between the utility company and the customer, allowing for more efficient and reliable energy distribution.
- Mobile payment integration: Prepaid energy meters can be integrated with mobile payment systems to provide customers with more convenient payment options, making it easier for them to top up their energy credit.
- IoT integration: Prepaid energy meters can be integrated with the Internet of Things (IoT) technology to enable remote monitoring and control of energy usage, allowing customers to optimize their energy consumption and reduce costs.
- Energy conservation: Prepaid energy meters can be used to encourage energy conservation by offering customers incentives for reducing their energy consumption, such as discounts or rebates.

CONCLUSION

Smart Energy meter architecture using GSM technology will allow users to pay for energy before using it. Consumers, therefore, hold credit, then use the energy until the credit is expended. If the available credit is exhausted then a relay cut-offs the electricity supply. An agreement is also made to intimate the user when their credit in their balance is poor, with the aid of the GSM contact module. This system was suggested as an innovative solution to the affordability problem in the Utilities sector. Since a device based on a

microcontroller is being developed, the readings can be registered continuously. It decreases human labor, thus increasing the efficiency of measuring bills for using energy. Smart energy meters will offer awareness-raising solutions for wasteful power wastage, which will help to rising electricity wastage. This module will reduce the strain of delivering energy by easily establishing the link, and no power theft will occur.

REFERENCES

1. D.Harshitha Reddy, P.Shilpa, 2018 'Smart Prepaid Energy Meter using GSM and Arduino'[ISSN NO :2249-7455].
2. SheelaSobana Rani, January 2014 'An integrated prepaid energy meter using GSM'
3. Sahana Y M1, Shruthi H2, Kavya D P3, Abhishek B C4, Pruthviraja L5. 2017 'Prepaid Energy MeterUsing GSM Technology'[ISSN: 2456-3315].
4. Uzair Ahmed Rajput, Khalid Rafique. 2018 'Modeling of Arduino-based Prepaid Energy Meter usingGSM Technology'[Vol. 9, No. 5, 2018]
5. Jubi.K, MareenaJohn , 2013'Prepaid Energy Meter with GSM Technology'[ISSN (CD-ROM): 2328-3629].
6. Mei-Sung Kang, et.al," Implementation of Smart Loading monitoring and Control System with ZigBee Wireless Network, IEEE Conference on Industrial Electronics and Applications,pp.907-912,2011
7. Khusvinder Gill, et.al, " A ZigBee-Based Home Automation System",IEEE Transactions on Consumer Electrionics, Vol, 55,No. 2, pp. 422-430 MAY 2009
8. N. Sriskanthan, et.al, " Bluetooth based Home Automation System", Microprocessors and Microsystems, Vol. 26,no.6,pp.281-289,2002
9. M. Zeghdoud, et.al, "Impact of Clear Channel Assessment Mode on the Performance of ZigBee Operating in a WiFi Environment", IEEE Workshop on Operator-assisted Community Networks, Berlin, pp. 1-8,September 2006.