



Low-Cost Wireless Sensor Monitoring System Using Photovoltaic (PV) Array Elements

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ABSTRACT

This research article presents low-cost wireless sensor monitoring systems for photovoltaic elements. Energy from sunlight is absorbed by the PV cells in the panel; this energy creates electrical charges that move in response to an internal electric field in the cell, causing electricity to flow. The battery source will store electricity, and the battery will give DC current to the power supply board. The current is supplied to the Atmega 328 microcontroller. Another power supply source is connected to the 12V DC load, which is connected to the current and voltage sensors. After sensing current and voltage by using CT and PT sensors, the measured values are given to the microcontroller. A microcontroller is programmed to monitor the loads such as fans, lights, and other appliances. If the energy level exceeds the limits, the GSM module sends an alarm message to the user. By using the GSM Module, the user can identify the supply and load.

Keywords: AT-mega 328 controller, GSM Module, Photovoltaic Array, Sensor

INTRODUCTION

Monthly forecasting of electric energy consumption plays an important role in the operation of thermal power plants and is one of the most important bases for coal dispatch, electricity trading, and soon in addition, monthly forecasting of electric energy consumption is vital for the planning and maintenance of the grid. However, a number of difficulties are associated with forecasting. First, the steady monthly consumption trends of electric energy often change every few years as a result of macroeconomic conditions and social development. Therefore, the data used for modelling can only be derived from a continuous number of years, during which macroeconomic conditions may have varied slightly. Second, the monthly consumption trend data is extremely complex because of the effects of people's living habits, weather conditions, and other unexpected factors. Thus, the monthly consumption trends often comprise at least three kinds of sub-trends, namely, a long-term rising trend, numerous periodic waves, and the stochastic series. [1]

Photovoltaic (PV) energy has persistently been considered a green and pollution-free renewable energy source to overcome the greenhouse effect and the energy crisis. The 40 GW of PV systems have been installed globally in 2014; as a result, the global cumulative PV capacity has reached 178 GW at the end of 2014. Residential homes have deployed a PV system to reduce energy costs. The residential PV market is increasing more steeply than the non-residential one [2].

Today users of electricity to residential, have no way of knowing how much electric power consumed by each of their devices electrical connected to the network by the mere fact of being connected, even when not operating, making it difficult they can have control of energy consumption from their homes. Furthermore, most users spend too much time away from home for their various activities, and so connecting or disconnecting their devices electrically is not recommended. During optimum periods of time, depending on the various applications of each electric apparatus. [3].

Networked devices have revolutionized the way we access and disseminate information and changed the way we communicate with each other. More and more homes are now Internet-enabled as people from all walks of life embrace this technology and the benefits it brings. Such benefits include shared Internet access, file and peripheral sharing, voice over IP, and online gaming, among others. At the simplest level, this might mean lights that switch themselves on when someone enters the room or an Internet radio appliance. Looking further ahead, home appliances will be required to automatically integrate, configure, and manage themselves and to form high-level applications. [4]

An electronic energy meter is used which is capable to communicate with central distribution office to provide great facility. The current transformer (CT) is attached to a line to measure the current flowing through the load, and the potential transformer (PT) is connected to the line to measure the terminal voltage of the load. 8-bit microcontroller ATMEGA8L is attached with the secondary of CT and PT. It has a built-in 6-channel analogue-to-digital converter (ADC). The microcontroller takes samples of the current and voltage from its ADC. Then it multiplies them to give them power in that instant and it processes these values of power to calculate the total power consumed by the load. [5]

Development and usage of green electricity are one of the maximum critical strength saving measures. In the course of the beyond 30 years, many evolved business nations and few growing nations have connected superb importance to the development of sun era and sun era has been extensively promoted and used in residential areas. The pace of research and application of solar energy in Europe is likewise very rapid and the usage of solar warmth is greater sizable, related to energy era, domestic warm water, heating, local heating water, and so forth. More than 90% of the solar heat is used for residential areas in the EU [6]

The most accurate information about the parameters of a photovoltaic array at a particular location is essential to optimize the exposition of the PV panels towards the sun irradiation and to develop such project. This information, in particular, array voltage and current, Irradiance, and ambient temperature are useful in power plant system design, efficiency, and cost analysis. The harvested energy decreases with an increase on module's temperature, in contrast the PV module temperature is highly influenced by the sun incident (irradiation), and the wind speed. Because of the lack of performance in some commercial PV modules, the efficiency is relatively lower at low levels of irradiance than at high [7]

People of the arena need to pay attention to renewable energy resources because of the problem and impact of non-renewable electricity sources. Due to global warming, greenhouse gas emissions, fluctuating oil fees, and growing strength demand in developing international locations should bear in mind new answers. So renewable power is laid low with the modern strength structure and direction of energy development as an essential element. Sun energy is a sort of renewable energy useful resource which has been good sized- scale improvement and complete packages because of energy transmission obstacles. Typically, solar electricity has many benefits than fossil-primarily based coal and oil because of reduce carbon emissions, smooth the air, and might generate once more within our lifetimes. Within the gift situation of the arena, the consumption of energy has been extended. Therefore, researchers have focused on developing solar power technology to reap a excessive-efficiency level with minimal investment cost and less environmental pollutants. For rural and mountainous areas far away from large power grids, generally, solar hybrid power systems are used [8]-[10].

Renewable energy is rapidly gaining significance as an energy useful resource as fossil gasoline charges fluctuate. At the academic stage, it's far consequently vital for engineering and era college students to have a know-how and appreciation of the technology related to renewable energy. One of the maximum famous renewable electricity assets is sun strength. Its miles to be had at once as sun isolation and in a roundabout way as wind electricity. Solar sends out energy in the shape of electromagnetic radiation. Its capacity is 178 billion MW, which is about 20,000 times the sector's demand. a number of the sun energy reasons evaporation of water, main to rains and introduction of rivers and so on. Some of it's far utilized in photosynthesis that is critical for sustenance of lifestyles on the earth [11].

Monitoring system is important to maintain a system's sustained operability, and for a user to understand glitches that occur while system is operating. In developing the PV system, information of photovoltaic characteristics is essential as well as the information on meteorological. Many monitoring systems have been developed in order to evaluate PV system performance. Several instruments using conventional electronics or based on microprocessor data acquisition system (DAQS) is developed. It is used to collect, register, integrate and record meteorological data and also the electrical characteristic of PV system. A wireless data acquisition system that helps to estimate solar energy potential considering the remote region's energy requirement has been proposed in. A system for the remote monitoring and control of complex stand-alone photovoltaic plants has been described in. This system records and periodically reports the overall performances. In case of incorrect behaviour, the system will immediately inform the operator [12].

BLOCK DIAGRAM

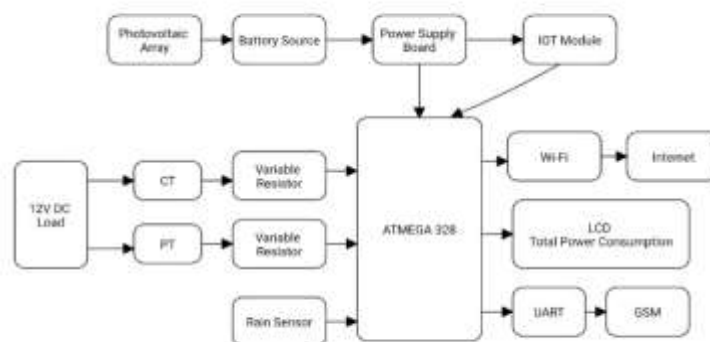


Fig.1: WIRELESS SENSOR MONITORING SYSTEM USING PV ELEMENTS

WORKING PRINCIPLE

By using GSM module, the end user can view energy parameters remotely. Control of energy parameters is also possible using the Arduino UnoATmega328 Microcontroller. A CT sensor is used to measure the current consumed by different loads and the voltage is measured by the PT sensor.

Both of them are connected to the controller through TX and RX pins and it can be connected to the internet. Through UART, it is connected to GSM and the intelligent programming is done by using microcontroller. An additional feature a rain sensor is used to avoid electrical hazards.

COMPONENT DETAILS

1. Photovoltaic Array

An active solar energy collection device that converts solar energy directly into electricity and whose primary purpose is to harvest energy by transforming solar energy into another form of energy or transferring heat from a collector to another medium by using mechanical, electrical, or chemical.

Solar PV systems convert sunlight into electrical energy. Photons of light hitting the solar panel and it knock the electrons in the substrate material into a higher level of activity; these electrons are then channelled off the panel to create DC electricity.

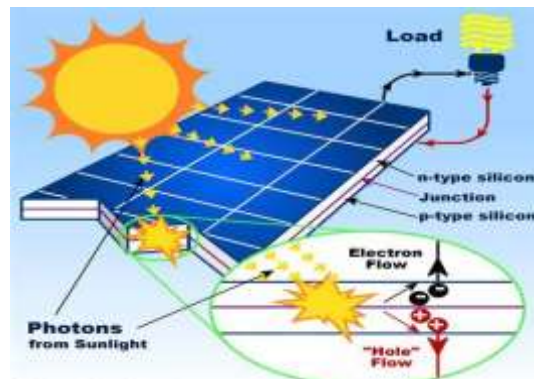


Fig:2-Photovoltaic Array

2. Photovoltaic Array Battery Source

Sealed Lead Acid 12v 1.3 Ah

Model-(1213) 12 volts 1.3 ah

- This sealed lead acid battery is an AGM (absorbent glass mat), maintenance-free, valve regulated (VRLA), rechargeable battery. It is able to be used with a wide variety of applications; it has a wide operating temperature, a long service life, and deep discharge recovery.
- AMP HOURS: 1.3 Length: 3.8 Volts: 12 Weight: 1.21 Width: 1.7 (1213) Volts: 1.3 Ah
- This sealed lead acid battery is an AGM (absorbent glass mat), maintenance-free, valve regulated (VRLA), rechargeable battery. It is able to be used with a wide variety of applications; it has a wide operating temperature, a long service life, and deep discharge recovery.
- Meets or exceeds the OEM sealed lead acid battery specifications.
- We supply only brand new, factory-fresh, high-quality batteries.
- These batteries are completely spill- and leak-proof.



Fig:3-Battery

3. ARDUINO UNO

The Arduino Uno is one kind of microcontroller board based on the ATmega328, and "Uno" is an Italian term that means "one." Arduino Uno is named for the upcoming release of a microcontroller board, namely the Arduino Uno Board 1.0. This board includes digital I/O pins 14, a power jack, analogue

I/O pins 6, and a ceramic resonator at 16 MHz, a USB connection, an RST button, and an ICSP header. All these can support the microcontroller for further operation by connecting this board to the computer. The power supply of this board can be done with the help of an AC to DC adapter, a USB cable, or a battery.[13]-[15]

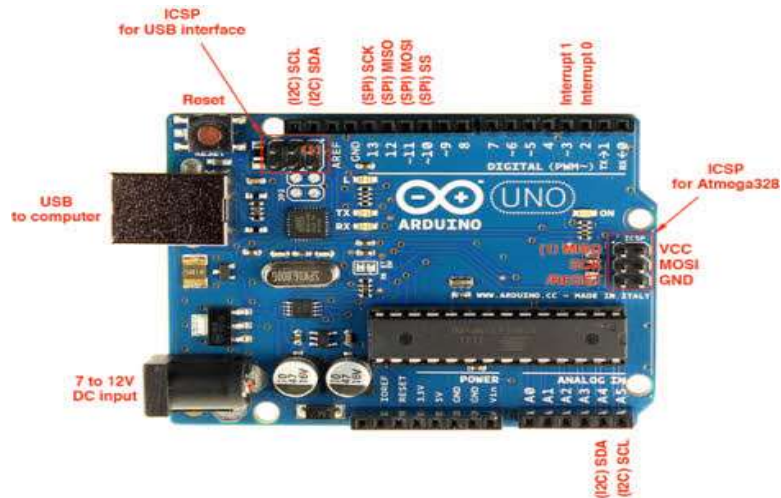


Fig:4-Arduino Uno ATmega328

4. LCD DISPLAY (16*2)

The 16x2 LCD used in this experiment has a total of 16 pins. Eight of the pins are data lines (pins 7 - 14), two are for power and ground (pins 1 and 16), three are used to control the operation of the LCD (pins 4-6), and one is used to adjust the LCD screen brightness (pin 3). The remaining two pins (15 and 16) power the backlight [16].

5. GSM MODULE

- The Global System for Mobile Communications (GSM) is a globally accepted standard for digital cellular communication.
- GSM is the name of a standardisation group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz [17]

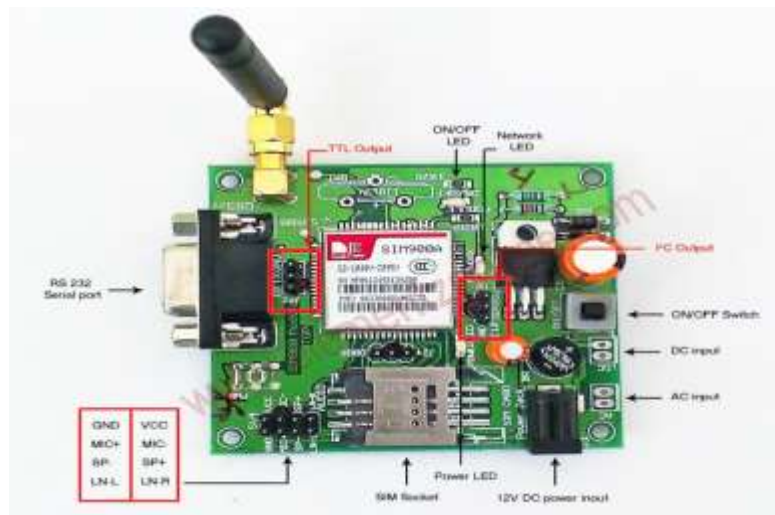


Fig:5-GSM Module

CODING

```
#include "LiquidCrystal.h"
#include<SoftwareSerial.h>
SoftwareSerial mySerial(6,7); //(Rx,Tx)
String num="9941739837";
```

```
float current;
float voltage;
int tempin=A0;
int tempin2=A1;
int a;
int v;
float power;
float t1;
float t2;
float t3;
int Trans1=A2;
int Trans2=A3;
int Trans3=A4;
int Trans1volt;
int Trans2volt;
int Trans3volt;
float rain;
int rainpin=A5;
int light=2;
LiquidCrystal lcd(13,12,11,10,9,8);
void setup()
{
lcd.begin(16,2);
mySerial.begin(9600);
Serial.begin(9600);
pinMode(light,OUTPUT);
lcd.setCursor(0,0);
lcd.clear();
}
```

EXPERIMENTAL SETUP AND RESULTS

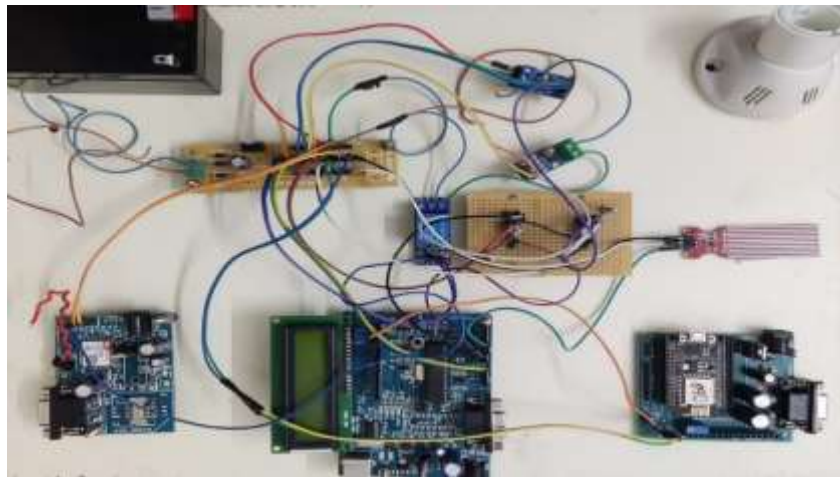


Fig:6 Assembly Kit

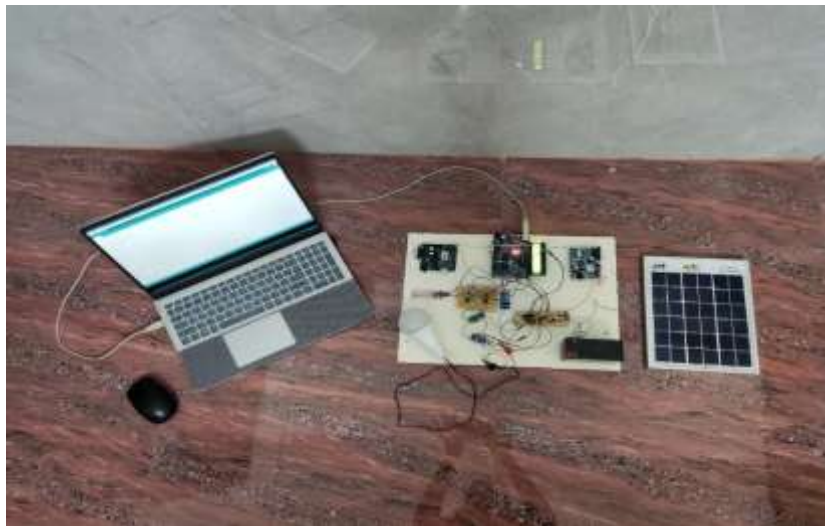


Fig:7 Complete Project Assembly



Fig:8 Load Voltage



Fig:9 Load Current

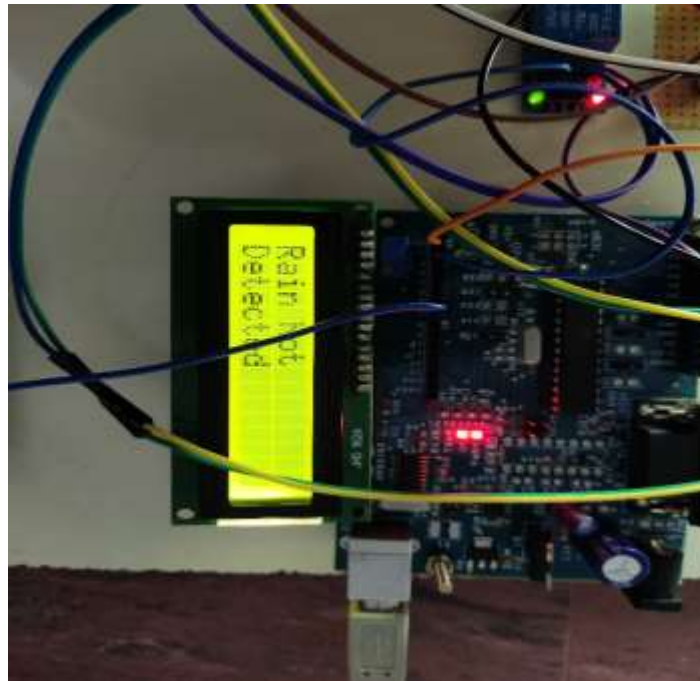


Fig:10 Rain not detected (LCD Display)

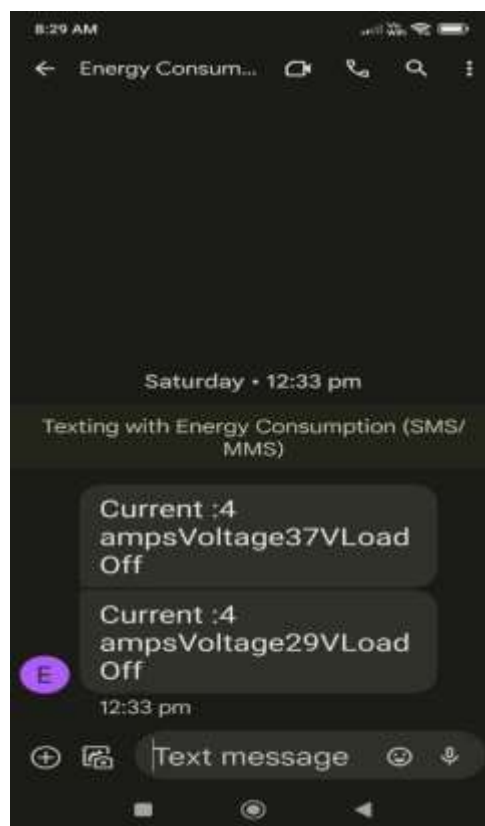


Fig:11 Getting SMS by GSM Module

LogID	DATA	Logdate	LogTime
1	0.00current_value_=.4voltage_value=_21	03/11/2023	12:38:26
2	0.00current_value_=.4voltage_value=_21	03/11/2023	12:38:34
3	0.00current_value_=.4voltage_value=_210.00current_value_=.4voltage_value=_21	03/11/2023	12:38:43
4	0.00current_value_=.4voltage_value=_21	03/11/2023	12:38:51
5	0.00current_value_=.4voltage_value=_210.00	03/11/2023	12:38:59
6	current_value_=.4voltage_value=_210.00current_value_=.4voltage_value=_21	03/11/2023	12:39:07
7	0.00current_value_=.4voltage_value=_21	03/11/2023	12:39:15
8	0.00current_value_=.4voltage_value=_210.00	03/11/2023	12:39:23
9	current_value_=.4voltage_value=_210.00current_value_=.4voltage_value=_21	03/11/2023	12:39:32

Fig:12 Cloud Data in Website (Energy Consumption)

CONCLUSION

In future eventually the technology will go towards the solar based energy source even for individual houses due to the raising the electrical tariff by the utility providers and also demand in the non-renewable energy sources. Eventually, because of the growth in the technology world, users will also interact and demand convenience and options to control their home appliances. This paper has explored and given the intelligent options for using solar energy and also provided control options for the end users.

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