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An IoT Based Smart Solar Photovoltaic Remote Monitoring and Control Unit

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ABSTRACT:

Using the Internet of Things Technology for supervising solar photovoltaic power generation can greatly enhance the performance, monitoring and maintenance of the plant. With advancement of technologies the cost of renewable energy equipments is going down globally encouraging large scale solar photovoltaic installations.

This massive scale of solar photovoltaic deployment requires sophisticated systems for automation of the plant monitoring remotely using web based interfaces as majority of them are installed in inaccessible locations and thus unable to be monitored from a dedicated location. The discussion in this paper is based on implementation of new cost effective methodology based on IoT to remotely monitor a solar photovoltaic plant for performance evaluation. This will facilitate preventive maintenance, fault detection, historical analysis of the plant in addition to real time monitoring. At present, a number of PV monitoring system have been put into operation .These systems often use wireless public networks such as GSM or other wireless communication networks for data transmission. But there are problems of high operation and maintenance cost which restrict the development of monitoring system and ultimately hinder the process of efficient generation monitoring in real time. This has influenced us to investigate a novel remote monitoring and control of PV system based on IoT. The experimental set up includes solar panels, temperature sensor LM35, voltage transducers, current transducers, SIM900A GPRS module. The visualization of the collected data in the control station has been done using website designed.

INTRODUCTION

The WOT concept was coined by a member of the Radio Frequency Identification (RFID) development community in 1999, and it has become more relevant to the practical world largely because of the growth of mobile devices, embedded and cloud computing and data analytics. “Web of Things” refers to the general idea of things, especially everyday objects, which are readable, recognizable, locatable, addressable, and/or controllable via the Internet, irrespective of the communication means (whether via RFID, wireless LAN, wide- area networks, or other means). Every day we encounter objects include not only the electronic devices but the products of higher technological development such as vehicles and equipment but things that we do not ordinarily think of as electronic at all - such as food and clothing.

The “things” of the real world shall integrate into the virtual world, enabling anytime, anywhere connectivity. The number of everyday physical objects and devices connected to the Internet was around 12.5 billion in 2010. The number of value expected to double to 25 billion in 2015 as the number of more smart devices per person increases, as far as to a further 50 billion by 2020. The impact and value that IOT brings to our daily lives become more prevalent as Smart devices connected in the IOT landscape. Better decisions such as taking the best routes to work or choosing their favorite restaurant is done by people.

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The Web of Things vision to successfully emerge, the computing criterion will need to go beyond traditional mobile computing scenarios that use smart phones and portables, and evolve into connecting everyday existing objects and embedding intelligence into our environment.

A huge amount of users in internet makes IoT(Internet Of Things) easier and smarter to implement communications quickly. IoT means storing all those related things since early days solar energy are in use and also human believe that solar energy provides energy for future.

Fig 1.1: Solar Panel Structure

Solar panel consists of more number of solar PV cells for energy consumption and reuse are represented in Figure 1.1 during this process if there may be any fault occurrence in solar PV cells that tend to entire system to failure so detecting those cells to work in an normal way the monitoring process is done.

OBJECTIVE OF THE PROJECT

The main aim of this project is based on implementation of new cost effective methodology based on IoT to remotely monitor a solar photovoltaic plant for performance evaluation. This will facilitate preventive maintenance, fault detection, historical analysis of the plant in addition to real time monitoring.

AIM OF THE PROJECT

The main aim of this project is to monitor the status of the photovoltaic system like voltage and the current values and send those parameters to the predefined web page via SIM 900A GPRS Module.

EXISTING SYSTEM

In the existing system, we were measure the parameters of the solar panel that means voltage and current levels of that photovoltaic cell and displayed on the LCD Screen. If the user wants the status of this system, then he should send the predefined status message to the GSM module SIM card. But there is no source to send the data to the web server, then he can monitor the status from anywhere in the world. To avoid this condition, we are developing the proposed system.

PROPOSED SYSTEM

In the proposed system, we are using the SIM900A GPRS Module, through which we are sending the parameters of the solar photovoltaic cell to the predefined web page. Then the user can monitor the status from anywhere in the world by just login into the web page. To do this we are using the LPC2148 microcontroller.

BLOCK DIAGRAM

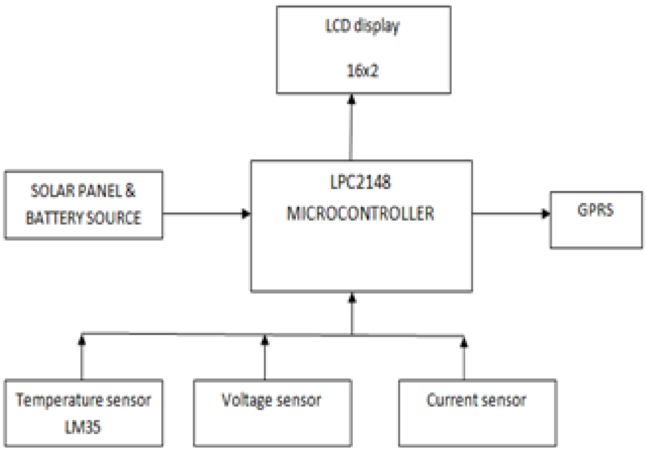

Fig 2.1: Block diagram of proposed system

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-SCPU with real-time emulation and

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embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 kb to 512 kb. A128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kb up to 40 kb, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

POWER SUPPLY

A battery is a device that can store electricity. Some are rechargeable, and some are not. They store direct current (DC) electricity. A battery really means two or more wet or dry cells connected in series for more voltage, or in parallel for more current, although people often call a cell a battery. AA, AAA, C, and D batteries all have 1.5 volts. The voltage of a cell depends on the chemicals used while the amount of power or current it can supply also depends on how large the cell is; a bigger cell of a given type can supply more amps, or for a longer time.

The chemical reactions that occur in a battery are exothermic reactions and, thus, produce heat. For example, if you leave your laptop on for a long time, and then touch the battery, it will be warm or hot. However, the batteries used in laptops are called lithium-ion batteries and they sometimes do have a fire hazard (A few years ago, dell laptops that that were powered by lithium batteries began to catch fire, though this event was rare.).

Batteries come in lots of different shapes and sizes and voltages. It is possible, but not easy, to run wires to use an odd size battery for an odd purpose. Batteries are always more costly/expensive than mains electricity. But mains electricity is not suitable for things that are mobile. Bicycles have tail-lights that can be operated by batteries, and sometimes by a little generator powered by the wheels. Hand and foot generators can be used to replace batteries in various devices, but they can be tiresome.

Wind-up generators are now available to power small clockwork radios, clockwork torches, etc. Since clockwork clocks have been around for hundreds of years, and batteries for two hundred, it is amazing that no-one thought of a clockwork torch until recently.

Rechargeable batteries are recharged by reversing the chemical reaction that occurs within the battery. But a rechargeable battery can only be recharged a given amount of time (recharge life). Even iPods, with built in batteries, cannot be recharged forever. Moreover, each time a battery is recharged , its ability to hold a charge is degraded a bit. Non-rechargeable batteries should not be charged as various caustic and corrosive substances can leak out, such as potassium hydroxide.

Fig 2.2: DC Battery

MAX232

Max232 IC is a specialized circuit which makes standard voltages as required by RS232 standards. This IC provides best noise rejection and very reliable against discharges and short circuits. MAX232 IC chips are commonly referred to as line drivers.

Fig 2.3: MAX232 IC

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To ensure data transfer between PC and microcontroller, the baud rate and voltage levels of Microcontroller and PC should be the same. The voltage levels of microcontroller are logic1 and logic 0 i.e., logic 1 is +5V and logic 0 is 0V. But for PC, RS232 voltage levels are considered and they are: logic 1 is taken as -3V to -25V and logic 0 as +3V to +25V. So, in order to equal these voltage levels, MAX232 IC is used. Thus this IC converts RS232 voltage levels to microcontroller voltage levels and vice versa.

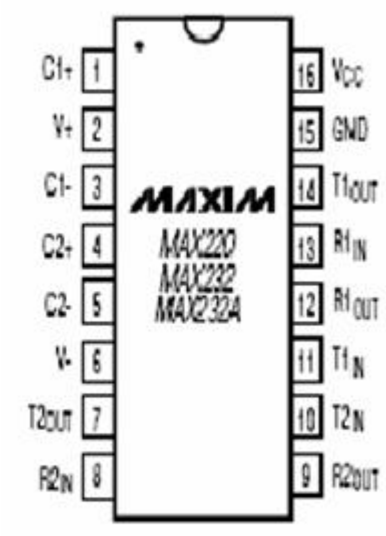

Fig 2.4: MAX232 pin diagram

CURENT AND VOLTAGE SENSING CIRCUITS

Voltage divider circuit

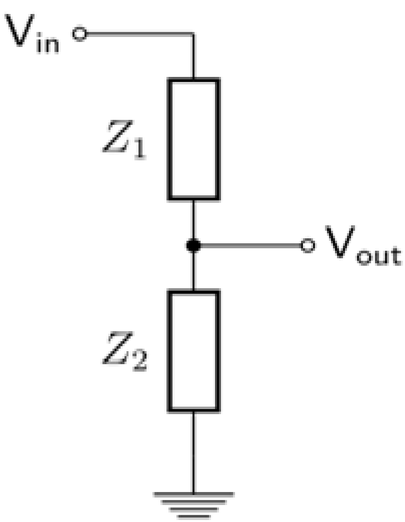

Fig 2.5: A simple voltage divider

In electronics, a voltage divider (also known as a potential divider) is a passive linear circuit that produces an output voltage (Vout) that is a fraction of its input voltage (Vin). Voltage division is the result of distributing the input voltage among the components of the divider. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them.

Resistor voltage dividers are commonly used to create reference voltages, or to reduce the magnitude of a voltage so it can be measured, and may also be used as signal attenuators at low frequencies. For direct current and relatively low frequencies, a voltage divider may be sufficiently accurate if made only of resistors; where frequency response over a wide range is required (such as in an oscilloscope probe), a voltage divider may have capacitive elements added to compensate load capacitance. In electric power transmission, a capacitive voltage divider is used for measurement of high voltage.

Applications

- Voltage dividers are used for adjusting the level of a signal, for bias of active devices in amplifiers, and for measurement of voltages.
- A Wheatstone bridge and a multimeter both include voltage dividers.
- A potentiometer is used as a variable voltage divider in the volume control of many radios.

ARM7 MICROCONTROLLER

ARM is an acronym for advanced RISC machine and is manufactured by Phillips. ARM7 is based on reduced instruction set computing architecture. ARM7 is most successful and widely used controller family in embedded system applications. The advantage of low power consumption and low cost increases the range of applications from portable devices to almost all embedded electronic market. It is preloaded with many in-built features and peripherals making it more efficient and reliable choice for an high end application developer. It also supports both 32-bit and 16-bit instructions via ARM and THUMB instruction set.

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LPC 21XX series of microcontroller are based on ARM 7 TDMI – S architecture.LPC stands for Low Power Consumption, because for the reason it have different voltages for operation and not like other controllers where the entire controller (CPU + peripherals of controller operate at +5V Vcc).

The ARM7TDMI-S is a general purpose 32-bit microcontroller, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro-programmed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and Impressive real-time interrupt response from a small and cost-effective controller core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory.

Pin Diagram:

ARM7 LPC2148 microcontroller is a 64 pin dual-in package. There are basically 2 ports in LPC2148, Port0 and Port1. Port0 has 32 pins reserved for it. And Port1 has 16 pins. So total it comes to 32+16 = 48 pins. If it were really 2 ports then the number of port pins should have been 32 + 32 = 64.

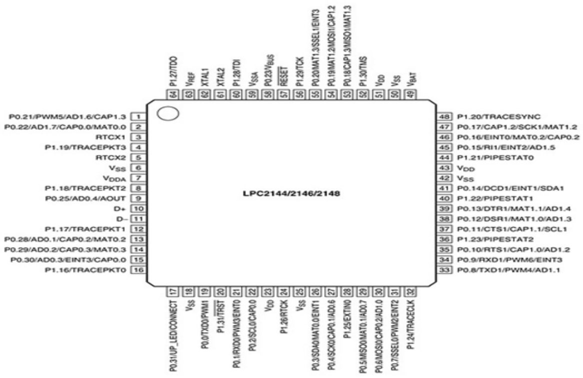

Fig 2.6: Pin Diagram of LPC2148

Architectural Overview:

The ARM7TDMI-S is a general purpose 32-bit microcontroller, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers (CISC).

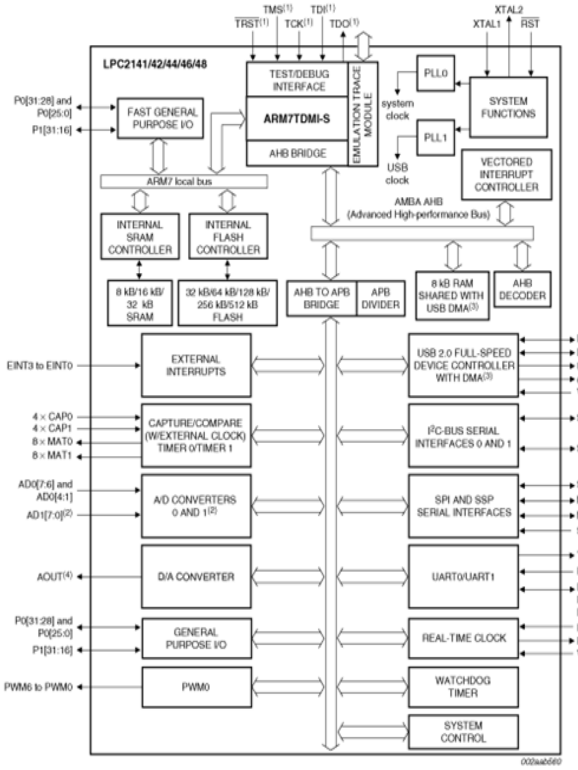

Fig 2.7: Architecture of ARM7 LPC2148

This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective controller core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7TDMI-S controller also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue. The key idea behind Thumb is that of a super-reduced instruction set.

Essentially, the ARM7TDMI-S controller has two instruction sets:

- The standard 32-bit ARM set.
- A 16-bit Thumb set.

The Thumb set's 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16-bit controller using 16-bit registers. This is possible because Thumb code operates on the same 32-bit register set as ARM code.

Thumb code is able to provide up to 65 % of the code size of ARM, and 160 % of the performance of an equivalent ARM controller connected to a 16-bit memory system. The particular flash implementation in the LPC2148 allows for full speed execution also in ARM mode. It is recommended to program performance critical and short code sections (such as interrupt service routines and DSP algorithms) in ARM mode. The impact on the overall code size will be minimal but the speed can be increased by 30% over Thumb mode.

IMPLEMENTATION

TEMPERATURE SENSOR

LM35 converts temperature value into electrical signals. LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration since it is internally calibrated. . The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air.

Fig 3.1: Temperature Sensor

GPRS /GSM SIM900A MODEM

GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz. The Modem is coming with RS232 interface, which allows you connect PC as well as microcontroller with RS232 Chip(MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet through simple AT commands.

Fig 3.2: GPRS Module

MODULE SETUP

Step 1: Insert SIM card into the SIM slot.

Fig 3.3: Insert SIM card into the SIM slot

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STEP 2: PLUG IN 12V -2A DC POWER ADAPTER, POWER LED IS LIT

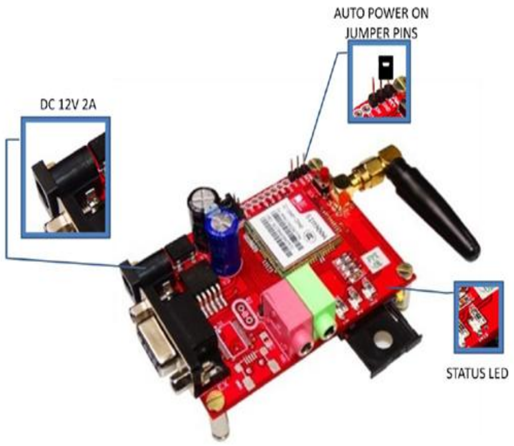

Fig 3.4: Plug in 12V -2A DC power adapter, power led is lit

STEP 3: PRESS AND HOLD POWER BUTTON (TO TURN ON MANUALLY WITHOUT JUMPER)

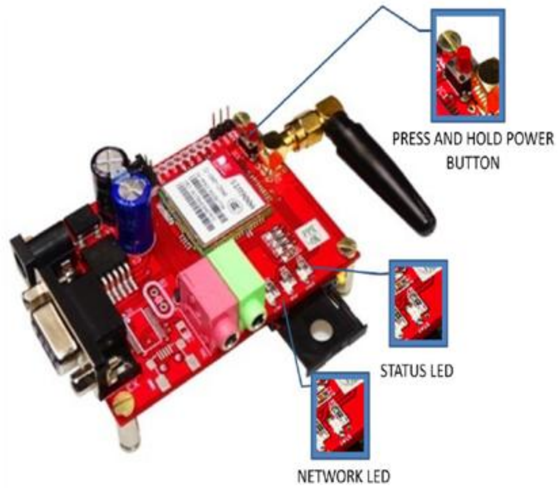

Fig 3.5: Power button Indication

STEP 4: CONNECT TO PC THROUGH RS232 CABLE

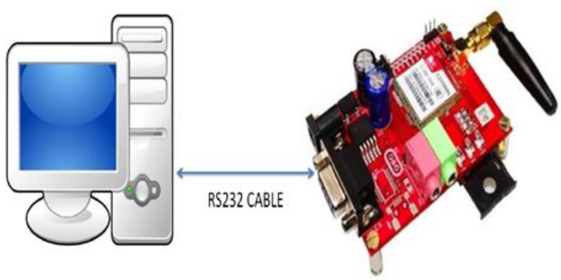

Fig 3.6: Connect to PC through RS232 cable

NARATION OF GSM SIM900A MODEM

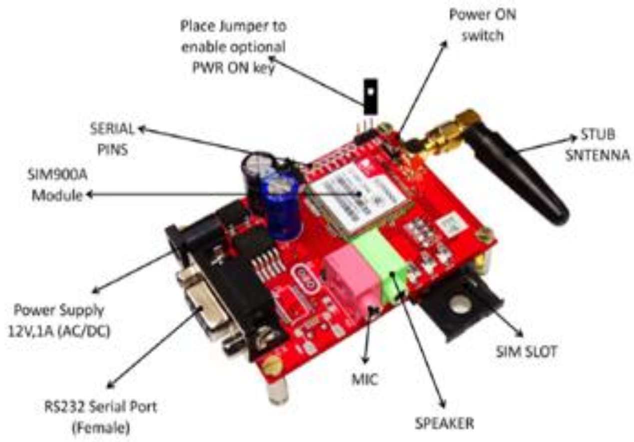

Fig 3.7: Architecture of GPRS Module

LIQUID CRYSTAL DISPLAY

LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
4. Ease of programming for characters and graphics.

These components are “specialized” for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (Hitachi) and can display messages in two lines with 16 characters each.

It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own.

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Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

LCD screen

LCD screen shown in figure 3.13 consists of two lines with 16 characters each. Each character consists of 5x7 dot matrix. Contrast on display depends on the power supply voltage and whether messages are displayed in one or two lines. For that reason, variable voltage 0-Vdd is applied on pin marked as Vee. Trimmer potentiometer is usually used for that purpose. Some versions of displays have built in backlight (blue or green diodes).

When used during operating, a resistor for current limitation should be used (like with any LE diode).

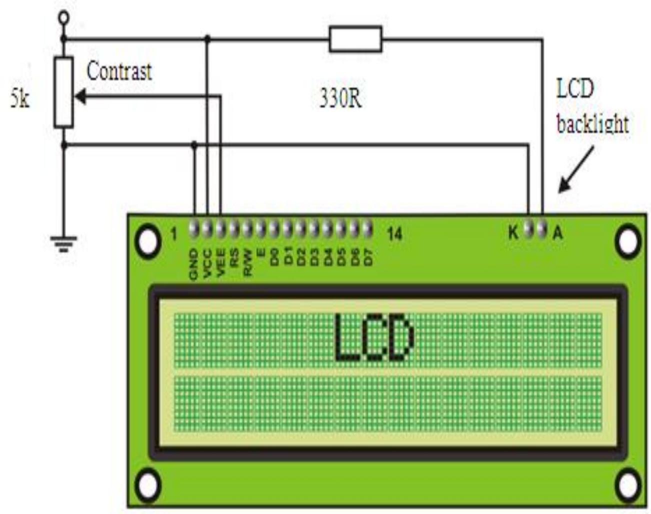

Fig 3.9: LCD connection

RESULTS

The implementation of realization of "An IoT Based Smart Solar Photovoltaic Remote Monitoring and Control unit" is done successfully. The communication is properly done without any interference between different modules in the design. Design is done to meet all the specifications and requirements.

PROPOSED SYSTEM RESULTS

This project is to monitor the status of the photovoltaic system like voltage and the current values and send those parameters to the predefined web page via SIM 900A GPRS Module.

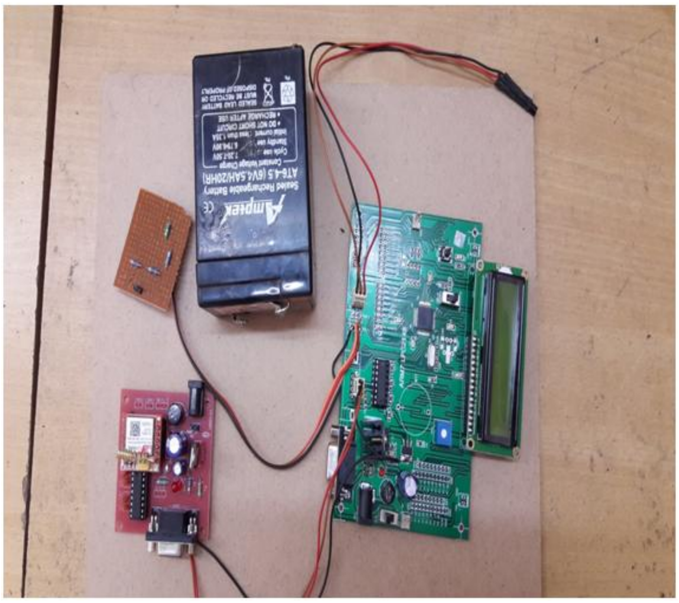

Fig 5.1:Proposed system kit diagram

The main aim of this project is to monitor the status of the photovoltaic system like voltage and the current values and send those parameters to the predefined web page via SIM 900A GPRS Module. To do this project, we are using the LPC2148 (ARM7) microcontroller, which has in-built ADC channel of 10-bit. The solar panel will give you the DC voltage and that was stored in the DC battery. We are using the circuit to measure the voltage generated by the solar cell and the current values using the voltage divider circuits and the resistive circuits. And besides that we are using the temperature sensor (LM35). The voltage and current sensing circuit and the temperature sensor values are given to the ADC channel pins of the LPC2148 microcontroller. The ADC will convert those analog values into corresponding digital values. The microcontroller will read the ADC data register values and display those on the LCD screen and for every specific time period, these values are sending to the predefined web page by using the SIM900A GPRS module.

The code was written in the embedded C language and the code was compiled using the KEIL compiler, which will generate the executable hex file. The hex file was dumped into the LPC2148 microcontroller by using the FLASH MAGIC software.

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ADVANTAGES AND APPLICATIONS

ADVANTAGES

1. Ability to interface with other intelligent control systems
2. Simplicity of the system.
3. Accuracy of the system
4. Real time monitoring
5. Emergency alerts when parameters exceeds their threshold values

APPLICATIONS

1. Used for access control system and appliances controlling system
2. It is used for agricultural or Green House security systems
3. Useful for Weather monitoring systems

CONCLUSION AND FUTURE SCOPE

CONCLUSION

As per literature survey done there are much more areas improved by defining problems in solar panels related to various factors, provides information related to survey on IOT, also implemented the low cost monitoring system for obtaining the defected solar panels. Finally they designed, developed, and trial work of a performance monitoring system of distributed solar panels along with automated data logging.

FUTURE SCOPE

In future, instead of the LPC2148 microcontroller, we will use the raspberry pi 3 board. The raspberry pi 3 has in-built WI-FI module. So, there is no need of external GPRS module.

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