SMART GRID MANAGEMENT IN RENEWABLE ENERGY SYSTEM USING WIRELESS SENSOR NETWORK

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Abstract
In this paper, intend a proficient monitoring system for generating solar power. The working mechanism monitors the power from the load side and sends to monitoring unit. Each solar panel which is connected can be controlled by connecting and disconnecting as per the demand. Here we are implementing the Internet of things module with web browser application which monitor and detect the faulty solar panel. This Internet of things module and web browser in the system control and disconnect the fault solar panel from the network. By the time period of 2 seconds the data's between the generation and utility unit will be sent continuously to the web page for further purpose. In experimental section we obtain the volt- age of about 5v and 25v, in the sample manner the output voltage by the voltage sensor is varied from 0 to 5V. As per the result gained by the data, it is proven that the proposed mechanism is far better than the traditional systems.

Keywords: wireless sensor networks, Internet of things, solar power, smart grid

I. INTRODUCTION

Wireless Sensor Networks making our day-to-day life more innovative and smart, by integrating it influences in various comfort, health and safety applications. Smart grid had achieved a more flexible as well as efficient electricity system with advancement in information and communication technologies. Accordingly solar cells are the well known distributed renewable power generators, but compared to the traditional energy production scenario they are difficult to predict the demand-supply problem. It path a way for bidirectional energy flows in the low-voltage power grid but, it results in drawbacks like voltage violations and grid in- stabilities. The above mentioned requirements enable the need of a smart grid extension, which should be a better smart and wireless energy man- agement application.

The energy distribution grid which we are using is followed for almost a century. As the global changes with technology advancement and consumer demands there is a need of effective grid system. According to the research by 2020 there will be a huge demand for an advanced grid which able to balance the demands. The major impact for the cause is increasing electricity cost, society, lifestyle and other strategies based on sustainability practices. The major drawback faced by the current electricity grid is lack of capability in processing the information and communication effectively. To overcome this issue a better smart grid is to be emerged.

Wireless Sensor Networks with smart grid will be a boon for intelligent de- vices. It is because of its factors like; innovative in information, communications, con- trolling and monitoring. These are all now becoming mandatory for the current application as per the lifestyle. The smart grid is not only initiated for power distribution but also essential for the industrial and residential customers. A perfect power distribution minimize the cost by avoid investment on additional capacity. It enables industrial and residential customers to experience a minimum energy bill by means of automated shifting on flexible loads. These all can be achieved only by means of integrating the network on controlling the energy source Wireless Sensor Networks will be one of the dominant technology advancement in monitoring various applications in most of the scenarios. In other words, a smarter grid can achieve balancing measures during the power failures especially in situations like natural calamities. By increasing the distribution generation's capacity it will increase the independency on grid. As a result there is valuable amount on emission of green house gases with burning of fossil fuels can be reduced. These advantages carry no use in case of other faults like voltage rise, reverse power flow, etc. These distributed generations are modeled with electronic converters and inverters for achieving islanding mode incase of grid failure or in any power shutdowns. There are phases in sensing and control system such as Sensing phase, data communication phase and control phase. The Wireless Sensor Nodes is implemented for enabling the sensing part more effective. Some of advantages of WSN are its tiny size, enhancement in electric power systems and it's infra- structure is less nature. A combination of ultra low power RF signals using WSN transceiver module is designed for data communications. Next a control system is applied in power electronic converters which act as an intermediary on transmitting power generation into the grid.

In order to discover the faulty solar panels Internet of Things module is implemented which is an advanced data collection and representation which exploits net- working, sensing, and AI technology to deliver complete systems for a service. This sys- tem has a unique flexibility and ability to be suitable for industrial and commercial application. They enhance data collection, automation, and much more through smart device and powerful enabling technology. It has two main parts; Internet being the backbone of connectivity, and Things meaning objects / devices The Internet of Things, also sometimes referred to as the Internet of Everything (IoE), consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware. The Internet of Things refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. The Internet of things platform is a suite of components that enable: Deployment of applications that monitor, manage, and control connected devices.

The Internet of things can provide remote data collection from connected devices, independent and secure connectivity between devices and device/sensor management. In the Internet of things concept, it would be worthwhile to deep dive in order to get familiar with the building blocks of Internet of things :

- Sensors & Sensor technology – They will sniff a wide variety of information ranging from Location, Weather/Environment conditions, Grid parameters, Movement on assembly lines, Jet engine maintenance data to Health essentials of a patient
- IoT Gateways –As the name rightly suggests, are the gateways to internet for all the things/devices that we want to interact with. Gateways help to bridge the internal network of sensor nodes with the external Internet or World Wide Web. They do this by collecting the data from sensor nodes & transmitting it to the internet infra- structure.
- Cloud/server infrastructure & Big Data – The data transmitted through gateway is stored & processed securely within the cloud infrastructure using Big Data analytics engine. This processed data is then used to perform intelligent actions that make all our de- vices 'Smart Devices'.
- End-user Mobile apps – The intuitive mobile apps will help end users to control & monitor their devices (ranging from room thermostat to jet engines & assembly lines) from remote locations. These apps push the important information on your hand-held devices & help to send commands to your Smart Devices!
- IPv6 – IP addresses are the backbone to the entire IoT ecosystem. Internet is concerned about IP addresses only & not if you are a human or a toaster. With IPv4 we were running out of IP addresses, but with IPv6 (launched in 2012) we now have 3.4*10^38 IP addresses!

Further in this paper the first section is deals with the need of solving the problem identified, the next section is about explaining the traditional methods. Then the third section deals with the proposed methodology followed by results and discussion. The final section is about conclusion and future work to be carried.

II. RELATED WORK

The smart grid (SG) is come to the existence in many of the countries. It has been in- stalled with smart meters for generating and consuming electricity for both consumers as well as the grid operators. The implementation of smart grid minimizes the carbon foot- print by enabling the advancement in efficiency and reliability. It achieves maximum electricity generation, distribution and utilization.

The sunlight irradiance blocking obstacles affect the photovoltaic (PV) panel. The solar panel protection glasses get dirt with field-aged degradation. In addition to it the I-V characteristics in the PV cells were also gets affected. The PV provides performance along with characters parameters in sharing valuable information during the power generation. Here there is no proper correlation between visual defects and performance.

In the production factory the PV panels get tested with all standard conditions. Here the cost is very high for dismounting, installing and testing. It gains sub-optimal electric power generation during the production life of solar panel at minimum cost. The micro- controllers and CMOS RF-transceivers in the PV panels are used for sharing the informatics and communications. It requires minimum cost for monitoring characterizing the PV panels in the field. These PV generators are generally based on distributed monitoring and testing the devices. Dynamic energy management in, they analyze the SG's optimal energy management, which results in unpredictable load demands and distributed energy resources. In the same work they had deeply analyze about the delay intolerant (DI) and delay tolerant (DT) in load demands. The main motto of SG is optimal usage of energy resources in the system. The long-term time is reduced as per the average cost which calculated to the total cost of supporting all users' load demands. The time-coupling problem is more complex to solve, so we formulate Lyapunov optimization theory and implement dynamic energy management scheme. According to which it dynamically clears the issues at each slot as per the current system state.

Quality-optimized multimedia information gathering scheme in introduced optimized sky camera multimedia information gathering scheme. It improvises the quality and increase the energy of wireless sensor network based on the internet. In each node these energies were harvested and reduce the multimedia packet distortion, it achieves by the combination of transmitted power control with relay node selection strategies. An analytical control system based on a DP approach which increase the grid's power flow management which are attached with PV system is shown in optimal power management.

III. PROPOSED SYSTEM ARCHITECTURE AND WORK

It contains several important components. The main components of the system are described as follows;

Voltage Sensor:

The existing sensors are generally sense the electrical type or optical signals. But the implementation of voltage sensor and current sensor techniques were perfect choice of method for measuring conventional current and voltage. The main duty of the voltage sensor is to monitor and measure the voltage supply. In the voltage sensor the voltage itself it considered as input and output are be analog voltage signals, switches, audible signals, analog current level, frequency or even frequency. Some voltage sensor provides sine and some as pulse trains as the output. The voltage sensors all produce outputs as Amplitude Modulation, Pulse Width Modulation or even Frequency Modulation. Figure 1 shows the proposed system architecture.

Current sensor:

Current sensor is used for measuring AC and/or DC current levels. For current sensor an advanced technology is required, as it sense various characteristics as per the applications. The current sensor discussed about here is the one which measure and pro- vides some sort of output. But the main thing here is to be notice, is the current sensor will address the where AC and/or DC current which to be measured. Another important thing is whether the sensor is in-line with the circuit or clamped around the wire. Mostly the sensors carrying wire for producing magnetic field. In circuits the current is directly measured by using current sensing resistors.

Wireless transceiver nRF24L01

In this propose architecture Nordic nRF24L01+ is highly integrated with ultra low power (ULP) 2Mbps RF transceiver and IC for the 2.4GHz ISM (Industrial, Scien- tific and Medical) band. At maximum RX/TX and currents lower than 14mA, a sub µA is in down mode and supply range is between 1.9 to 3.6V with advanced power manage- ment. The nRF24L01+ provides a true ULP solution provides battery life between months to years by means of coin cell or AA/AAA batteries. An Enhanced ShockBurst™ hardware protocol accelerates with the offloads time critical protocol functions, by means of microcontroller its achieves a flexible wireless connectivity at low cost.

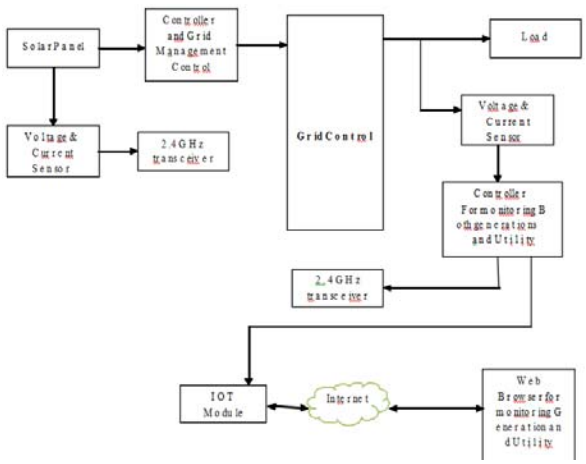

Fig.1: Proposed System Architecture

On the application controller, a high speed SPI interface is accelerated by the SPI interface along with RF transceiver, RF synthesizer, and baseband logic. In the pro- posed architecture there is a no need of external loop filter, resonators, or VCO varactor diodes. Only low cost ±60ppm crystal, matching circuitry and antenna is assembled in the architecture. The nRF24L01+ is available in a compact 20-pin 4 x 4mm QFN package.

Microcontroller

The microcontroller process high-performance with Microchip picoPower 8-bit AVR RISC, it combines with other parameters like 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts. The other parts are serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator and five software's are selectable at power saving modes. The device gets function at 1.8-5.5 volts with powerful instructions in a single clock cycle. The de- vice attains 1 MIPS per MHz throughputs with balanced power consumption and high processing speed.

Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board with ATmega2560 (datasheet). It is provided with 54 digital input/output pins in which 15 pins are used for WM outputs. Then there are 16 analog inputs, 4 UARTs hardware serial ports, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. All the components are required to support microcontroller which are connected to the computer by means of a USB cable. It can be power with AC-to-DC adapter or battery in order to start functioning. This mega is a shield designed that gains a compatible mode for Arduino Duemilanove or Diecimila. The Mega 2560 is advancement than the Arduino Mega; it is a unique board which does not require FTDI USB-to-serial driver chip.

The ATmega16U2 that is ATmega8U2 in the revision 1 and revision 2 boards is programmed as USB-to-serial converter. Revision 2 of the Mega2560 board consist of resistor pulling 8U2 HWB line to ground that makes simple to insert into DFU mode. The features in the revision 3 boards are 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF enables the shield to attach with voltage in the board. On upcoming technology the shield will enhanced with AVR that operates 5V and Arduino Due that operate with 3.3V. The 8U2 is replaced by the stronger RESET circuit and the second pin is left without connected for future purposes.

Internet of Things

The Internet of Things is the chain of daily objects like electronics, software, sensors, and connectivity which exchange data. A networked computer is getting attached with all things by means of internet and process information exchange among the network. The things may be light bulbs, toasters, refrigerators, flower pots, watches, fans, planes, trains, automobiles, or anything else around us, by means of network input is accepted and generates output as per the protocol. It shows that computer with internet can permeating everything around us either which can be uniquely identifiable or embedded with computing devices.

A chip ESP8266 (presently ESP8266EX) is also manufacturing wirelessly networkable micro-controller modules. It is a system-on-a-chip (SoC) that has the capacity of 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2). The other factors are gen- eralpurpose input/output (16 GPIO), Inter-Integrated Circuit (I²C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I²S interfaces with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and pulse-width modulation (PWM). A 32-bit RISC CPU is employed with Tensilica Xtensa L106 running at 80 MHz (or overclocked to 160 MHz). The memory devices such as 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM with SPI accessed external flash memory are placed in the Internet of Things (IoT) architecture.

IV. PROPOSED WORK

In our proposed system, we use advanced monitoring system for effectively utilizing the solar electricity. In the present work, Solar panel main station is directly connected to the radio channel which is a transceiver of length 16 data channels thereby more data can be transferred. The main station can control the data transfers as Internet of things is directly connected to Main station. In the load side endlessly the power is monitored which are send to monitoring unit. The system is controlled by the solar panel with connecting and disconnecting as per the demands.

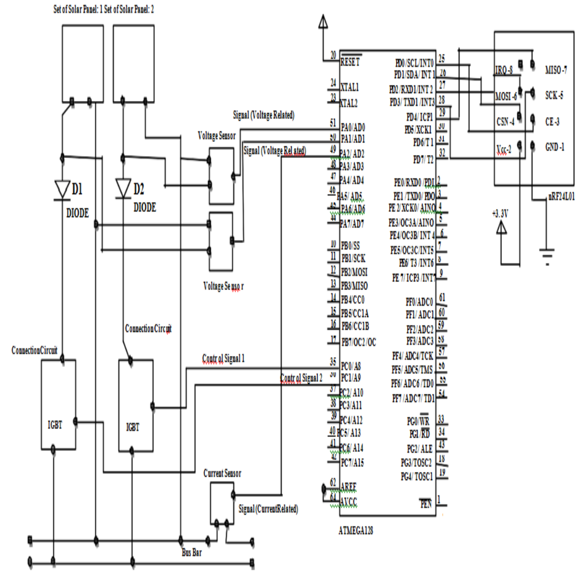

Fig-2: Circuit Diagram for Solar panel monitor

An Internet of things module is inserted in the solar network which detects the fault solar panel and disconnects them from the entire network with the help of web browser application. As mentioned above, the entire monitoring is done at the Internet of things module and shared with the web browser. The web page will display the power output of the solar panel continuously with time between the generation and utility unit.

In Figure 2 the circuit diagram for Solar panel monitor is given. Mega 128 is the popular microcontroller for communicating voltages and currents which are generated in the solar panel. The monitoring process is handled with wireless communication of NRF24L01 and the power is low with 2Mhz data rate. The solar panel and bus bar is gets connected by means of connector circuit known as IGBT. The voltage sensor measures each voltages and the output is transferred from microcontroller to analog pin which are connected. The conversion of signal voltage to measured voltage can be done by applying the following formula;

Measured voltage = analog (0) (voltage sensor connected to pin)* (5.0/1024.0)*10; Value 5.0 – denotes the voltage maximum

1024— analog to digital conversion 0 – 1023 (number pulses counted)

10 – Conversion factor (from 5v to 50v)

Total current of solar panel supplied to load is calculated using the following formula

Current Measurement Amps = ((Analog input(1)(*5/1024)) 2.5(offset value)

The important parameters of the solar panel such as, Peak power, maximum voltage, maximum current, open circuit and short circuit voltages are measured and tabulated in table 1.

Illumination W/m^2	Solar Panel 1 (in Volts)	Solar Panel 2 (in Volts)	Total Voltage (in Volts)
100	3.4	3.6	3.4
200	4.7	4.4	4.5
300	5.8	5.5	5.6
600	8.2	7.8	8.1
700	9.2	8.9	9.1
800	10.6	10.3	10.2
900	11.8	11.5	11.3
1000	12.8	12.5	12.4
1500	13.4	13.2	13.1

Table 1: Properties of PV module

The variation of power output of solar panel 1 and 2 is measured as a function of illumination intensity. The measured power output of each panel and the total generated power are tabulated in table 2. As can be seen from the table 2, the voltage of solar panel increases with increasing the illumination intensity thereby the total power of the PV unit.

Load Power (Lighting Load)	Grid Power	Solar Panel Connected to Grid (Max : 12 W)
1W	2W	Panel 1 is Connected Panel 2 & 3 is not connected
3W	6W	Panel 1 ,2 is connected Panel 3 is not connected
6W	12W	All solar panel connected to grid
12W	24W	All solar panel connected to grid
18W	24W	All solar panel connected to grid

Table 2: Variation of output power of Solar Panel as a function of illumination intensity

The maximum efficiency of Solar panel depends on angle and intensity of light illumination (lighting load) to the Solar panel. After connecting the load to grid, the values are measured and tabulated in Table 3. As shown in the table 3, the grid power increasing with lighting load power. The grid power increasing from 2W to 24W by varying the load power from 1W to 18W.

V.RESULTS AND DISCUSSION

The functionalities of the whole power monitoring system are given as a flow chart in Fig.3. Internet of things module is used for data collection and posting into the web browser through the Wi-Fi network. The data like voltage, current etc. collected from the solar panel is formulated to the data packets in microcontroller program. This program will send the data to the internet through IOT Wi-Fi Module. This module has an IP address obtained from the local network for internet connectivity. The user can call the IP address from the web browser. This browser will collect the data posted from the IOT module and displayed in the browser. The user can view the solar panel data from the web browser and make an analysis of using this data

Table 3: Load Connected to Grid (All data based on 12V & at Peak load generation)

PMAX (WP)	2W
MPP Voltage (V)	13.1 V
MPP Current (mA)	170
Open Circuit Voltage (V)	14 V
Short circuit Current (mA)	200

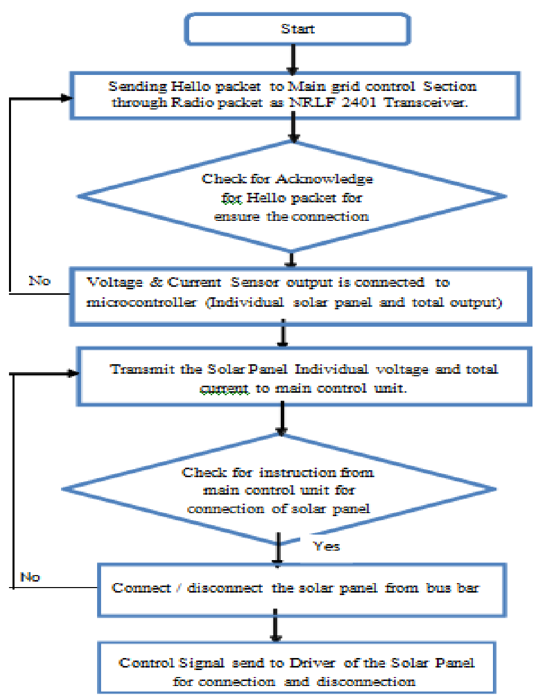

Fig: 3 Flow Chart for the smart grid management in solar panel using Internet of things

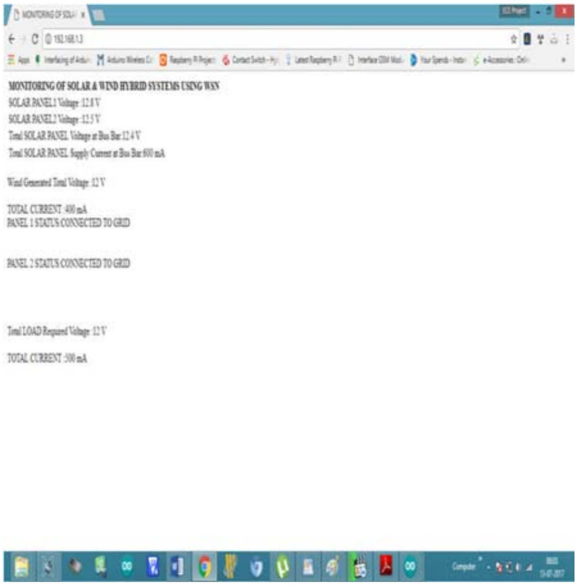

Fig.4: Display of significant parameters of solar panel

The significant parameters of the solar panel are displayed in user webpage as shown in Fig. 4. This webpage continuously displays Solar panel data for every 15 sec as programmed.

The bus bar from the solar panel section is getting connected with set of solar panel by means of solar circuit. By the proposed arrangement each solar panel is connected with individual voltage sensor. Accordingly the driver circuit of IGBT establishes the connection between solar panel and bus bar. The microcontroller (ATMEGA 128) triggers IGBT and the microcontroller receives the analog input from the voltage sensor. The voltage sensor measure the voltage in the range of 5 to 25 V, in the simple manner and the output voltage of the voltage sensor is varied from 0 to 5V. As per the Hall effect based linear current element, the work carried out and the total current generated by the solar panel is sensed by current sensor ACS 712.

The total energy harvested by Solar panel = Source voltage * efficiency Value * Size * Cell Efficiency *1000

Source Voltage - the amount of irradiance value for the source in unit W/m2 Size – size of the solar cell in cm2.

Cell Efficiency - Energy conversion efficiency of the solar cell

The above mentioned formula is applied to calculate effective voltage from solar panel. The solar panel is as per the lightening of sunlight. The maximum solar panel out- put will be 5 to 6 hrs and this received output is progressed for connecting peak time load and to battery for charging purpose.

VI. CONCLUSIONS

In this paper we analyzed how WSN is influenced in our day-to-day life and various drawbacks were facing on the basis of application mode. Owing to these issues, an advanced smart grid mechanism is proposed with photovoltaic system using wireless sensor network with Internet of things. It consumes less power and the solar panel attached in the circuit is get monitored by the Internet of things module. There is adjustment is done by attaching and detaching as per the load management. The results received were organized in the web page by means of web browser. Finally, on the result section attained results prove that our proposed mechanism implementation achieves effective electricity by means of solar panel using photovoltaic. Thus shows this mechanism is far better than traditional methodologies and in future it can be further improved as per the technological improvement with our lifestyle.

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