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A REAL TIME SOLAR POWER MANAGEMENT SYSTEM IN LABVIEW

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Abstract— In this research, we offer a graphical user interface (GUI) that is both effective and efficient in order to control and monitor in real time the DC power that is generated by solar panels and the DC power that is used by load both locally and remotely. The server and the client both have their own graphical user interface (GUI). While the client GUI may be accessed by using a web browser from any part of the world, the server computer must be located close to the solar panels in order to monitor and manage activities locally. An authorised person can monitor and control all operations from any location in the world. LabVIEW and LabVIEW UI builder are used to create the graphical user interfaces for the server and client, while Arduino Uno, current and voltage sensors, relays, and a charge controller are utilised in the development of the hardware. It is possible to record and access a database file in order to do historical research on a renewable energy source (RES) system. The monitoring interface employs real-time measurement results in order to produce graphs displaying power, current, and voltage. This will also assist to improve the performance of the solar system that is currently in place, as well as the performance of other alternative sources of energy. This graphical user interface for the monitoring of the system displays graphs and metres for measuring voltage, current, and power output and consumption. The controlling function allows the solar system to be turned on or off, as well as increasing or decreasing energy consumption and generation, and switching to another system that is available..

Index Terms—photo voltaic,power conditioning unit, wirelessmonitoring, load control, solar power optimization.

I. INTRODUCTION

The majority of our modern manufacturing is concentrated on conventional energy sources such as coal, oil, natural gas, and uranium. These are the fundamental drivers of our industrial activity. In the meanwhile, we will have two primary issues with them: they produce numerous forms of pollutants, and they pose a threat to the environment. Things like climate change and nuclear waste can put the quality of life we have on this planet in peril if we do not care about the environment.

After a certain number of years, the limited energy supply will run out, which will create a significant risk for humankind and make it difficult to guarantee that we will always have

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access to energy in the years to come. This situation will represent a big threat. On the other hand, renewable energy sources take use of flows that occur naturally in their environments. Due to the fact that these renewable sources of energy only utilise a small percentage of the flow, they are incapable of causing any damage to the natural environment. Solar energy is one of these natural resources, and it may be utilised in a wide range of settings because to its versatility. One of these responsibilities is the production of electrical power. The work begins with an explanation of the functionality of photovoltaic technologies, and then moves on to demonstrate the implementation of the hardware that was designed for the purpose of data collection (voltage, line currents, etc.) online. After this, the work concludes with a discussion of the implications of the findings.

The inaccessibility of grid energy, the unpredictability of power outages, rising power bills, and anxiety over maintenance are the top concerns of customers in the modern market [1]. The solar power pack is an alternative for generating electricity that is dependable, economical, and does not have any unwanted side effects. As a result of the tried and true technology that they make use of, they are incredibly efficient while at the same time requiring very little in the way of maintenance. Solar power packs only require a one-time investment and get care of both the problem of not having access to grid electricity and the problem of having unpredictable power. Concerns have been raised about budget cuts and rising power rates [2]. They are also favourable to the environment. A combination of the terms "photo," which refers to light, and "voltaic," which refers to electricity, "photovoltaic" (PV) is the abbreviation for this technology. Therefore, the production of electricity from light is at the heart of photovoltaic technology, which is the technical word used in the scientific community to refer to solar energy [2]. Solar cells or solar photovoltaic arrays are utilised to accomplish the conversion of sunlight into energy at this location. Photovoltaic (PV) systems powered by the sun are comparable to other types of power generation systems. Only the equipment that is used in solar photovoltaic (PV) systems is different from the equipment that is used in traditional electromechanical (EM) power producing systems. However, the fundamentals of how it works and how it connects to other electrical systems are unchanged. Even though a solar photovoltaic (PV) array will generate electricity when it is subjected to sunlight, a number of additional components are necessary to correctly conduct, control, convert, distribute, and store the energy that is generated by the array [3]-[6].

I. PRINCIPLE OF OPERATION

The solar modules provide energy, which is then stored in the battery bank by charging the battery bank with that energy. The Power Conditioning Unit is responsible for achieving this result (PCU). Up to eighty percent of the battery's DOD must be drained (Depth of Discharge). The power that is produced is sent to the PCU through the DC distribution board, which is located in the Main Junction Boxes [7]. The Power Conditioning Unit serves several purposes, including those of an inverter, AC battery charger, and solar charge controller. Through the AC Distribution Board, the output of the PCU is sent to the load. Solar photovoltaic (PV) components such as solar modules, junction boxes, DCDB, PCU, ACDB, and battery banks can be interconnected with the use of interconnecting cables..

Sun intensity:Under a full bright sun, the magnitude of thephotocurrent is reach to maximum. At a lower sun intensity, the power shifts downward as shown by the characteristic graph figure 2 below [8]-[9].

On a lower sun intensity day, the short-circuit current decreases a lot, but the open-circuit voltage change is small. Although the power we get is changed by the different sun intensity, the efficiency is the same. Because of the lower solar energy impinging on the module, we get a lower power output.

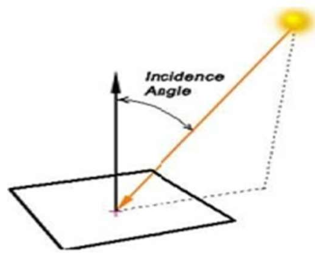

Fig. 1: Graphical representation of sun intensity

Sun angle

The cell output current is given by I = I0cosθ Where:

I0 = current with vertical sun impinging, and

θ = angle to the vertical position.

This cosine formula works extremely well for sun angles spanning from 0 to 50 degrees. By 50 degrees, the cosine law predicts that there will be a large drop in the relative current, and after 85 degrees, the cell will no longer produce any power [3]. It is derived from the PV cell's Kelly cosine power-angle curve, which provides the information. A representation of the curve may be seen in figure 3, which depicts the sun's angle. It is estimated that around 3,850,000 exajoules (EJ) of solar energy are taken in annually by the atmosphere, seas, and land masses of the Earth. In 2002, this amount of energy was equivalent to what the entire globe consumed in a single year. Photosynthesis is responsible for the capture of roughly 3,000 EJ in biomass per year [10].

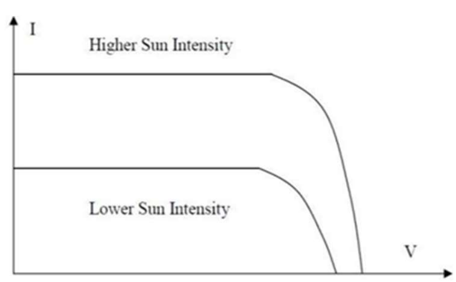

Fig. 2: Graphical representation of sun angle

The amount of solar energy that reaches the surface of the planet is so enormous that the amount of energy that can be harvested from all of the Earth's non-renewable resources, including coal, oil, natural gas, and mined uranium, in a single year is approximately equal to about half of what can be harvested from the sun in a single year. Solar photovoltaics are a clean and renewable source of electricity. This power may be used to a variety of uses, such as the desalination of sea water, the heating of a home's interior, or the provision of electricity. The milestone of 100 GW of total installed capacity has been reached by the time 2012 came to a close. After hydropower and wind power, solar photovoltaic is presently the third most important renewable energy source in terms of the capacity that has been installed all over the world. Solar photovoltaics are used in more than one hundred nations. Installations can be fixed on the ground (and are sometimes incorporated into farming and grazing), or they can be put into the roof or walls of a structure [8].

I. EXPERIMENTAL SETUP

A. Software Implementation

NI LabVIEW, which is an abbreviation for Laboratory Virtual Instrument Engineering Workbench, and User Interface (UI) Builder are the foundations upon which software is developed. National Instruments' LabVIEW is a platform for system design and a development environment for a visual programming language. LabVIEW was created by the company. LabVIEW is a software development environment that includes a large number of components; several of these components are necessary for doing any kind of test, control application, or measurement [3]. LabVIEW applications are termed virtual instruments (VIs). The controls and indicators that make up the graphical user interface are what are used to construct the front panel. The graphic source code is located on the rear panel of the device. The block diagram is comparable to a flowchart in a number of respects [6]. With the aid of the LabVIEW Connect for Arduino Toolkit, you'll have an easier time utilising LabVIEW to interface with the Arduino board. You are able to manage the Arduino board using this toolkit, as well as gather data from it using LabVIEW. After the data has been imported into LabVIEW, it will do analysis using the hundreds of built-in functions of LabVIEW, construct algorithms and libraries to control the Arduino platform, and show the results using a streamlined user interface..

B. Server and Client Graphical User Interface or Programs

LabVIEW makes it easy to create interfaces that are straightforward and straightforward to grasp. One is a server programme, which is often known as the primary programme, and the other is a client programme. There are two different kinds of interfaces or programmes that may be built. LabVIEW was used in the development of the project's primary user interface, which was the server interface. The server application is interfaced with the hardware of the entire system (Arduino, sensors, and relays) in order to monitor and regulate the energy production of the solar system as well as the energy that is used by the load locally. Even if the client application does not require any other software, it is still possible to remotely monitor and control the functioning of the system by utilising a browser. Internet and a server computer with a defined Internet protocol (IP) are required for monitoring and controlling the amount of electricity produced by solar panels. The primary server application must be running on this computer. The solar system may be viewed on the web from any device that supports the Hypertext Transfer Protocol (HTTP), and it can be managed by a person who is permitted to do so. System performance may be watched and adjusted by entering a valid login and password in addition to a Uniform Resource Locator (URL) (for example, http://smartsolarsystem.net84.net/), which is used as a test URL. The graphical user interface of the server is seen in Figure 3. This user interface has a number of tabs that each represent a particular functionality. The Home page includes metres and graphs for power generation and consumption, metres and graphs for voltage output, metres and graphs for power generation by solar panels, and indications for the state of the solar system. The button for controlling the emergency shutdown is located here.

Fig. 3. Server Graphical Interface for Data Acquisition Electricity control

LabVIEW Client Interface: LabVIEW Web UI Builder gives users the ability to create web-based, lightweight thin client applications using graphical programming. This capability is made available by LabVIEW. Through the use of a web browser and graphical user interfaces, these apps give users the ability to remotely monitor and control measurement and automation systems that are based on LabVIEW (GUIs). The combination of online services and browser-based clients connected to the Internet is depicted in Figure 4 [8].

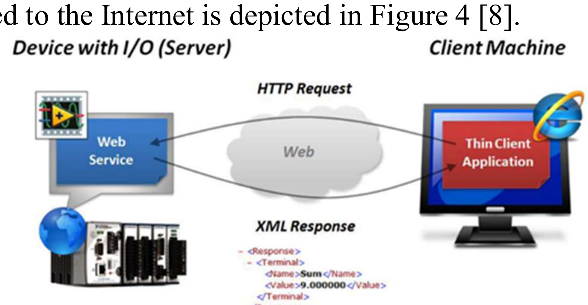

Fig. 4. Combination of Web Services and Browser-based Clients

LabVIEW UI offers simple features comparable to those found in LabVIEW software, which may be used to construct a variety of interfaces for real-time monitoring and control. Figure 5 depicts the client interface, which, if the user has a valid login and password, may be accessed from any location in the globe to perform real-time monitoring and control operations. It has the identical capabilities as the server software. It is a clone of the server located at the distant location..

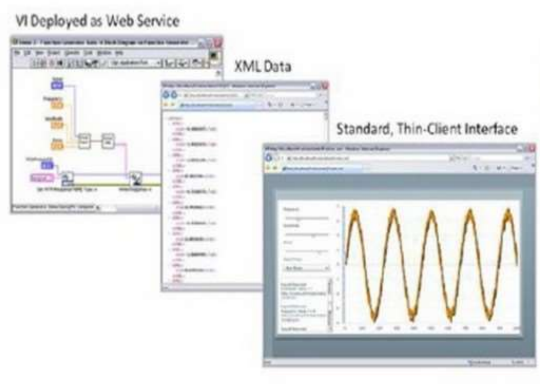

Fig. 5. Client Interface for remote site

C. Real Time Web-based Communication with LabVIEW Application

Through the use of LabVIEW Web services, a web client has the ability to communicate and share data with a distant LabVIEW stand-alone programme across a network. A web service may be thought of as a collection of VIs and other files that, when executed on a server, answer to HTTP requests that come from clients. The following are some examples of contexts in which web services are useful:

Users are able to invoke the Web service VIs using any HTTP-capable web client, such as a conventional web browser, in order to exchange data utilising a URL and conventional HTTP methods, such as POST.

Through the use of bespoke thin clients, users are able to remotely monitor and operate embedded programmes.[3]

The HTTP request is processed by the server application, which then responds to the client interface. The client transmits data to the controller using the web service, and the controller then receives real-time data on voltage, current, and power and displays it on the GUI. In order to make use of a web service, a client must first submit a request to the distant computer that is hosting the service (referred to as the "server programme"). The server programme will then process the request and return the client a response (XML data). The client has the option of displaying the raw XML data; however, it is more standard practise to parse the data and provide it to the user as part of a graphical user interface (GUI), as seen in the figures below (Fig. 6 and Fig. 5 [9]). Using Arduino in conjunction with LabVIEW to perform real-time monitoring and control from a distant place is one of the significant contributions made by this research. LabVIEW Arduino programme (server programme) will not work with web service because continuous request from client programme will cause it to hang due to while loop for Arduino coding and will not show any results on client interface. LabVIEW Arduino programme will not work with web service because of continuous request from client programme. Declaring variables that are global in scope within the server's application is the

solution to this issue. Every piece of information that is received from sensors is recorded in variables and shown on the graphical user interface of the server. It is necessary to have another VI where the global variables are called from the main application in order to setup this VI so that it can be used to put up the web service.
Fig. 6. Web services with the user interface [8]

D. Hardware

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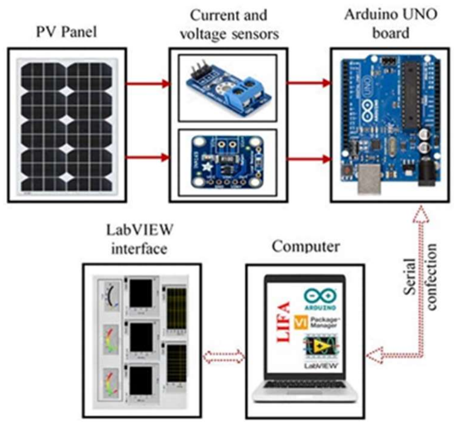

Fig. 7. Flow Diagram of Whole System

Declaring variables that are global in scope within the server's application is the solution to this issue. Every piece of information that is received from sensors is recorded in variables and shown on the graphical user interface of the server. It is necessary to have another VI where the global variables are called from the main application in order to setup this VI so that it can be used to put up the web service..

1. Arduino Mega 2560

The ATmega2560 serves as the foundation for the microcontroller board known as the Arduino Mega 2560. It features a 16 MHz crystal oscillator, as well as 16 analogue inputs, 54 digital input/output pins (of which 15 may be utilised as PWM outputs), 4 Universal Asynchronous Receiver/Transmitters (UARTs), and 54 digital input/output pins [49]. The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of Static Random Access Memory (SRAM), and 4 KB of Electrically Erasable Programmable Read-Only Memory (EEPROM), all of which can be read and written with the help of the EEPROM library [10]. [11] The bootloader uses 8 KB of the flash memory. Depending on the amount of inputs that are required, other Arduino boards like the UNO can be utilised.

2. Solar Panel

Solar panels are a type of photovoltaic cell that may generate power from sunlight. A solar panel is an assemblage of photovoltaic cells that has been packed and joined together. There are many different kinds of solar cells now available on the market, including:
Mono-crystalline silicon (mono-silicon or single silicon)
Polycrystalline silicon (multi-crystalline, multi-silicon, ribbon) [11].
In order to conduct our experiment, we utilised a polycrystalline solar panel with 50 watts, 18 volts, and 2.5 amperes.

3. Current sensor

The Allegro ACS712 current sensor provides cost effective and accurate solutions for DC current sensing. ACS712 con- sists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. A pair of current sensor is deployed each power generation by PV module and power utilization by load [5].

4. Relay

5V single pole double throw relay is used for switching, through which solar system can be shut down or switched to other available energy source. Fig. 8 shows connection of current and voltage sensors and relay with Arduino board. Voltage is measured using voltage divider circuit for this purpose two resistors are

II. CONCLUSION

LabVIEW provides easy tools to design any type of graphical interface that is easy understandable for everyone. The NI LabVIEW Interface for Arduino Toolkit enables to use low cost and effective hardware like Arduino with LabVIEW thus use of expensive DAQs has been avoided. This paper discussed efficient method of controlling and monitoring solar panel power from remote areas using Arduino, NI LabVIEW and Web browser. GUI is designed to provide interactive graphical interface to server as well as for user for monitoring generation and consumption of power. Implementation of this proposed prototype will benefit in terms of protection, operation, monitoring and maintenance of solar systems.

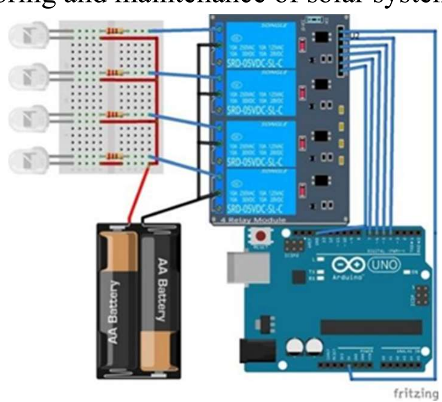

Fig. 8. Circuit Diagram of System

Fig. 9. complete prototype of proposed system

The hardware of the system is shown in Fig.
9. All sensors and relay are connected to LabVIEW server program through Arduino board. All real time data is sent to computer to real time monitor and control DC power. Data coming from voltage and sensors are then multiplied by using equation 1 to find the power.

$$P = V * I \qquad (1)$$

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