A Solar Tracking and Remote Monitoring System Using IoT

Fariha Khatoon and Sandeep Kumar

Abstract In this paper, for smart management and control of solar tracking system, a prototype is built to test or check the management and control of the system. The newly build prototype is developed for many applications with the aim of being a powerful tool for the learning of the smart solar energy system. The Internet of Things incorporates everyday objects using the Internet to extend into the real world. Here, we facilitate IoT technology for supervising solar PV (photovoltaic) power generation which can enhance the maintenance, monitoring, and performance of the plant. This will provide tracking of the solar panel and turning it in the direction of the sunlight. This is all possible using LDR sensors. The IoT automatically keeps track of the amount of voltage supply received by the solar panel in direction of sunlight. The proposed system displays the usage of the power of solar PV online. Finally, its application is discussed further.

Keywords Arduino · LDR · Solar PV · IoT

1 Introduction

Several technologies recently enabled trends of Internet of Things (IoT) which includes the availability of ubiquitous wireless communication, sensing capabilities, communication, onboard computing with low power devices, low cost, and small form factor. IoT has many applications which diverse such as smart grids, smart cities, transportation, habitat monitoring, environmental, industrial automation, office, home, health care, and medical [1].

77.9% of electricity is generated using fossil fuel and nuclear by the traditional method. These methods are the causes of global warming and climate change and are the heavily polluting environment. We may have heavy natural disasters due to

F. Khatoon (✉) · S. Kumar
Department of Electronics and Communications, Sreyas Institute of Engineering and Technology, Hyderabad, Telangana, India
e-mail: farihakhatoon@gmail.com

S. Kumar
e-mail: er.sandeepsahratia@gmail.com

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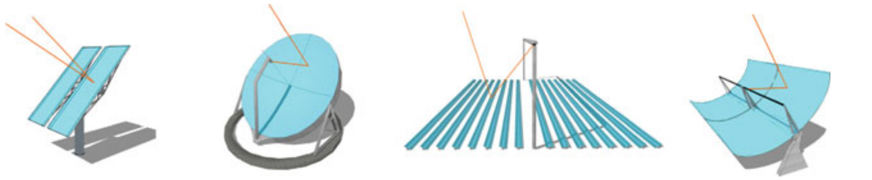

(a) Heliostat (b) Parabolic (c) Linear Fresnel (d) Parabolic Trough

Fig. 1 Solar concentrator systems

the usage of fossil energy sources. Therefore, we need to go with eco-friendly energy (solar, wind, hydropower, and geothermal) sources even more than that we are using now. The solar energy provides more efficiency than any other renewable energy and is harmless to the ecosystem. To get more efficiency from the solar panel, different technologies have been researched and one of them is by solar tracking system which controls the system by aligning it with the sun which makes solar tracking key for getting more efficiency [2]. Our aim is to provide a powerful system for solar tracking fields with less cost and easy implementation.

2 Literature Survey

2.1 Solar Concentration Technology

There are different types of renewable energies such as biomass, waste energy, wind energy, hydropower, ocean energy, solar energy, and geothermal energy [3]. The technologies which solar energy employs reach in three different ways: photophysically, photochemically, and thermally which are photovoltaic, photosynthesis, and heat engine or process heating [4].

To obtain the above task, we use lenses or mirror to concentrate solar flux on the receiver [5]. The mirrors are of four type's parabolic trough, heliostat, dish, or linear Fresnel as shown in Fig. 1 [6]. There are two main technologies for solar concentration: concentrated photovoltaic (CPV) and concentrated solar thermal power (CSP). In the last few decades, the scientists and researchers have produced the combination of both CSP and CPV which is said as concentrated photovoltaic thermal (CPVT) [7]. The CPVT is more potential due to its unique features [8].

2.2 Solar Tracking

With enough precision and by means of solar position algorithm, we can define the change in direction of the sun because the sky is moving and earth is in constant rotation [9]. The issue for system efficiency is the system demand for the mechanism for the system alignment with the sun [10]. Regarding the rotation and position, solar trackers are classified. Linear concentration system is the system which has like parabolic troughs or linear Fresnel [11]. It has subcategories such as tilted-axis systems, horizontal and vertical.

Whereas point-focus system which has two rotation axes is employed with dish modules and heliostats [12]. Depending on the rotation axis position, the subcategories are polar trackers, target aligned, and Azimuth–elevation [13]. Regarding control type, solar trackers are classified into two types: passive and active solar trackers [14]. Based on thermal expansion, a couple of actuators are composed which work against each other are said to be passive solar tracker [15]. Where on the other hand active trackers can be classified in electro-optical sensor data and time-controlled PC based, auxiliary bi-facial solar cell and microprocessor based, and fourth is the combination of all three [16].

The closed-loop and open-loop controllers both can be found with respect to control of active solar trackers [17]. In the literature survey, we studied about solar equations or a hybrid, bi-facial cells, electro-optical sensors, maximum beam, control based on continuous movements, closed-loop, open-loop, and one- and two-axis tracking systems [18]. Even with these many variations in the solar tracking system, there is no indication of a system which can adapt to any solar technology with location and time-independent [19]. Related to this a new sun tracker is produced whose main aim is to avoid solar tracking problems with time and location [20].

3 Methodology

The proposed system uses the concept of solar tracking using LDRs which use light intensity to measure the direction of sunlight and rotate the solar panel into that direction. The hardware of the system consists of main blocks such as IoT module, motor driver, LDR sensors, and LCD. The microcontroller used in the proposed system is Arduino Nano to which all the other elements are attached. The main need of a microcontroller is to understand the light intensity from the LDR sensor and rotate the solar PV panel in that direction. The other use of Arduino is to send the data using an IoT module onto the web page [21] (Fig. 2).

The solar PV panel provides data about how much amount of voltage is produced to the microcontroller. An extra battery is used in case of grid failure the system does not stop working. The higher amount of voltage cannot be given directly to Arduino. Because Arduino Nano uses the only 5 V to work. If higher voltage is provided to the microcontroller, the Arduino can get damage. The temperature is also measured and can be analyzed on a web page. If the temperature increases more than the threshold level, the buzzer starts beeping which is an alert about high heat that can damage the system [22].

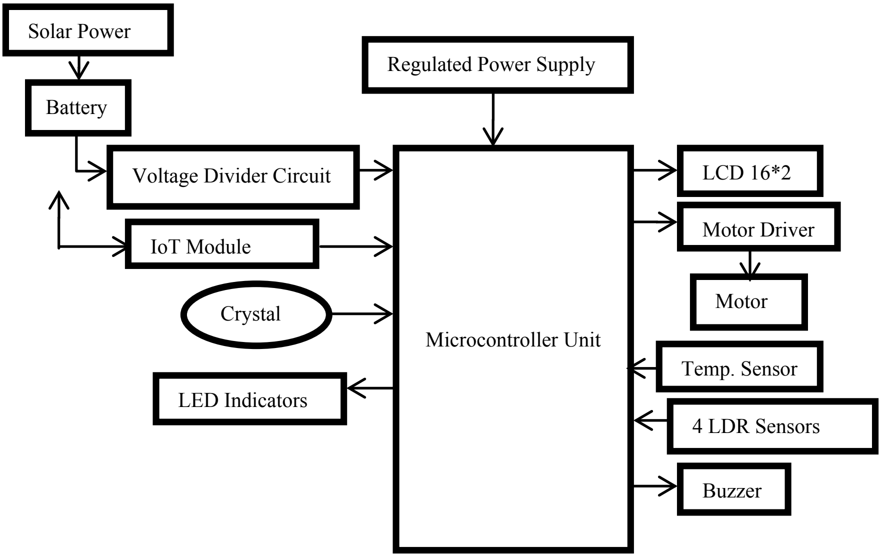

Fig. 2 Block diagram of proposed system

The proposed system uses four LDR sensors in which two LDR sensors are used to rotate motor no. 1 and two LDR sensors are used to rotate motor no. 2. The above-mentioned devices are connected to the analog pins of the Arduino. The analog pins are the inputs to the microcontroller. Let us further study digital pins which are the outputs from the microcontroller. The IoT module used in the system is ESP8266. ESP8266 offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor. When ESP8266 hosts the application, and when it is the only application processor in the device, it is able to boot up directly from an external flash. It has integrated cache to improve the performance of the system in such applications and to minimize the memory requirements. The two pins of ESP8266 are used which are transmitter and receiver pins. The IoT module is used to transmit the data such as temperature, solar PV panel voltage, and LDR sensor values [23] (Fig. 3).

To provide the value of LDR on the system at that instant LCD is used. The LCD is connected to the digital pins of the Arduino. In the given system, the LCD acts as output, and the other output device is the motor driver which is used to rotate the solar PV panel. The dual axis solar tracker uses two motors in which motor no. 1 operates according to two LDRs and the motor no. 2 operates according to rest two LDRs. The motor no. 1 is connected in the vertical direction to the solar PV panel and rotates in clockwise and anticlockwise directions according to the LDR values. The motor no. 2 is connected in horizontal direction to the solar panel and is used to flip the solar panel front and backward direction [24].

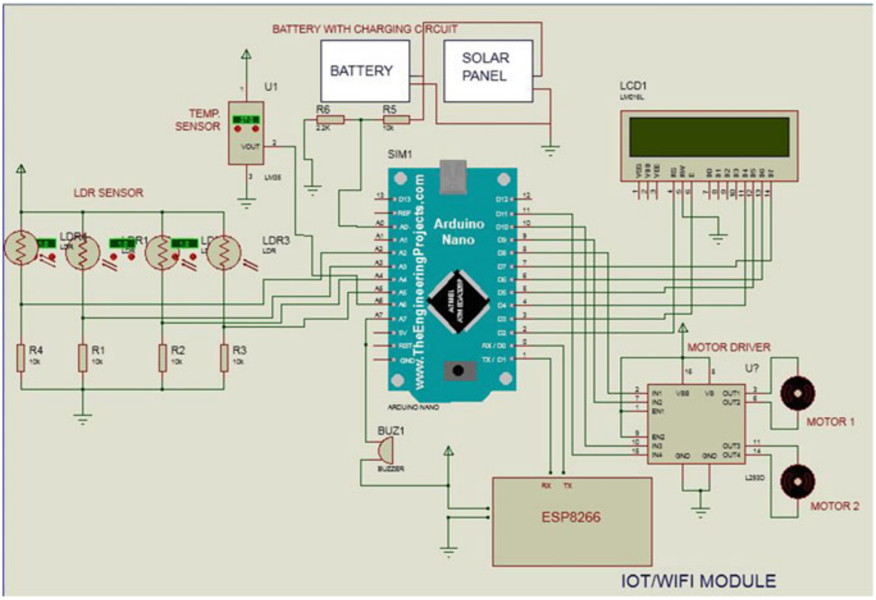

Fig. 3 Circuit diagram of solar remote monitoring and tracking system

The system consists of four LDRs in which the two LDRs which rotate motor no. 1 are opposite to each other. The rest two LDRs which rotate motor no. 2 are opposite to each other. The motor driver used in the system is the L293D IC [25].

4 Control and Management of the System

The connection between the Arduino Nano and IoT (Internet of Things) server is established by initializing power supply to both of them. Initially, the power supply is provided to all the devices of the system. After establishing the communication, the inputs from all the sensors are updated over IoT using IoT module. The system consists of four LDRs whose values are provided to the Arduino Nano which is later on updates the values over IoT using IoT module. If any of the LDR senses the light intensity less then provided values, the motor starts rotating the solar panel in clockwise direction which can be said as it rotates the solar PV panel in the direction of sunlight. If there is a condition that if the voltage passes the threshold level, this triggers the buzzer and the system alarms. The values such as resistance of LDR and temperature, and battery voltage are updated on the web page automatically [26] (Fig. 4).

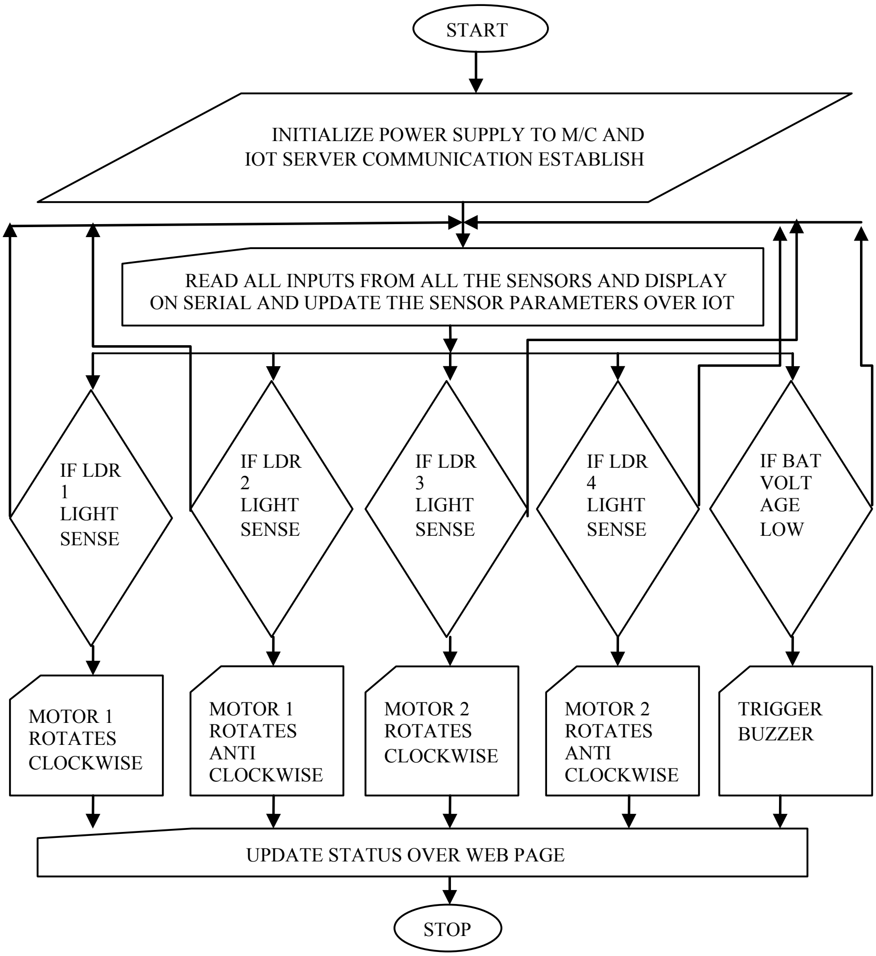

Fig. 4 Operation of proposed system

5 Result

The proposed system consists of the main block of IoT module/Wi-Fi module which is used to update the values over the Internet on a provided web page. The values which are provided on the web page consist of a data logger which provides not only the data of that day but also the data from previous days. This helps in analyzing the data and voltage of the solar PV panel every day. The given webpage consists of six fields in which data of six devices are provided [27]. The devices are

a. Solar PV panel
b. Temperature
c. LDR sensors (Fig. 5).

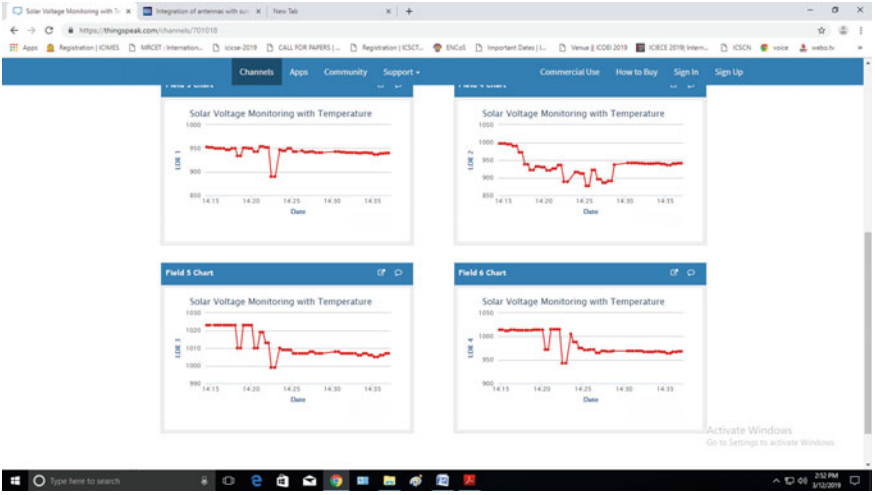

Fig. 5 Design of web page

The values of the system are monitored on the web page and using the Internet can be checked all around the world. The main advantages of the proposed work is to monitor the system with a less human effort. The values of the LDR determine the direction of sunlight and the direction of the solar PV panel. The voltage of solar panel defines the efficiency and the time at which we are getting a higher amount of current in a day, and the temperature determines the heat of the sunlight and if any damage can be caused by heat to the system [28].

The LDR sensor used in the system is generally in four directions. Consider them as North, South, East, and West in which the LDRs are placed. The direction is determined by the values of LDRs the lesser the LDR value the solar panel will be rotated in the opposite direction (Fig. 6).

The result of the proposed system shows that as the values of LDR change with change in sunlight, the system shifts the direction of solar PV panel. According to Fig. 7, its very clear the power generation is more in case of sun tracking solar system as compared to fixed solar system.

Let us take an example, at 14:25 the field 3 which represents LDR 1 is just below 950 Ω, the field 4 which represents LDR 2 is below 900 Ω, the field 5 which represents LDR 3 is below 1010 Ω, and the field 6 which represents LDR 4 is below 1000 Ω. The above readings show that the LDR 2 has lesser value, so the solar panel will be rotated in the opposite direction to the LDR 2. The voltage produced in the solar panel depends on the heat generated by sunlight. The proposed system is a prototype which uses a smaller solar panel which produces approximately 0.1 v. The higher the temperature the more it produces voltage. There is a change in voltage in point form because the voltage is produced at a higher efficiency due to the rotation of solar panel in sunlight direction (Fig. 8).

Fig. 6 Fields in the web page consisting of data

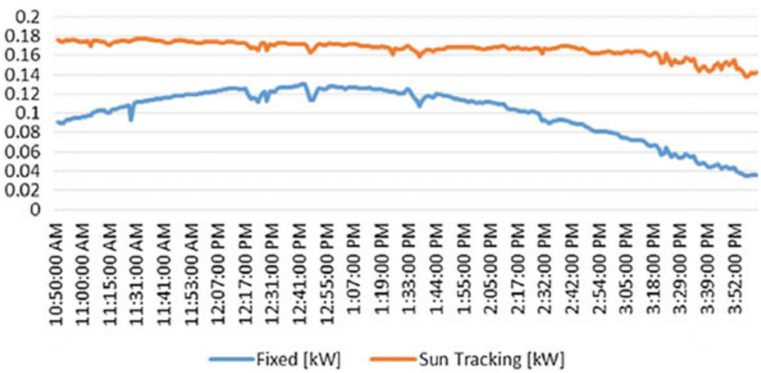

Fig. 7 Fixed versus sun tracking power generation

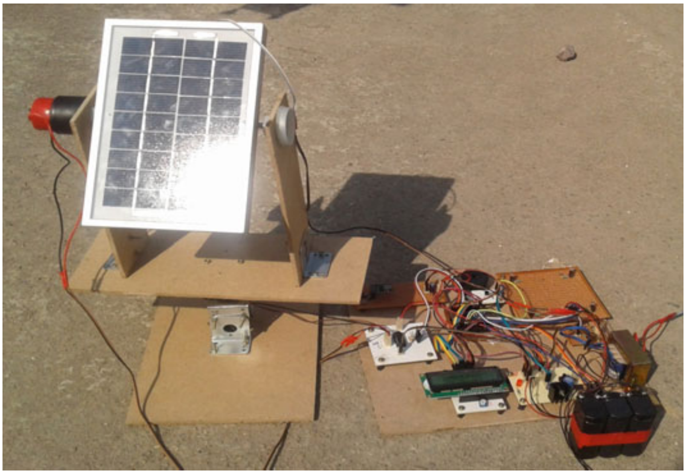

Fig. 8 Proposed system in real time

6 Conclusion

The proposed system is a prototype built to control and manages the solar tracking system. The system was initially built to test if the system can work in a given environment. The aim of the project was to make a powerful tool which can have a wide range of application. The Internet of Things is used to supervise the solar PV power generation which can enhance the performance, management, and maintenance of the system. The system will help in tracking and turning the solar panel in the direction of sunlight using LDRs. The IoT helps in tracking the voltage supply of the solar PV panel.

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