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Design and implementation of solar-grid based charging station for electric vehicle with fault detection method using R-Pi and IoT processor

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ABSTRACT

In this research describes the electrical vehicle (EV) charging station using PV panel with fault detection methods. The PV modules will failure for some time, because of some external factors and internal factors. In direct fault condition the monitor and analyze the external factors such as the life span, high intensity and breakage of the PV panels using Raspberry Pi (R-Pi) processor with internet of things (IoT) system. In power demand/day on the PV panel will be evaluated and analyzed through R-Pi processor and IoT. The efficiency and the range values of the PV panels will be monitored and analyzed through IoT. Proposed work explains, how the fault detection techniques have been improved and adopted in using R-Pi processor through IoT platform. The proposed dataset pre-processing system is incorporated with IoT module. The grid fault clearing time will be compared with the actual values through R-Pi processor. The PV panel faults are detected using thermal image processing, that image parameter values analysis through IoT based internal monitoring system.

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1. INTRODUCTION

The renewable solar energy is most useful and demand will be increased by 50% by 2030. High level of CO2 emission is the reason for global warming and green house effect. The major benefit of electrical vehicle (EV) is improved for the reason of poor air quality and CO2 emissions. The air pollution considerably minimized with towards incrasing the electric vehicle. The Power Ministry of India has declared that the EV charging station extended 2.5 times in the metro cities, that is more than 20-30% incresed in previous year. Every EV’s should be recharged with the help of charging stations without renewable energy. The renewable charging stations plays vital role in charging the EV vehicle [1], [2]. It provides electrical power to the EV and directly monitoring and controlled with IoT-R-Pi processor. The power source for each charging stations comes from the PV panels wihtout dealy. The PV panels were used in the charging stations with some external and internal defects such as cracks in cell, fault occurs in electric grid, and hotspots occurs in solar panel. These all factors will monitor and controlled in our proposed module. Split encapsulation over cells and interconnections much essential in this proposed model. The faults in the PV panels are analyzed using the R-Pi processor–4GB RAM DDR-4bit single board computer (SoC). The Raspberry Pi is a small-sized computer used for analyzing thermal images. The PV Panel defects are identified and analyzed by an image processing method. Using this method the infrared thermal cameras (MNX90640) capture the image of the PV panels and analyze the PV panel image whether it is good or faulty panel acknowledged by the help of R-Pi processor. It is checked in the parameter values in monitoring contol centre. The temperature, pressure, humidity, and altitude of the PV panels are monitored on the regular basis [3]-[6], which is directly affects the electrical grid output. The Arduino Uno is an open-source microcontroller board used for converting analog to digital value for PV panel [7]-[9]. The data collected from the R-Pi and Arduino Uno are fed into the IoT platform and monitored continuously. The power demand for the charging stations is the major part and they are also calculated by: i) analyzing the demand power value/day, ii) load curve load factor, iii) station capacity factor, iv) reserve capacity, v) station usage factor, and vi) units generated/annum.

The purpose of solar energy to power the vehicle is the main focus of this research. The motor engine incorporated PV-power electric vehicle is driven by the energy stored in the battery, allowing the vehicle to travel in any direction. In many research works, no real-time open source dataset has been used for fault detection in solar R-pi processor. The aim of this paper is to present a low-cost real-time solution for the internet of things. This solar system can intelligently record, control, and monitor the generated energy in different environmental conditions/installations.

2. PROPOSED METHOD AND DESIGN

The experimental setup shows Figure 1 that using a multimeter, the short circuit current and the open circuit voltage are calculated. The maximum current is measured with the help of the ammeter and the maximum voltage are calculated with the help of the voltmeter. The variation of Imax and Vmax can be done with the help of the rheostat which is connected to the load resistor. The cell temperature variation is observed with the help of the infrared thermal camera (MNX90640). To clearly capture the PV cell separately, the thermal camera – IoT R-Pi processor is kept at 5m distant separately.

To avoid isolation reflection, it will be inclined and recording thermographs measure the temperature at each and every point of the panel. This will explain the collection of infrared radiation emitted by the solar panel. The captured thermal images will be transferred through Wi-Fi, where it transfers it to the Raspberry Pi 3 processor and the image is analyzed in the processor. The captured thermal image has three common issues with defective individual cells and the substrings. When they are connected, it shows visible heating, denoting that the testing is required and they will be non-functional due to miswired panels and worn-out. This comes out when the entire panel gets hotter when compared with the others [10], [11]. The process of delaminating is that they get externally damaged or substandard with the solar panel quality. The EVA protective layer will delaminate; micro-cracking and cell rupture will start to appear during transportation or installation due to physical stress. IR cameras are easy to use and they can detect conditions and defects at early stages to avoid serious problems. Image processing in R-Pi pseudocode is much easier than the normal thermography that is labeled in Figure 2. These are the most important advantages of thermal thermography [12]-[15]: i) They can used from a safe distance because they are non-contact and non-destructive; ii) The condition of the installation and components will get a clear picture; and iii) No processing is needed because they are available in real time.

To measure barometric pressure and temperature the suitable and best low cost key solution is BMP-180 Sensor. Here, the pressure changes with altitude and it is also used as an altimeter [16]-[19]. The BMP-085 is the predecessor of the BMP-180, the latest generation which gives very accurate values in digital form and they are very likely suitable for domestic applications. By optimization because of it its low power and voltage they are used in mobile phones, GPS, PDAs, and outdoor equipment. It offers an excellent performance at a very fast rate with respect to time and they have 0.25 m altitude noise. BMP-180 is additionally distinguished by its very stable behavior (performance) with relevance the independency of the provision voltage. The BMP-180 offers a pressure measuring range of 300 to 1100 hP a with an accuracy right down to 0.02 hP an advanced resolution mode. It is equipped with the piezo-resistive which aims for high precision, sharpness and offers wide range stability. The chip can receive only 1.8 V to 3.6 V input voltage. Nevertheless, with outer circuit added, this module becomes compatible with 3.3 V and 5 V. Therefore, it is used on Arduino/Seeeduino or Seeeduino Stalker without modification. They're employed in the indoor navigation, GPS-enhancement for dead-reckoning, slope detection, sports devices, e.g., altitude profile, forecast, vertical velocity indication (rise/sink speed).

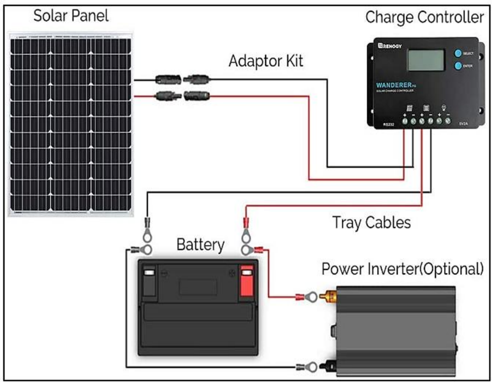


Figure 1. Block diagram

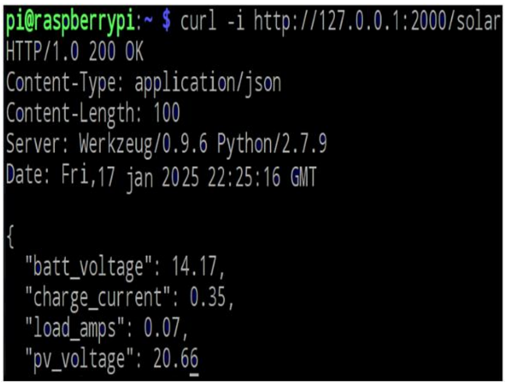


Figure 2. Proposed algorithm code

3. METHOD APPLY IN REAL-TIME DATASET

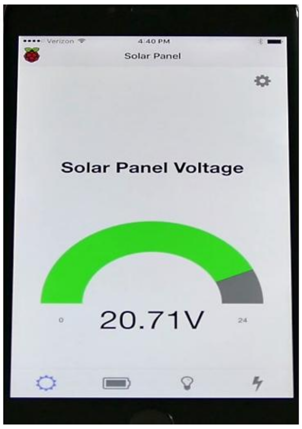
BMP-180 sensor is attached to the electrical device and connected by means of the Raspberry Pi 3 processor. The Arduino is powered by an external source. The BMP-180 sensor senses the temperature, pressure, altitude, and therefore the water level pressure. The program is coded into the Raspberry Pi to detect the temperature, pressure, altitude, and water level pressure in terms of the Python language and therefore the code is executed to seek out the extent of the temperature, pressure, altitude, and water level pressure of the atmosphere. With the assistance of this detection using BMP-180 sensors are able to easily find the healthy and the faulty solar panels were easily identified. Proposed real-time dataset was used in this research [20].

The Raspberry Pi platform, originally intended for educational purposes has become famous immediately after its introduction in 2021. The next-generation Raspberry Pi 3 (RPi4 hereinafter) was released in 2015, when almost six million Raspberry Pi of the primary generation are already sold. The second generation relies on the Broadcom BCM2836 system on a chip with a quad-core ARM Cortex-A7 processor and a Video Core IV dual-core GPU with 1 GB of RAM presented. This small, universal, and still good-performance platform is self-evidently suitable for such mobile applications in machine vision and robotics. To capture the PV panel images by following command "sudo fswebcam solar4.jpg". Proposed learning platforms for IoT-Raspberry Pi monitor and control the entire system. The Raspberry Pi may be a popular platform because it offers a whole Linux server on an awfully tiny platform for a very low cost. In fact, one amongst the foremost difficult parts of using Raspberry Pi for learning about IoT is picking the correct code "sudo fswebcam".

4. RESULTS AND DISCUSSION

The BMP-180 sensor starts reading values by using the command sudo python finalcode.py. It sends them through Raspberry Pi to the cloud platform. This platform is straightforward to use and might be easily integrated with Raspberry Pi. Moreover, it's a built-in dashboard feature, in order that it's possible to create an interesting dashboard to point out using charts. Figures 3(a) and 3(b) are obtained experimental in real time voltage. Figure 4 identifies the healthy panel image. Figure 5 shows the RGB feature of healthy panel output.

(a)



(b)

Figure 3. Demonstration of the solar monitoring system: (a) experimental model integrated with Raspberry Pi and (b) solar output monitoring using mobile app

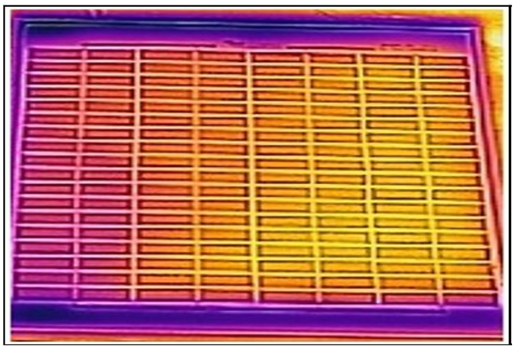


Figure 4. IR image of healthy panel

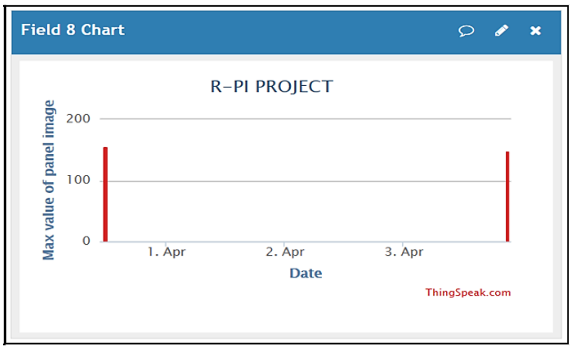


Figure 5. RGB features of healthy panel

When employing a raw image format, the dynamic range of the displayed image may only be an approximation thereto within the raw file. While for a grey-level image the entire number of accessible L grey levels varies from 0 to 256, for a thermal image, the relative range extends from a minimum to a maximum temperature value. Because the tonal distribution varies on temperature, a thermal image may be classified consistent with its color/tonal intensities. Nevertheless, the root of the variance gives the quality deviation, which is informative about the contrast of a picture. Figure 6 describes IR image faulty panel outcome. Figure 7 shows the faulty panel output. In other words, it describes the spread within the image data: a high-contrast thermal image will have a hot temperature distribution. Within the majority of thermal image-based diagnostics, variance could be a key indicator of possible defects. As shown in Figures 4 and 6, the horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in particular tone. The vertical axis represents the scale of the real that's captured in every one of those zones [21]-[23]. Thus, the histogram for an awfully dark image will have the bulk of its data points on the left side and center of the graph. The demand and production values of the EVs will be changing according to the entry of vehicles into the charging station, and depending upon the climatic conditions production values will be changing respectively [24]-[27]. Let us consider a charging station has the following daily load cycle shown in Table 1.

In distribution, load may vary depending on consumer demand. Table 2 displays the results comparison for proposed and existing work. The above waveform (Figure 8) displays the variation of the distribution load with respect to the time period is known as load curve. Based on this curve to identify the maximum demand of a charging station in particular area. These load variation during the whole day (24 hours) are recorded and plotted against time on the graph, and the peak hours are noted in 11 to 14. The obtained graph is called as daily load curve, depicted in Figure 8. The time period in which we get the maximum load is called maximum demand. Consider the maximum demand = 100 kW, Time period = 2 hours (10 AM–12 PM). Figure 9 shows the overall PV performance monitoring system.

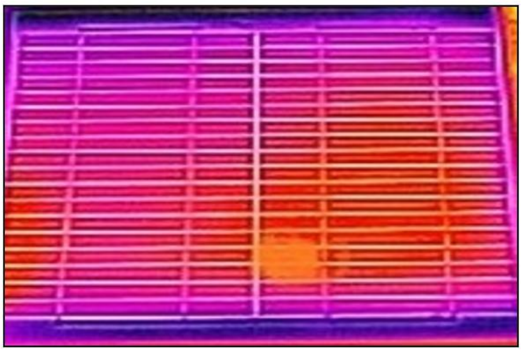


Figure 6. IR image of faulty panel

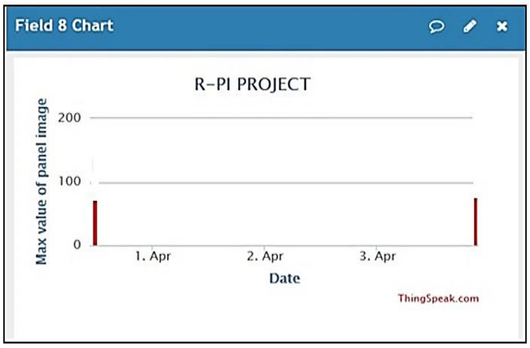


Figure 7. RGB features of faulty panel

Table 1. Daily load curve

Time (hrs)	0-4	4-6	6-10	10- 12	12-16	16-20	20-24
Load (kW)	5	15	50	100	75	60	30

Table 2. Comparison of result data with existing work

Reference	Controller/algorithm	Output power	Grid fault clearing time
[4]	Grey wolf optimization (GWO)	50 W	4.5 s
[13]	Modifies particle swarm (MPSO)	45 W	2.0 s
[17]	Hybrid particle swarm (HPSO)	65 W	3.5 s
Proposed work	IoT-R-Pi	100 W	1.5 s

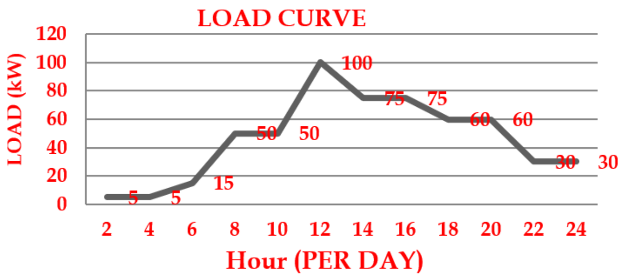


Figure 8. Load curve

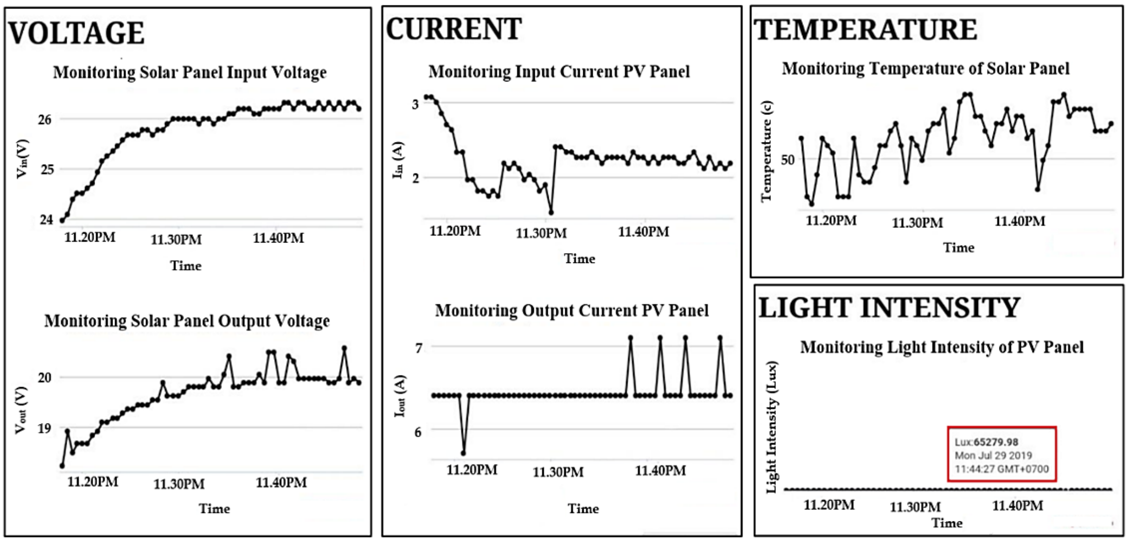


Figure 9. PV monitoring system

5. CONCLUSION

In EV charging station using infrared thermography presented. The PV-grid monitoring and detecting fault panels with the help of image processing in Raspberry Pi-4 processor using IoT. The PV temperature, pressure, humidity, and altitude are calculated with the help of R-Pi. These panel parameters are fixed in suitable positions in the battery charging system. The storage battery directly connected with grid tied system. This platform is highlight to use and might be easily integrated with Raspberry Pi-IoT. Moreover, the PV dashboard monitoring control system to creates all data in dashboard to point it out. The demand and production values in a charging station are calculated and the losses were calculated respectively. The fault detection methods using solar panels-grid tied system were discussed and compared the existing method.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY

The datasets utilized and/or analysed in this study are available from the corresponding author of the original dataset upon reasonable request.

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