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PERMANENT MISMATCH FAULT IDENTIFICATION OF PHOTOVOLTAIC CELLS USING ARDUINO

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Abstract

Over the past few years, various industries have learned that photovoltaic (PV) system fault protection must be refined to include additional fault protection that is not provided in most of the existing PV system installations. In order to implant effective efficiency over PV cells the voltages, resistance and temperature are readily analysed and displayed via Liquid Crystal Display (LCD) which is tracked by controller continuously. Fault detection in solar panels is an active research area and evolves continuously demonstrating an academic interest as well. Fault detection aims at detecting faulty and degraded solar panels as early as possible. The fault detection is based on the comparison between the measured and prediction results of the power production. The model estimates the power production using solar irradiance and PV panel temperature measurements. Prior to model development, a data analytic procedure was used to identify values irrespective of a normal PV system operation. PV system analysis was tracked continuously by Arduino. It is highly reliable and able to detect all significant mismatch faults over a certain threshold.

Keywords:

Solar Irradiance, Photovoltaic System, Arduino, Mismatch Fault

1. INTRODUCTION

It is known fact that solar energy is the non-conventional form of energy. The sunlight falls on earth round the clock to meet the world's energy demand. Here the challenge is to learn how to extract that energy in a cost-effective way. Around the past decade the adequate usage of the photovoltaic cells has become enormous besides the energy obtained from the cells are 100% greener than other sources. Generally the efficiency of the PV cells is reduced due to various faults such as permanent mismatch faults (PMF) and temporary mismatch faults (TMF). The permanent mismatch fault mainly focuses on the failure of the solar panel in natural conditions such as crack, hotspots, soldering faults and other major physical faults. The usage of microcontroller paves the way to identify the defect in sophisticated manner. Once the permanent mismatch fault occurs, the human interference into the circuit is needed to rectify it. The Parameters voltage, resistance and temperature of the panel are recorded on real time basis. In any case if there is any abnormality in these parameters during certain period of time then the PMF persist. The microcontroller engaged here is the Arduino Uno series, mainly used for its speed of 16 MHz and has a wide reusable general purpose input and output pins. For the simple and clear notification for the user it is provided through the (16*2) Liquid Crystal Display (LCD). The computed parameters are being displayed spontaneously in LCD. The Light Dependant Resistor (LDR) is passed down for determining the presence of sunlight and it is interfaced with the Arduino, thereby preceding its corresponding actions. The piezo electric buzzer and the Light Emitting Diode (LED) are used in reserve. The User Interface Switch (UIS) provides the control over the alarm to the user. Finally, Switched mode power supply 12V: 1A is used to power the entire board [1].

2. FAULT ANALYSIS

The importance of photovoltaic cell/module as a continuous operating system is a well-known necessity. Reliable predictive and preventive maintenance techniques are needed to assure lifetime efficiency in service. For this we need to know the possible kind of defects can occur such as soldering faults, cracks in solar panel and discontinuity in wiring. It leads to Hotspots invisible to naked eye, dust accumulated particles are detected and analysed. The overall efficiency of the panel decreases when there is a fault. Apart from the efficiency, the panel lifetime plays a vital role. In order to increase the efficiency of the panel we compute certain parameters from which we can identify the type of fault occurred [2]. In this section we are going to discuss three parameters of the panel to identify permanent mismatch fault (PMF).

- Voltage of the panel (Vp)
- Temperature of the panel (Tp)
- Resistance of the panel (Rp)

2.1 MEASUREMENT OF VOLTAGE (Vp)

The voltage of the panel determines the output of the panel in accordance with the radiation from the sun. Thus the voltage level (Vp) is significant in fault analysis [3]. In order to measure the panel voltage we are going to deduce the panel voltage from higher level to lower level (microcontroller max Vin) and it is done with the help of voltage divider circuit.

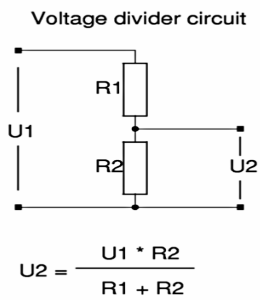

Fig.1. Voltage divider circuit

In this case we took the 10.7V panel for which the voltage has to be monitored.

Assuming the values,

$$U1 = 10.7V, U2 = 5V, R2 = 1K \quad (1)$$

To find the value of R1,

$$5 = (10.7*1)/(R1+1)$$
$$(R1+1) = 10.7/5$$
$$(R1+1) = 2.14$$
$$R1 = 2.14-1$$
$$R1 = 1.14 \quad (2)$$

The above equation provides the value of the R1 to be used in the circuit.

2.2 MEASUREMENT OF TEMPERATURE (Tp)

The system continuously monitors the surface temperature of the Solar panel with the help of the temperature sensor LM 35 and it has the wide range of sensing temperature (-550 C to 1500 C). The analog output voltage from the sensor is directly proportional to the temperature around sensor. Now the analog output voltage from the sensor is fed to the microcontroller via analogue port (A). The sensor and the microcontroller interface is given in the Fig.2 below.

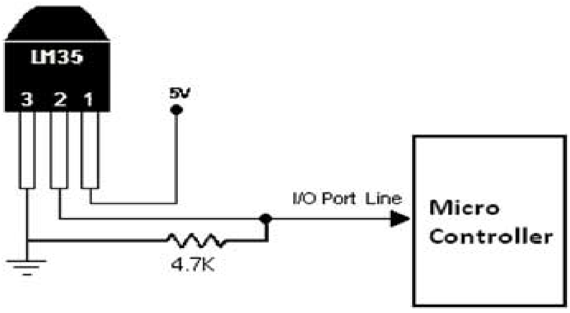

Fig.2. LM35 interface with Microcontroller

2.3 MEASUREMENT OF RESISTANCE (RP)

The resistance value of the panel is used to find the discontinuity in the panel trace and also to consider soldering faults occurred in the panel. This measurement of the resistance can be done only when the panel is in offline condition. The offline condition is achieved only during the night time. Thus the resistance is measured only during the night time with the help of the light dependent resistor circuit which is attached to the microcontroller.

The circuit used to measure the resistance of the panel is same as the voltage divider circuit and thereby the resistance (R1) is replaced with the solar panel. The external voltage is applied in that circuit along with the output voltage (V) is computed and thus resistance is calculated.

3. EXPERIMENTAL SETUP

Arduino is an open-source computer hardware and software company, project and user community. It designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. Entire experimental setup is controlled with the help of the Arduino, which is the advanced version of the microcontroller 8051 series and has more programmable memory and GPIO pins. The single phase 230V is fed into the apparatus by converting it into 12V through Switched Mode Power Supply (SMPS). The 12V driven by the 12V, 500mA double throw relay and the buzzer circuit. While the maximum power fed to the Arduino is 5V through LM7805 voltage regulator and to the 16*2 LCD circuit.

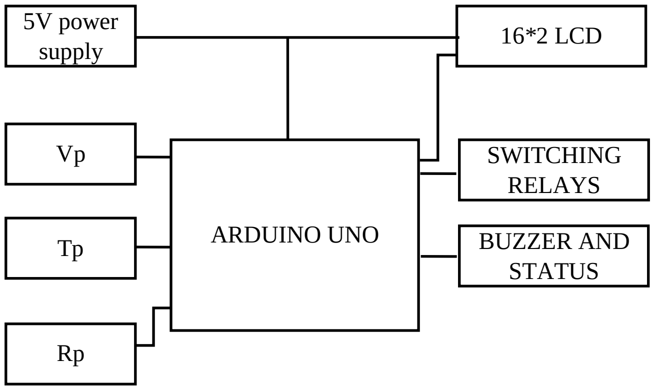

Fig.3. Arduino-Block Diagram

3.1 POWER SUPPLY

Light Dependant Resistors (LDR) is used to sense the presence of light and also to notify whether its day or night. It uses LCD to display it. The LDR interfaced with the Arduino is used to identify the resistance of the panel in the night time. The value of the resistance will be accurate if measured in night time when the voltage level is zero.

3.2 LCD ARDUINO INTERFACE

The output of the fault analysis is being observed with the help of liquid crystal display. The power supply to the LCD is provided through the port Vss and Vcc from the arduino. And LED+ and LED- provide the supply for LED backlight. The data pins D4 to D7 are directly connected to arduino digital output pin buttoned up with LCD [4].

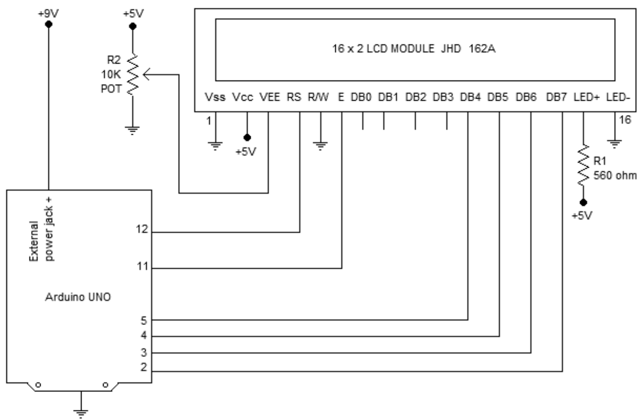

Fig.4. LCD interfacing with Arduino

Fig.5. Reading obtained from LCD panel

3.3 BUZZER INTERFACE WITH ARDUINO

The piezo electric buzzer connected across the circuit is used to indicate the abnormal level indication of voltage, resistance, temperature. The user interface switch provided will help the user to enable the alert produced by the buzzer.

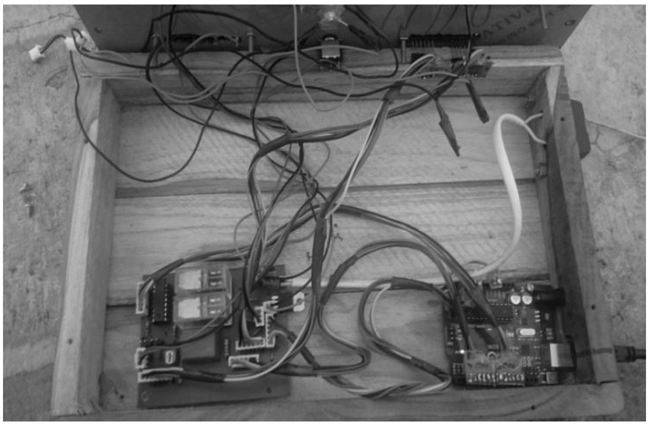

Fig.6. Entire setup after wiring (box opened)

4. DISCUSSIONS

Mismatch faults in PV system are based on parameter variations are proposed for first time. The performance of the system are analysed based on it. The parameters are voltage, temperature and resistance. Based on the results, photovoltaic system faults are analysed and modified with the help of Arduino controller. The future research plans is to address some intelligent features that is used for fault detection and localization in PV system regarding the inference obtained.

5. OBSERVATION AND RESULT

The analysis over this setup results in interfacing the panel and circuit and obtained its variations in temperature, voltage and resistance during day and night continuously through Arduino [5].

The ratings of the solar panel used for interfacing are shown below:

Table.1. Specification of the panel used

Parameter	Indication	5.00 Wp
Maximum Power	Pmax	5.00 Wp
Voltage at maximum power	Vmp	8.5V
Current at maximum power	Imp	0.59A
Open circuit voltage	Voc	10.7V
Short circuit voltage	Isc	0.66A
tolerance		+5% or -5%
Normal operating cell temperature		45^0 C

We obtained the panels,

Maximum voltage = 10.7V

Maximum Temperature = 800^oC

Resistance of the panel = 10MΩ

Table.2. Obtained range of values from solar panel

Sl. No	Parameter	Range
1	Vp	9V-11V
2	Tp	20^oC-120^oC
3	Rp	< 1.5MΩ

By these parameters if a voltage reduces or temperature increases or if there is a change of resistance it indicates the user through buzzer sound.

6. CONCLUSION

This paper briefs on whenever there is an abnormality in the voltage, resistance and the temperature of the photovoltaic panel there will be proper intimation to the user and thereby he finds it easy to switch down the faults. They find their predominant application over all photovoltaic cells where their corresponding output pays to some ethical needs for the user. It alerts the user in the right time to make sure that the panel is operating in maximum uptime thereby increasing the overall efficiency of the system.

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