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Isolation of Solar Panels and Associated Components during Heavy Lightning Using Vajrapaat App

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Abstract--Users demand on power supply is increasing day by day based on the population and the rise in their usage of electrical components. In current scenario, meeting out the power demand with conventional energy sources alone is not possible. One of the promising and continuously available sources is solar energy. In solar power plants, some maintenance issues are happening in the power production such as panel cleaning, hot spot, components failure due to heavy lightning etc. Even the lightning arresters are provided in the power plants, components failure are happening at some part of the power plant. This paper focuses on the alternate solution to avoid the components failure during heavy lightning time. Vajrapaat app based Arduino controller unit with GSM module has been suggested solar panels and associated electric components isolation and is detailed in this work. The prototype model is developed and is validated under different system operating conditions.

IndexTerms—Vajrapaatapp, GSM module, Arduino controller, solar panels, lightning.

I. INTRODUCTION

The increase in power demand can be meeting out with the help of both conventional and non-conventional energy sources. Power generation from solar energy [1] is the most promising one in meeting power demand.

Solar energy is radiant light and heat from the sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic [3], solar thermal energy, solar architecture etc. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the capture and distribute solar energy or convert it into solar power. Active solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

The generation of power from solar energy is simple and economical compare to the other conventional energy sources. Even the installation cost of the solar power plant is a bit costlier, but the power production rate is far better than the other sources like wind energy and hydel power. So the solution for the problems in solar power plant will increase the rate of production of power than the normal rate.

In solar power plants, some of themaintenance issues are raised such as panel cleaning, hot spots, cable burn outs during heavy lightning time, panel angle adjustment for maximum power extraction and etc. in the plant operation. One of the problems in the solar power plants is the cable burnouts and the panel damage due to the lightning strike. In general, losses due to heavy lightning is heavy in power houses, transmission lines, communication towers, buildings with huge height and sometimes it kills the lives of animals and human being too and regarding this lot of investigations [8-10] are going on towards the point of arresting the lightning effectively. In case of solar power plants, cable burnouts are happening during heavy lightning time even the lightning arresters are provided in the plants at specific points and it is damaging the solar panels also at moments. Once the cables are getting burned out, the maintenance engineers have to wait for some time to replace the burned cables in case of unavailability of spare cables in the plant. Until the spare cables getting received from outside, the power generation from the particular panels is absent and it will affect the desired power generation value.

In this project work a solution for the above mentioned problems are proposed. By using this proposed project in solar power plants the problems like the cable burnouts and the damage of solar panels and the components used in production of solar power will be decreased to a minimum level.

II. LIGHTNING

Lightning is a violent and sudden electrostatic [4] discharge where two electrically charged clouds in the atmosphere collide with each other during a thunderstorm.

Lightning [2] creates a wide range of electromagnetic radiations from the very hot plasma created by the electron flow, including visible light in the form of black body radiation. Thunder is the sound by the shock wave formed as

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gaseous molecules form a rapid pressure increase.

In solar power plants at the time of heavy lightning, there is a problem of cable burnouts and the components failure. If heavy lightning strikes the solar panels the cables connected to the solar panels to transfer the produced power cannot hold that much power present in the lightning strike, so the components will fail and the damage will happen to those components. Even the lightning arresters are provided; there are problems if those arresters will fail.

A lightning arrester is a device used to protect the electric and tele-communication systems from the effect of lightning. The typical lightning arrester has a high-voltage and a ground terminal. Whenever a lightning happens, it travels to the line of the arrester from the power line; the current from the earth is delivered to the earth.

The lightning arresters are placed where wires enter a structure, preventing damage to electronic instruments present inside and the safety of the instruments around them. The smaller arresters are called as the surge protectors

If these lightning arresters are failed or absent, when the lightning strikes the electrical system introduces thousands of kilovolts that may damage the transmission lines, and also cause a severe damage to transformers and corresponding electronic devices. The improper earthing leads to failure of electrical components during the heavy lightning condition.

III. PROPOSED SYSTEM

This proposed work is to isolate the battery units and concerned loads during the lightning based on the Vajrapaat App (available in play store and is developed by Kuppam Engineering College in association with ISRO) controlled control circuit. This will help us to avoid cable burnout issues and components failure or malfunction due to lightning. The block diagram of proposed system is shown in Fig. 1. The proposed system consists of Vajrapaat App connected GSM control unit and Arduino controller based isolation unit. Once the heavy lightning condition is detected, Arduino controller receives the control signal from Vajrapaat App enabled GSM control unit. Immediately, it will open the main relay between the power line and solar panels with its associated electrical components. After the preset value of 1 hour time delay, controller will verify the control input from GSM [6] unit. If the heavy lightning possibility is dropped, then Arduino controller unit will reconnect the solar associated power components on power delivery line.

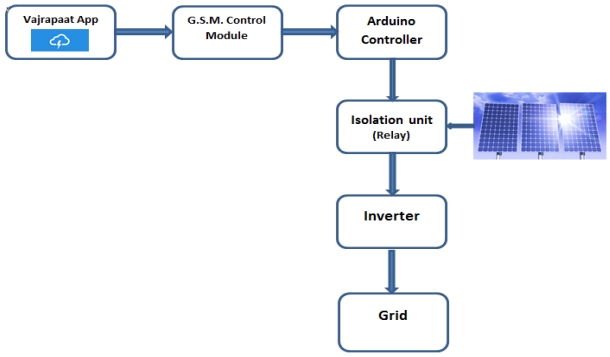

Fig. 1 Block diagram of proposed system

Whenever the lightning happens near a solar plant which consists of the proposed isolation unit, the Vajrapaat app senses the lightning strike before 40 minutes and sends a signal to GSM module and then the GSM module senses it and it sends a signal to the arduino controller to isolate the circuit which is connected to the solar panels. Then the relays will break the circuit and after the specific delay time if there no sense of lightning, the circuit will be automatically reconnected.

Already Vajrapaat app based siren for few Kilometers surroundings has been established at Kuppam Engineering College campus and the launching event is shown in Fig. 2. It will give the alert 40 minutes before the heavy lightning.The same system is planned to utilize to isolate the battery and load units during heavy lightning time but the problem involved in this model is isolation is possible only through human intervention. It is not feasible always in real time because isolation of electrical equipment may be improper if the control operator not responding to the lightning alert signal properly and at in time. This problem is resolved in this proposed system with the help of Arduino controller unit by continuously monitoring heavy lightning alert.

Fig2.Launching of Vajrapaat App based siren system for heavy lightning alert at Kuppam Engineering College campus

Vajrapaat App based isolation unit helps to avoid the cable burnouts during heavy lightning condition. Normally, during heavy lightning time (rainy time) the power production through solar panels is almost zero and hence isolating the solar panels and concerned electrical components may not disturb the power production process. Once the heavy lightning condition is over, then all the devices get back to the work automatically based on the continuous checking of heavy lightning condition.

IV. EXPERIMENTALSETUP AND RESULTS

The experimental setup of the proposed work consists of a GSM module, Arduino controller, Solar panels and relays. This system also consists of Vajrapaat app based heavy lightning system alert in it process.Basically, heavy lightning conditioning will be predicted based on Vajrapaat appand it will be monitored by the control room. Once the heavy lightning condition is predicted, the information will be sent to the user's mobile numbers registered in this app. In this proposed work, the alert received through the G.S.M. module will act as a control signal for the Arduino controller in taking the decision in connecting/disconnecting the solar panels and the associated electrical components in its operation.

In order to verify the system operation, making the heavy lightning condition is not practically possible. To ensure the system operation during the heavy lightning condition, SMS based control input is applied to the Arduino controller. In this hardware portion, GSM module will give a signal to the Arduino controller whenever there is lightning strike happens before 40 minutes. The information i.e. alert message is set manually for the demo purpose in this realization and is automatic in case of practical heavy lightning condition alert process.

The experimental setup of the proposed system is depicted in Fig. 3. The arrangement consists of three solar PV modules of 5 W capacitieseach; GSM Module, Arduino controller, Relay unit, battery and lighting load of LED strips are connected. Arduino controller [5]along with the relay unit in the proposed system works as an isolation unit.

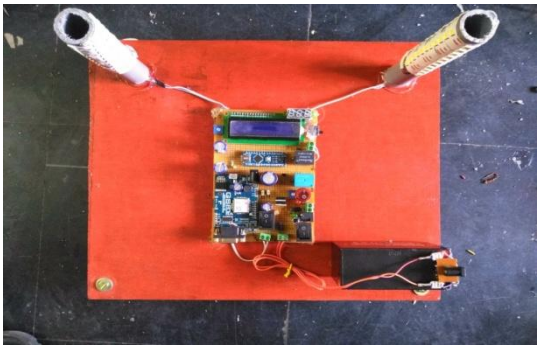

Fig. 3 Proposed system prototype model

Whenever the GSM module sends the signal to the controller regarding the heavy lightning, it will isolate the solar panels by tripping the relay unit through which the solar panels are connected using cables.Relays [7] will trip the circuit whenever it senses a signal from the Arduino controller. The rating of the relay used in this work is 12 volts.Liquid Crystal Display (LCD) displays whether the solar panels connected or disconnected with the load.In this circuit the battery is used to supply power to the components present in the circuit. The rating of the battery is 12 volts. The operating conditions of the proposed system are detailed as different cases as follows.

Case-1: Normal operating condition

In this case, there is no sense of signal from the GSM module, so the system is in normal state i.e. in connected state. In this case, loads are connected to the PV modules through the relay circuit which is normally in closed condition. The LED strips glowing condition indicates the connection of PV modules and the status the PV modules connection is displayed in LCD as 'Panel Connected' and is shown in Fig. 4.

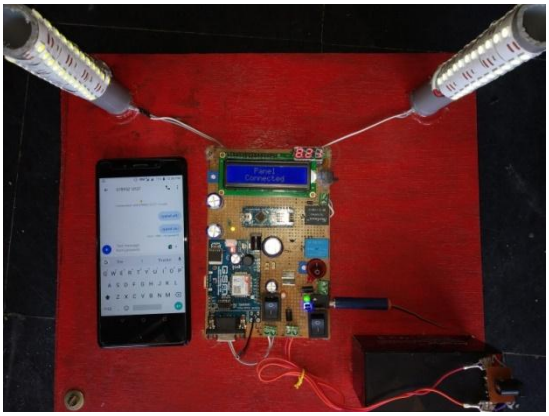

Fig. 4. System status during normal operating condition

Case-2: During heavy lightning alert condition

In this case, the Arduinocontroller continuously monitors the heavy lightning alert signal after the preset time period of 1 hour. In this prototype model, instead of preset time period of 1 hour, it is set as 20 seconds for the continuous checking of heavy lightning condition. As the production of heavy lightning condition for demo purpose, the manual alert condition will be setup through the GSM module and thereby the relay unit will move into normally open condition. Because of this PV modules and the associated electrical components will be disconnected from the system. The corresponding status is displaying as 'Panel disconnected' and shown in Fig. 5. The Arduino controller will continuously checking the lightning alert after the preset time period of 20 seconds in this prototype model.

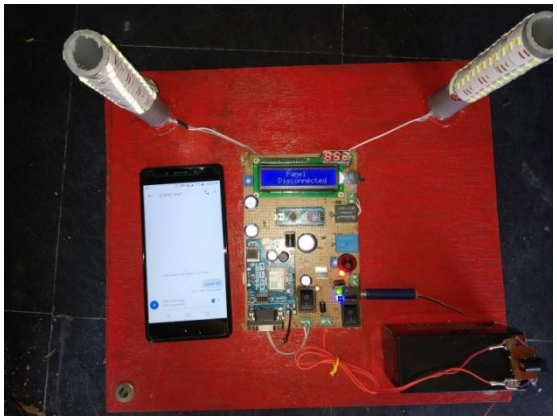

Fig. 5. System status during heavy lightning alert condition

Case-3: Reconnection of panels and associated components

After sometime if there is no chance of lightning, the PV modules and associated components will be connected back to the system with the help of Arduino controller. So the display shows as 'Panel Connected' and is shown in Fig. 6.Once the panels are reconnected, those will generate the power based on the irradiance.

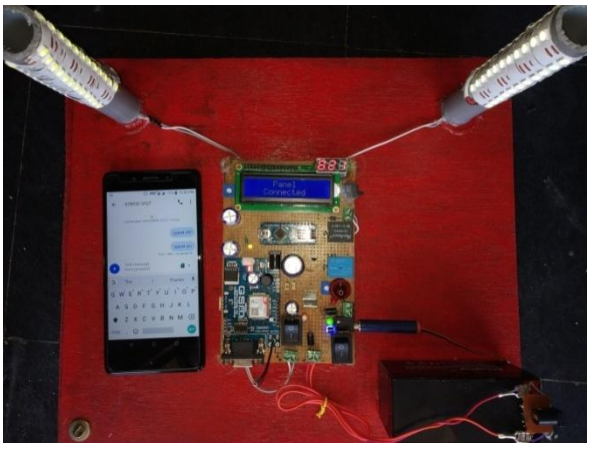

Fig. 6. System status during reconnection

In all the cases, the power generation process is not disturbed at any point unnecessarily because the irradiance is almost nil during the heavy lightning condition. Once the climatical condition is reverted back to normal condition, PV modules and panels will be reconnected in system operation. This kind of proposed system avoids the unnecessary burn outs and faults conditions; since they are isolated well in advance disconnected from the system structure before the heavy lightning condition is arises. In case of real time implementation, rating and type of relays should be selected properly. For the entire plant one proposed module is enough to give the heavy lightning alert condition. Based on the amount of PV modules connected in series in an array and in parallel connections, the number of relay units can be decided based on power plant capacity. Accordingly, the components rating used in this prototype model can be changed.

V.CONCLUSION

The isolation of solar panels and associated electrical components in the solar power plant with Vajrapaat app based control circuit has been detailed in this paper. This will isolate the system components from the system structure i.e. open circuited, well in advance before the heavy lightning condition. This will reduces the maintenance cost due to cable burnouts under heavy lightning conditions. This proposed work can be extended to other places where the protection of electrical components against heavy lightning condition is needed. Based on the place of application, the components ratings can be altered to ensure the safety operation.

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