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Analysis of Solar String Failure Under Different Fault Conditions

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ABSTRACT
Solar energy is the most exciting use of solar power. Among the various Renewable Energy resources, solar energy potential is much higher than others. Solar energy produces no pollution, has no environmental effects. This proposed work proposes analysis of different fault condition in PV system. In existing system, the failure was detected in solar module. It is difficult to detect the failure and it is time consuming, expensive in cost. In proposed system, monitoring the solar string, thereby detecting the fault based on the power decrement due to a solar string failure. The unit can be introduced inexpensively, when compared with the system required for monitoring at a panel. Consequently, string monitoring is highly effective in the detection of solar panel failures. This proposed work has planned to use MATLAB/SIMULINK tool for simulation. The faults conditions are analyzed by comparisons of traditional condition of solar PV and VI characteristics with faulty condition characteristics. The simulation results of MATLAB simulation model shows the results for various fault condition. The analysis has been done based on simulation results and theoretically. It is evident that the performance of the proposed method is excellent and it is practically implementable.

***KEYWORDS**: Solar energy; Renewable Energy; PV system; MATLAB; SIMULINK*

INTRODUCTION

Renewable Energy

The energy which is collected from the natural resources like sunlight, wind, tides, geothermal heat etc. is called Renewable Energy. As these resources can be naturally refilled, for all purposes, these can be reflected to be immeasurable unlike the narrowing conventional fossil fuels. The worldwide energy crunch has provided a changed impulsion to the evolution and development of Hygienic and Renewable Energy Sources.

Solar Energy

Sun powered energy, a non-ordinary thoughtful of energy. Sun powered energy has been utilized by human race since extended times utilizing a heap of innovations. Sun oriented radiation and optional sun powered fueled asset like tidal and wind power, hydroelectric and biomass, are in charge of a large portion of the promptly accessible no expected sorts of energies on earth. Just a little divide of the trappable sunlight based vitality is utilized. Sun oriented fueled power era relies on upon photovoltaic setup alongside hotness motors.

Energy from Sun

In one minute, the sun provides enough energy to supply the world's energy needs for one year. In one day, it provides more energy than the world's population could consume in 27 years. The energy is free and the supply is unlimited. All we need to do is find a way to use it. The largest solar electric generating plant in the world produces a maximum of 354 megawatts (MW) of electricity and is located at Kramer Junction, California. Since India has abundant sources of RE especially sunlight, it can cater all the energy needs of the country. The country receives an average radiation of 5 KWh per square meter (m) per day and with 2300 to 3200 sunshine hours per year.

The potential of solar photovoltaic has therefore been estimated at 20 MW per square km and that of solar thermal applications at 35 Mw per s.q.m.

Solar Panel

A Solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. Most modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can be either the top layer or the back layer. Cells must be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells are connected electrically in series, one to another to the desired voltage, and then in parallel to increase amperage. The wattage of the module is the mathematical product of the voltage and the amperage of the module. The manufacture specifications on solar panels are obtained under standard condition which is not the real operating condition the solar panels are exposed to on the installation site. A PV junction box is attached to the back of the solar panel and functions as its output interface. External connections for most photovoltaic modules use MC4 connectors to facilitate easy weatherproof connections to the rest of the system. A USB power interface can also be used. Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability (amperes) of the solar panel or the PV system. The conducting wires that take the current off the modules are sized according to the ampacity and may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated. Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of

cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way. Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure

Solar Power Plant

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination. Concentrated solar power systems use lenses or mirrors and solar tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect. Photovoltaic's were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. Commercial concentrated solar power plants were first developed in the 1980s. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale photovoltaic power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The current largest photovoltaic power station in the world is the Pavagada Solar Park, Karnataka, India with a generation capacity of 2050 MW. The International Energy Agency projected in 2014 that under its "high renewables" scenario, by 2050, solar photovoltaics and concentrated solar power would contribute about 16 and 11 percent, respectively, of the worldwide electricity consumption, and solar would be the world's largest source of electricity. Most solar installations would be in China and India.[3] In 2017, solar power provided 1.7% of total worldwide electricity production, growing 35% from the previous year.[4] As of 2018, the unsubsidised levelised cost of electricity for utility-scale solar power is around $43/MWh.

LITERATURE SURVEY

"Solar PV Module Fault Analysis Using Artificial Intelligence" Mandip Ojha, Prof Nilesh Chamat

This paper addresses the way for real time observance and fault analysis in electrical solar PV (photo voltaic) systems is projected. This approach is based on a comparison between the performances of a faulty electrical solar PV module, with its correct model by quantifying the precise differential residue which can be associated with it. The electrical signature of each default measure mounted by considering the deformations induced on the I-V curves and PV curves. All fault cases like module to module fault, short circuit fault, open circuit fault, cell- ground faults and totally different shading patterns measure are thought-about. The projected technique measure usually generalized and extended to further forms of faults. This faults condition was analyzed by comparisons of traditional condition solar PV and VI characteristics with faulty condition characteristics. The simulation results of MATLAB simulation model shows the results for various fault condition with variation of solar irradiation.

"Study of Partial shading effect on Solar Module Using MATLAB" Satyendra Vishwakarma

Solar cells are connected in series and parallel in order to generate high voltage and current respectively. Sometimes PV module is shaded due to nearby building, passing clouds. Solar cells arrays are subject to shadows from both predictable sources as well as from such unpredictable sources as bird droppings or fallen leaves. The percentage power loss is much greater than the percentage of array area which is shadowed.

For smaller arrays with few or no parallel connections, one leaf could cause the system output. To reduce such effects bypass diodes are used. The bypass diode will make sure the operation of the module with partial or full shaded modules at reduced voltage. However the number of bypass diodes used in a module is limited, so shading of one single cell will affect the system performance. In this paper, a PV module which is partially shaded is discussed. The different level of shading on current-voltage characteristics and power output of module are investigated.

"Classification of causes of broken solar panels in solar power plant" Yuji Higuchi and Tadatoshi Babasaki

In this paper, we report various methods for classifying faults that use the data of string measurement devices used for continuously monitoring solar power panels remotely. Low power generation of solar panels is caused not only by panels being broken but also by shadows cast by structures, weeds, etc. If these failures can be classified by using the data of remote string measurement devices, it is expected that the number of unnecessary repairs will be reduced, making preparations for possible failures more efficient. We focused on low-open circuit voltage cluster failure, shadows, and weeds, which often decrease power generation at solar panels, and we examined these classification methods with string measurement data. Furthermore, a failure classification flow was created by combining various failure detection methods. When comparing this flow with the results of drone inspection, the accuracy rate was 74.0%.

"A Hybrid Maximum Power Point Tracking Technique for Partially Shaded Photovoltaic Arrays" Hadi M. El-Helw, Ahmed Magdy, Mostafa I. Marei

This paper introduces a hybrid maximum power point tracking (MPPT) technique for photovoltaic (PV) arrays working under partial shading conditions (PSCs).

This fresh algorithm can unite a conventional MPP algorithm, such since trouble plus scrutinize (TPS) or incremental conductance (IC), by means of the non-natural neural system (NNS) practice. The proposed amalgam MPPT algorithm is base on the NNS plus second-hand to envisage the worldwide utmost power point (UPP) province by estimating its electrical energy restrictions. as a result, the predictable MPP algorithm searches for the MPP in the predict province. The planned modus operandi is modeled and replicated by means of MATLAB/Simulink. The consequences are evidence for the efficacy of the planned amalgam MPP modus operandi to pathway the worldwide MPP perfectly with a speedy rejoinder compare to the NNS. This increases the yield supremacy altitude of the PV assortment less than diverse shading pattern.

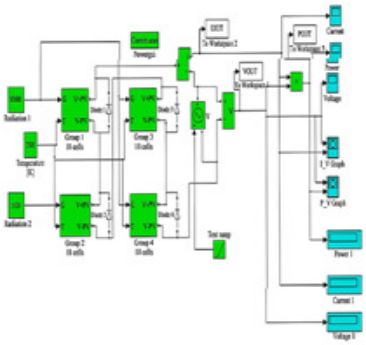
"Artificial neural network-based modeling and fault detection of partial shaded photovoltaic modules" H. Mekki, A. Mellit, H. Salhi

In this paper, a fault exposure method for the photovoltaic element under partially shaded circumstances is presented. It comprises to use an artificial neural network in order to appraisal the production photovoltaic current and voltage under variable working conditions. The restrained data (solar irradiance, cell temperature, photovoltaic current and

voltage) at Renewable Energy Laboratory REL, Jijel University (Algeria), have been used. The comparison between the predictable current and voltage with the ones measured gives valuable information on the functioning state of the measured photovoltaic component. To display the efficiency of the proposed technique, numerous shading patterns have been examined. The outcomes showed that the calculated method precisely detects the protecting effect on the photovoltaic segment.

SYSTEM IMPLEMENTATION

In Existing system, the solar fault was detected in module itself. The module consists of two groups series connected. Each group consists of 18 cells connected in series. A bypass diode is connected in ant parallel with each group. When the PV modules are connected in series, they will conduct the same current but the voltage across them will be different. These voltages are added together to determine the resultant output voltage. The simulation of a two module implemented in Matlab/Simulink. The simulation allows modifying the environmental data and the characteristic parameters of the implemented photovoltaic module such as irradiance, temperature, short circuit current, open circuit voltage, etc.



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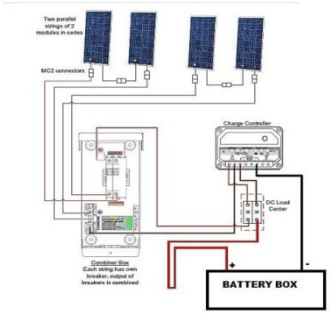
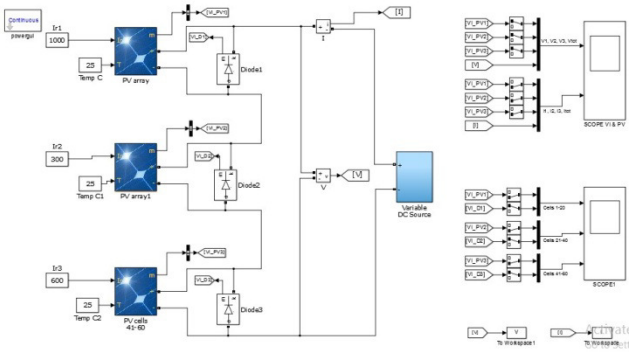
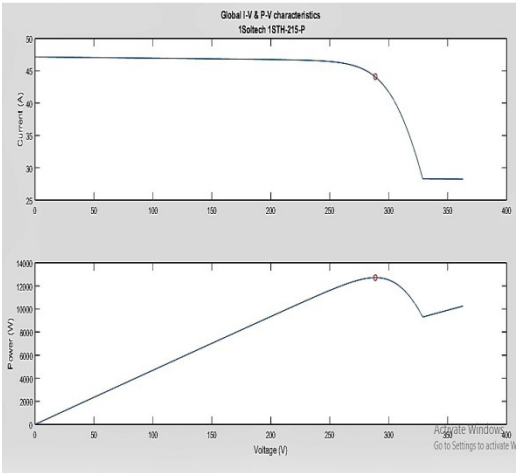


Simulation Circuit



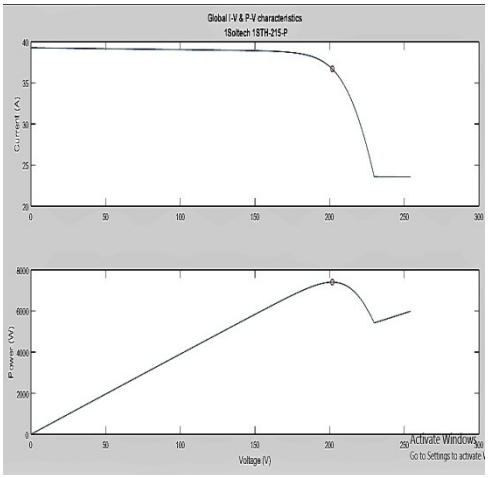
RESULTS AND DISCUSSION

IV & PV Characteristics without String Failure



In this case, six strings are connected in parallel and ten modules are connected in series per string. The maximum output voltage and current is 290V & 44.1A respectively. The maximum power output is 12789W.

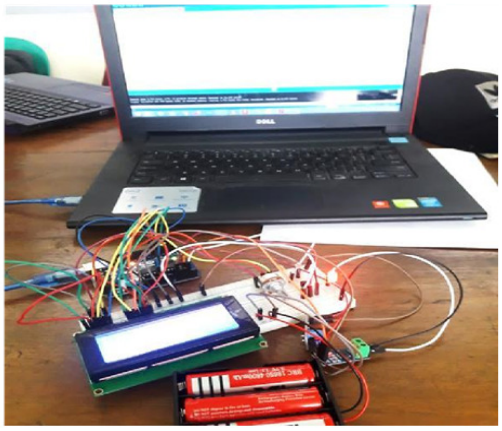
IV & PV Characteristics with String Failure



For the same case, if string failure occurs 6 strings are connected in parallel and 8 modules are connected in series per string. The maximum voltage and current is decreased about 232V and 44.1A respectively. The maximum power output is decreased about 10231W.

Comparison of with String Failure and without String Failure

WITHOUT STRING FAILURE					WITH STRING FAILURE				
Np	Ns	Vma (V)	Ima (A)	Pma (W)	Np	Ns	Vma (V)	Ima (A)	Pma (W)
2	4	116	14.7	1705	2	3	87	14.7	1278
6	10	290	44.1	12789	6	8	232	44.1	10231
10	10	290	73.5	21315	9	9	261	66	17265
10	5	145	73.5	10657	8	4	116	58	6820



CONCLUSION

Recent advantages in photovoltaic (PV) systems encourages it's penetration into power system to a large extent. But, the faults may occur in the PV systems during the process of design, installation and operation. In addition, faults in the PV system due to the unpredictable environmental conditions, several fault locations, mismatches among PV modules. So, fault analysis becomes a vital role to maintain stable power generation and efficiency of the system. In this project, the proposed model is used to detect failure in PV string. The proposed model is simulated in MATLAB/SIMULINK and obtained different output waveforms for different fault conditions. The faults conditions were analyzed by comparisons of traditional condition of solar PV and VI characteristics with faulty condition characteristics. The simulation results were analyzed practically and theoretically. The obtained simulation results evident that the performance of the proposed method is excellent and it is practically implementable.

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