ANN BASED MPPT TECHNIQUE UNDER PARTIALLY SHADED CONDITIONS FOR GRID CONNECTED PV APPLICATIONS

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Abstract - *Solar photovoltaic (PV) systems are gaining importance increasingly as it directly converts solar radiation into electrical energy which is renewable and environment friendly. Where it has a numerous advantage, some disadvantages are also there like its dependency on environmental conditions. The power developed by solar panel decreases if it does not get uniform radiation. Sometimes due to nearby buildings, passing clouds etc. PV module might be partially shaded because of which power output of solar panel may get decrease this is called partial shading conditions. It causes significant reduction in the system power output. To overcome this, maximum power point-tracking under partial shading condition by continuous duty cycle variation schemes have been proposed, in which proposed LUO converters are connected to PV module to enable maximum output voltage at any given condition. In this proposed system a new method of Artificial Neural Network based Maximum Power Point Tracking (ANN-MPPT) has been implanted, which is capable of tracking the Maximum Power Point in the presence of other local maxima. The proposed scheme tracks Maximum Power Point (MPP) by continuous variation of converter's duty cycle without the use of costly components such as signal converters and microprocessors thereby increasing the compactness of the system. The converter's goal is to operate at unity power factor and provide input currents with a tolerable harmonic content in a grid interface. Finally, to validate the proposed controls, we will conduct a series of numerical simulations using MATLAB 2021a /Simulink software.*

Key Words: *Artificial Neural Network, Maximum Power Point, Solar photovoltaic.*

1. INTRODUCTION

Among the various renewable energy resources, photovoltaic (PV) energy is of special interest. The ability of direct conversion to electric power in addition to its minimal running cost and reduced emissions forms a solid foundation of merits. Hence, the massive penetration of PV-based systems in the energy market is understandable. Despite the several advantages of PV systems, their non-linear environmental dependent characteristics form a major challenge. The tracking of PV arrays maximum power point is mandatory for improving the overall system efficiency. Power generation as well as distribution systems are experiencing considerable modifications, due to advanced technologies like amalgamation of large-scale renewable distributed generations, improved communication as well as control schemes, and increased storage capability. Among various renewable resources, solar PV (Photovoltaic) based energy generating system is widely used because of its static structure, minimal size as well as low maintenance cost. But, the output voltage of the PV system is generally minimum and this in turn affects the efficiency and reliability of the system. Hence, there is a need for a high switching frequency device to boost the minimal PV voltage in order to equal the utility grid voltage. This is obtained by incorporating the PV panel with a DC/DC converter which boosts the PV voltage and improves the energy extraction.

2. PARTIALLY SHADED CONDITION

Partial shading is the condition of the closed parts of the surface of a solar cell from sun exposure. The condition was caused by the presence of an object that is blocking the solar cells. By blocking the solar cells will result in a decrease in the power produced by solar cells. The decrease is affected by solar irradiation received by solar cells, thereby reducing the value of the output current generated. A solar PV system contains multiple PV modules in parallel and series. The generated power from the particular PV Array is total of the power produced from each solar module. In present scenario grid-connected PV arrays are placed at facades, roofs, or usually in cities, where partial shading phenomena may be frequent. If some of the solar cells are shaded or perhaps do not receive adequate solar irradiation, as demonstrated in Figure 1.3 that dissipates the power produced by the other solar cells.

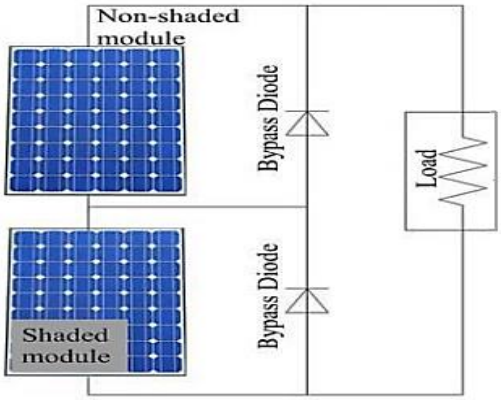

Fig – 1 PV array under partial shading conditions

The V-I curve of every single solar module is demonstrated. If the solar module functions at current Ia, the shaded solar module operate in the reverse biased region and serves as a load somewhat than power source. Due to this kind of high-power diffusion, heat is produced which often causes irreversible damage. Under partial shading conditions, photovoltaic (PV) arrays are subjected to different irradiance levels caused by non-uniform shading. As a result, a mismatch between the modules, a reduction in the power generated, and the hotspot phenomenon will be observed. This movement causes a photo current which rely mainly on intensity and wavelength of solar irradiation. As mentioned above if solar radiation is not falling on PV cell it becomes inactive and functions as a p-n junction diode. In this condition PV cell does not generate current or voltage.

3. SYSTEM DESIGN

The PV converts the daylight into DC power by receiving energy from sun. To accomplish the necessary voltage and current, the PV cluster comprises various sun powered cells which are connected in series and parallel. The PV array output is largely affected due to different atmospheric condition such as solar intensity, temperature, resistance, cloud etc. The sun is an eco-friendly and everlasting reliable energy source. The energy radiated from sun is received directly for power generation by way of photovoltaic. One of the significant methodologies utilized from solar power is photovoltaic (PV) which is capable of converting sunlight into electricity using photovoltaic effect. The basic building block of photovoltaic modules which produces electricity from the light energy by photovoltaic effect is a Solar cell. The PV module efficiency relies on the tangible utilized in photovoltaic cells and the technique used to form a module by placing the solar cells. Efficiency of solar module is about 12-29 % in conversion of sunlight to electric energy. Among which gallium Arsenide solar cells have 29% of maximum efficiency, whereas solar cell with silicon have 12-14% of efficiency. The performance of PV module may also drop due to temperature in PV module and load conditions. Hence to increase the derivation of power from PV module, optimal power point operation of module is important. To accomplish this controller called maximum power point tracker is necessary. The MPPT alter the voltage and current of PV module output to evaluate the point of operations which deliver the maximum power. PV cells are manufactured from different materials.

Mono-crystalline and polycrystalline are the popular techniques of silicon. Conventional solar cell gives less than 2W near to 0.5V hence to obtain a required voltage as output a number of cells are linked in series to make a solar panel. Hence the panels are integrated into an array. The series connection of an array results in high output voltage. During the process if PV cell have no solar radiation it function as a p-n junction diode. When solar radiation falls on the PV cell due to the interaction between incident photons and cell atom, pairs of electron holes are produced. The electric field produced by the junction of cell divides the photo generated electron-hole pair with electrons and holes drifting to n region and p region of the cell. This movement causes a photo current which rely mainly on intensity and wavelength of solar irradiation. As mentioned above if solar radiation is not falling on PV cell it becomes inactive and functions as a p-n junction diode. In this condition PV cell does not generate current or voltage. However, when cell is linked with an external large supply than cell voltage it produces a current ID which is called dark current. The PV system used for power conversion consists of several series and parallel combination of PV modules the tracking controller and power converters like DC-DC converter and inverter. Hence the generated DC voltage can be amplified using DC-DC converter and converted to AC by using the inverter. The PV panel should be selected as per the rating of the load.

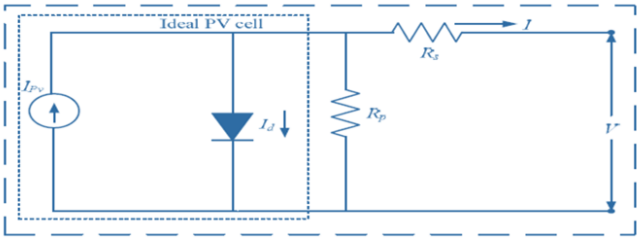

Fig. 2 - Equivalent circuit of PV cell

3.1 Exiting Work

The most important motivating factors towards the use of renewable energy sources for power generation are depletion of fossil fuel reservoirs, increased oil prices, and global warming. Among the various renewable energy sources available, photovoltaic (PV) or solar energy has several advantages namely it is omnipresent, eco-friendly, absence of rotating of parts added with various favourable government policies. As a result, the total installed photovoltaic capacity in various countries has increased from 0.3 to 35 GW during the period 1997 to 2020. Further, the evolution of smart grid concept has accelerated the widespread use of PV systems and solar energy is expected to play a vital role in distributed generation (DG) systems. However, there are several challenges for PV power generation such as low power conversion efficiency and increased installation cost. Further, the maximum output power from a PV system largely varies under changing atmospheric conditions. The maximum power point (MPP) in a PV power generation system is a unique point in the power-voltage (P-V) curve at a Development of an improved P&O algorithm assisted through a colony of foraging ants for MPPT in PV system. Given solar insolation and ambient temperature and it varies with environmental conditions. In order to maximize the efficiency of PV power generation systems, a maximum power point tracking (MPPT) technique has been integrated with such systems and is an essential component in PV systems now. Maximum power point tracking is a major challenge in the use of PV systems since the current –voltage (I-V) and power voltage (P-V) curves are nonlinear in nature.

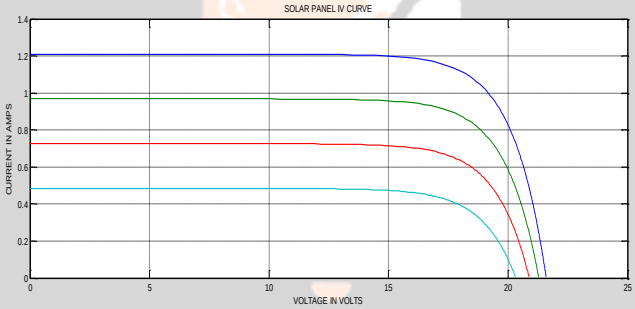

Fig. 3 - Single solar module IV curve

To complicate further, this characteristic curves depend on solar insolation and ambient temperature. As these parameters vary continuously, tracking MPP is a major problem. However, when the PV arrays in a PV power generation system receive uniform solar insolation, there exists a single MPP in the P-V curve. MPPT is then performed using several traditional methods and few of the prominent schemes are perturb and observe (P&O), incremental conductance (INC) and hill climbing (HC) method. These methods vary in complexity, sensors required, convergence speed, and cost of the system.

3.2 Proposed Work

Fossil fuels currently meeting all global energy demands, and it needs to reach a certain limit. Excessive consumption of fossil fuels in every human activity will lead to undesirable phenomena. This phenomenon is in the form of pollution to the atmosphere and the environment, the result of the pollution are global warming, greenhouse effect, extreme climate change, ozone layer depletion, and acid rain. Since 1970, science has proven that natural phenomena are related to the use of fossil fuels. The foundation of fossil fuels become the reason of these natural phenomena, is due to greenhouse gases in the form of carbon dioxide (CO2) and methane (CH4). The impact of this phenomenon can be avoided by two alternatives, specifically improving the quality and efficiency of fossil fuels or replacing fossil fuel with environmentally friendly, clean and renewable energy. Seeing from all energy sources, solar energy is in the first choice because of its quantity and equi Table distribution in nature better than other renewable energy sources such as wind, geothermal, and water pressure. These improvements aim to reduce dependency on fossil fuel power plants. Solar power plants in Indonesia are currently only used as public and household street lighting. Solar power generation is very reliant on solar irradiation received by solar cells. The irradiation can affect the value of the output power generated from solar cells. The sun transmits energy in the form of electromagnetic radiation. The radiation can change in value based on the type of beam. The types of beams are divided into two types namely direct and diffuse. Direct radiation is solar radiation that comes directly taken by the earth without flattening on the surface of the atmosphere. Diffuse radiation is a type of solar radiation through the process of spreading to the atmosphere. The spread prompts the amount of irradiation that reaches the earth to be diminished. Power generation from renewable

energy sources like solar and wind turbines will have a significant role in the future electricity Supply. Solar PV (photovoltaic) technology has been well developed and is one of the most promising sources of renewable energies. The PV system can be grid-connected or can work in standalone mode. The main weakness of the PV system is high installation cost and low efficiency. Hence, it is essential to operate the PV system at its maximum power point.

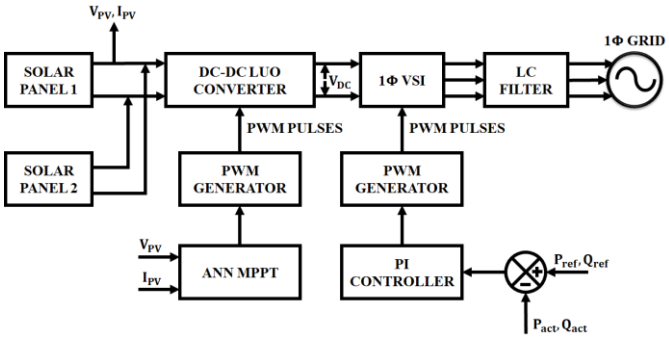

Fig. – 4 The proposed Block Diagram

In Photovoltaic (PV) systems, maximum power point tracking (MPPT) is an indispensable task. In solar PV (photovoltaic) system, tracking the module's MPP (maximum power point) is challenging due to varying climatic conditions. Moreover, the tracking algorithm becomes more complicated under the condition of partial shading due to the presence of multiple peaks in the power voltage characteristics. In this proposed system presents an ANN (Artificial neural network) AI based algorithm for MPPT (maximum power point tracking) under partial shaded condition in PV system. The proposed converter (Luo converter) is implemented to boost up a converter output voltage and maintained constant throughout the system.The DC voltage is converted into AC voltage by means of a single phase inverter. During the grid connection operation, the inverter will convert the DC into AC voltages by using PWM signals. The PV system along with the proposed MPPT algorithm was simulated using Matlab/Simulink Sim scape tool box. The simulated system was evaluated under uniform and non-uniform irradiation conditions and the results are presented.

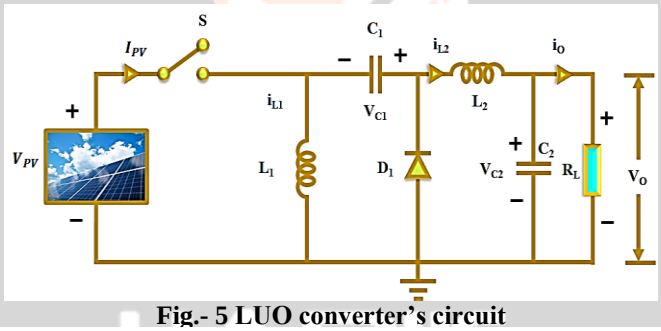

Fig.- 5 LUO converter's circuit

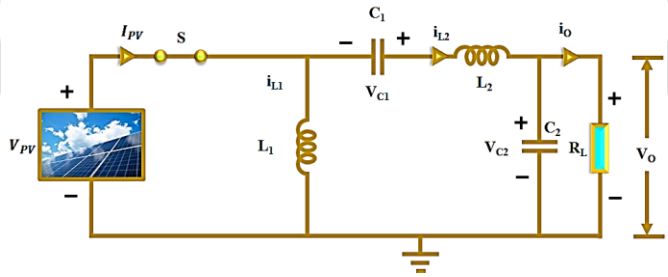

Fig. 6 - LUO converter's circuit (Mode 1)

4. SIMULATION DIAGRAM

Simulink® is a block diagram environment for multidomain simulation and Model-Based Design. It supports system-level design, simulation, automatic code generation, and continuous test and verification of embedded systems. Simulink is widely used in automatic control and digital signal processing for multidomain simulation and model-based design. One of the main advantages of using Simulink blocks is that they are easy to understand and manipulate. You can drag and drop blocks from various libraries, configure their parameters, and connect them with wires to form your system. You can also create custom blocks using MATLAB functions or other Simulink models. Simulink is a block diagram environment used to design systems with multidomain models, simulate before moving to hardware, and deploy without writing code.

Simulink® is a graphical modeling and simulation environment for dynamic systems. Create block diagrams, where blocks represent parts of a system. A block can represent a physical component, a small system, or a function. An input/output relationship fully characterizes a block. Simulink model components include Subsystem blocks, Model

blocks, Stateflow charts, and Simulink to Simscape™ converter blocks. To display units on a model, in the Debug tab, select Information Overlays > Units. It includes simulation, baseline, and equivalence test templates that let you perform functional, unit, regression, and back-to-back testing using software-in-the-loop (SIL), processor-in-the-loop (PIL), and real-time hardware-in-the-loop (HIL) modes. When you want to run a simulation one step at a time from the beginning, you can start the simulation by clicking Step Forward. In the Simulink Toolstrip, on the Simulation tab.

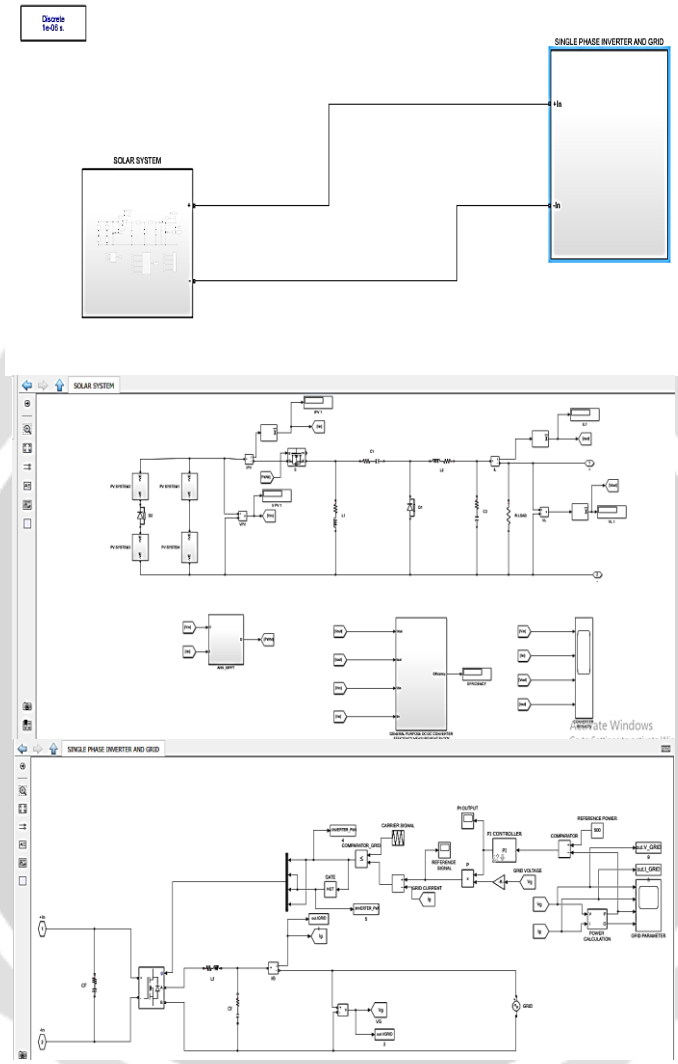

Fig. 7 - Simulation Diagram

4.1 Result and Discussion

Case 1: Under Normal Operation Without Partially Shaded Condition

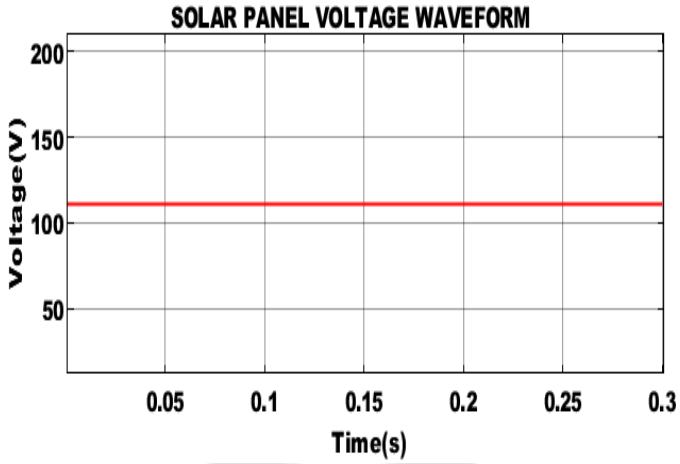

Fig. 8 - solar panel voltage waveform

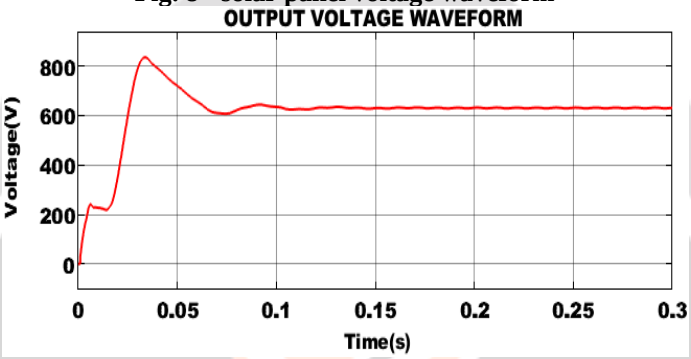

Fig. 9 - output voltage waveform

At a normal operation without partially shaded condition, input voltage of 111V is fed to the LUO converter. The output voltage may be coming around 630V. Using ANN mppt algorithm it track the maximum power from the PV panel. The output voltage get constant and maintained by using proposed converter.

Case 2: Under Partially Shaded Condition

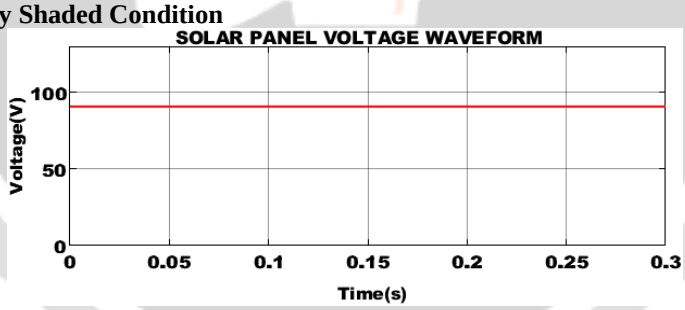

Fig.10 - Solar panel voltage waveform

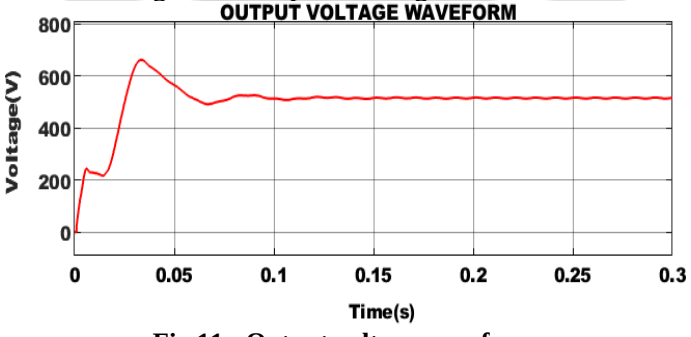

Fig.11 - Output voltage waveform

The partially shaded condition is achieved by either decreasing the intensity of the any two or three of the PV panel nearly 700. Now under partially shaded condition, input voltage of 90V is fed to the LUO converter. The output voltage may be coming around 530V. Using ANN mppt algorithm it track the maximum power from the PV panel. The output voltage get constant and maintained by using proposed converter. From the cases 1 & 2 we conclude that converter efficiency is nearly is 97% for both cases. The proposed ANN controller tract the maximum power and proposed converter maintain the output voltage constant.

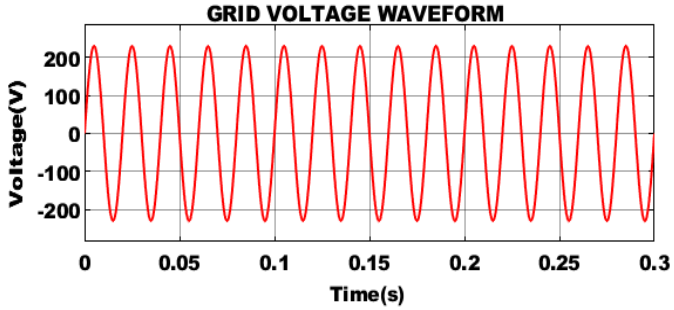

Fig. 12 - Waveforms representing - Grid voltage

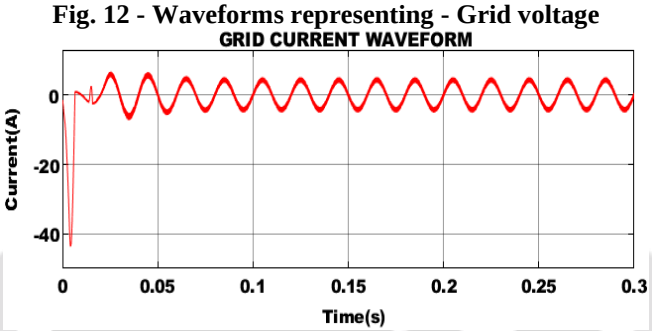

Fig. 13 - Waveforms representing - Grid current

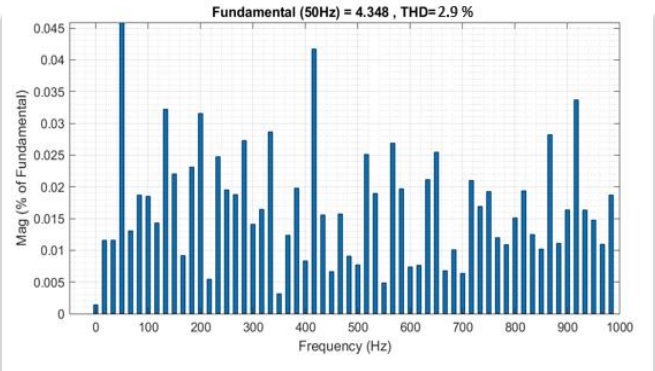

Fig. 14 - THD result of the grid current

The proposed technique of Single-phase grid based on PI controller system is highly successful in maintaining a unity power factor. The coming figure shows the THD result of the proposed grid voltage waveform. This Project has presented a complete control strategy for a single-phase PV inverter operating in grid connected mode. For the synchronization of PV inverter with the grid a single phase PI controller is presented. The performance of PI controller is validated under varying frequency conditions. The grid connected PV system is tested under two different modes of operations, which are PV under partially shaded condition and normal mode of operation without partially shaded operation

5. CONCLUSIONS

In solar PV (photovoltaic) system, tracking the module's MPP (maximum power point) is challenging due to varying climatic conditions. Moreover, the tracking algorithm becomes more complicated under the condition of partial shading due to the presence of multiple peaks in the power voltage characteristics. A stable power from the PV of desired voltage level is acquired using a highly efficient LUO converter and ANN MPPT. The ANN technique attains the maximum power form the PV panel in any condition. ANN-based MPPT controller shows high performance and give very good results. The operation of the single phase grid and it is synchronized by using a PI controller. From the simulation results obtained using MATLAB, it is concluded that the proposed technique is successful in maintaining the reliability and stability of the output voltage system under partially shaded condition. The link voltage is fed to the grid via single phase inverter, which assists in DC-AC conversion and finally grid synchronization is achieved by PI controller. The grid synchronization is achieved by synchronizing the inverter output current with injected grid voltage. The goal of synchronization algorithm is to extract the phase angle of grid voltage. The feedback values are transformed into an appropriate reference frame by utilizing extracted grid angle. A simulation model is created in MATLAB for the solar system to examine its effectiveness.

FUTURE SCOPE

Electrical energy is the most unprecedented inventions of all times. The growing requirement for electricity and inadequate amount of fossil fuel diverts our attention towards renewable sources of energy. Therefore, multiple researches are going on to create power from sustainable power sources like wind, hydro, solar, geothermal and tidal etc. Recently electricity generation from solar photovoltaic is becoming popular as it is free of cost, low maintenance, noiseless, pollution free and its capability of directly conversion from sunlight into electrical vitality. So, Commercialization of solar systems being taking place with a rapid pace all over the world. But it is protectorate on irradiation and atmospheric Condition and its high capital expenses prevents us to make entire utilization of available solar energy into electricity. In the large-scale PV arrays, static reconfiguration increases wiring and installation complexity in locations with optimal irradiation. On the other hand, dynamic reconfiguration leads to a massive increase in the number of switches and sensors required. To overcome these issues, Applying the image processing method instead of the short-circuit current method would be the future of this work. As an advantage, the image processing method eliminates the need for current sensors. To detect shading patterns, PV Subarrays are depicted and analyzed at specified intervals.

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