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Performance Study of a Standalone PV Generation System- A Review

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ABSTRACT: This paper presents a technical overview of the direct utilization of solar radiation using solar cell and discussing about maximum extracting power from the solar system and converts in to ac supplies with maximum efficiency and provides the stable as well as pure sinusoidal inverter output under the nonlinear load and changing weather conditions. In this paper we focused on the various way and techniques used for getting highly efficient and good quality output of the standalone PV generating system**.**

KEYWORDS*:* Solar Cell, doping, diode, reverse saturation current, inverters, off-grid, peak load hours, maximum power point tracking (MPPT), high step-up converter.

I. INTRODUCTION

The energy demand is tremendously growing every year. Fossil fuels like coal, oil, and gas are dominant sources of energy from past decades and hence are called the traditional energy sources. Due to massive consumption of fossil fuels in order to fulfill the present energy demand, the environment has got affected negatively and thus this is an alarming status for sustainable human progress. The urge of this challenge is underlined by limited resources of the fossil fuels on the Earth and increasing demand for energy production and for sustainable development we have to look for environmentally friendly energy sources, known as renewable or sustainable energy sources. This is the reason why the attention is turning to the renewable energy sources. The renewable energy has been framed because it is considered inexhaustible from the point of view of human civilization and is based on the continuing flows of energy. One of these is solar radiation from the sun which is an infinite source of energy for the Earth. The solar energy received by earth from the sun in just one hour is equal to the total amount of energy consumed by humans in one year.Solar radiation utilization can be of two viz. direct utilization and indirect utilization of solar radiation. Direct utilization of solar radiation employs solar cell which directly converts sun light into electricity, for solar power generation. In indirect utilization of solar radiation, solar radiation is concentrated to heat the working fluid which is used as water heater for solar collectors. Power generated from solar energy can be used either as off-grid (stand-alone) or grid connected. Both applications have own importance in power system. In off-grid the required power is generated by the solar farm itself. In grid connected it can be used in two ways, either to supply continuous power to particular defined loads or to supply power to loads during peak load hours only

II.STANDALONE PV GENERATION SYSTEM

The configuration of a standalone PV generation system is shown in the fig.-1. The system mainly composed of PV module (including PV cells array), high dc to dc step-up (boost) converter, full bridge PWM inverter, system controller and output nonlinear load.

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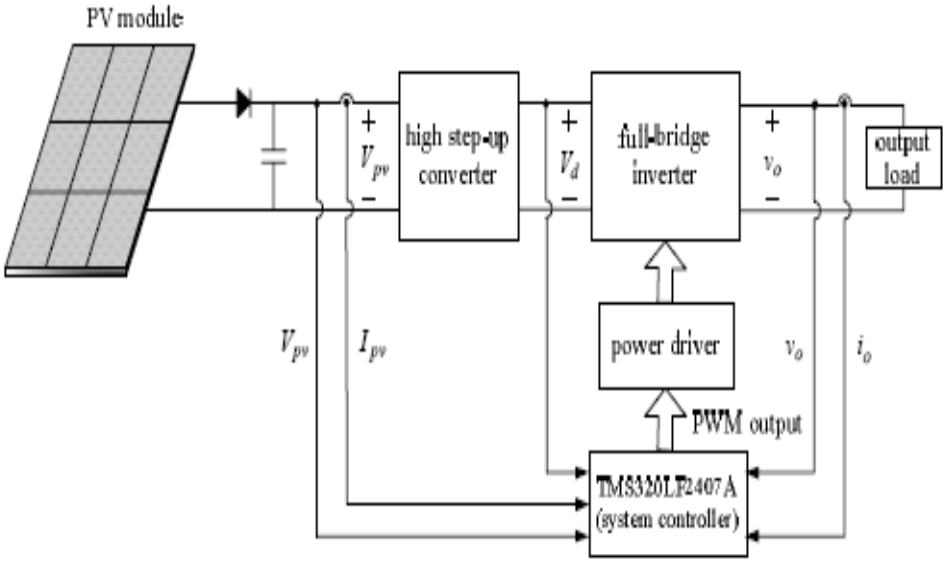

Fig.-1 A standalone PV generation System

III. PV MODULE

The PV module is also termed as solar Panel in which 28 to 36 PV cell are connected in series and for large- scale generation of solar electricity these solar panels are connected together into a solar array. In solar photovoltaic energy conversion sunlight is directly converted into electricity. A photovoltaic device has a built-in asymmetry due to doping by virtue of which electrons excited by sunlight are pulled away before their return to ground state and fed to an external circuit. This extra energy of electrons due to excitation generates a potential difference or electron motive force (e.m.f.) and thus drives the electrons through a load in the external circuit to do electrical work. It conducts like a diode in the dark and generates a voltage when charged by the sun.

The characteristic equation of the output current can be expressed as:

$$I = I_{pv} - I_0 \left\{ e\left(\frac{V + IR_s}{V_t * a}\right) - 1 \right\} - \frac{V + IR_S}{R_p}$$

Where, I_{pv}=Current generated by the incident solar radiation

I_o=Reverse saturation or leakage current of the diode

V_t =Thermal voltage of PV module with Ns number of PV cells connected in series $=N_sKT/Q$

K=Boltzmann constant=1.3806503 x 10-23J/K

Q=Electron Charge=1.60217646 x 10-19 C

T=Temperature in Kelvin

a=Diode ideality constant (1<a<1.5)

R_p ,R_s = parallel and series resistances provided by manufacturer after MPPT(maximum power point tracking) by High dc-dc step up converter

IV.HIGH STEP UP CONVERTER (BOOST CONVERTER)

This dc to dc high step up converter is user to step up the PV module generate low voltage from the solar energy, this step up voltage I used to charge the backup battery a well as inverter for feeding online load. The high step up converter performs also a very important role to track the maximum power point in solar system as well as make a constant voltage at dc bus. By using parallel converters efficiency can improve of the system.

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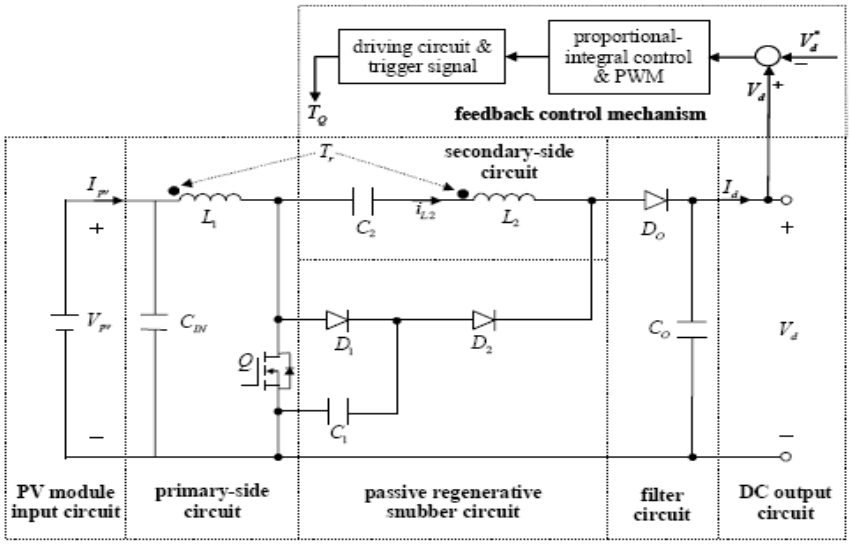

Fig.-2 High step up (Boost) converter

V.FULL BRIDGE PWM INVERTER

The unipolar PWM full bridge inverterwhichfour power semiconductors and a low pass filter is regarded as a dc to ac converting circuit to meet the requirements of ac power source. since the quality of output of a standalone PV generation system is highly dependent on performance of the PWM inverter sometimes an adaptive total sliding mode control (ATSMC) system is used by way of witching the all four power semiconductors maintain the sinusoidal output voltage with lesser total harmonics distortion (THD) and remain stable in nonlinear load.

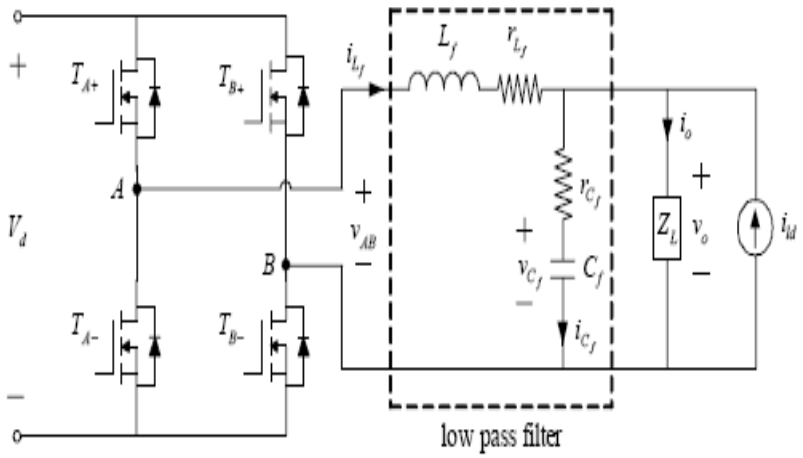

Fig.-3 Full bridge PWM inverter with a low pas filter

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VI. CONTROLLER

The controller control all the convertersused in PV system likedc to dc high step up converter, battery converter. The MPPT achieved by the step up converter by using perturbation and observation method due to their simplicity and robustness to change of model parameters. Dual loop control technique is used for control of this converter where the output voltage is set as the reference value for the inner current loop. The battery converter is controlled in current reference tracking mode to avoid charging and discharging frequently.

VII. REVIEWS

[1] The performance analysis of standalone PV system is not same as it is for grid connected system. The author describes different examples and cases in this paper. The existing quantities for assessing the performance of SAS are array yield, reference yield, final yield, PV energy consumed; capture losses and performance ratio (PR). The PR shows that how the potential energy of solar system is used. Author introduced some new performance parameters in this paper. These performance parameters are usage factor (UF) and production factor (PF). The normal performance parameters have only been elaborated to measure the system performance but not to recognize that the bad result is due to the poor sizing or to a technical problem. And also it is impossible to find out the technical reasons of PV system. The UF and PF allow overcoming this fact and giving indication on the system operation.

[2] For making the standalone PV generation system more flexible and expandable, the high step up converter and pulse with modulation (PWM) inverter is used. The adaptive total sliding mode control (ATSMC)system is introduce for the controlling of output voltage of the PWM inverter which maintain the output more sinusoidal with lower total harmonics distortion (THD) and lesser variation under nonlinear load. In this paper author describe the PV generation system by using the mathematical modeling of each component of the system. The system having main components are a PV modules, a high step-up converter, a full bridge inverter, a system controller and output load.

[3] For achieving the more flexible and expendable PV generation system, the backup power circuit is introduced with high step up converter and PWM inverter. The main parts of the standalone PV system are a PV module, an active sun tracker, a high step up converter, a unipolar PWM full bridge inverter and an output nonlinear load. In this paper author make the mathematical model of each component and then check the effectiveness of high step up converter, inverter, and active sun tracker. The result shows that the maximum conversion efficiency is comparatively higher than the conventional.

[4] This paper presents the mathematical modeling and the control screams having MPPT control and provided for the three converters, which are the dc-dc boost converter, battery converter and inverter. In the stand-alone PV system, both dc bus voltage and ac output voltage are kept stable even when the source and load are changing. The inverter is used to supply nonlinear load which is represented by a single phase diode rectifier with a capacitor and resistor connected in parallel at the dc terminal of the rectifier. The current is intermittent, but the voltage is kept stable and has a good quality. The result shows of the modeling in Matlab/Simulink that boost converter can track the maximum power point of the solar panel, the battery converter have a constant dc bus voltage , and the inverter have high quality sinusoidal ac voltage with the nonlinear load.

[5] In this paper the Monte Carlo approach is used for analyzing the behavior of electrical load and for taking into account the stochastic variability of electrical energy demand. This approach is also used for the calculating the power production of standalone PV generation system as a function of hourly solar irradiation of the installation site. The Monte Carlo method is a computational algorithm that relies on repeated random sampling to compute its results.

[6] The near-Maximum-Power-Point-Operation (nMPPO) design is used instead of maximum power point technique (MPPT) method in this paper the reason behind it is to reduce the conversion loss of MPPT at non full load operation. For the PV generation system lead acid battery are widely used. The result shows of this paper that the loss of load probability

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for full night lighting in the lighter (50W) solar system is zero in a particular interval (more than two months) while for the higher load (100W) solar LED system , the loss of load probability is increased (3.6%) in spring.

[7] In this paper the Ni-MH battery and ultra-capacitor are used as an energy storing device in the standalone PV generation system. The controlling of the battery converter is in the current mode for tracking the charging and discharging reference current which is controlled by the energy management system and the boost converter can track the maximum power point of the solar panel while the ultra-capacitor converter is controlled compensate the solar irradiation variation, load variation and to maintain dc bus voltage. And the result shows that control method can be used for reliable and high quality standalone PV generation system and the two energy storage device can complement for the each other which increase the life of battery as well as reduce the capacity of battery.

[8] This paper presents the comprehensive sizing methodology that could contain all key elements which are important to obtain a practical sizing result for the standalone PV system. Initially a selected solar radiation model based on the weather data is formulated to synthesis various chronological solar radiation pattern. Then a selected load simulator is formed to simulate realistic load patterns. And at last two reliability indices, EENS (Expected energy not supplied) and EEES (Expected excessive energy applied) are incorporated with annualized cost of system (ACS) to form a new objective function called Annualized reliability and cost of system (ARCS) for optimization. The optimal sizing objective was also developed in such a way that reliability and coat of the system considered simultaneously. And proposed model was solved by PO algorithm.

[9] This paper presents an efficient and frequency controller for the standalone PV system with the battery storage element. The MPPT (maximum power point technique) is used to extract the maximum power available in the PV array instead of variation of weather conditions. And the proposed controller is based on perturb and observe (P&O) technique which is used to extracts the maximum power available in the PV array with certain oscillations due to its intrinsic characteristics. The battery storage element is used to compensate the variation in weather conditions as well as nonlinear load.

[10] This paper presents the standalone three phase PV generation system. Due to several drawbacks of high PV side voltage, a low voltage PV source is used in this system and using high voltage gain front end dc to dc converter which is capable for achieving high efficiency and maximum power point so, the limitation of the low voltage PV system is overcome. By using the required power tracking scheme instead of conventional MPPT scheme the battery have long life because of not having overcharge and deep discharge. The overall efficiency of the system reaches up to 94% due to use of special high gain and high efficiency converters.

VIII. CONCLUSION

In this paper we are studying the various part of standalone generating system and their working. In this system the high dc-dc step up converter is responsible for the maximum power point tracking, battery converter is responsible for the constant dc bus voltage and the inverter is responsible for the stable and high quality output within the nonlinear load. The controller control that the all three converters can work together and remain coordinated to perform perfectly.

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