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Low Harmonic Mitigation Through Fuzzified Inverter Control For Grid Connected Solar Energy System

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ABSTRACT
With increasing renewable distributed generation(DG) units connected to utility power grids, deterioration of power quality at the point of common coupling (PCC) becomes a major concern. Power electronic devices in DG units generate harmonics; these harmonics along with harmonics from other nonlinear load in the system might cause excessive harmonic distortion at the PCC. In this paper, an extensive literature review is conducted focusing on harmonic mitigation techniques through advanced control methods for grid-interfacing inverter. The intend of the fuzzy logic approach is to meet high quality output, minimum THD,fast response and high robustness.
Keywords: Distributed-generation,harmonic-mitigation,Total harmonic distortion, power quality

I. INTRODUCTION

In this modern world ruled by science, the demand of electrical power increases for every year due to growing industries, commercial and domestic applications, etc. To meet the demand, the renewable energy systems have been designed instead of conventional systems of electric power generation. Out of the available renewable energy sources, solar PV based system design plays a vital role for the generation of electrical power as it is pollution free, noiseless and has abundant energy [1-3]. For these reasons, PV has been used as the input source for the proposed inverter topology and Perturb and Observe (P&O), Maximum Power Point Tracking (MPPT) algorithm is used to extract maximum power from the solar PV panel because it is simple, cost effective and easy to implement [4-5]. The major issue lies in converting the available dc sources into ac sources with better power quality aspects such as THD, power factor, etc.

To ensure a good quality of power supplied to the consumers, utility companies need to maintain harmonics level within an acceptable limit as indicated in different grid codes. For example, according to IEEE std. 519, the acceptable limit of the voltage total harmonic distortion (THD) at the PCC with each consumer is 5% [2]. To mitigate harmonic distortions, passive LCL or LC filters are traditionally used with the grid interfacing inverters, however, such filters have disadvantages such as the fixed compensation capability, creation of resonance problem etc.To overcome the limitations of passive filters, the DG interfacing converters can be utilized to operate as power conditioners for

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power quality improvement. Although, the primary function of the interfacing converter is to supply real power to the grid, it can also provide auxiliary harmonic compensation service upon the availability of sufficient apparent power rating. With proper design and control, the DG interfacing converters can improve the system efficiency and ensure reliable harmonic compensation performance. The electric power distribution systems are unbalanced due to untransposed distribution lines and unbalanced loads. Also the loads on the power system vary from time to time. Hence there is the need to design and active power filter, which is capable of maintaining the THD limit within the IEEE norms under variable load conditions.

This chapter presents a fuzzy logic based PWM current control technique which performs well under unbalanced and variable load conditions since the controller do not need an accurate mathematical model; it can work with imprecise inputs and can handle nonlinearity.

II. PROPOSED SYSTEM

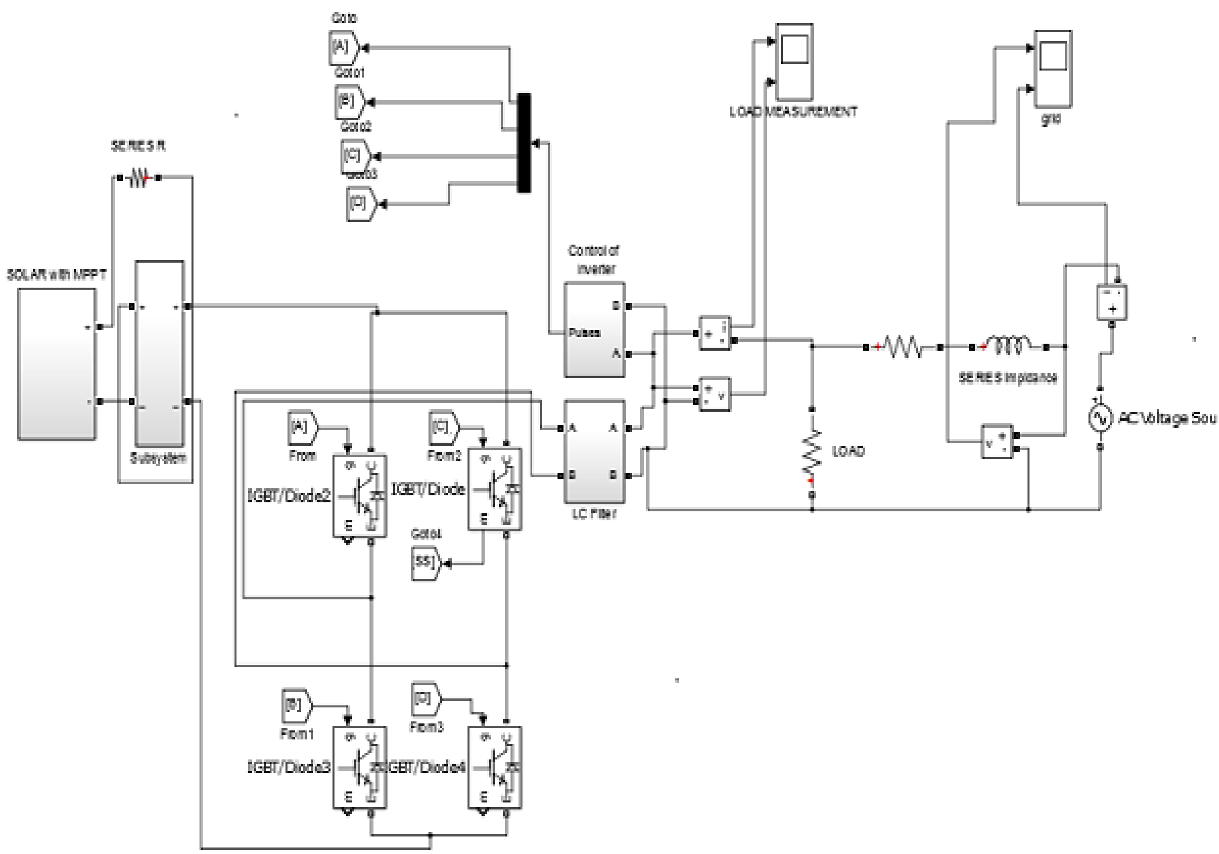

Figure1. Schematic Diagram of Proposed Low harmonic mitigation through Inverter control for grid connected renewable energy sources (using MATLAB Simulink)

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2.1 Solar PV Panel

Solar PV systems are usually consists of numerous solar arrays, although the modules are from the same manufactures or from the same materials, the module performance characteristics varies and on the whole the entire system performance is based on the efficiency or the performance of the individual components.

Maximum Power Point Tracking, frequently referred to as MPPT, operates Solar PV modules in a manner that allows the modules to produce all the power they are capable of generating. MPPT is not a mechanical tracking system but it works on a particular tracking algorithm and it based on a control system. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different. MPPT algorithms are used to obtain the maximum power from the solar array based on the variation in the irradiation and temperature. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. Here Perturb and Observe algorithm is used. Rating of solar panel used here is 480W, Output 150V is given as input to fly back converter to obtain constant DC.

2.1.1 MATLAB SIMULINK Model of Solar PV

The primary component of grid-connected PV systems is power conditioning unit (PCU). The PCU converts the DC power produced by the PV array into AC power as per the voltage and power quality requirements of the utility grid.

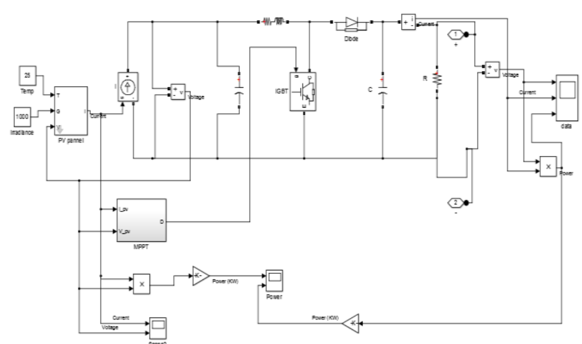

Figure 2. MATLAB SIMULINK Model of Solar PV

A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the AC power produced by the PV system to either supply on-site electrical loads or to back-feed the grid when the PV system output is greater than the on-site load demand. This safety feature is required in all grid-connected Factors Facts Module technology Modules account for 40–50 % of total system costs. These determine the total area needed to install the system. Less area per watt is desired to maximize roof or land use O&M Grid tied PV systems do not have notable O&M costs .Most small scale grid-tied systems do not have moving parts and therefore maintenance is minimal Large-scale systems may use tracking systems and therefore may require more work Battery assisted systems may require acid refills when valve regulated batteries are not used .Some arrays will require regular cleaning. This could represent additional costs especially for large scale systems Energy use and cost System size depends mostly on energy use, solar resource and component efficiency .Reducing energy consumption greatly reduces the initial capital cost investment necessary PV systems can be cost competitive in locations with high energy prices and Net metering programs. The assumption that PV is expensive is therefore relative to the solar resource and utility energy prices in a location indirect benefits Emissions reductions provide a wide range of economic, environmental and health benefits. These are difficult to quantify, yet they cannot be ignored. Application of MATLAB/SIMULINK in Solar PV Systems PV systems, and ensures that the PV system will not continue to operate and feed back into the utility grid when the grid is down for maintenance or during grid failure state. In grid-connected systems, switching of AC power from the standby generator and the inverter to the service bus or the connected load is accomplished by internal or external automatic transfer switches.

2.2 Development of Fuzzy Based Current Controller

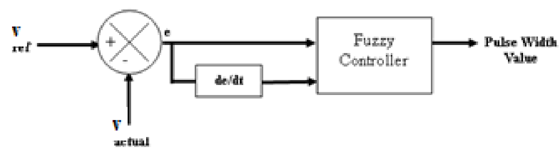

Figure 3. Schematic diagram of fuzzy controller

Fuzzy logic controller architecture is shown in fig. In this proposed approach, fuzzy logic based voltage controller has been designed. To control various nonlinear applications, fuzzy controller is the most appropriate solution. Fuzzy logic controller comprises of membership functions (input/output). The input response collected in the knowledge base is categorized into error'd' and change in error 'de'.

2.3 Space Vector Pulse Width Modulation

PWM controls the inverter output voltage and minimizes the THD considerably. Moreover, filters such as LC, LCL, etc may not eliminate the lower order harmonics and hence, PWM has been used for the reduction of such lower order harmonics. But, there are some drawbacks in PWM such as

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Lower order harmonics may not be eliminated effectively, The higher PWM frequency would increase the power losses along the switches[6]. Due to the above limitations of the PWM approaches, SVPWM techniques have become an attractive research solution. In this research work, Space Vector PWM (SVPWM) has been used. SVPWM receive reference sine wave as the input from the current controller. From the grid voltage, instantaneous active voltage component (V_d) and instantaneous reactive voltage component (V_q) are separated using Transformations. The magnitude estimation of (V_d) and (V_q) is given by $|V_{ref}|$. Then, the angle is extracted from the active and the reactive voltage component. The attained angle is compared with the angles and the appropriate sector for that angle is identified. Now, each sector represents 60^0 .The adjacent vectors in each sector of SVPWM need to be averaged. Two adjacent vectors and zero vectors are combined to generate the appropriate PWM signals.

III. SIMULATION RESULTS

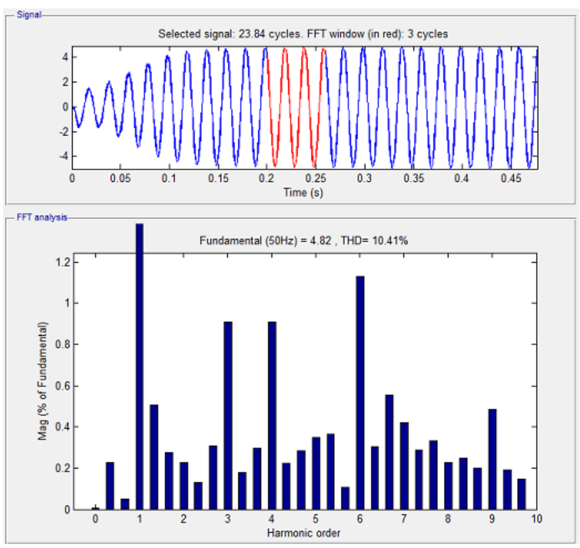

Figure 4. THD result without fuzzy-inverter controller

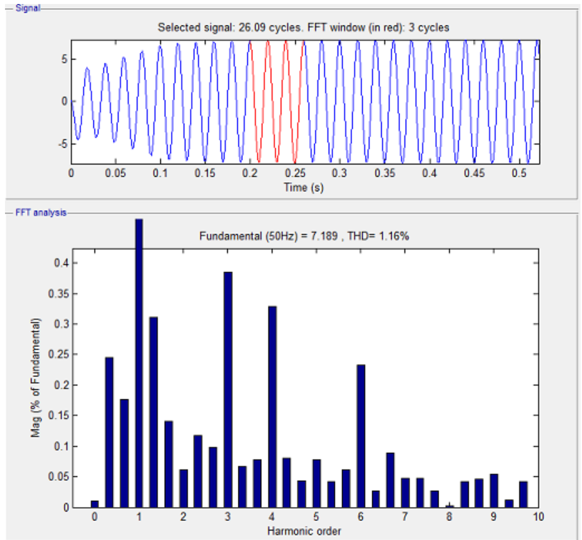

Figure 5. THD result with fuzzy–inverter controller

IV. CONCLUSION

In this paper, harmonics generated by a solar PV system reviewed.LC type filter is used to reduce harmonics.Futher to reduce low harmonics fuzzy controller method which acts as error block is used. Error Output of fuzzy controller is given to inverter which always ensures to get constant reference voltage (say 230V).Using FFT analysis simulation is carried out and where, there is considerable percentage reduction in THD is achieved.

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