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Solar inverter using dq controller with power quality management at various load conditions

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ABSTRACT: In the modern era the dependence on the total fuel is stoke due to the lack of reverse position and like in price. This is the scientist to users on the development of renewable energy resources like solar, wind, tidal etc. In this paper on robust controllers the basics of dq- controllers are analysed with variable load conditions with solar power generation. By the usage of dq - controller or synchronous reference frame controller would help to transform the three phase time varying signals into DC signals will help to control the grid voltage and current more sophisticatedly. A current controller is used in the perspective paper; this coupling of the signal between the two synchronous frames is analysed thus the modification is implemented. In order to increase the overall efficiency of the system. Because coupling between two synchronous frame loads leads to the unsatisfactory performance of the PI controller. The maximum power point MPPT technique uses perturb and observable (P&O)methodsin which the controller determines the maximum power and the power transfer will be at minimum power point. The load regulation and line regulation carried out in the proposed system are stimulated and analyzed using MATLAB/Simulink.

KEYWORDS: solar inverter, dq- controller, P&O, MPPT, Synchronous controller, load regulation, line regulation.

I. INTRODUCTION

In the 20th century the replacement of fossil fuel with renewable energy resources was greatly decreased because of the like in the price of petroleum products of reserve and pollution.

Utilization of non-renewable resources like coal, gas, and oil is rising alarmingly quickly. The current situation of inadequate energy resource storage and society's steadily rising energy demand, along with the warning of global warming, has inspired working engineers to continue their research activities to integrate renewable energy effectively resources available on the current grid. This has encouraged the use of alternative energy sources in addition to conventional energy sources, such as solar, wind, tidal, and geothermal sources. One of these is the capacity to capture and effectively use solar energy due to its abundant availability.

Extra energy produced by the rooftop PV panel may be exchanged with the utility grid. As a result, electricity is transferred between the main grid and the secondary grid in response to the current electric demand and weather. To increase the output voltage, the intermediate DC-DC boost converter enables the solar PV system to run at its maximum power point (MPP). In order to offer a controlled duty cycle to the DC-DC boost converter and collect the most power possible from the solar PV system, the maximum power point tracking (MPPT) method based on perturb and observe (P&O) has been applied [11]. For connecting a variable dc PV source with a three-phase utility grid, the proposed study develops a two stage power converter topology with a dc-dc converter and VSI. The PV array voltage is increased using the dc-dc converter to the desired level. VSI uses a dq controller with MPPT to achieve autonomous control of active and reactive power. Three controllers are used in the suggested configuration: a voltage controller to keep the dc link voltage constant, an MPPT controller to get as much power, and an SPWM-based dq-controller to achieve independent management of active and reactive power.

A space vector-based hysteresis current controller is used to regulate this solar inverter, which also functions as a shunt active filter

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(SVHCC). For medium voltage applications, this arrangement might meet the needs to maintain standard power quality [7]. When there is sufficient solar energy, a two-stage power converter operating at maximum power can send any excess photovoltaic energy to the electric grid while alsocompensating for harmonic currents in loads connected to the PCC (Point of Common Coupling).

The design and construction of a power electronic converter for the integration of a PV array to a three-phase utility grid, allowing independent control of active & reactive powers [2]. A boost converter and a voltage source inverter are used to connect the PV array to the grid (VSI). To maintain a constant dc voltage of 200V at the dc link, the duty ratio of the boost converter is adjusted using a PI controller.

Multiple-input multiple-output (MIMO) systems include three-phase grid-connected systems. They feature multiple inputs and outputs. By applying a broadband excitation to each input, measuring responses at each output in turn, and cross-correlating each input-output signal combination, it is possible to measure all the frequency responses of such systems. The impedance measurement in the direct-quadrature (dq) reference frame is a nice illustration of such a process. The non-stationary grid-connected system is transferred to a rotating reference frame in the dq transformation. The transformation turns two DC quantities from three (balanced) AC quantities, considerably simplifying controller design and analysis. Using MIMO approaches, various grid impedance or inverter output impedance components can be monitored concurrently during a single measurement cycle [3]. The system's operational settings can be maintained constant during the measurements, which considerably cuts down on the total measurement time. The measurement of the d and q components of grid-connected inverter output impedance and/or grid impedance using orthogonal binary sequences is demonstrated.

The dq domain in was used to apply the measuring technique based on maximum length binary sequence (MLBS) injection. By independently injecting the MLBS into the d and q components of the grid reference voltage and measuring the corresponding components from the inverter output currents and voltages, the d and q components of the inverter output impedance were derived in this work. When identifying MIMO systems, approaches that simultaneously perturbed every system input have a number of significant advantages over those that sequentially perturbed each individual system input. This method assures that each impedance component is measured with the system in the same conditions, which may not be the case if successive perturbations are applied. It also reduces the overall experimentation time because the system only needs to reach a dynamic steady state once.

In order to extract the dual characteristics, a generalised "dq" and adaptive PLL-based approach is used in this research to demonstrate a multifunctional voltage sourced-converter (VSC) driven solar photovoltaic (SPV) system [10]. On the basis of the availability of active power at the DC-side collector bus and acting as an active harmonic filter, they include improved active power sharing features (AHF). Compared to its conventional counterpart, such as synchronous reference frame theory, the given control requires less computation and is simpler to formulate (SRFT).

II. TOPOLOGY

The solar inverter is the energy source for the system. The usage of solar panels using P&O MPPT would lead to more efficient and sophisticated control which integrated with thedq - controller for the smooth handling and power quality enhancement of the system over grid side. Figure 1 shows the block diagram of the proposed system.

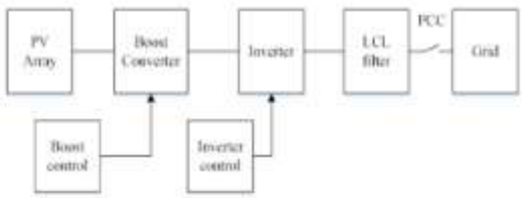

Figure 1: Block diagram of proposed method

The overall efficiency of the system relied on the power generation and power transfer over the stage of the proposed system. The P&O, MPPT, dq- controller is a better choice over other options because it has more efficiency and a simple controller. The power generated then passes through a power factor correction circuit which would help to control the power of the system. Then the voltage is fed to a voltage source inverter which is controlled by a dq - controller. By controlling the three - phase voltage and current at load side would result in the enhancement of the efficiency of the system. Figure 2 represents the complete diagram of the proposed system.

III. OPERATING PRINCIPLES OF THE PROPOSED SYSTEM

The proposed system has two sections which are used to control the power factor of the system and the grid side voltage and current. The generated voltage by the solar panel is inverted to three phase voltage generated and will be synchronous with the grid. The DC - link voltage system will be kept at a constant in order to obtain the constant grid side voltage. The controller is done by dq - controller in the dq - controller. The abc reference frame is converted into dq frame, i.e. DC signals to control the system sophisticatedly.

The process of power transfer will be controlled smoothly to obtain the power quality enhancement and to limit the efficiency of the system, the voltage generated by the solar panel is magnified by using a boost converter of which it will help for the MPPT technique. The voltage obtained ie DC link voltage maintained at a constant voltage. The DC link voltage will act as the govertysource for the voltage source inverter which will then invert the voltage into three phase voltage. The dq controller continuously monitored and maintained the voltage at the reference. The power quality and efficiency of the system will be monitored continuously .Figure 3 shows the complete diagram of the control system.

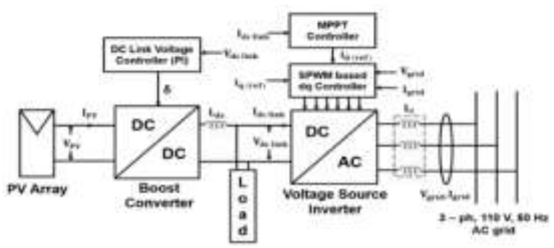

Figure 2: schematic diagram of the proposed system

IV. DESIGN OF THE PROPOSED SYSTEM

A solar panel P&O MPPT based boost converter dq controller and voltage source inverter are the components of the proposed system.

A. DC link control

Design of the solar inverter involves the proper solution of the solar panel and controlling technique for the system table 1 shows the properties of the solar panel used in the proposed design.

Table 1: Parameters of solar panel

Sl. No	Parameter	Value
1.	Open circuit voltage	36.3
2.	short circuit current	7.84
3.	Current at maximum power point	7.35
4.	Voltage at maximum power point	29
5.	Number of parallel modules	18
6.	Number of series modules	25
7.	Voltage	120

The MPPT technique used in the proposed system is P&O. The algorithm for the P&O MPPT is given in figure 3.

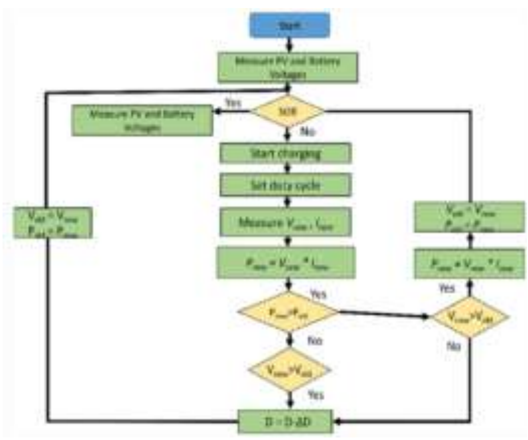

Figure 3: P&O MPPT Algorithm

To achieve the constant voltage level at DC like a boost converter technique is used

$$V_{input} = (1 - D)V_{dclink} \qquad (1)$$

$$\frac{V_{out}}{V_{input}} = \frac{1}{(1-D)} \qquad (2)$$

Where D is duty cycle of the switching cycle

$$D = \frac{(V_{input} - V_{output})}{V_{input}} \qquad (3)$$

D value varies from 30% to 90% of the pulse width modulation (PWM). D is controlled by the P&O

MPPT and a PWM generator. Figure 4 shows the control diagram of the DC link voltage controller.

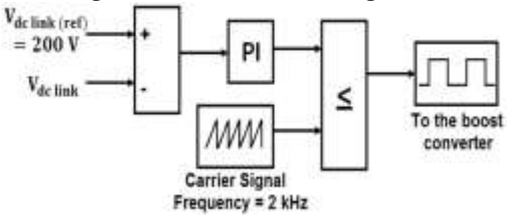

Figure 4: DC link voltage controller

B. SPWM based DQ controller

Synchronous reference frame controller or dq controller is used to convert generated three phase voltage and current into a synchronous frame to grid voltage and current. So that the three phase signals are transformed into DC signals. A phase locked loop (PLL) is used widely for the purpose. PI controllers are widely used because of the ability to minimize the steady state error.

The power ratings are impressed as follows

P=3/2(vd id +vqiq) (4)

Q=3/2(vq id – vdiq) (5)

Where

P: Active power

Q: Reactive power

vd =vd* - w iq Lf + vd (6)

vq = vq*+ w id Lf + vq (7)

in which, w = 2πf

$$\begin{bmatrix} ua \\ ub \\ uc \end{bmatrix} = \begin{bmatrix} \sin(wt) & \cos(wt) & 1 \\ \sin(wt-120) & \cos(wt-120) & 1 \\ \sin(wt+120) & \cos(wt+120) & 1 \end{bmatrix} \begin{bmatrix} ud \\ uq \\ u0 \end{bmatrix} \quad (8)$$

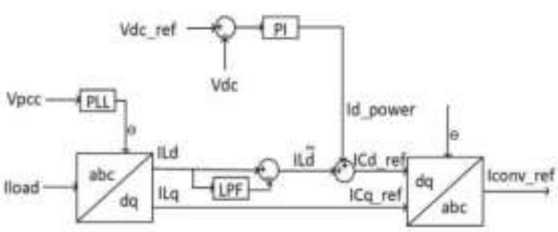

Figure 5: Generating reference current using synchronous reference Frame theory.

C. Modified Control Scheme

The modified control scheme is a robust controller which works together over the control system for the system. It will be the continued controller of P&O, MPPT and dq controller. Together the design archives the power quality enhancement and higher efficiency.

V. RESULT AND DISCUSSION

A 100 KW system is developed and verified by MATLAB/simulink. The solar panel is used as the voltage source even though the solar panel is a current source. The frequency selected for P&O, MPPT, dq controller are 10Hz. Figure 6 shows the PV characteristics and VI characteristics of the solar panel.

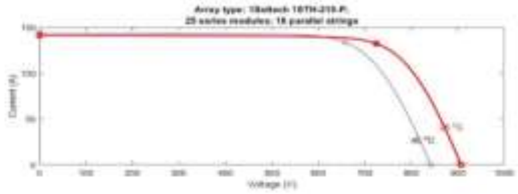

Figure 6: VI Characteristics of the Solar panel

For the smooth operation of the system the DC link voltage is maintained at 400V. Figure 7 shows the voltage and current developed by the solar at various irradiance levels.

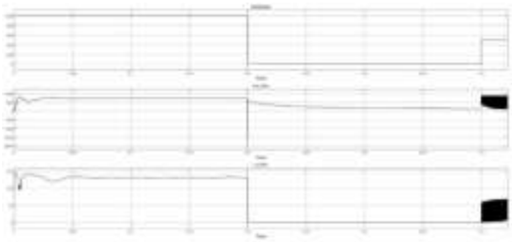

Figure 7: Solar Panel Irradiance

The Dc link current over the complete cycle is theoretically zero. Which will result in the steady static performance of the system. Figure 8 shows the three phase voltage and current generated by the inverter side from the graph is clear that the voltage is constant over the period for testing the system load regulation and line regulation are carried out.

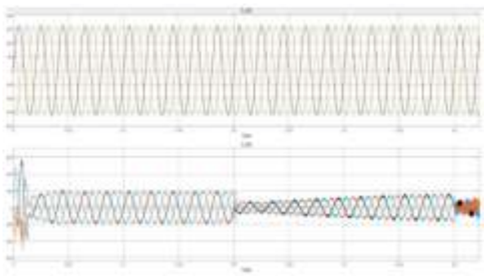

Figure 8: Output voltage and current

During the period the load is constant from the graph it is clear that the voltage and current are constant over the period. In the beginning an asymptotic of the system is stability over a small inverted drive from (0.2 - 0.4) sec the load is varied from the base value to 2005 of the connected value and varies to base value. The current is diminished to ⅓ rd but the voltage remains constant which shows the performance of the system. After 0.45 the load again varies to 300% of the connected values, even if the current varies the voltage 5kv remains the same and the efficiency of the system will be high.

The testing of the system varies over the time between (0.2 - 0.4)s. In order to analyze the performance of the system figure 9 shows the switching of load and irradiance curve.

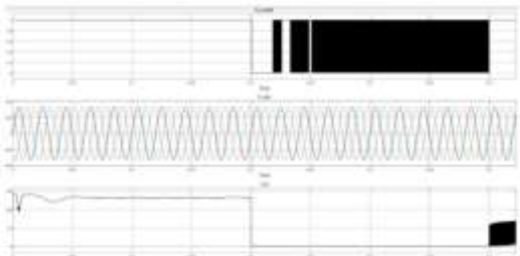

Figure 9: switching of load according to the solar radiance

From the figure (8,9) it is clear that the variation in switching the load doesn't alter the overall efficiency of the system.

The figure 11 shows the switching pulse generated by the dq- controller.

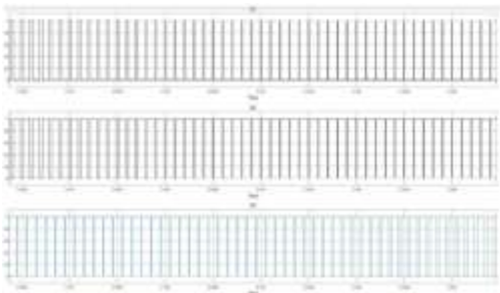

Figure 11: switching pulses of VSI

From the figure it is clear that the cycle of the switching pulse varies in accordance with the load change.

VI. CONCLUSION

The dependence and interaction of solar inverters over the grid is considerably high due to the development of renewable energy resources. In this proposed system a 100kw solar inverter is being designed and developed. The integration over the grid is also analyzed from the fact that it is clear that the overall performance of the proposed system is high when compared with conventional systems. It will act like a grid solar inverter so doesn't require a storage system which will reduce the overall loss of the system for the installation. The total harmonic distortion and power factor all monitored continuously over the period. The results show that the pf at the system is high when compared to the conventional system. The system can be integrated into its grid system without additional systems.

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