

A NETWORK ASSOCIATED DOUBLE VOLTAGE SOURCE INVERTER WITH POWER QUALITY ENHANCEMENT BY EMPLOYING ISCT SCHEME

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ABSTRACT

The main aim of project is to enhance the power quality by employing dual voltage source inverter. The proposed scheme is comprised of two inverters, which enables the microgrid to exchange power generated by the distributed energy resources (DERs) and also to compensate the local unbalanced and nonlinear load. The control algorithms are developed based on instantaneous symmetrical component theory (ISCT) to operate DVS in grid sharing and grid injecting modes. The proposed scheme has increased reliability, lower bandwidth requirement of the main inverter, lower cost due to reduction in filter size, and better utilization of microgrid power while using reduced dc-link voltage rating for the main inverter. These features make the DVS scheme a promising option for microgrid supplying sensitive loads. the proposed topology validated through simulation results.

Index Terms: Power quality, distributed energy source, Grid connected inverter, instantaneous symmetrical component theory (ISCT).

1.INTRODUCTION

The proliferation of power electronics devices and electrical loads with unbalanced nonlinear currents has degraded the power quality in the power distribution network. Moreover, if there is a considerable amount of feeder impedance in the distribution systems, the propagation of these harmonic currents distorts the voltage at the point of common coupling (PCC). At the same instant, industry automation has reached to a very high level of sophistication, where plants like automobile manufacturing units,

chemical factories, and semiconductor industries require clean power.

For these applications, it is essential to compensate nonlinear and unbalanced load currents. Load compensation and power injection using grid interactive inverters in microgrid have been presented in the literature. A single inverter system with power quality enhancement is discussed in. The main focus of this work is to realize dual functionalities in an inverter that would provide the active power injection from a solar PV system and also works as an active power filter, compensating unbalances and the reactive power required by other loads connected to the system. In, a voltage regulation and power flow control scheme for a wind energy system (WES) is proposed. A distribution static compensator (DSTATCOM) is utilized for voltage regulation and also for active power injection. The control scheme maintains the power balance at the grid terminal during the wind variations using sliding mode control. A multifunctional power electronic converter for the DG power system is described in.

This scheme has the capability to inject power generated by WES and also to perform as a harmonic compensator. Most of the reported literature in this area discuss the topologies and control algorithms to provide load compensation

capability in the same inverter in addition to their active power injection. When a grid-connected inverter is used for active power injection as well as for load compensation, the inverter capacity that can be utilized for achieving the second objective is decided by the available instantaneous microgrid real power. Considering the case of a grid-connected PV inverter, the available capacity of the inverter to supply the reactive power becomes less during the maximum solar insolation periods.

At the same instant, the reactive power to regulate the PCC voltage is very much needed during this period. It indicates that providing multi functionalities in a single inverter degrades either the real power injection or the load compensation capabilities. This paper demonstrates a dual voltage source inverter (DVSI) scheme, in which the power generated by the microgrid is injected as real power by the main voltage source inverter (MVSI) and the reactive, harmonic, and unbalanced load compensation is performed by auxiliary voltage source inverter (AVSI). This has an advantage that the rated capacity of MVSI can always be used to inject real power to the grid, if sufficient renewable power is available at the dc link.

In the DVSI scheme, as total load power is supplied by two inverters, power losses across the semiconductor switches of each inverter are reduced. This increases its reliability as compared to a single inverter with multifunctional capabilities. Also, smaller size modular inverters can operate at high switching frequencies with a reduced size of interfacing inductor, the filter cost gets reduced. Moreover, as the main inverter is supplying real power, the inverter has to track the fundamental

positive sequence of current. This reduces the bandwidth requirement of the main inverter. The inverters in the proposed scheme use two separate dc links. Since the auxiliary inverter is supplying zero sequence of load current, a three-phase three-leg inverter topology with a single dc storage capacitor can be used for the main inverter. This in turn reduces the dc-link voltage requirement of the main inverter. Thus, the use of two separate inverters in the proposed DVSI scheme provides increased reliability, better utilization of microgrid power, reduced dc grid voltage rating, less bandwidth requirement of the main inverter, and reduced filter size. Control algorithms are developed by instantaneous symmetrical component theory (ISCT) to operate DVSI in grid-connected mode, while considering nonstiff grid voltage.

II. PROPOSED DUAL VOLTAGE SOURCE INVERTER

A. System Topology

The proposed DVSI topology is shown in Fig. It consists of a neutral point clamped (NPC) inverter to realize AVSI and a three-leg inverter for MVSI [18]. These are connected to grid at the PCC and supplying a nonlinear and unbalanced load. The function of the AVSI is to compensate the reactive, harmonics, and unbalance components in load currents. Here, load currents in three phases are represented by i_{la} , i_{lb} , and i_{lc} , respectively. Also, $i_g(abc)$, $i_{\mu gm}(abc)$, and $i_{\mu gx}(abc)$ show grid currents, MVSI currents, and AVSI currents in three phases, respectively. The dc link of the AVSI utilizes a split capacitor topology, with two capacitors $C1$ and $C2$. The MVSI delivers the available power at distributed energy resource (DER) to grid. The DER can be a dc source or an ac source with

rectifier coupled to dc link. Usually, renewable energy sources like fuel cell and PV generate power at variable low dc voltage, while the variable speed wind turbines generate power at variable ac voltage. Therefore, the power generated from these sources use a power conditioning stage before it is connected to the input of MVSI. In this study, DER is being represented as a dc source. An inductor filter is used to eliminate the high-frequency switching components generated due to the switching of power electronic switches in the inverters. The system considered in this study is assumed to have some amount of feeder resistance R_g and inductance L_g . Due to the presence of this feeder impedance, PCC voltage is affected with harmonics. Section III describes the extraction of fundamental positive sequence of PCC voltages and control strategy for the reference current generation of two inverters in DVSI scheme.

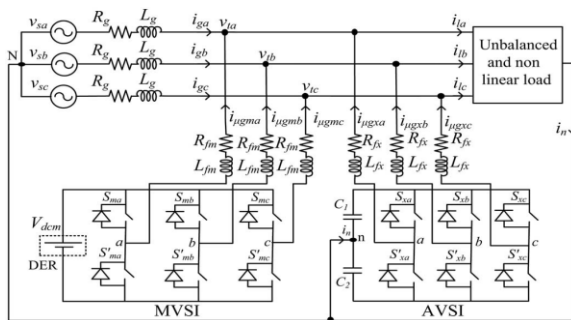


Fig.1 . Topology of proposed DVSI scheme.

III. CONTROL STRATEGY FOR DVSI SCHEME

A. Fundamental Voltage Extraction

The control algorithm for reference current generation using ISCT requires balanced sinusoidal PCC voltages. Because of the

presence of feeder impedance, PCC voltages are distorted. Therefore, the fundamental positive sequence components of the PCC voltages are extracted for the reference current generation. To convert the distorted PCC voltages to balanced sinusoidal voltages, $dq0$ transformation is used. The PCC voltages in natural reference frame (v_{ta} , v_{tb} , and v_{tc}) are first transformed into $dq0$ reference frame as given by

$$\begin{bmatrix} v_{td} \\ v_{tq} \\ v_{t0} \end{bmatrix} = C \begin{bmatrix} v_{ta} \\ v_{tb} \\ v_{tc} \end{bmatrix}$$

where

$$C = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin \theta & \sin(\theta - \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) \\ \cos \theta & \cos(\theta - \frac{2\pi}{3}) & \cos(\theta + \frac{2\pi}{3}) \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

In order to get θ , a modified synchronous reference frame (SRF) phase locked loop (PLL) [23] is used. The schematic diagram of this PLL is shown in Fig. It mainly consists of a proportional integral (PI) controller and an integrator. In this PLL, the SRF terminal voltage in q -axis (v_{tq}) is compared with 0 V and the error voltage thus obtained is given to the PI controller. The frequency deviation $\Delta\omega$ is then added to the reference frequency ω_0 and finally given to the integrator to get θ . It can be proved that, when, $\theta = \omega_0 t$ and by using the Park's transformation matrix (C), q -axis voltage in $dq0$ frame becomes zero and hence the PLL will be locked to the reference frequency (ω_0).

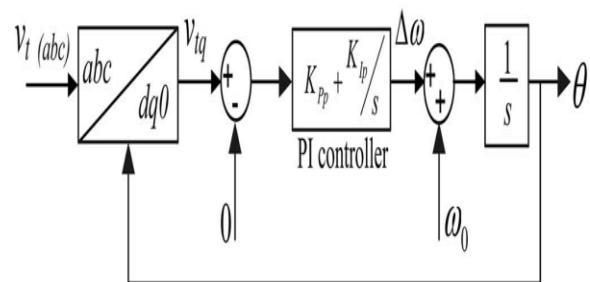


Fig.2 Schematic diagram of PLL.

B. Instantaneous Symmetrical Component Theory

ISCT was developed primarily for unbalanced and nonlinear load compensations by active power filters. The system topology shown in Fig is used for realizing the reference current for the compensator. The ISCT for load compensation is derived based on the following three conditions

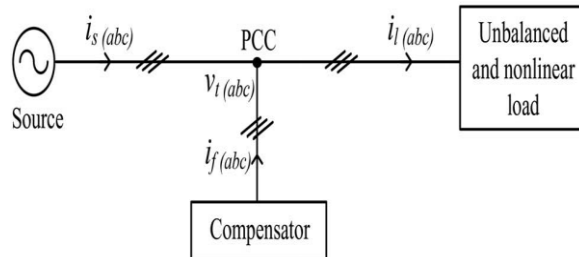


Fig.3. Schematic of an unbalanced and nonlinear load compensation scheme.

IV. SIMULATION RESULTS

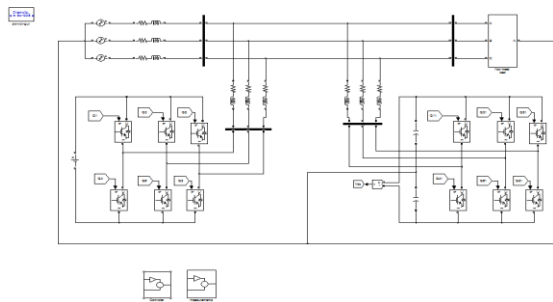


Fig 4 Matlab/simulink diagram of proposed DVSI system

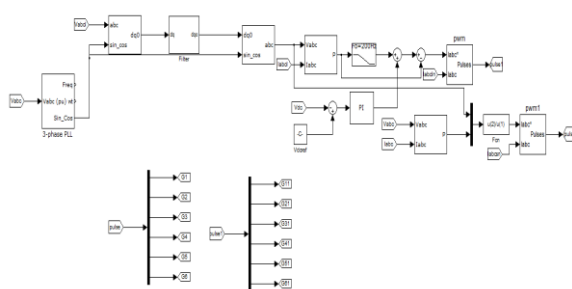


Fig 5 Controller SUBSYSTEM

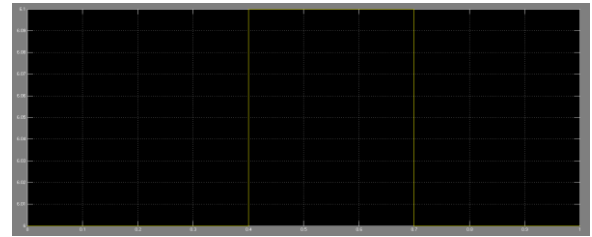


Fig 6 load active power

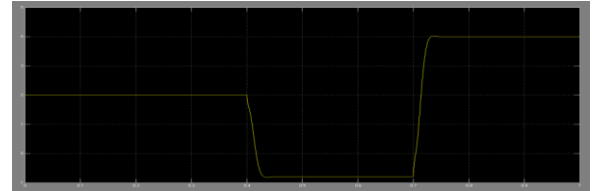


Fig 7 Active power supplied by grid

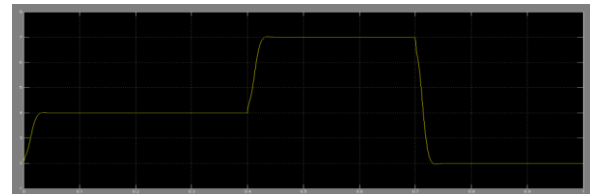


Fig 8 active power supplied by MVSI;

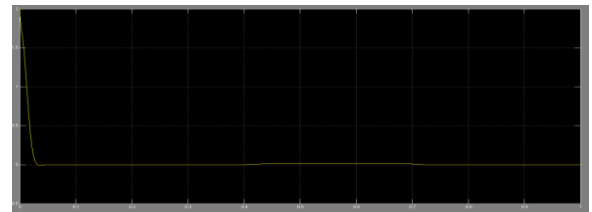


Fig 9 active power supplied by AVSI.

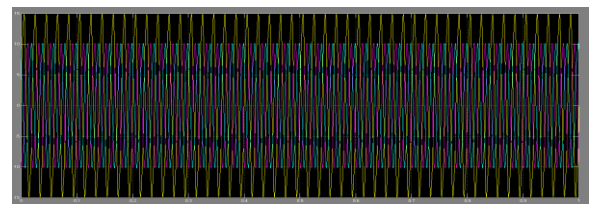


Fig 10 load currents

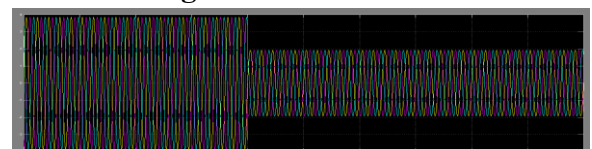


Fig 11 grid currents

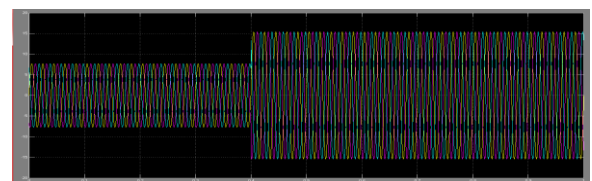


Fig 12 MVSI currents

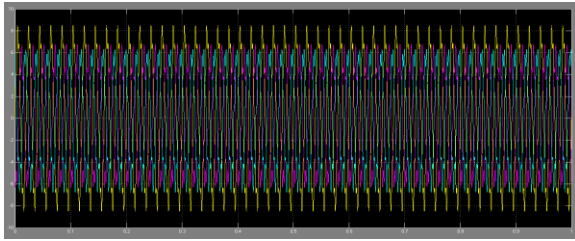


Fig 13 AVSI currents

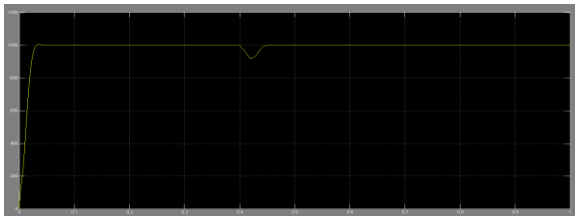


Fig 14 DC Link voltage

V.CONCLUSION

The proposed DVSI is Control algorithms are developed to generate reference currents for DVSI using ISCT. The proposed scheme has the capability to exchange power from distributed generators (DGs) and also to compensate the local unbalanced and nonlinear load. The performance of the proposed scheme has been validated through simulation and experimental studies. As compared to a single inverter with multifunctional capabilities, a DVSI has many advantages such as, increased reliability, lower cost due to the reduction in filter size, and more utilization of inverter capacity to inject real power from DGs to microgrid. Moreover, the use of three-phase, threewire topology for the main inverter reduces the dc-link voltage requirement. Thus, a DVSI scheme is a suitable interfacing option for microgrid supplying sensitive loads.

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