ESTIMATED DROOP CONTROL FOR GRID-CONNECTED DUAL VOLTAGE SOURCE INVERTERS

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Abstract

Renewable Energy Sources (RES) are considered as the replacement of conventional energy sources. These RES can use wind energy, solar light, bio waste and can also be in the form of small hydro power units. These RES has very poor power quality and contains voltage fluctuations and variable frequency. These factors make RES a stability risk for the main utility grid. As a solution, currently inverters with different design techniques are being used as an interface between RES and main utility grid. The current study proposed a new technique "estimated droop control" for inverter design. The conventional droop control technique which was already used in inverter design, has difficulty in synchronizing parallel connected inverters with different droop gains and line impedances. The proposed "estimated droop control" does not use any predefined droop values for inverters and all inverters are responsible for the estimation of their own droop values with respect to their output power. Therefore, inverters are not bound to use same and static droop values which are considered as a vital communication link. The proposed design methodology has made inverters independent from this only virtual link of communication due to which the reliability of a system has increased. The proposed design technique has given very good results in a simulation run.

1. INTRODUCTION

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. 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 gridconnected 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 micro-grid 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 period. 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.

2.Existing system:

The scheme ensures that unity power factor (UPF) is achieved at the load terminal during nominal operation, which is not possible in the traditional method. Also, the compensator injects lower currents and, therefore, reduces losses in the feeder and voltage source inverter. Further, a saving in the rating of DSTATCOM is achieved which increases its capacity to mitigate voltage sag. Nearly UPF is maintained, while regulating voltage at the load terminal, during load change. The state-space model of DSTATCOM is incorporated with the deadbeat predictive controller for fast load voltage regulation during voltage disturbances. With these features, this scheme allows DSTATCOM to tackle power-quality issues by providing power factor correction, harmonic elimination, load balancing, and voltage regulation based on the load requirement. It uses a three phase, four-wire, two-level, neutral-point-clamped VSI. This structure allows independent control to each leg of the VSI.

There are different types of power generators in a microgrid and it is very important to keep control over all these generators. This control is responsible for equal power sharing and for regulating voltage amplitude and frequency. There are two types of control schemes:

1. Communication based control.

2. Non-communication based control.

In communication based control, a supervisory control over all generators is needed. This supervisory control receives information from all terminal generators and try to keep balance in power sharing among these generators. This technique is not very reliable as it needs high bandwidth communication link for fast sharing of information. This control is not feasible when generators in microgrid are spread over a vast area and there is a long distance between them. If this supervisory control or master control fails due to any reason then the whole system may stop working.

In this case another problem of dispatching these generators in microgrid will be possible. A non-communication based technique enables every unit in microgrid to regulate their output voltage and frequency so these units can share active and reactive power demand accordingly. This technique uses a method of frequency and voltage droops as in conventional power system generators [15]. This control allows every unit to change active and reactive load if there is any change happens in frequency or voltage of a system respectively [2]. These frequency and voltage droops act as a vital communication link. A non-communication based control increases the reliability of a system as all units are independent and responsible for their individual control of frequency and voltage. This advantage gives a motivation to use droop control for DG units in microgrid. This technique is also not a perfect one, it still needs improvements. There are a few drawbacks in this technique i.e. due to droop characteristics, frequency and voltage of DG units may drop to a lower level values different from the nominal values [2]. Secondly if the difference in voltage and frequency is beyond a certain range then it is difficult to synchronize DG units. This happens when the distance between DG units is large which results in different line impedances for every unit. This project work is carried out to address these two above mentioned problems so that every unit can regulate its voltage amplitude and frequency at or around specific set references. The main goal of this thesis work is to operate DG units in microgrid with almost same amplitude and frequency so that they can keep synchronization almost in every case.

3. System Modeling and Design

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). 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.

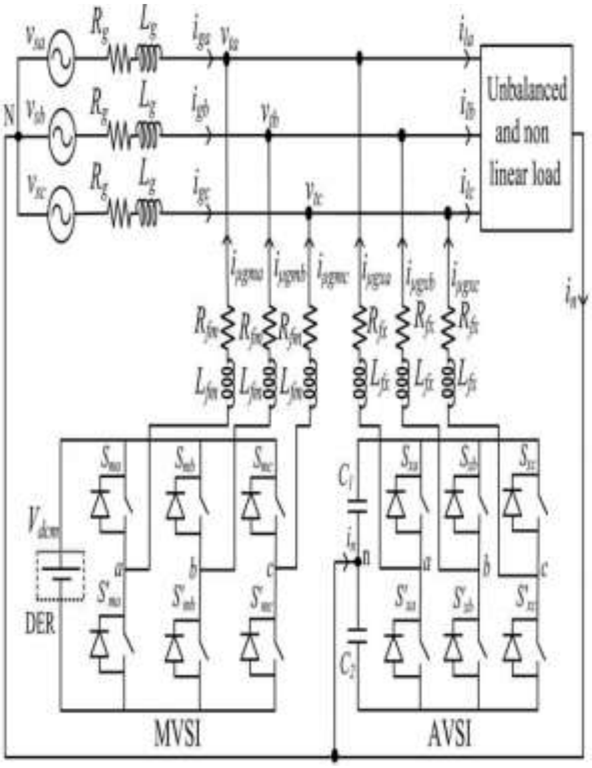

Fig. 1. Topology of proposed DVSI scheme.

3.1 POWER QUALITY

The contemporary container crane industry, like many other industry segments, is often enamored by the bells and whistles, colorful diagnostic displays, high speed performance, and levels of automation that can be achieved. Although these features and their indirectly related computer based enhancements are key issues to an efficient terminal operation, we must not forget the foundation upon which we are building.

Power quality is the mortar which bonds the foundation blocks.

Power quality also affects terminal operating economics, crane reliability, our environment, and initial investment in power distribution systems to support new crane installations. To quote the utility company newsletter which accompanied the last monthly issue of my home utility billing: „Using electricity wisely is a good environmental and business practice which saves you money, reduces emissions from generating plants, and conserves our natural resources.‟ As we are all aware, container crane performance requirements continue to increase at an astounding rate. Next generation container cranes, already in the bidding process, will require average power demands of 1500 to 2000 kW – almost double the total average demand three years ago. The rapid increase in power demand levels, an increase in container crane population, SCR converter crane drive retrofits and the large AC and DC drives needed to power and control these cranes will increase awareness of the power quality issue in the very near future.

3.2 CONTROLLING SYSTEM

The concept of instantaneous reactive power is used for the controlling system. Following this, the 3-phase voltage upon the use of the park presented by Akagi [24] has been transformed to the synchronous reference frame (Park or dq0 transformation). This transformation leads to the appearances of three instantaneous space vectors: Vd on the d-axis (real or direct axis), Vq on the q-axis (imaginary or quadrature axis) and V0, from the 3-phase voltage of Va, Vb and Vc. The related equations of this transformation, expressed in the MATLAB software, are as follows: A dynamic computation shows that the voltage oscillations in the connecting node of the flickergenerating load to the network are created by 3 vectors: real current (ip), imaginary current (iq) and the derivative of the real current with respect to time ( ). In general, for the complete voltage flicker compensation, the compensating current (ic) regarding the currents converted to the dq0 axis is given as [3]: where R and X are the synchronous resistance and reactance of the line and f is the correcting coefficient. The constant k is also used to eliminate the average reactive power of the network [3]. If the compensation current of the above equation is injected to the network, the whole voltage flicker existing in the network will be eliminated. Regarding the equation, related to the dq-transformation of the 3-phasevoltages to the instantaneous vectors, it is obvious that under the conditions of accessing an average voltage flicker, Vd and V0, the obtained values are close to zero and Vq is a proper value adapting to the voltage oscillation of the network.

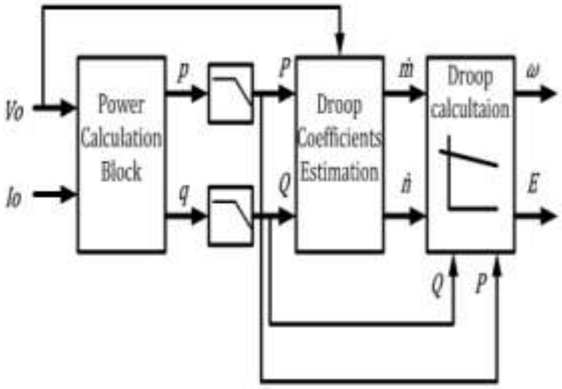

Figure 2: Estimated Droop control scheme

1. Power calculation block which has output voltage V0 and output current I0 as input signals. This block gives active power P and reactive power Q as outputs, which are used for droop coefficients estimation and droop control.
2. Droop estimation block which has active power, reactive power and output voltage as inputs, which results in estimated droop coefficients.
3. Droop curve implementation and reference signal generation.

SIMULATION RESULTS

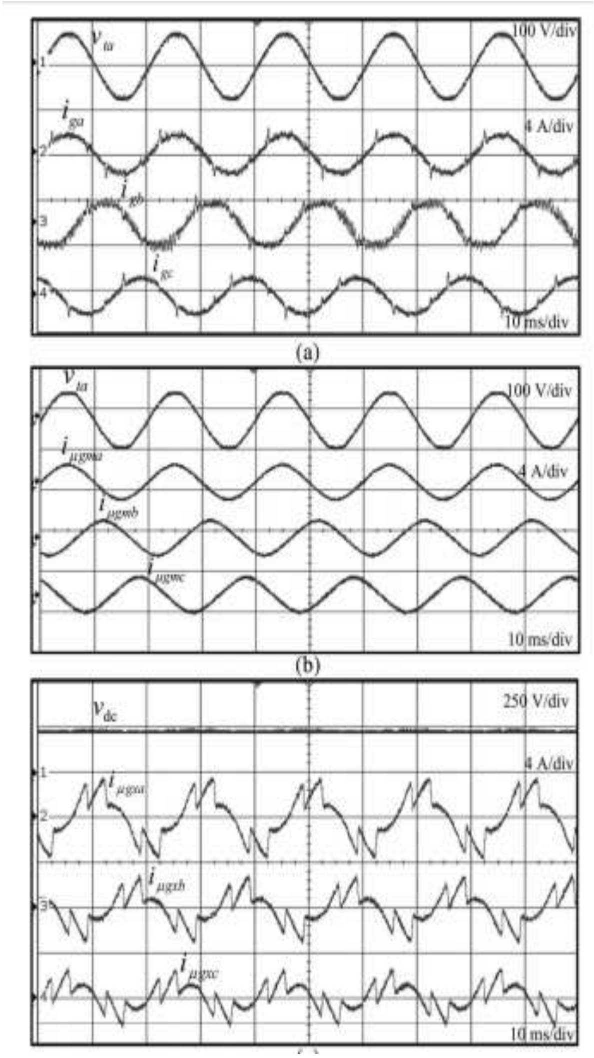

Fig. 3. Experimental results: (a) PCC voltage (phase-a) and grid currents after compensation; (b) MVSI currents; and (c) dc-link voltage and AVSI currents.

Conclusion

This paper work is conducted to improve the stability and reliability of low and medium voltage Mirogrids consisting of more than one RES. Grid forming inverters are used as an interface between main utility grid and these RES. These inverters are used to extract power from these RES units and then process it according to the requirements of main utility grid and local load. Different techniques for inverter design has been studied which are in use nowadays. A brief review of the existing power system structure is included for understanding how the conventional power system is working. Then Microgrid system is explained in detail including its structure and all fundamental parameters which can affect its performance. To improve the reliability of a system a non-communication based technique is preferred namely ”Estimated Droop Control”. The droop gains for each inverter are estimated online and then adapted by each inverter. The amplitude estimation of the inverter output voltage is done by using a generalized integrator, its gains are provided by Kalman estimator. The phase and frequency of the inverter output voltage are estimated by a PLL technique with Kalman estimator. Then the results are shown and compared with the conventional droop control scheme. This comparison shows that the estimated droop control not only improves the stability of the system but also improves the reliability. The reliability is of more concern about how much an inverter is independent in its operations. In the conventional droop control scheme droop gains of an inverter are used as (virtual) means of communication with one another in same microgrid. In the Estimated droop control scheme these droop gains are estimated online and no predefined values are used. This method increases the reliability of a system by freeing each inverter in a system from this only virtual communication link. Stability is also improved by this proposed technique as it is shown by simulation results especially in case of different line impedance.

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