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An Effective Micro Grid Load Demand Sharing Methodology

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ABSTRACT

For the operation of standalone micro grids, an important task is to share the load demand using multiple distributed generation (DG) units. In order to realize satisfied power sharing without the communication between DG units, the voltage droop control and its different variations have been reported in the literature. However, in a low-voltage micro grid, due to the effects of nontrivial feeder impedance, the conventional droop control is subject to the real and reactive power coupling and steady-state reactive power sharing errors. Furthermore, complex micro grid configurations (looped or mesh networks) often make the reactive power sharing more challenging. To improve the reactive power sharing accuracy, this paper proposes an enhanced control strategy that estimates the reactive power control error through injecting small real power disturbances, which is activated by the low-bandwidth synchronization signals from the central controller. At the same time, a slow integration term for reactive power sharing error elimination is added to the conventional reactive power droop control. The proposed compensation method achieves accurate reactive power sharing at the steady state, just like the performance of real power sharing through frequency droop control. Simulation and experimental results validate the feasibility of the proposed method.

Keywords:— *Micro grid, Load Demand, Active power, Reactive power, Distributed generation.*

I. INTRODUCTION

The application of distributed power generation has been increasing chop-chop within the past decades. Compared to the standard centralized power generation, distributed generation (DG) units deliver clean and renewable power on the brink of the Customer's finish. Therefore, it will alleviate the strain of the many typical transmission and distribution infrastructures. As Most of the weight units are interfaced to the grid victimisation power physical science Converters, they need the chance to appreciate increased Power generation through a versatile digital management of the facility Converters.

On the opposite hand, high penetration of power physical science primarily based weight unit units additionally introduces some problems, resembling system Resonance, protection interference, etc. so as to beat these issues, the small grid construct has been projected, that is accomplished through the management of multiple weight unit units. Compared to one weight unit, the small grid can do superior power management inside its distribution networks. additionally, the islanding operation of small grid offers high dependableness power offer to the crucial masses. Therefore, small grid is taken into account to pave the thanks to the long run sensible grid. In AN islanded small grid, the masses should be properly shared by multiple weight unit units. Conventionally, the Frequency and voltage magnitude droop management is adopted, that aims to realize small grid power sharing in an exceedingly suburbanized manner. However, the droop management ruled small grid is at risk of have some power management stability issues once the weight unit feeders are principally resistive. It also can be seen that the important power sharing at the steady state is often correct whereas the reactive power sharing is sensitive to the impacts of mismatched feeder electrical resistance. Moreover, the existence of native masses and therefore the networked small grid configurations usually more worsen reactive power sharing issues. To solve the facility management problems, some improved ways are projected. In, the virtual frequency–voltage frame and virtual real and reactive power construct were developed. that improve the soundness of the small grid System. However, these ways cannot suppress the reactive power sharing errors at constant time. in addition, once little synchronous generators are incorporated into the small grid, correct power sharing between inverter-based weight unit units and electrical machine primarily based weight unit units are more difficult in these ways.

In, each the reactive power and therefore the harmonic power sharing errors were reduced with the non-characteristic harmonic current injection. though the facility sharing drawback was self-addressed, the corresponding steady-state voltage distortions degrade the small grid power quality. In, a "Q–V dot droop" methodology was conferred. It may be ascertained from that the reactive power sharing improvement isn't obvious once native masses are enclosed. In, the reactive power sharing error reduction is accomplished victimisation extra PCC voltage mensuration. In, the predominant virtual output electrical device is placed at the weight unit output terminal, that is especially centered on preventing the facility management instability. additionally, inside the virtual electrical resistance management frame, the reactive power sharing errors may be more reduced through a noteworthy model-based droop slope modification theme.

As the virtual electrical resistance motor-assisted management methodology has the power to handle the facility management instability and power sharing errors at constant time, it's thought of to be a promising thanks to give superior small grid performance. However, it's price mentioning that the aforesaid virtual impedance control methods were developed based on simplified micro grid configurations. Indeed, due to the "plug-and-play" feature of DG units and loads, the micro grid configuration also changes with time. Without the real-time information of the micro grid configuration, virtual impedance control may not work properly as desired.

In response to the islanding micro grid control challenges, this paper presents a simple reactive power sharing compensation scheme. The proposed method first identifies the reactive power sharing errors through injecting small real-reactive power coupling disturbances, which are activated by the low-bandwidth synchronization flag signals from the central controller. Then the accurate reactive power sharing is realized by manipulating the injected transient real-reactive power coupling using an intermittent integral control. With the proposed scheme, reactive power sharing errors are significantly reduced.

After the compensation, the proposed droop controller will be automatically switched back to the conventional droop controller. Note that the proposed accurate power control method is effective for micro grids with all types of configurations and load locations, and it does not need the detailed micro grid structural information. Simulation and experimental results are provided to verify the proposed load demand sharing method.

Conventionally, PI, PD and PID controller are most popular controllers and widely used in most power electronic appliances however recently there are many researchers reported successfully adopted Fuzzy Logic Controller (FLC) to become one of intelligent controllers to their appliances [3]. With respect to their successful methodology implementation, this kind of methodology implemented in this paper is using fuzzy logic controller with feed back by introduction of voltage respectively. The introduction of change in voltage in the circuit will be fed to fuzzy controller to give appropriate measure on steady state signal. The fuzzy logic controller serves as intelligent controller for this propose.

However, in this paper authors have incorporated the features of APF in the, conventional inverter interfacing renewable with the grid, without any additional hardware cost. Here, the main idea is the maximum utilization of inverter rating which is most of the time underutilized due to intermittent nature of RES. It is shown in this paper that the grid-interfacing inverter with fuzzy logic control technique can effectively be utilized to perform following important functions: 1) transfer of active power harvested from the renewable resources (wind, solar, etc.); 2) load reactive power demand support; 3) current harmonics compensation at PCC; and 4) current unbalance and neutral current compensation in case of 3-phase 4-wire system. Moreover, with adequate control of grid-interfacing inverter, all the four objectives can be accomplished either individually or simultaneously.

II. DISTRIBUTED GENERATION

Distributed generation, also called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy rates electricity from many small energy sources. Currently, industrial countries generate most of their electricity in large centralized facilities, such as fossil fuel (coal, gas powered) nuclear or hydropower plants. These plants have excellent economies of scale, but usually transmit electricity long distances and negatively affect the environment.

Most plants are built this way due to a number of economic, health & safety, logistical, environmental, geographical and geological factors. For example, coal power plants are built away from cities to prevent their heavy air pollution from affecting the populace. In addition, such plants are often built near collieries to minimize the cost of transporting coal. Hydroelectric plants are by their nature limited to operating at sites with sufficient water flow. Most power plants are often considered to be too far away for their waste heat to be used for heating buildings.

Low pollution is a crucial advantage of combined cycle plants that burn natural gas. The low pollution permits the plants to be near enough to a city to be used for district heating and cooling. Distributed generation is another approach. It reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in the same building. This also reduces the size and number of power lines that must be constructed. Typical distributed power sources in a Feed-in Tariff (FIT) scheme have low maintenance, low pollution and high efficiencies. In the past, these traits required dedicated operating engineers and large complex plants to reduce pollution. However, modern embedded system can provide these traits with automated operation and renewable, such as sunlight, wind and geothermal. This reduces the size of power plant that can show a profit.

III. CONFIGURATIONS FOR DES

Case 1: A Power Converter connected in a Standalone AC System or in Parallel with the Utility Mains

Figure 1 show a distributed power system which is connected to directly load or in parallel with utility mains, according to its mode. This system consists of a generator, an input filter, an AC/AC power converter, an output filter, an isolation transformer, output sensor (V, I, P), and a DSP controller. In the Figures, a distributed generator may operate as one of three modes: a standby, a peak shaving, and a standalone power source. In a standby mode shown in Figure 3 a generator set serves as a UPS system operating during mains failures. It is used to increase the reliability of the energy offer and to boost the general performance of the system.

The static switch SW one is closed traditional operation and SW two is open, whereas just in case of mains failures or excessive dip detection SW one is open and SW two is at the same time closed. during this case, management techniques of DES square measure terribly the same as those of UPS. If a transient load will increase, the output voltage has comparatively massive drops because of the interior resistance of the electrical converter and filter stage, which often lead to malfunction of sensitive load. Figure 1 will is a peak shaving or interconnection with the grid to feed power back to mains.

In each modes, the generator is connected in parallel with the most grids. during a peak shaving mode, this generator is running as few as many hundred hours annually as a result of the SW one is simply closed throughout the restricted periods. Meanwhile, in associate interconnection with the grid, SW one is often closed and this technique provides the grid with continuous wattage. additionally, the device connected in parallel to the mains will serve additionally as a supply of reactive power and better harmonic current elements.

In a standalone AC system shown in Figure 2 the generator is directly connected to the load lines while not being connected to the mains and it'll operate severally. during this case, the operations of this technique square measure the same as a standby mode, and it serves unendingly not like a standby mode and a peak shaving mode.

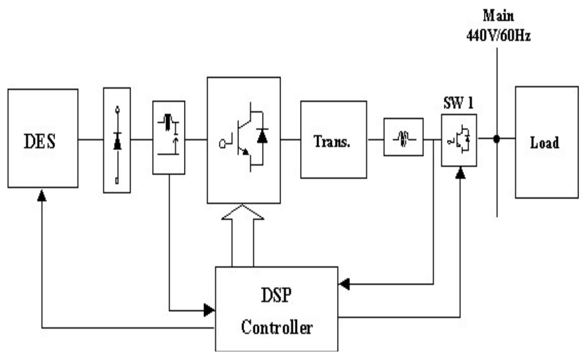

Figure 1. Block diagram of a peak sharing mode

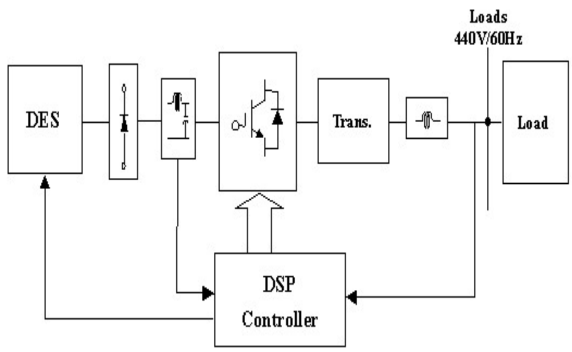

Figure 2. Block diagram of a standalone mode

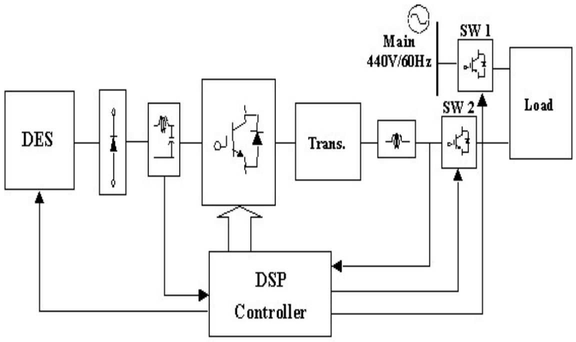

Figure 3. Block Diagram of a Standby Mode

As shown in Figure 3 the output voltage of the generator is fed to a DC/AC converter that converts a DC output of the generator to be fixed voltage and frequency for utility mains or loads. The DSP controller monitors multiple system variables on a real time basis and executes control routines to optimize the operation of the individual subsystems in response to measured variables. It also provides all necessary functions to sense output voltages, current, and power, to operate protections, and to give reference signals to regulators. The output power of the converter is controlled according to the reference signal of the control unit.

As described above, in order to compensate for reactive power and higher harmonic components or to improve power factor, the active power (P) and reactive power (Q) should be controlled independently. Moreover, the above system needs over-dimensioning some parts of the power converter in order to produce reactive power by the converter at rated active power.

Because a power converter dimensioned for rated current can supply reactive power only if the active component is less than rated. Therefore, a control strategy easy to implement is required to ensure closed loop control of the power factor and to provide a good power quality. In case that a generator is used for distributed generation systems, the recent research focuses are summarized as follows:

1. Control strategy which permits to connect more generators on the network
2. Compensation of the reactive power and higher harmonic components
3. An active power (P) and a reactive power control (Q) independently
4. Power factor correction
5. Synchronization with the utility mains
6. System protections

Case II: Power Converters supplying power in a standalone mode or feeding it back to the utility mains Figure 2 shows a block diagram of multiple power converters for a standalone AC system or feeding generated powers back to the utility mains. If all generators are directly connected to the loads, the systems operate as a standalone AC system. Meanwhile, if these are connected in parallel to the mains, these provide the utility grids with an electric power. Each system consists of a generator, an input filter, an AC/AC power converter, an output filter, an isolation transformer, a control unit (DSP), a static switch (SW 1) and output sensors (V, I, P). The function of the static switch (SW 1) is to disrupt the energy flow between the generator and mains or loads in the case of disturbances in the mains voltage. As shown in Figure 4, this configuration is very similar to parallel operation of multiple UPS systems except that the input sources of inverters are independent generation systems such as micro turbines, fuel cells, and photo voltaic, etc. instead of utility mains.

In case of parallel operation of UPS systems, a recent critical research issue is to share linear and nonlinear load properly by each unit. In general, the load sharing is mainly influenced by non uniformity of the units, component tolerance, and line impedance mismatches. Another issue is a proper control scheme without any control interconnection wires among inverters because these wires restrict the location of the inverter units as well as these can act as a source of the noise and failure. Moreover, in three-phase systems they could also cause unbalance and draw excessive neutral currents.

Even if conventionally passive L-C filters were used to reduce harmonics and capacitors were employed to improve the power factor of the ac loads, passive filters have the demerits of fixed compensation, large size, and resonance. Therefore, the injected harmonic, reactive power burden, unbalance, and excessive neutral currents definitely cause low system efficiency and poor power factor. In particular, a power factor can be improved as AC/AC power converters function a complete active filter for better power quality and the above problems should be overcome by a good control technique to assure the DES to expand increasingly around the world.

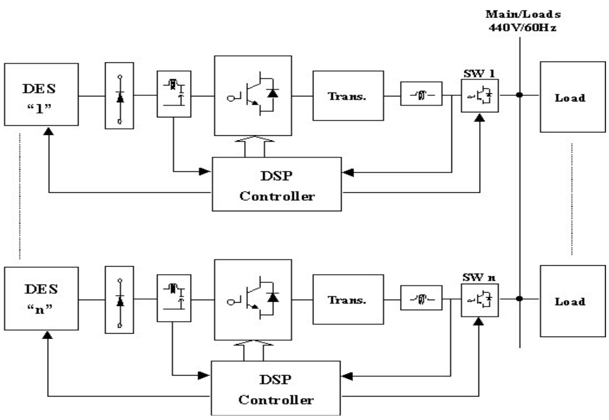

Figure 4: Block diagram of power converters connected in parallel

So the above issues can be applied to distributed power systems similarly, and the recent research focuses are summarized as follows:

1. Standardized DES modeling using the software tools
2. Equal load sharing such as the real and reactive power, the load harmonic current among the parallel connected inverters.
3. Connection capability of more DES to the utility mains in best conditions
4. Independent P, Q control of the inverters
5. Power factor correction
6. Reduction of Total Harmonic Distortion (THD).

Distributed Generation (DG) is commonly defined as electric power generation facilities that are not directly connected to a bulk power transmission system. They cover a multitude of energy sources, fuels, and conversion methods to produce electricity through photovoltaic (PV) arrays, wind turbines, fuel cells, micro turbines, liquid and gas-fueled reciprocating engines, etc. Given the wide variety of sources, it is natural that specific impacts associated with DG would vary with type and application. However, there are many common threads on how DG benefits the customers they serve and society at large. This is demonstrated in this paper through several examples, giving testimonials of the positive impact these installations have.

III. Modeling and Control of Inverter Interfaced DG Units

Basically each DG unit may have DC type or rectified generation unit (Fuel cell, solar cell, wind turbine, micro turbine…), storage devices, DC-DC converter, DC-AC inverter, filter, and transformer for connecting to loads or utility in order to exchange power. Model and dynamic of each of this part may have influence in system operation. But here for simplification it is considered that DC side of the units has sufficient storage and considered as a constant DC source. Hence only DC-AC inverter modeling and control investigated in this paper.

A circuit model of a three-phase DC to AC inverter with LC output filter is further described in Figure As shown in the figure, the system consists of a DC voltage source (Vdc), a three- phase PWM inverter, an output filter (Lf and C with considering parasitic resistance of filter- Rf). Sometimes a transformer may be used for stepping up the output voltage and hence Lf can be transformer inductance

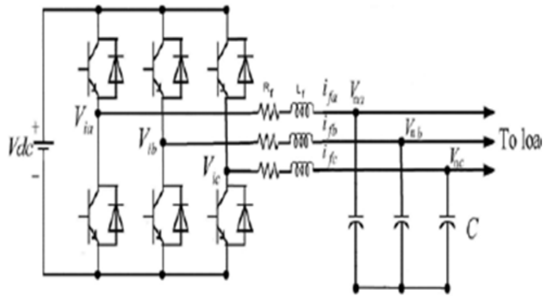

Figure 5. PWM Inverter Diagram

There are two ways for controlling an inverter in a distributed generation system

A. PQ Inverter Control

This type of control is adopted when the DG unit system is connected to an external grid or to an island of loads and more generators. In this situation, the variables controlled by the inverter are the active and reactive power injected into the grid, which have to follow the set points Pref and Qref, respectively. These set points can be chosen by the customer or by a central controller. The PQ control of an inverter can be performed using a current control technique in QD reference frame which the inverter current is controlled in amplitude and phase to meet the desired set-points of active and reactive power.

With the aim of Park transform and equations between inverter input and output, the inverter controller block diagram for supplying reference value of Pref and Qref is as figures. For the current controller, two Proportional-Integral (PI) regulators have been chosen in order to meet the requirements of stability of the system and to make the steady state error be zero. With this control scheme, it is possible to control the inverter in such way that injects reference value of Pref, Qref into other part of stand-alone network. When the output voltage is needed to be regulated, the PV control scheme that is similar to PQ mode with feedback of voltage used to adjust Qref.

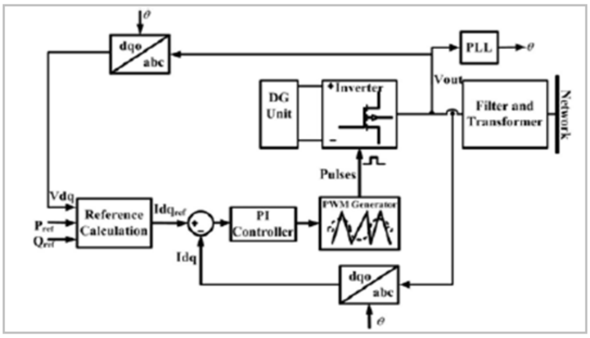

Figure 6. PQ control scheme of inverter

B. Vf Inverter Control

This controller has to act on the inverter whenever the system is in stand-alone mode of operation. In fact in this case it must regulate the voltage value at a reference bus bar and the frequency of the whole grid. A regulators work in order to keep the measured voltages upon the set points. Moreover the frequency is imposed through the modulating signals of the inverter PWM control by mean of an oscillator. A simple PI controller can regulate bus voltage in reference value with getting feedback of real bus voltage. Figure 7 outlines this control strategy. In this case it is obvious that the DG unit should have storage device in order to regulate the power and voltage.

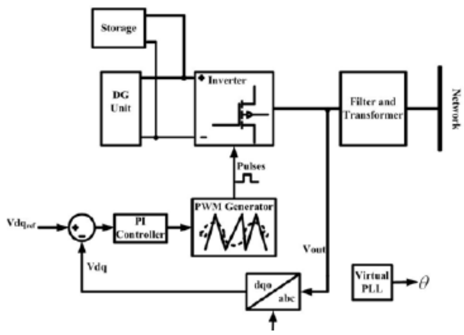

Figure 7. Vf control scheme of inverter

Table 1. DG System Parameters

Parameter		Values
Interfaced Inverter (Simulation& Experiment)	Filter Inductor (L_f/R_f)	L:5mH/R:0.2Ω
	Filter Capacitor (C_f)	40uF
	Sampling-switching frequency	9kHz-4.5kHz
Microgrid Parameter (Simulation)	Rated RMS voltage (Line-Line)	208V (60Hz)
	Total Loads	3525W-1425Var
Droop coefficients (Simulation)	Frequency droop D_P	0.00125 Rad / (Sec • W)
	Voltage droop D_Q	0.00143 V/Var
	Integration dead-band	6 W
	Integral gain Kc	0.0286 V/ (Sec • W)
	LPF time constant τ	0.0159 Sec
Microgrid Parameter (Experiment)	Rated RMS voltage (Line-Line)	104V/60Hz
	Total Loads	540W/280Var
Droop coefficients (Experiment)	Frequency droop D_P	0.00143 Rad/(Sec • W)
	Voltage droop D_Q	0.00167 V/Var
	Integration dead-band	6 W
	Integral gain	0.0286 V/ (Sec • W)
	LPF time constant τ	0.0159 Sec

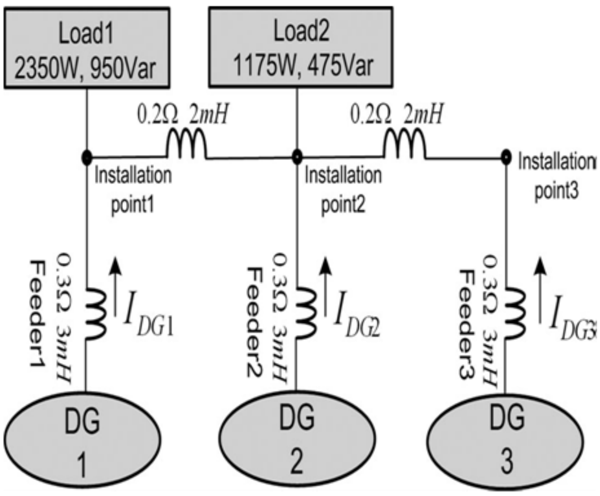

Figure 8: Networked Micro Grid in the Simulation

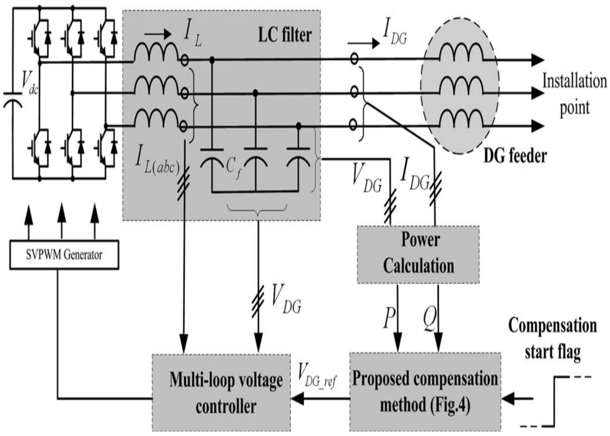

Figure 9. Configuration of the DG unit.

IV. Experimental Results

The Simulation Results of network is shown in below:

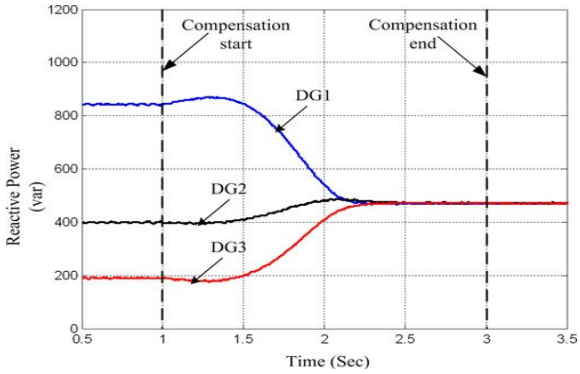

Figure 10. Simulated reactive power sharing performance in a net work micro grid (compensated is activated at 1 s) DG1, DG2, DG3.

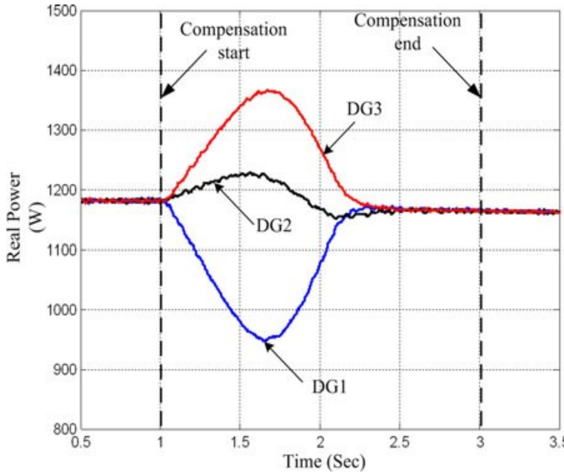

Figure 11. Simulated real power sharing performance in a network micro grid (compensated is activated at 1s) DG3, DG2, DG1.

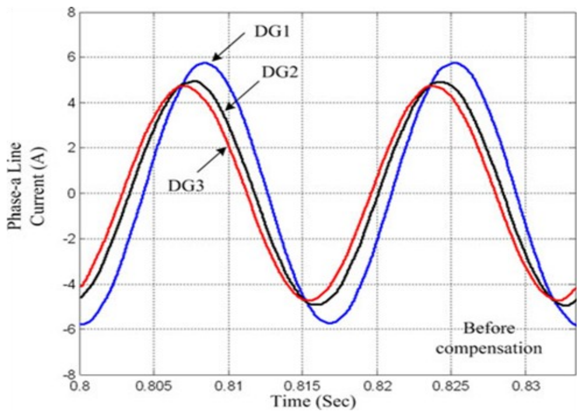

Figure 12. Simulated DG Currents Before Compensation. DG1, DG2 , DG3.

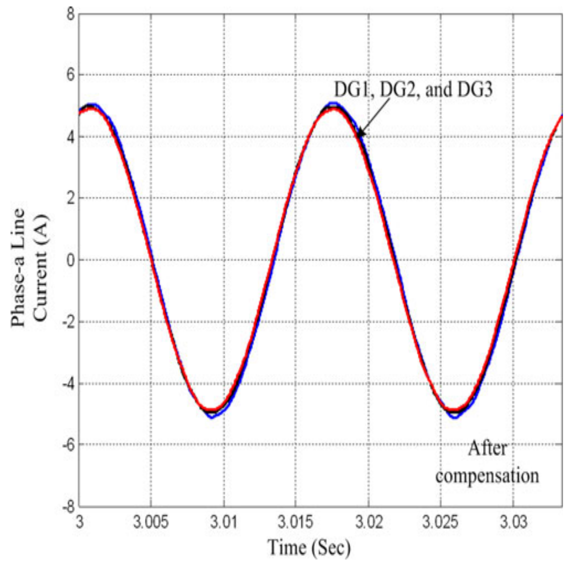

Figure 13. Simulated DG Currents after Compensation. DG1, DG2, DG3.

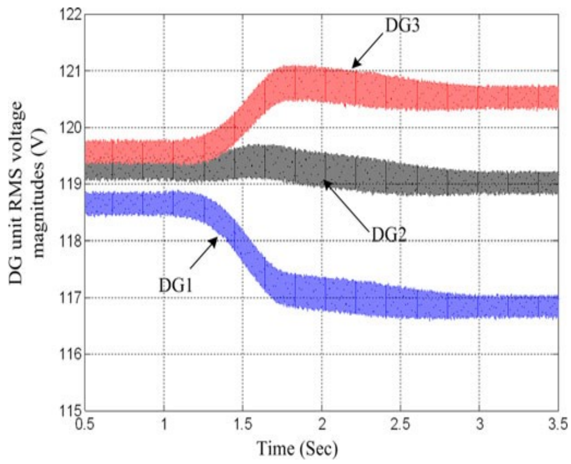

Figure 14. Simulated DG voltage magnitudes. DG3,DG2 ,DG1

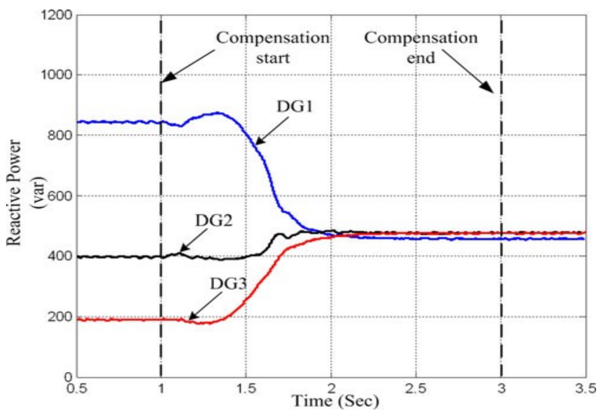

Figure 15. Simulated reactive power sharing performance in a net work micro grid (0.1 s synchronization flag delay in DG unit 1). DG1, DG2, DG3.

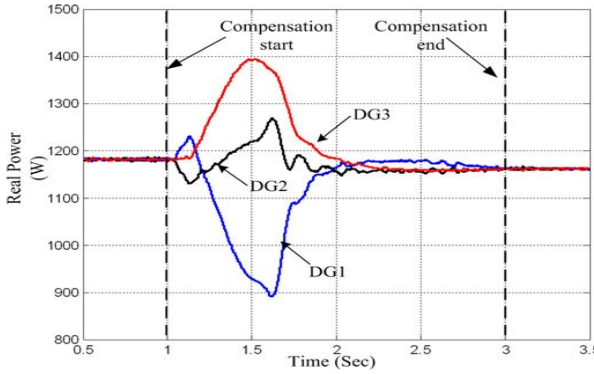

Figure 16. Simulated real power sharing performance in a net work micro grid (0.1 s Synchronization flag delay in DG unit 1). DG3, DG2, DG1.

V. CONCLUSION

In this paper, an improved micro grid reactive power sharing strategy was proposed. The method injects a real-reactive power transient coupling term to identify the errors of reactive power sharing and then compensates the errors using a slow integral term for the DG voltage magnitude control. The compensation strategy also uses a low-bandwidth flag signal from the micro grid central controller to activate the compensation of all DG units in a synchronized manner. Therefore, accurate power sharing can be achieved while without any physical communications among DG units. In addition, the proposed method is not sensitive to micro grid configurations, which is especially suitable for a complex mesh or networked micro grid.

REFERENCES

[1] Tine Vandoorn, Bert Renders, Frederik De Belie, Bart Meersmanand" A Voltage-Source Inverter for Microgrid Applications with an Inner Current Control Loop and an Outer Voltage Control Loop"**.**

[2] Daniel Nahum Zmood*, Student Member, IEEE* and Donald Grahame Holmes*, Member, IEEE"* Stationary Frame Current Regulation of PWM Inverters With Zero Steady-State Error".

[3] Josep M. Guerrero, *Member, IEEE*, Luis García de Vicuña, José Matas, Miguel Castilla, and Jaume Miret, *Member, IEEE* "Wireless Controller to Enhance Dynamic Performance of Parallel Inverters in Distributed Generation Systems"

[4] Fang Z. Peng, Yun Wei Li and Leon M. Tolbert" Control and Protection of Power Electronics Interfaced Distributed Generation Systems in a Customer-Driven Micro grid"

[5] Emanuel Serban(1), Senior Member, IEEE, Helmine Serban(2), Member, IEEE "A Control Strategy for a Distributed Power Generation Micro grid Application with Voltageand Current Controlled Source Converter"

[6] A.E. Hammad, Comparing the Voltage source capability of Present and future Var Compensation Techniques in Transmission System, IEEE Trans, on Power Delivery. Volume 1. No.1 Jan 1995.

[7] G. Yalienkaya, M.H.J Bollen, P.A. Crossley, "Characterization of Voltage Sags in Industrial Distribution System", IEEE transactions on industry applications, volume 34, No. 4, July/August, PP.682-688, 1999.

[8] Haque, M.H., "Compensation of Distribution Systems Voltage sags by DVR and D-STATCOM", Power Tech Proceedings, 2001 IEEE Porto, Volume 1, PP.10-13, September 2001.

[9] Anaya-Lara O, Acha E., "Modeling and Analysis Of Custom Power Systems by PSCAD/EMTDC", IEEE Transactions on Power Delivery, Volume 17, Issue: 2002, Pages: 266-272.

[10] Bollen, M. H. J., "Voltage sags in Three Phase Systems", Power Engineering Review, IEEE, Volume 21, Issue: 9, September 2001, PP: 11-15.

[11] R. Meinski, R. Pawelek and I. Wasiak, "Shunt Compensation For Power Quality Improvement Using a STATCOM controller Modeling and Simulation", IEEE Proce, Volume 151, No. 2, March 2004.

[12] J. Nastran, R. Cajhen, M. Seliger, and P. Jereb, "Active Power Filters for Nonlinear AC loads, IEEE Trans. on Power Electronics Volume 9, No.1, PP: 92-96, Jan 2004.

[13] L. A. Moran, J.W. Dixon, and R. Wallace, A Three Phase Active Power Filter with fixed Switching Frequency For

[14] N. F Nik Ismail, I. Musirin, R. Baharom, D. Johari" Fuzzy Logic Controller on DC/DC Boost Converter" 2010 IEEE International Conference on Power and Energy (PECon2010), Nov 29 - Dec 1, 2010, Kuala Lumpur, Malaysia.

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