POWER FLOW CONTROL AND POWER MANAGEMENT WITH BACK-BACK CONVERTERS IN A UTILITY CONNECTED MICROGRID SYSTEM

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Abstract— This paper proposes a method for power flow control between utility and microgrid through back-to-back converters, which facilitates desired real and reactive power flow between utility and microgrid. In the proposed control strategy, the system can run in two different modes depending on the power requirement in the microgrid. In mode-1, specified amount of real and reactive power are shared between the utility and the microgrid through the back-to-back converters. Mode-2 is invoked when the power that can be supplied by the distributed generators (DGs) in the microgrid reaches its maximum limit. In such a case, the rest of the power demand of the microgrid has to be supplied by the utility. An arrangement between DGs in the microgrid is proposed to achieve load sharing in both grid connected and islanded modes. The back-to-back converters also provide total frequency isolation between the utility and the microgrid. The impact of dc side voltage fluctuation of the DGs and DG tripping on power sharing is also investigated. The model of the microgrid power system is simulated in MATLAB.

Keywords—microgrid, back-to-back, inter-link converter, voltage control mode, PQ control mode

I. INTRODUCTION

The interconnection of distributed generators (DGs) or embedded generators operating at remote end to the utility framework through power electronic converters has raised worry about legitimate load sharing between various DGs and the network. Microgrid can for the most part be seen as a bunch of appropriated generators associated with the primary utility matrix, as a rule through voltage-source-converter (VSC) based interfaces. Concerning the interfacing of a microgrid to the utility framework, it is essential to accomplish an appropriate load sharing by the DGs. A heap offering to negligible correspondence is the best in the circulation level as the system is intricate, can be reconfigured and traverse over an expansive territory. The most widely recognized strategy is the utilization of hang attributes. Parallel converters have been controlled to convey wanted genuine and receptive energy to the framework. The utilization of neighborhood motions as criticism to control the converters is alluring, since in a genuine framework, the separation between the converters may make a between correspondence unreasonable. In view of this, this paper proposes a design that is appropriate for providing electrical energy of high caliber to the microgrid, particularly when it is being provided through controlled converters. The genuine and receptive power sharing can be accomplished by controlling two autonomous amounts—the recurrence and the crucial voltage greatness [1-5]. The framework dependability amid stack sharing has been investigated in [2] and [3].

Transient dependability of energy framework with high infiltration level of energy gadgets interfaced (converter associated) disseminated age is investigated in [5-12]. In [11], the coordination of the rate of progress of recurrence (ROCOF) and under/finished recurrence transfers for disseminated age insurance considering islanding discovery and recurrence stumbling prerequisites is explained. The strategy depends on the idea of utilization district, which characterizes an area in the trigger time versus dynamic power awkwardness space where recurrence based transfers can be acclimated to fulfill the counter islanding and recurrence stumbling necessities all the while. When all is said in done, a microgrid is interfaced to the primary power framework by a quick semiconductor switch called the static switch (SS). It is fundamental to ensure a microgrid in both the matrix associated and the islanded methods of operation against all flaws. Inverter blame streams are constrained by the evaluations of the silicon gadgets to around 2 for every unit appraised current. Blame streams in islanded inverter based microgrids might not have sufficient extents to utilize customary overcurrent insurance procedures [12]. To conquer this issue, a dependable and quick blame discovery strategy is proposed in [13]. The point of this paper is to set up a power gadgets interfaced microgrid containing appropriated generators. A plan for controlling parallel associated DGs for legitimate load sharing is proposed. The microgrid is associated with the utility with back-toback converters. Bidirectional power stream control between the utility and microgrid is accomplished by controlling both the converters. The consecutive converters give the truly necessary recurrence and power quality separation between the utility and the microgrid. An appropriate hand-off breaker co-appointment is proposed for insurance amid shortcomings. The plan not just guarantees a fast and safe islanding at initiation of the blame, yet in addition a consistent resynchronization once the blame is cleared.

II. STRUCTURE AND OPERATION OF SYSTEM

A simple power system model is shown in Fig. 1.

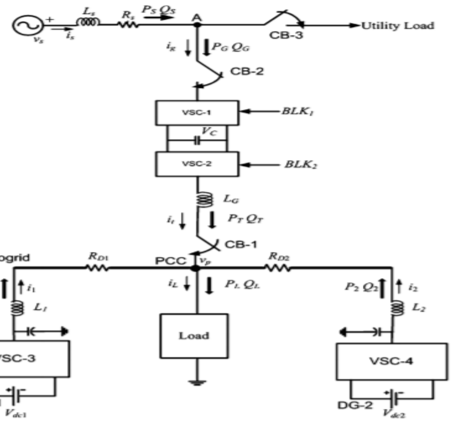

Fig. 1. The proposed microgird configuration

The framework can keep running in two unique modes relying upon the power necessity in the microgrid. In mode-1, a predefined measure of genuine and receptive power can be provided from the utility to the microgrid through the consecutive converters. Rest of the heap request is provided by the DGs. The power prerequisites are shared relatively among the DGs in light of their appraisals. At the point when the aggregate power age by the DGs is more than the heap necessity, the abundance control is sustained back to the utility. This mode gives a smooth operation in a legally binding course of action, where the measure of energy devoured from or conveyed to the utility is pre-indicated. At the point when the power necessity in the microgrid is more than the consolidated most extreme accessible age limit of the DGs (e.g., when cloud lessens age from PV), a pre-determined power spill out of the utility to the microgrid may not be feasible. The utility will at that point supply the rest of the power prerequisite in the microgrid under mode-2 control, while the DGs are worked at greatest power mode. When every one of the DGs achieve their accessible power confines, the operation of the microgrid is changed from mode-1 to mode-2. While mode-1 gives a safe legally binding concurrence with the utility, mode-2 gives more dependable power supply and can deal with substantial load and age vulnerability. The microgrid can't supply/ingest more power than the pre-indicated greatest cutoff. The rating necessity of the consecutive converters will rely upon the greatest power moving through them. The maximum power flow will occur when

• the load demand in the microgrid is maximum
• maximum power is generated by DGs

III. CONVERTER STRUCTURE AND CONTROL

The converter structure for VSC-3 is appeared in Fig. 1. DG-1 is thought to be a perfect dc voltage source The converter contains three H-spans. The yields of the H-spans are associated with three single-stage transformers that are associated in wye for required disengagement and voltage boosting [14]. The protection speaks to the exchanging and transformer misfortunes. In this paper, a LCL channel structure is smothered the exchanging sounds. The converters of the back-toback converters have same structure yet they are provided by the regular capacitor voltage as appeared in Fig.1. It is to be noticed that, while VSC-2 has a yield inductance (appeared in Fig. 1), VSC-1 is specifically associated with the point A without a yield inductance. The equal circuit of one period of the converter is appeared in Fig.2. The fundamental point of the converter control is to create the exchanging capacity. All the four VSCs are controlled using the above control strategy which is diagrammatically represented in Figure 3. Hence, all these controllers require the reference voltages which are the actual voltages at the particular instant.

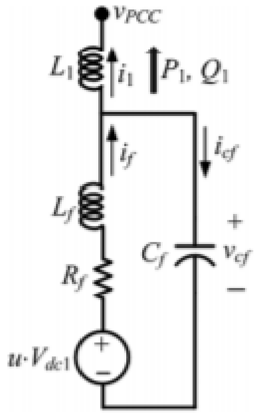

Fig.2. Electrical equivalent of converter

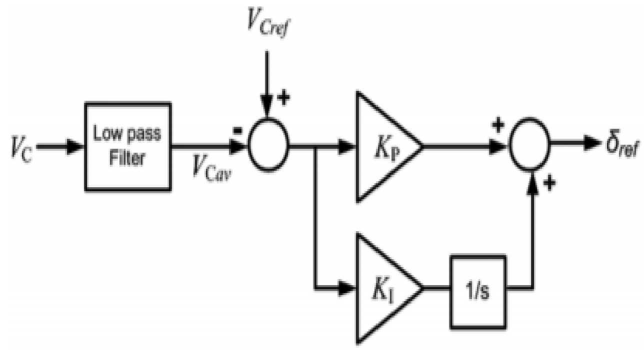

Fig.3 : Proposed converter control strategy

IV. BACK-TO-BACK CONVERTER REFERENCE GENERATION

This segment portray the reference age for the back-toback VSCs. Both the VSCs are provided from a typical capacitor of voltage as appeared in Fig.1. Contingent upon the power necessity in the microgrid, there are two methods of operation. Reference plot for VSC-1 is produced as appeared in Fig.3. In the first place the deliberate capacitor voltage is gone through a low pass channel and contrasted and the reference capacitor voltage. The mistake is bolstered to a PI controller to produce the reference edge. VSC-1 reference voltage size is kept steady, while edge is the yield of the PI controller. The immediate voltages of the three stages are gotten from them. It is to be noticed that the reference ages of the DGs are not the same as reference age of the consecutive converters. The control procedure for both the DGs is the same and subsequently just DG-1 reference age is examined here. It is accepted that in mode-1 the utility supplies a piece of the heap request through the consecutive converters and rest of the power request in the microgrid is provided and managed by the DGs.

V. SIMULATION STUDIES

Case-1: Load Sharing of the DGs With Utility

On the off chance that the power prerequisite of the heap in microgrid is more than the power produced by the DGs, the adjust control is provided by the utility through the consecutive converters. The coveted power stream the utility to the microgrid is controlled by (7) and (8), while hang (10) controls the sharing of the rest of the power. It is wanted that half of the heap is provided by the utility and rest of the heap is shared by DG-1 and DG-2. Fig. 10 demonstrates the genuine and receptive power sharing amongst utility and the DGs. Fig. 11(a) demonstrates the stage a reference and yield voltage, while three-stage voltage following mistake is appeared in Fig. 11(b). It can be seen that the following blunder is under 0.2%. Fig. 12 demonstrates the capacitor voltage and the yield of the point controller. At 0.1 s, the impedance of the heap is divided and at 0.35 s, it is changed back to its ostensible esteem. It can be seen that the framework experiences insignificant transient and achieves its relentless state inside five cycles (100 ms) for both the drifters.). The hang coefficients are picked with the end goal that both dynamic and responsive forces of the heap are separated in a proportion of 1:1.25 between DG-1 and DG-2.

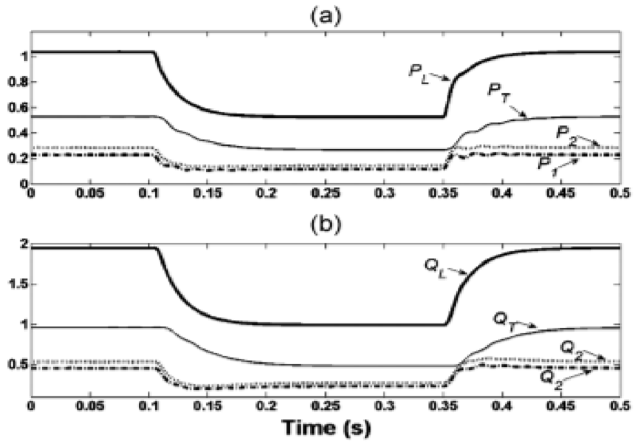

Fig.10 Real and reactive power sharing for Case-1

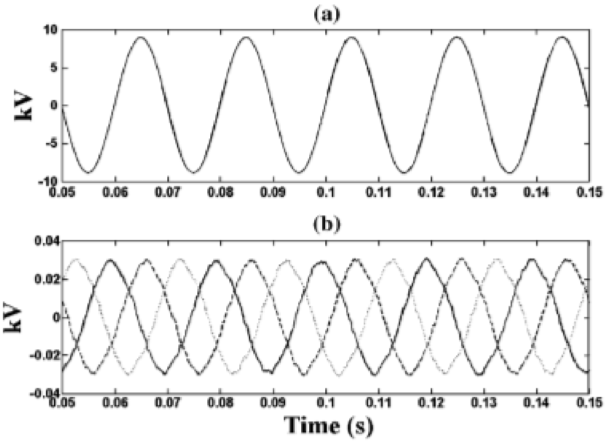

Fig. 11. Voltage tracking of DG-1 Case-1

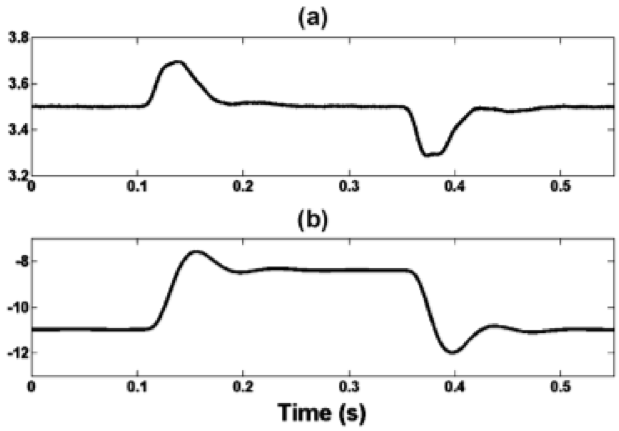

Fig.12. Capacitor voltage and angle controller output for Case-1.

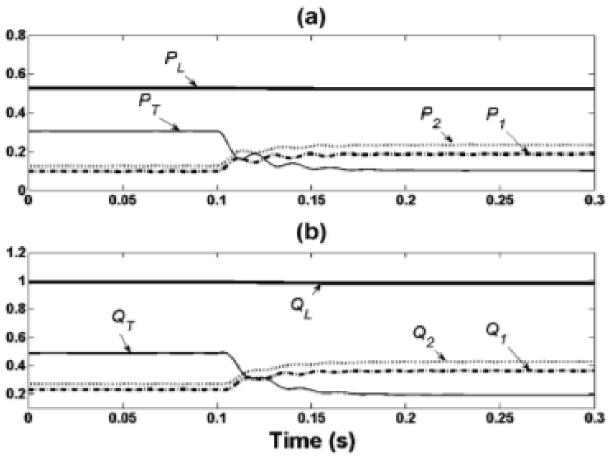

Fig. 13. Real and reactive power sharing for Case-2.

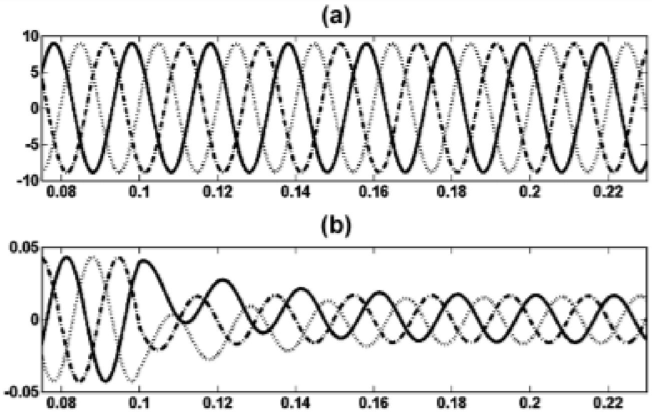

Fig.14. (a) PCC voltage (b) Current injected at PCC for case 2

Case-2: Change in Power Supply From Utility

On the off chance that the power spill out of the utility to the microgrid is changed by changing the power stream references for VSC-2, the additional power necessity is naturally gotten by the DGs. Fig. 13 demonstrates the genuine and receptive power sharing. Fig. 14 demonstrates the PCC voltage and change in current infusion at PCC from utility. It can be seen that the PCC voltage stayed adjusted and without transient, while the infused streams achieve unfaltering state inside four cycles.

Case-3: Power Supply From Microgrid to Utility

At the point when the power age of the DGs is more than the power necessity of the heap, abundance power can be nourished back to the utility through the consecutive converters. It is wanted that the utility supplies half of the microgrid stack at first. The DG yield builds naturally to supply the aggregate load power and energy to the utility, as apparent from Fig. 15. Fig. 16(a) demonstrates the stage a voltage at PCC. Fig. 16(b) demonstrates the three-stage current infused by the utility to the microgrid.

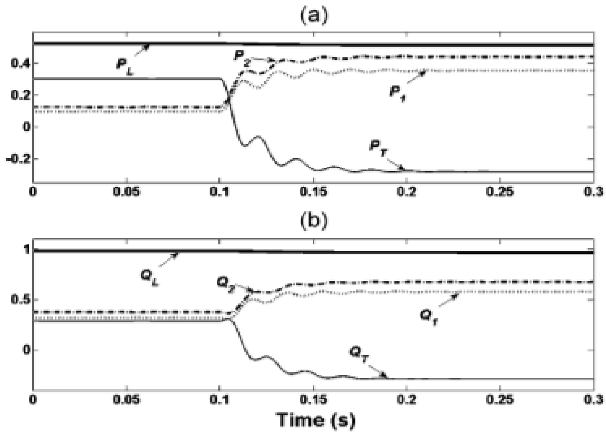

Fig. 15. Real and reactive power sharing during power reversal (Case-3)

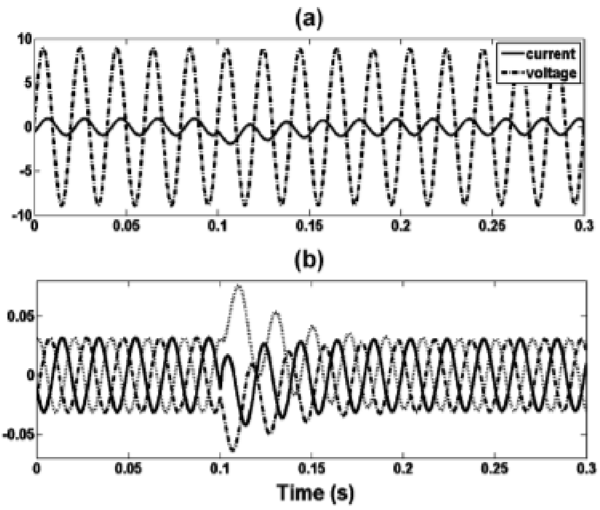

Fig. 16. PCC voltage and injected current for Case-3

Case-4: Load Sharing With Motor Load

In this area, stack imparting to the enlistment engine stack is examined. An impedance stack is a boundless sink. Toward the starting it is accepted that the utility supplies 0.2 MW of genuine power and 0.5 MVAr of receptive energy to the microgrid. At that point at 0.05 s, the power reference is changed with the end goal that the utility supplies 0.3 MVAR of responsive power and no genuine power. The power sharing outcomes for this case are appeared in Fig.

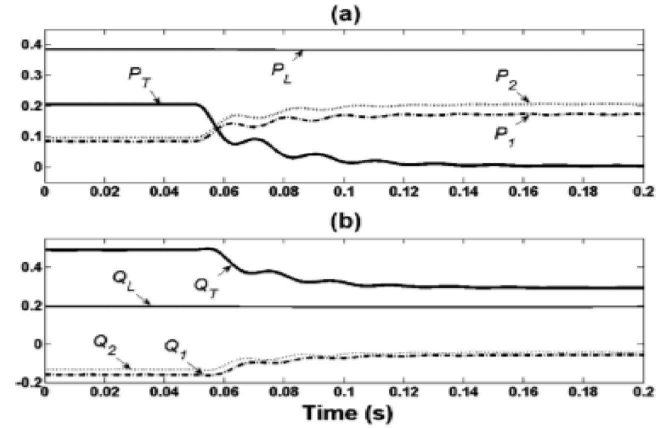

Fig. 17. Real and reactive power sharing with motor load

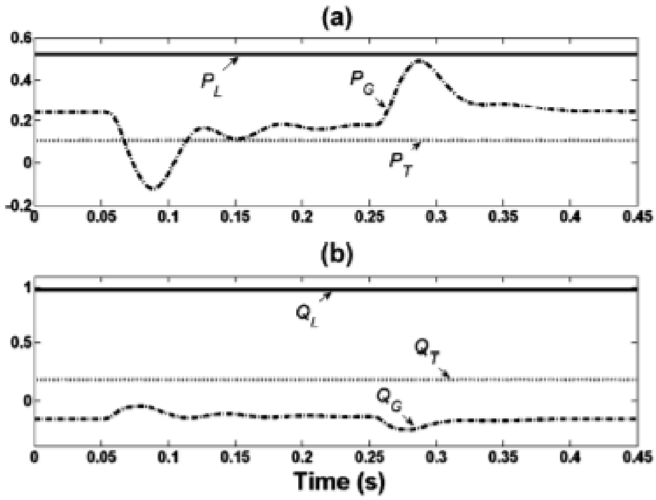

Fig. 18. Real and reactive power during frequency fluctuation

Case-5: Change in Utility Voltage and Frequency

Fig. 18 demonstrates the framework reaction for recurrence change in the utility side from 0.05 s to 0.25 s. At 0.05 s, the utility recurrence dropped by 0.5%, and at 0.25 s, it returns to its underlying estimation of 50 Hz. Fig. 19 demonstrates the power and the responsive power amid this condition. It can be seen that the heap control and the infused energy to the microgrid remain practically undisturbed. The dc capacitor voltage and the yield of the edge controller are appeared in Fig. 20. It can be seen that while the dc capacitor voltage is kept up at its pre-indicated esteem, the point drops in sensitivity for the source voltage drop to keep up the infused control consistent.

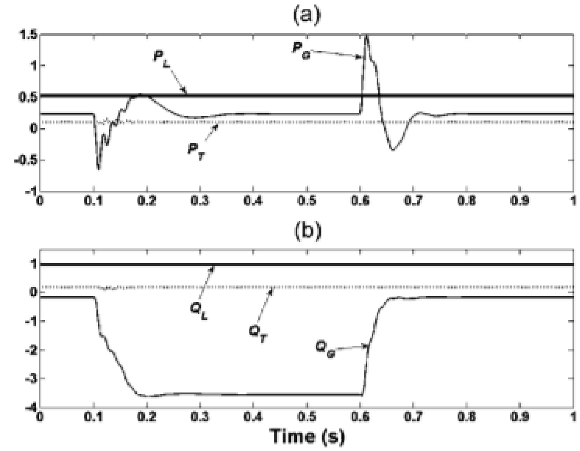

Fig. 19. Real and reactive power during voltage sag

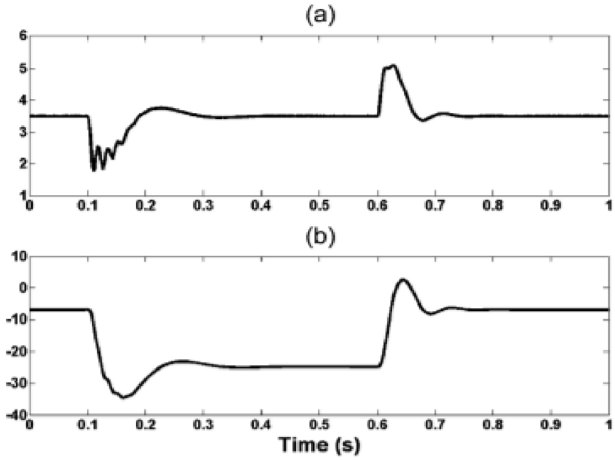

Fig. 20. DC capacitor voltage and angle controller

Case-6: Islanding and Resynchronization

A solitary line to ground blame happens at point F, which is somewhere between the utility source and point An, as appeared in Fig. 21. Amid this time, the consecutive converters begin nourishing the blame as appeared by in Fig. 21, which will bring about the fall of the capacitor voltage. The resynchronization procedure begins at 0.25 s when the Br_Close flag of CB-2 is produced. Therefore, at 0.35 s, the Br-Close flag of CB-1 is produced. The dc capacitor voltage and the point controller yield are appeared in Fig. 22. Fig. 23 demonstrates genuine and responsive power sharing.

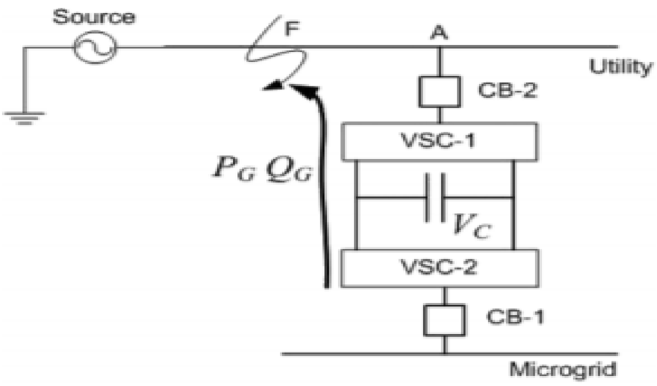

Fig. 21. Location of LG fault

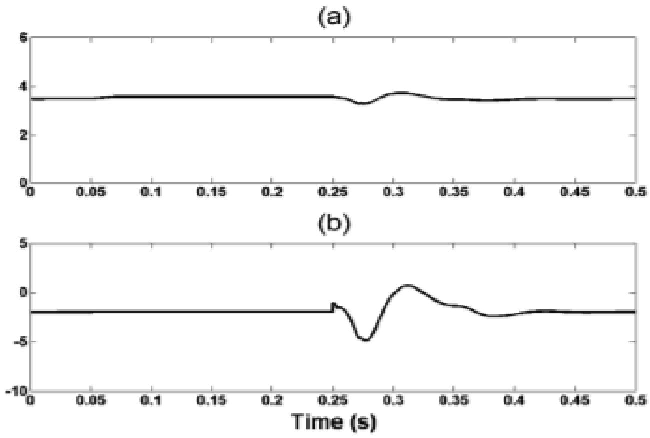

Fig. 22. DC capacitor voltage and angle controller

Case-7: Variable Power Supply From Utility

In cases exhibited above, it has been expected that the framework is running in mode-1 where DGs can supply the adjust of the heap prerequisite once the pre-determined measure of energy is drawn from the utility. The accompanying illustration demonstrates the change from mode-1 to mode-2 when the most extreme accessible power that can be provided by the DGs is come to. At first, the microgrid is running in mode 1. At 0.1 s, the info control from DG-1 all of a sudden decreases to 60 KW. DG-2 at that point supplies the setback as can be found in Fig. 24. This mode change is started with VSC-2 hang increases of and . The outcomes are additionally appeared in Fig. 24.

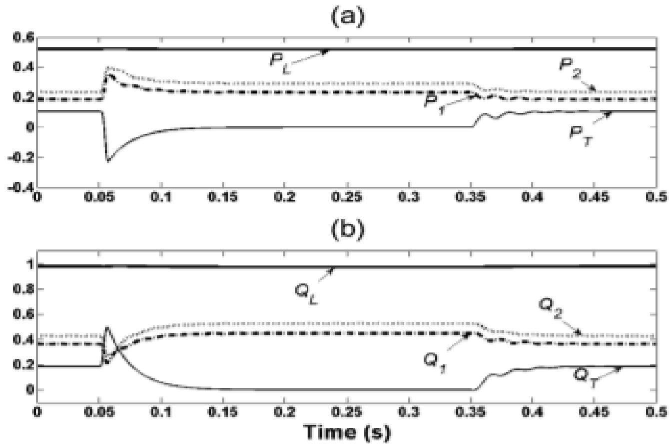

Fig. 23. Real and reactive power during islanding and resynchronization

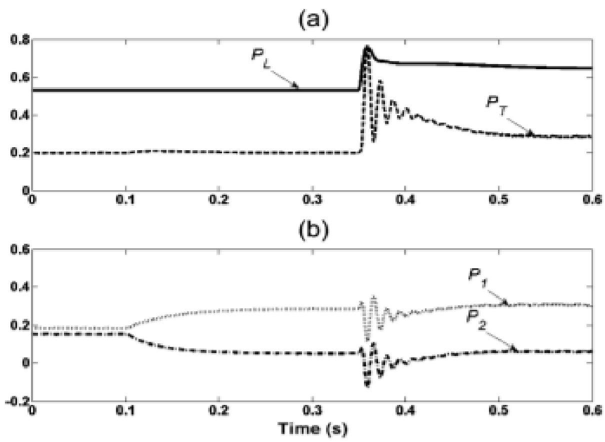

Fig. 24. Real power sharing during power limit and mode change

Case-8: DC Voltage Fluctuation and Loss of a DG

A reenactment is done in which it is expected that DG-2 is equipped for providing the abundance stack request, while the utility supplies the pre-determined measure of energy in mode-1. On the off chance that this isn't conceivable, a change to mode-2 will be essential, which isn't appeared here.

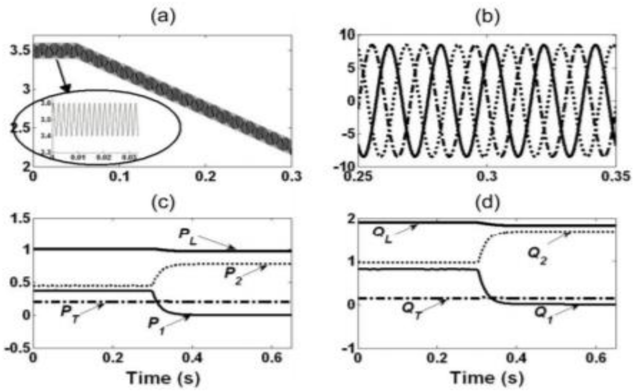

Fig. 25. DC voltage fluctuation in DG-1 and its tripping

The reproduction comes about for this case are appeared in Fig. 25. It can be seen that there is a slight drop in the heap control demonstrating a slight microgrid voltage drop. However the utility power stays unaltered and that provided by DG-2 increments.
To approve a legitimate load offering to different DGs, two more DGs are associated with the microgrid. The DG parameters, yield impedance, converter structure and controller are the same as those utilized for DG-1 and DG-2. The hang coefficients for the four DGs are picked with the end goal that they share both genuine and responsive power in the proportion of DG-1: DG-2: DG-3: DG-4 equivalent to 1:1.25:1.55:1.72. The heap is additionally circulated in three better places to accomplish a microgrid structure comparative as appeared in Fig. 26 with and . Fig. 27 demonstrates the genuine power sharing, where the heap control request is multiplied at 0.3 s, and took back to beginning an incentive at 0.8 s. It is obvious from the assume that a legitimate load sharing happens in the coveted proportion.

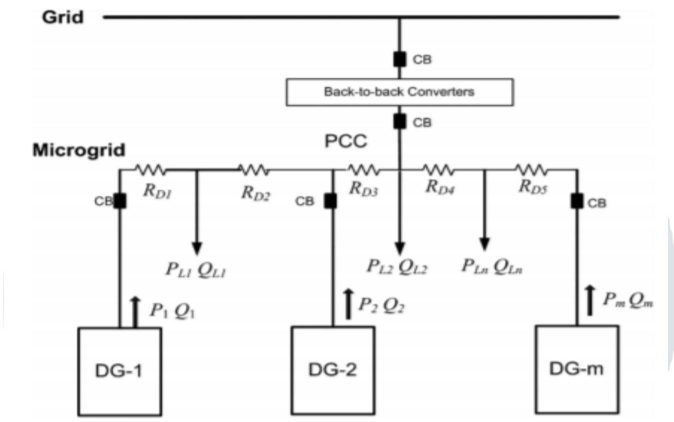

Fig. 26. Microgrid structure with large number of DGs and loads

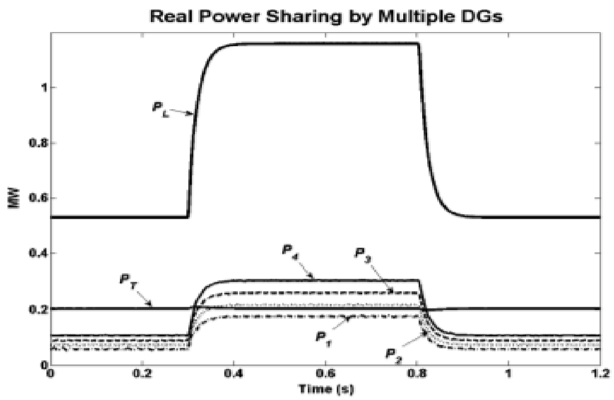

Fig. 27. Real power sharing with four DGs

VI. CONCLUSIONS

In this paper, a load sharing and power stream control system is proposed for an utility associated microgrid. The utility conveyance framework is associated with the microgrid through an arrangement of consecutive converters. In mode-1, the genuine and receptive power stream amongst utility and microgrid can be controlled by setting the predetermined reference control stream for consecutive converters module. Rest of the power prerequisite in the microgrid is shared by the DGs relative to their rating. If there should arise an occurrence of high power request in the microgrid, the DGs supply their greatest power, while rest of the power request is provided by utility through consecutive converters (mode-2). A communicate flag can be utilized by the DGs to show their mode change. However just privately measured information are utilized by the DGs and no correspondence is required for the heap sharing. The utility and microgrid are completely disconnected, and henceforth, the voltage or recurrence changes in the utility side don't influence the microgrid loads. Legitimate exchanging of the breaker and other power hardware switches has been proposed amid islanding and resynchronization process. The adequacy of the controller and framework strength is explored in various working circumstance with different sorts of loads.

REFERENCES

[1] F. Katiraei and M. R. Iravani, "Power management strategies for a microgrid with multiple distributed generation units," IEEE Trans. Power Syst., vol. 21, no. 4, pp. 1821–1831, Nov. 2006.
[2] M. Reza, D. Sudarmadi, F. A. Viawan, W. L. Kling, and L. Van Der Sluis, "Dynamic stability of power systems with power electronic interfaced DG," in Proc. Power Systems Conf. Expo. (PSCE'06), 2006, pp. 1423–1428.
[3] J. M. Guerrero, L. G. de Vicuna, J. Matas, M. Castilla, and J. Miret, "A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1205–1213, Sep. 2004.
[4] M. C. Chandorkar, D. M. Divan, and R. Adapa, "Control of parallel connected inverters in standalone ac supply systems," IEEE Trans. Ind. Appl., vol. 29, no. 1, pp. 136–143, Jan./Feb. 1993.
[5] J. G. Slootweg and W. L. Kling, "Impacts of distributed generation on power system transient stability," in Proc. IEEE Power Eng. Soc. Summer Meeting, 2002, vol. 2, pp. 862–867.
[6] L. Yunwei, D. M. Vilathgamuwa, and C. L. Poh, "Design, analysis, and real-time testing of a controller for multibus microgrid system," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1195–1204, Sep. 2004.
[7] A. L. Dimeas and N. D. Hatziargyriou, "Operation of a multiagent system for microgrid control," IEEE Trans. Power Syst., vol. 20, no. 3, pp. 1447–1455, Aug. 2005.
[8] J. A. P. Lopez, C. L. Moreira, and A. G. Madureira, "Defining control strategies for microgrid islanded operation," IEEE Trans. Power Syst., vol. 21, no. 2, pp. 916–924, May 2006.
[9] S. Chakroborty, M. D. Weiss, and M. G. Simoes, "Distributed intelligent energy management system for a single-phase high-frequency ac microgrid," IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 97–109, Feb. 2007.
[10] S. M. Brahma and A. A. Girgis, "Development of adaptive protection scheme for distribution systems with high penetration of distributed generation," IEEE Trans. Power Del., vol. 19, no. 1, pp. 56–63, Jan. 2004.
[11] J. C. M. Vieira, W. Freitas, W. Xu, and A. Morelato, "Efficient coordination of ROCOF and frequency relays for distributed generation protection by using the application region," IEEE Trans. Power Del., vol. 21, no. 4, pp. 1878–1884, Oct. 2006.
[12] H. Nikkhajoei and R. H. Lasseter, "Microgrid protection," in Proc. IEEE Power Eng. Soc. General Meeting, Tampa, FL, 2007.
[13] H. Al-Nasseri, M. A. Redfern, and R. O'Gorman, "Protecting microgrid systems containing solid-state converter generation," in Proc. Int. Conf. Future Power Systems, 2005.
[14] A. Ghosh and A. Joshi, "A new approach to load balancing and power factor correction in power distribution system," IEEE Trans. Power Del., vol. 15, no. 1, pp. 417–422, Jan. 2000.
[15] A. Ghosh, "Performance study of two different compensating devices in a custom power park," Proc. Inst. Elect. Eng., Gen., Transm., Distrib., vol. 152, no. 4, pp. 521–528, Jul. 2005.