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Enhance the Power Quality and Management of Power in Microgrid Applications

Bagam Srinivasarao*, SVNL Lalitha and Yerra Sreenivasarao*****

Abstract: Hybrid ac/dc micro-grids have been intended for the better association of different distributed generation frameworks (DG) associated with the Power network, drawing out the essential components of ac and dc micro-grids. In this paper we are exhibiting a micro-network comprising of different distributed generation (DG) units which are associated with the indigenous conveyance matrix. We have composed another energy-management algorithm utilizing which we can execute every one of the operations of these different DG units associated with the micro-network for all sort of availability operations. The proposed micro-matrix comprises of a photovoltaic (PV) exhibit which acts as the essential generation unit of the micro-lattice and a proton-exchange membrane fuel cell to supplement the fluctuation in the power created by the Photovoltaic cluster. A capacity battery (lithium-particle) planned is consolidated into the micro-framework to decrease top requests amid network associated operation and to make up for any lack in the created control amid islanded operation. The control get ready for the DG inverters uses another model prescient control algorithm which engages speedier computational time for unlimited power structures by overhauling the persevering state and the transient control issues freely. The framework thought is verified through various test circumstances to display the operational capacity of the proposed micro-matrix, and the acquired outcomes are inspected.

Keywords: Microgrid, renewable energy, distributed generation, power quality.

1. INTRODUCTION

The use of distributed power generation has been growing rapidly in the earlier decades. Appeared differently in relation to the conventional fused power generation, distributed generation (DG) units pass on immaculate and renewable power close to the customer's end [1]. Along these lines, it can help the push of various standard transmission and transport systems. As most by far of the DG units are interfaced to the framework using power equipment converters, they have the opportunity to acknowledge redesigned power generation through a versatile propelled control of the power converters[2]–[4].

The back and forth movement research is moreover based on accomplishing a more splendid network through Demand Side Administration (DSM), extending imperativeness spares and improving the power way of the scattering system, for instance, consonant pay for nonlinear weights [5]–[8]. The blend of renewable sources can supplement the generation from the apportionment matrix. In any case, these renewable sources are spasmodic in their generation and might exchange off the steadfast quality and relentlessness of the transport orchestrate. Along these lines, imperativeness stockpiling devices, for instance, batteries and ultra-capacitors, are required to compensate for the irregularity in the renewable sources.

In this paper, a micro-lattice containing a photovoltaic (PV) show, a proton-exchange membrane fuel cell (PEMFC), and a lithium-molecule stockpiling battery (SB) is proposed. The PEMFC is used as a fortification generator unit to compensate for the power delivered by the spasmodic method for the PV group. The SB is actualized for pinnacle sharing in the midst of framework related operation, and to supply

* EEE Department, Laqshya Institute of Technology & Sc, Khammam. *Email: srinu.bagam@gmail.com*
** EEE Department, KL University, Vijayawada. *Email: lalitha@kluniversity.in*
*** EEE Department, Newtons College of Engineering, Macherla. *Email: yerra.rao@gmail.com*

control for any lack in created control in the midst of islanded operation and to keep up the security of the scattering compose. The proposed controller for the inverters of DG units relies on upon an as of late made model predictive control (MPC) algorithm, which enhances the resolute state and the transient control issues autonomously. Thusly, the estimation time is remarkably diminished. In what takes after, this paper gives an expansive response for the operation of a micro-network which will in the meantime dispatch bona fide and responsive power in the midst of both matrix related and islanded operations, compensate for sounds in the pile streams, and perform best sharing and load shedding under different working conditions.

2. SYSTEM DESCRIPTION AND MODELING

Figure 1 demonstrates the setup of the micro-grid proposed in this paper is intended to work either in the grid associated or islanded mode. The principle DG unit involves a 40-kW PV cluster and a 15-kW PEMFC, which are associated in parallel to the dc side of the DG inverter 1 through dc/dc help converters to direct the dc-interface voltage of the DG inverter at the coveted level by conveying the vital power.

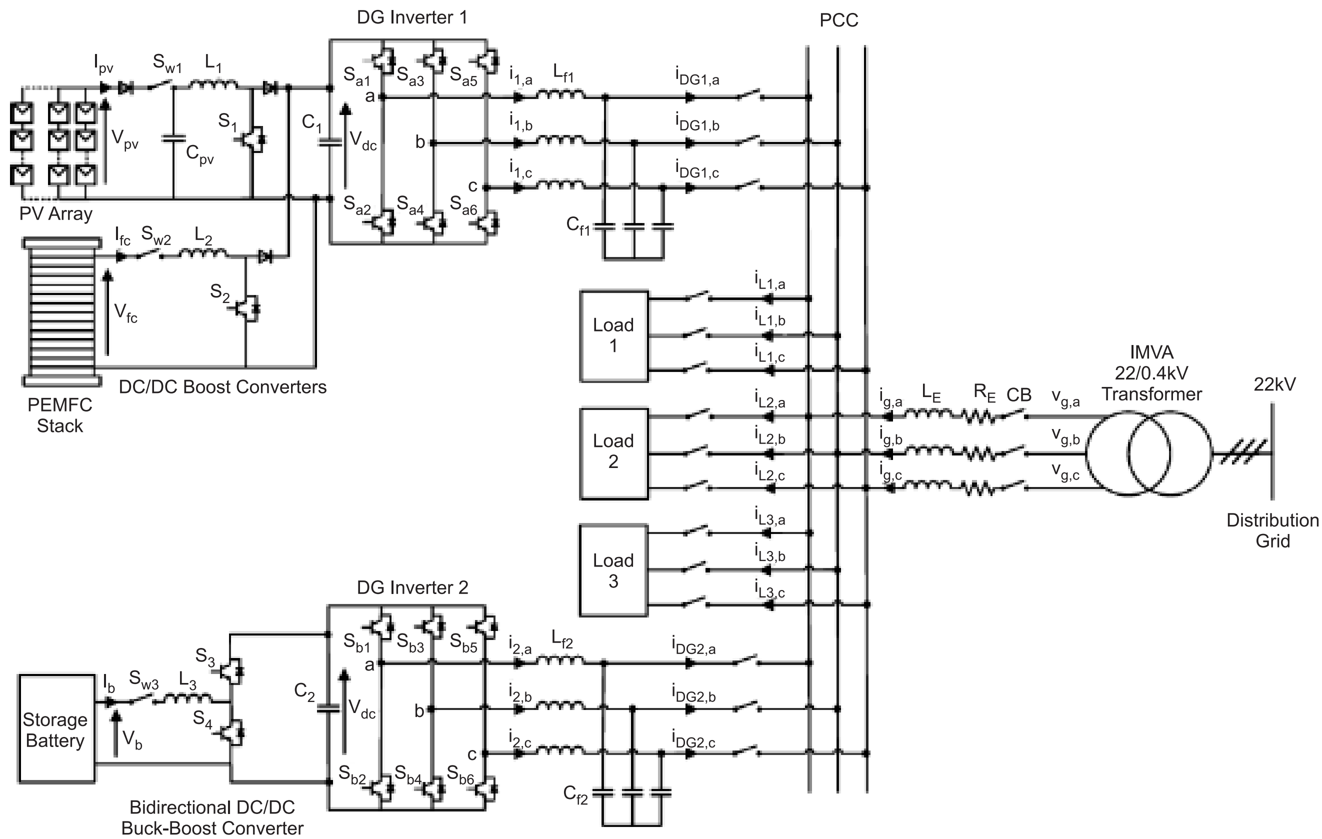

Figure 1: Overall configuration of the proposed micro-grid architecture

The PV cluster is actualized as the fundamental period unit and the PEMFC is used to go down the intermittent time of the PV display. Right when there is adequate sunlight, the PV show works in the MPPT mode to pass on most prominent dc control PPV, which is discussed in detail in [9] and [10], and the yield voltage of the PV cluster is permitted to vary inside an admissible range to ensure honest to goodness operation of the DG inverter. To keep up the level of the dc interface voltage Vdc at the required level, the PEMFC supplements the time of the PV display to pass on the basic P_{fc}. Exactly when the yield voltage of the PV cluster falls underneath a preset limit, the PV display is detached from the DG unit and the PEMFC capacities as the guideline period unit to pass on the required power. A 30-Ah lithium-molecule SB is connected with the dc side of DG inverter 2 through a bidirectional dc/dc buck-help converter to support the charging and discharging operations. In the midst of islanded operation, the part of the SB is to keep up the power alter in the micro-framework which is given by

$$P_{DG} + P_b = P_L \tag{1}$$

Where P_{DG} is the power conveyed by the fundamental DG unit, P_b is the SB control which is subjected to the charging and releasing limitations given by

$$P_b \leq P_{b,\, max} \tag{2}$$

P_L is the genuine power conveyed to the heaps. The vitality requirements of the SB are resolved in view of the state-of-charge (SOC) limits which are given as

$$SOC_{min} \leq SOC \leq SOC_{max} \tag{3}$$

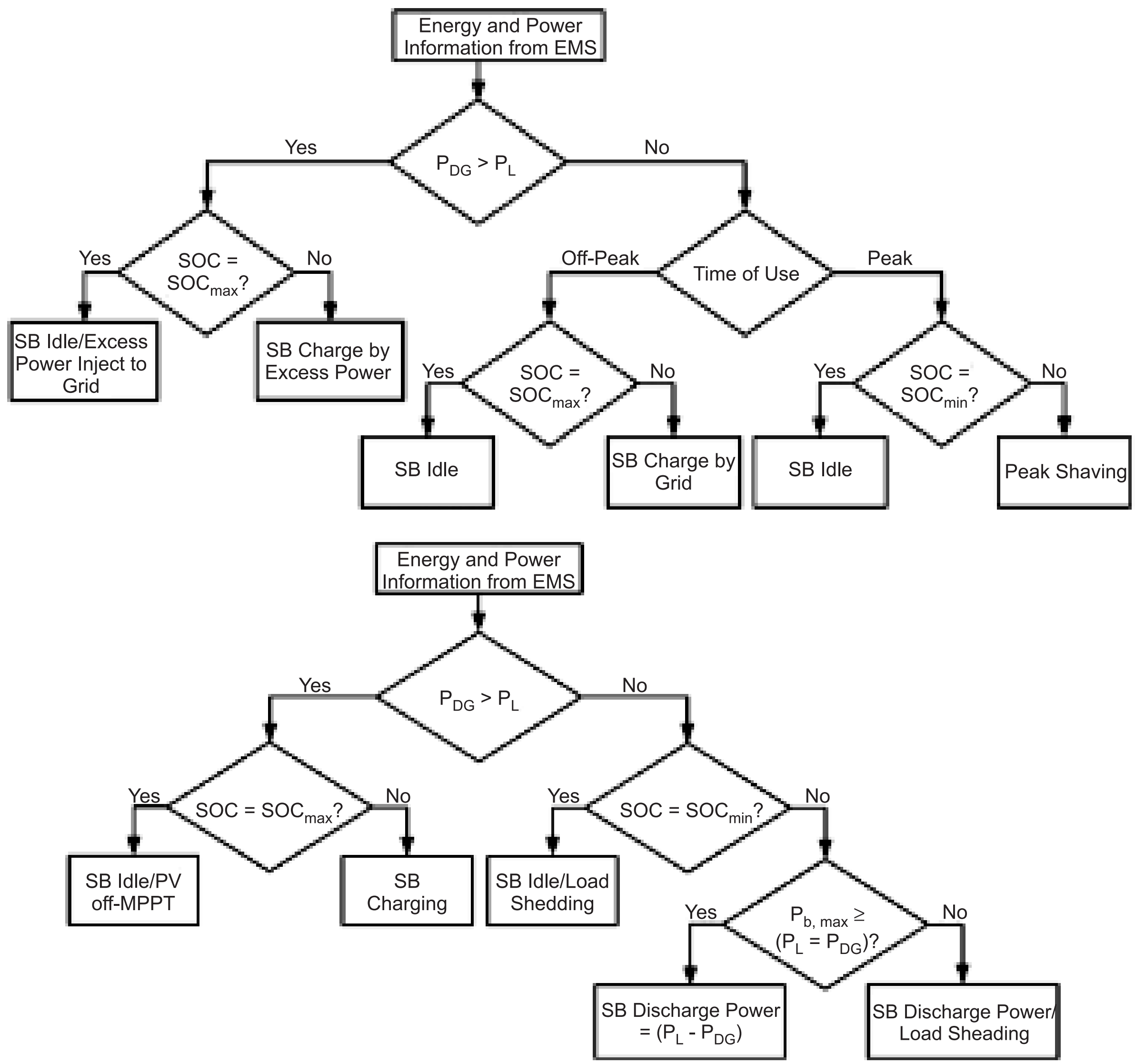

Figure 2 & 3: Operation of the SB during islanded operation

Regardless of the fact that the SOC of the battery can't be measured direct, it can be settled through a couple estimation procedures presented in [11] and [12]. Exactly when the micro-grid works islanded from the distribution grid, the SB can work in the charging, discharging, or sit out of rigging mode depending upon its SOC and Pb. The flowcharts in Figs. 2 and 3 pack the operation of the SB in perspective of the yield information gave by an imperativeness organization structure (EMS) in the midst of grid-related and islanded operation, exclusively. The EMS controls and screens unmistakable parts of drive organization, for instance, stack gaging, unit obligation, money related dispatch, and perfect power travel through a united server. Basic information, for instance, field estimations from adroit meters, transformer tap positions, and electrical switch (CB) status are altogether sent to the united server for get ready through Ethernet. In the midst of grid-related operation, the distribution grid is connected with the micro-grid at the reason for fundamental coupling (PCC) through an electrical switch (CB). The part of the rule DG unit capacities to give adjacent power and voltage support for the stacks and, hereafter, diminishes the heaviness of period and movement of constrain clearly from the distribution grid. With the duplication of constrain devices rigging being connected with the micro-grid, the store streams could be deformed on account of the proximity of symphonious parts. The DG units moreover capacity to compensate for any music in the streams drawn by nonlinear loads in the micro-grid, so that the sounds won't multiply to other electrical frameworks connected with the PCC. Generally, there are assortments in the power created by the PV display and that asked for by the loads. If the power made by the standard DG unit is more vital than the total load ask for in the micro-grid, the plenitude power can be used to charge the SB or injected into the distribution grid, dependent upon the SOC of the SB, as showed up in Figure 2. On the other hand, when the total load demand is more noticeable than the power made by the standard DG unit, the SB can be controlled to accomplish unmistakable imperativeness organization capacities depending upon its SOC and the season of utilization (TOU) of power. In the midst of off-pinnacle periods as showed up in Figure 2, when the cost of period from the grid is low and if the SB's SOC is underneath the most extraordinary SOC bind SOCmax, the SB can be charged by the grid and the stacks will be given by the essential DG unit and the grid. In the midst of pinnacle periods, when the cost of time from the grid is high and if the SB's SOC is over the base SOC control SOCmin, the SB can pass on energy to the grid to accomplish peak sparing.

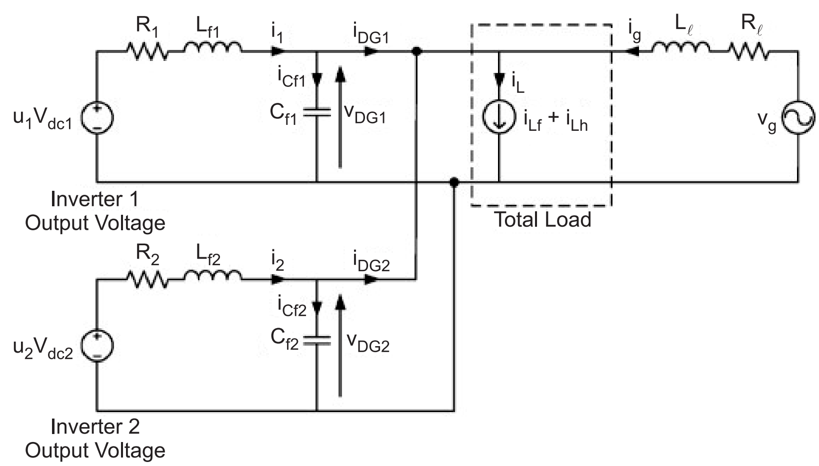

Figure 4: Equivalent single-phase representation of the DG inverters for grid connected operation.

Exactly when an accuse happens for the upstream arrangement of the distribution grid, the CB attempts to isolate the micro-grid from the distribution grid. The guideline DG unit and the SB are the sole power sources left to coordinate the heaps. For the circumstance when the period furthest reaches of the rule DG unit can't deal with the total load request, the SB is required to accommodate the lack in real and responsive energy to keep up the power modify and robustness of the micro-grid as showed up in Figure 3. Right when the total load ask for outperforms the period furthest reaches of the standard DG unit and the SB, the EMS recognizes a drop in the system repeat and load shedding for noncritical burdens is required to restore the structure repeat and keep up the robustness of the micro-grid.

3. DG INVERTER MODELING

Figures 4 and 5 show the equivalent single-phase representation of the DG inverters for grid-connected and islanded operation, respectively.

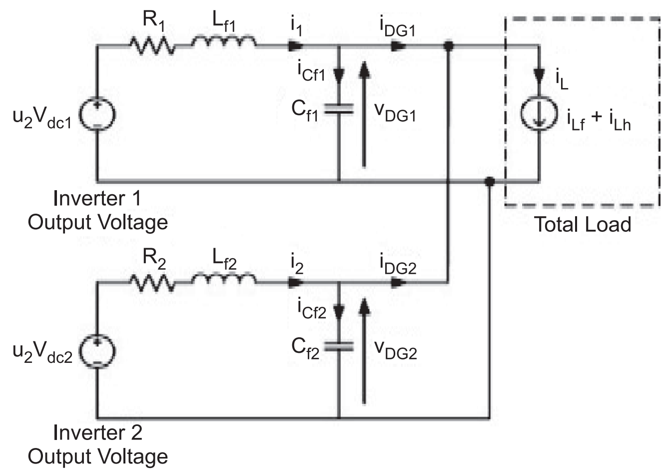

Figure 5: Equivalent single-phase representation of the DG inverters for islanded operation

In the grid-related mode, the grid voltage is known and the micro-grid confers the heap demand to the grid. From now on, to control the power passed on to the heaps, the yield current of the DG inverter is controlled using the current control mode (CCM). In the midst of islanded operation, the micro-grid will supply the general load ask for as showed up in Figure 5, and it is required that the yield voltage be coordinated to an immaculate sine wave with a settled enormity. This can be accomplished through the voltage-control mode (VCM). With the logical model presented in Section II-B, this paper proposes a novel MPC algorithm for the control of the DG inverters of the micro-grid. The proposed algorithm is an as of late made MPC algorithm especially planned for snappy testing structures, to track irregular banners with a specific end goal to deal with the twofold mode operation of the micro-grid. The algorithm separates the MPC progression into a continuing state sub-issue and a transient sub-issue, which can be fathomed in parallel in a dying down horizon frame. In addition, the tenacious state sub issue gets a dynamic system approach in which the computational versatile quality is portable. The deterioration furthermore allows the persisting state sub-issue to be settled at a lower rate than the transient sub-issue if essential.

These components accomplish a lower computational eccentrics and make it sensible for utilization in a fast testing structure like our micro-grid applications. In the generation focuses on in this paper, the reviewing between time is picked as 0.2ms, which is seen as truly little in customary MPC applications, however fundamental for the high demand of music being taken care of for our issue. As demonstrated by [13], looking at in the extent of numerous kHz is possible with condition of-the-craftsmanship code time strategies.

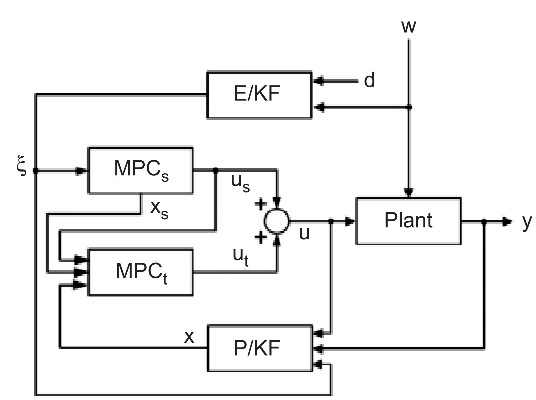

Figure 6 and 7: Overall MPC controller for the DG inverter with E/KF indicating the exogenous Kalmanfilter and P/KF meaning the plant Kalmanfilter

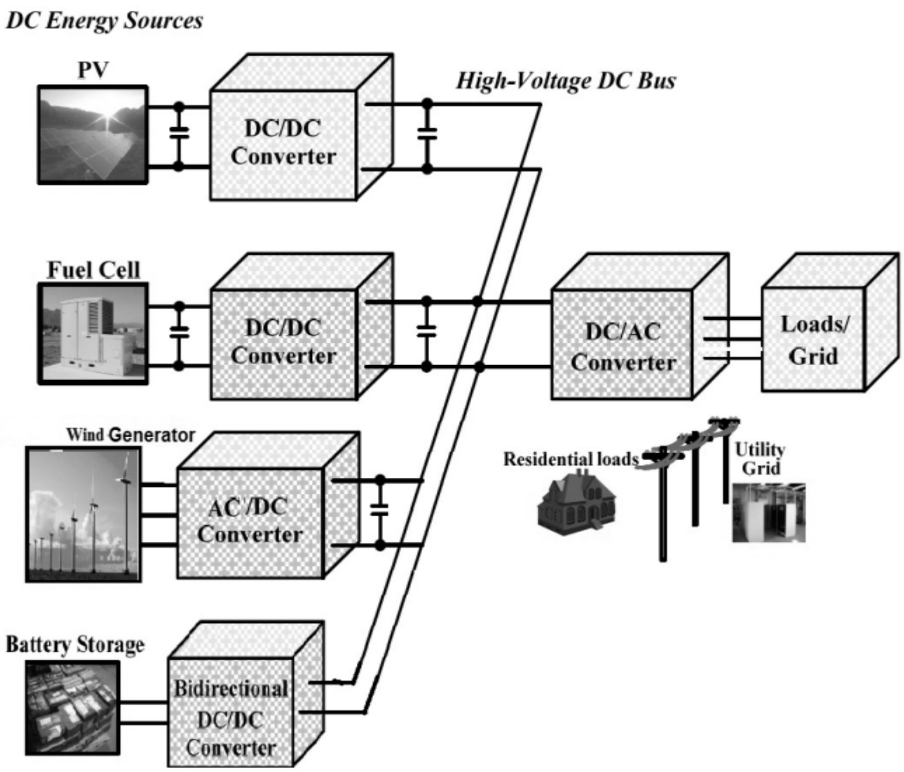

Figure 8: Schematic Diagram of Simulation Circuit

4. SIMULATION STUDIES

The simulation model of the micro-grid shown in Figure 1 is realized in Matlab/Simulink. The micro-grid is tested under various conditions to evaluate its capabilities when operating connected and islanded from the distribution grid.

Three distinctive load sorts comprising of linear and nonlinear burdens are considered in the studies. For load 1, a 15-kVA three-stage PWM customizable speed drive (ASD) with its arrangement as appeared in Figure 8 is utilized and stack 2 is comprised of a three-stage RL stack appraised at P_{L2} = 28 KW and Q_{L2} = 18.5 KVAr. Stack 3 is a noncritical three-stage dimmer load appraised at P_{L3} = 18 KW and Q_{L3} = 12.3 KVAr. Which is nonlinear in nature and will be shed under crisis conditions when the generation of the micro-grid can't take care of the heap demand? The per-stage currents i_{L1}, i_{L2}, i_{L3} and drawn by burdens 1, 2, and 3 for $0 \leq t \leq 0.2$ s are appeared in Figure 9.

A. Experiment 1: Power Quality Improvement with Load-Sharing During Grid-Connected Operation

The first experiment shows the capacity of the micro-grid to enhance the power nature of the distribution organize by making up for the harmonics in the total load current iL because of the nonlinear burdens that are associated with the distribution system, to such an extent that the harmonics won't proliferate to whatever is left of the distribution arrange amid grid-associated operation. In this experiment, the fundamental DG unit accounts for 20% of the total load request. The SB is working in the charging mode to store energy amid off-pinnacle period where the cost of generation from the grid is low to meet future sudden requests for power. The SB current I_b (as appeared in Figure 1) and the SOC amid charging for $0 < t < 0.06$ s are because of the fact that the controller needs a time of 3 cycles to track the created references. Amid unfaltering state condition, the total harmonic distortion (THD) estimation of i_L is 42.1% as appeared in Figure 12 (beat). With the principle DG unit making up for the harmonic currents as appeared in Figure 12 (center), the THD estimation of i_g is enhanced to around 0.4% as appeared in Figure 12 (base). To achieve power factor rectification at the grid side, the primary DG unit is likewise controlled to give the reactive part $i\_(Lf, q)$ of the current i_L as given in (5). Figure 13 demonstrates quit for the day of the grid voltage V_g and I_g of stage a for .It is watched that the waveform of I_g is in stage with that of V_g with power factor adjustment.

The total genuine and reactive power conveyed to the heaps is around 58 kW and 35 kVAr as appeared in the power waveforms of Figure 14. The genuine power dispatched by the fundamental DG unit is 11.6 kW (20% of the genuine power devoured by the heaps) as appeared in Figure 15, which shows the capacity of the primary DG unit to dispatch the required power. The primary DG unit likewise conveys the greater part of the reactive power required by the heaps to achieve unity power factor at the grid side. The genuine and reactive power conveyed by the grid is appeared in Figure 16. It can be seen from Figure 16 that the grid supplies 80% (46.4 kW) of the total genuine power conveyed to the heaps and dispatches an extra power of around 3 kW to charge the SB. It is likewise watched that the reactive power provided by the grid is zero, bringing about unity power factor at the grid side.

B. Experiment 2: Peak Sharing of Loads during Peak Periods

The power valuing in numerous nations is impacted by the TOU taxes. In DSM, energy-stockpiling gadgets can be utilized to lessen the weight of generation of power specifically from the distribution grid amid pinnacle periods. The second experiment exhibits the operation of the micro grid to achieve crest sharing keeping in mind the end goal to diminish the cost of generation from the grid when buyers practice DSM. Figure 17 demonstrates a commonplace hourly request reaction bend in a day showed by the strong line. As in experiment 1, the principle DG unit is controlled to convey 20% of the heap request. To achieve top sharing at 11:00 h, the SB is working in the release mode to give 20% (11.6 kW) of the heap request. With a further lessening of 20% in the power provided by the grid, the total load request at 11:00 h is diminished by a total of 40%.

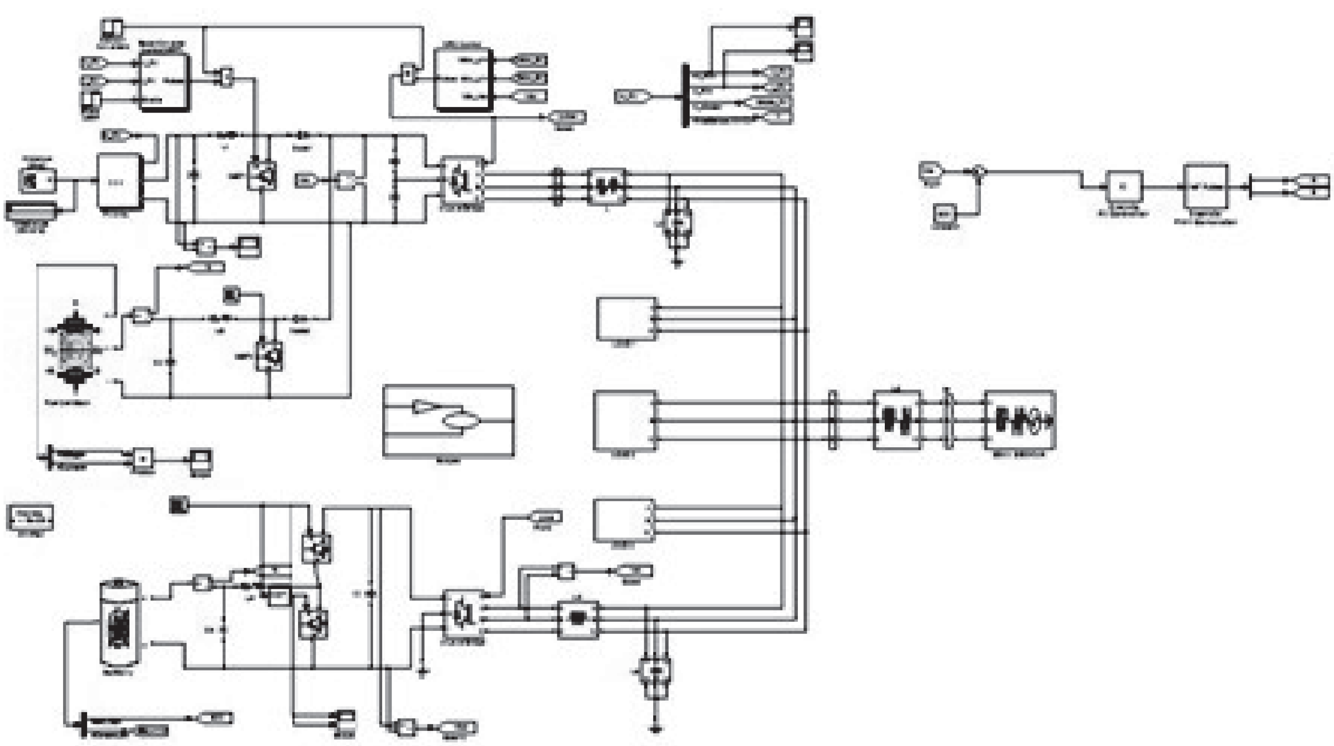

Figure 9: Grid Connected Operation

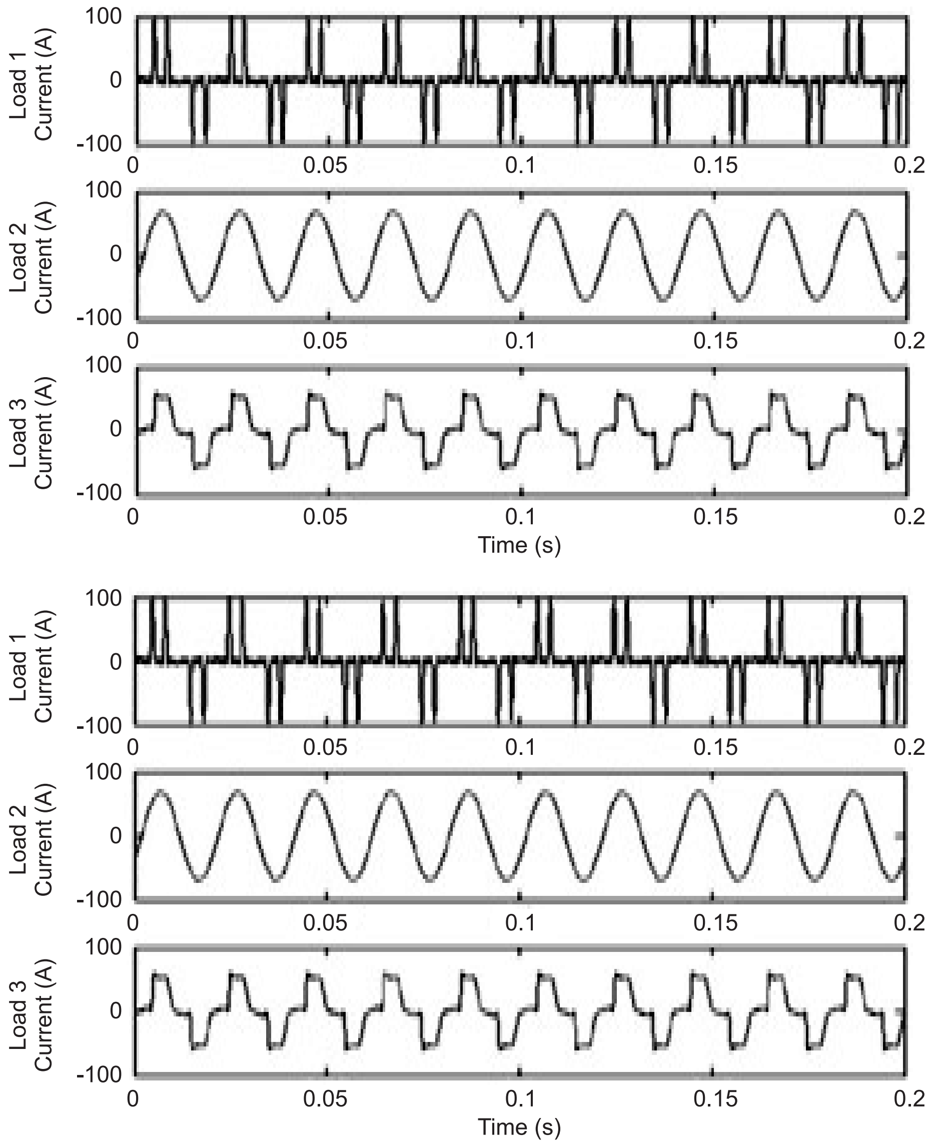

Figure 10: Per phase currents drawn by loads 1, 2 and 3

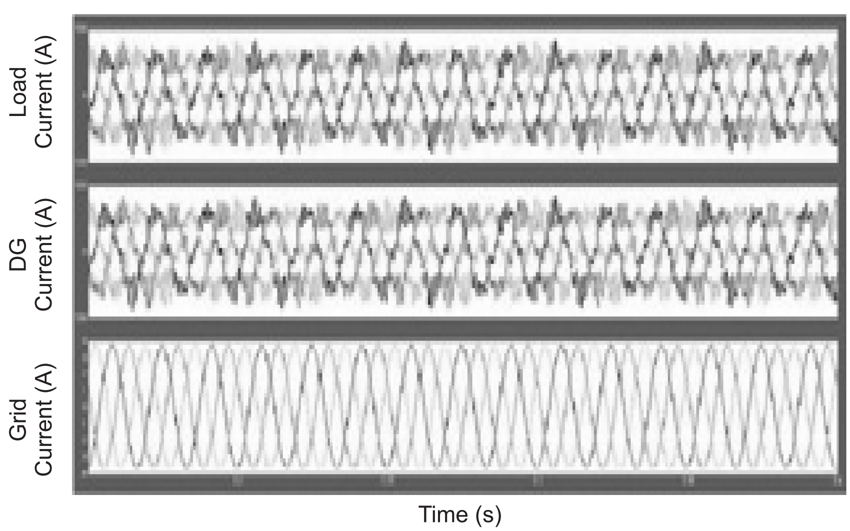

Figure 11: Three phase load current, three phase DG current, and three phase grid current

Figure 12: Real and reactive power delivered by the main DG unit

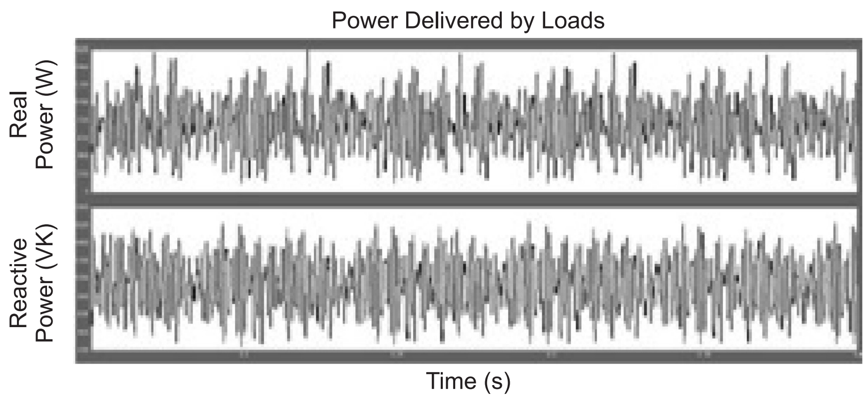

Figure 13: Real and reactive power consumed by loads

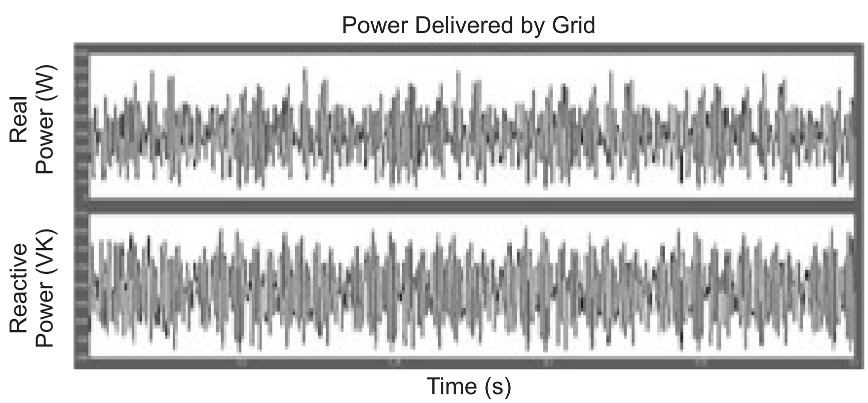

Figure 14: Real and reactive power delivered by the grid

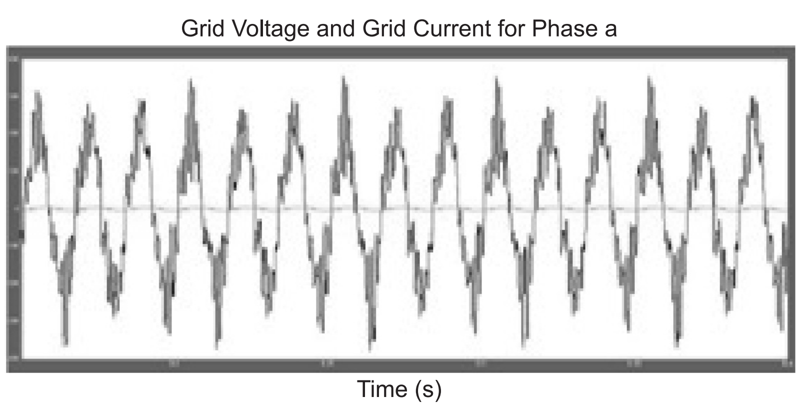

Figure 15: Grid voltage and grid current per phase

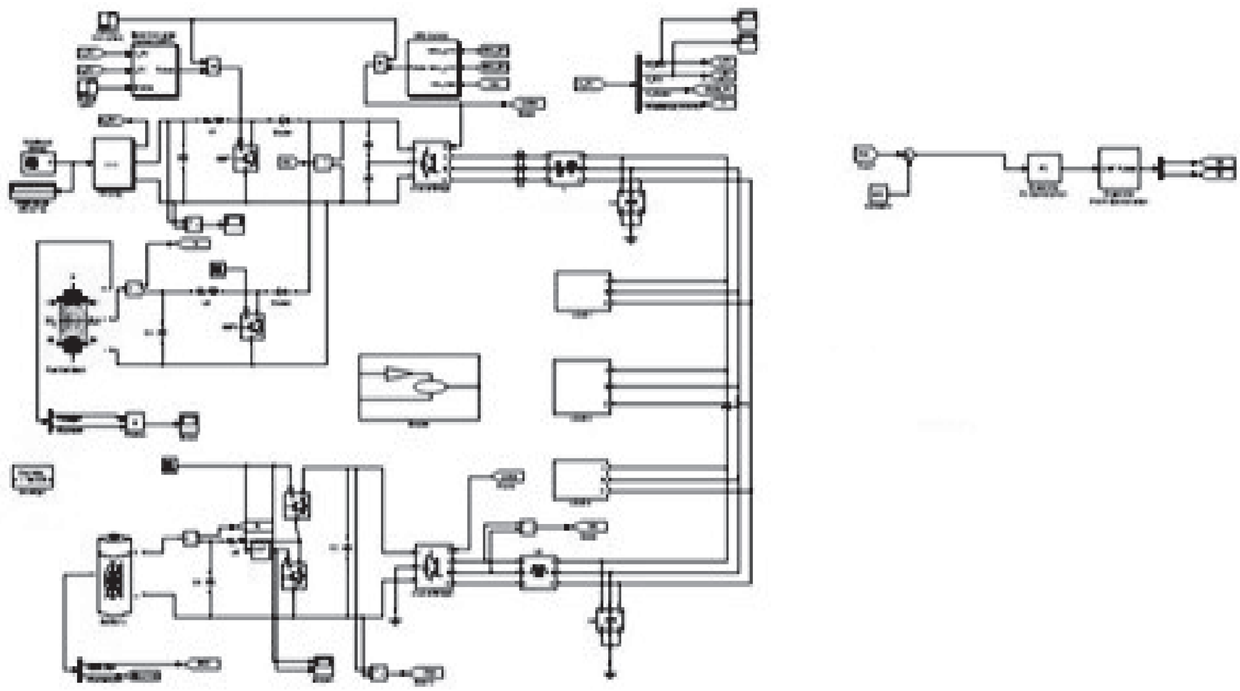

Figure 16: Islanded operation

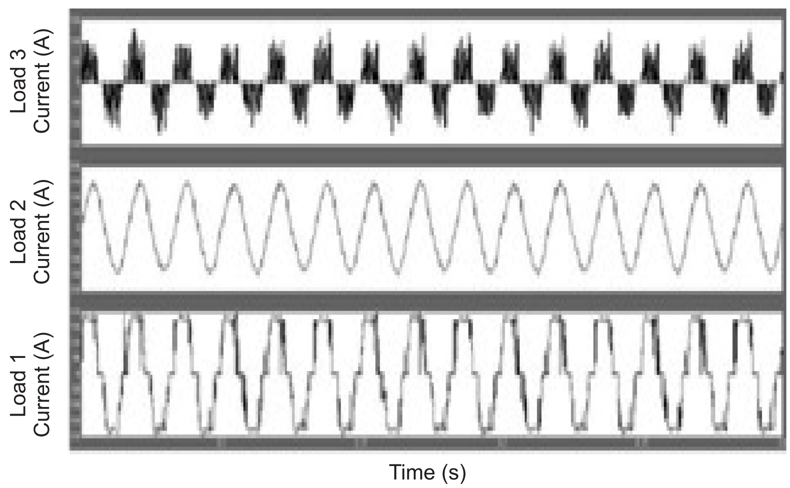

Figure 17: Per phase currents drawn by loads 1, 2 and 3

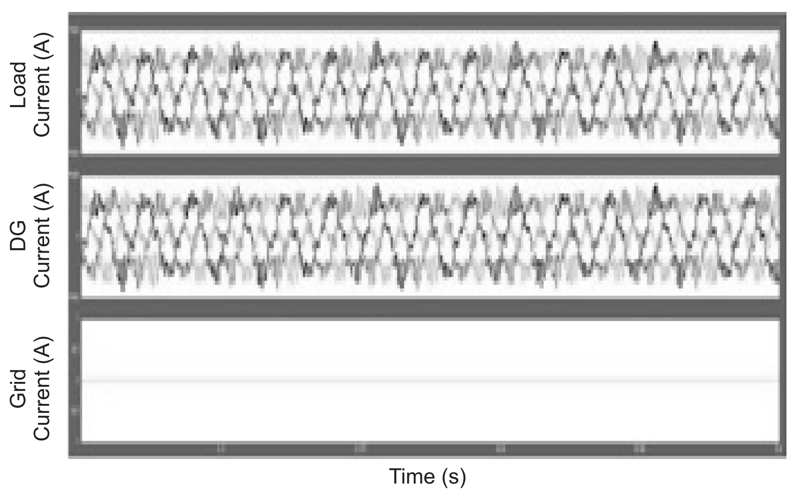

Figure 18:Three phase load current, three phase DG current, and three phase grid current

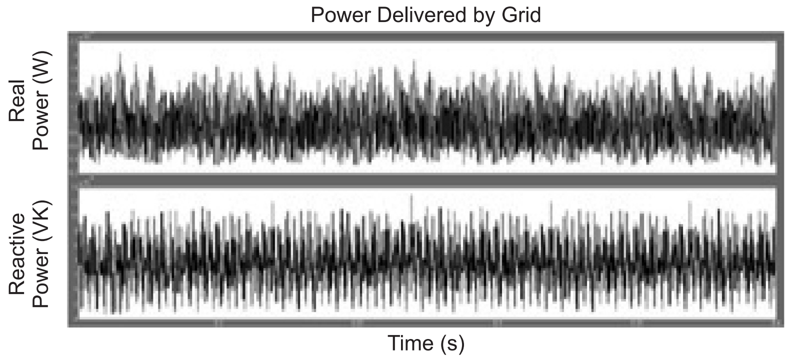

Figure 19: Real and Reactive power delivered by main DG unit

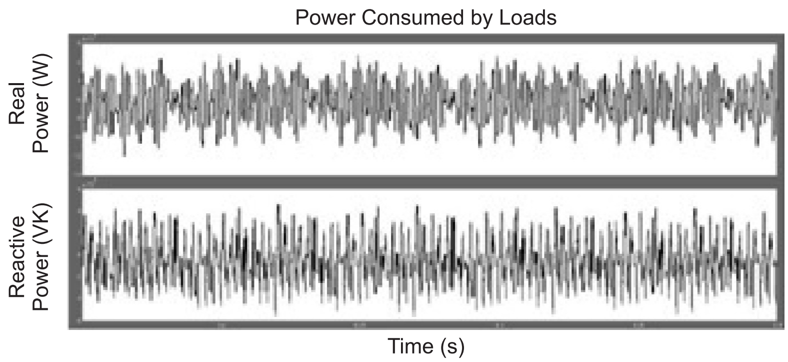

Figure 20: Real and reactive power consumed by loads

5. CONCLUSION

In this paper, we have presented a control system that coordinates the operation of multiple distributed generation inverters in a micro-grid for grid-connected and islanded operations. The proposed controller for the distributed generation inverters is based on a newly developed model predictive control algorithm which decomposes the control problem into steady-state and transient sub problems in order to reduce the overall computation time.

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