

A NOVAL METHOD FOR IMPROVING POWER QUALITY OF THE DISTRIBUTION SYSTEM CONNECTED TO THE MICROGRID

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Abstract:- This project presents a flexible ac distribution system device for microgrid applications. The device aims to improve the power quality and reliability of the overall power distribution system that the microgrid is connected to. The control design employs a new model predictive control algorithm which allows faster computational time for large power systems by optimizing the steady-state and the transient control problems separately. Extended Kalman filters are also employed for frequency tracking and to extract the harmonic spectra of the grid voltage and the load currents in the microgrid. The design concept is verified through different test case scenarios to demonstrate the capability of the proposed device and the results obtained are discussed. Detailed simulations to support the same have been carried out in MATLAB, and the results are presented.

1. INTRODUCTION

The idea of micro grid network has offered purchasers with expanded unwavering quality and decrease in all out vitality misfortunes, and has turned into a promising option for customary influence conveyance system. One range of study for the association of a microgrid to the appropriationsystemis the effect of force quality (PQ) issues on the general powersystemexecution. These PQ issues incorporate voltage and recurrence deviations in the network voltage and sounds in the lattice voltage and load streams.

To overcome the previously mentioned PQ issues, a few power-molding types of gear, for example, dynamic channels, uninterruptible power supplies, dynamic voltage restorers, and brought together PQ conditioners are generally utilized by purchasers to ensure their heaps and systems against PQ unsettling influences in the conveyance arrange. Notwithstanding, these devices are normally introduced at the buyer sides and the PQ issues that they are fit to deal with are generally restricted.

In any case, dc control from photovoltaic (PV) boards or energy units must be changed over into air conditioning utilizing dc/dc sponsors and dc/air conditioning inverters keeping in mind the end goal to interface with an air conditioner system. In an air conditioner system,

inserted air conditioning/dc and dc/dc converters are required for different home and office offices to supply diverse dc voltages. Air conditioning/DC/AC converters are generally utilized as drives so as to control the speed of air conditioning engines in modern plants. The keen matrix idea is right now winning in the electric power industry. The goal of building a shrewd lattice is to give solid, amazing electric energy to computerized social orders in an earth well disposed and feasible way.

One of most essential fates of a keen matrix is the propelled structure which can encourage the associations of different air conditioning and dc era systems, vitality stockpiling choices, and different air conditioning and dc loads with the ideal resource usage and operation effectiveness. To accomplish those objectives, control devices innovation assumes a most essential part to interface distinctive sources and loads to a keen matrix. This venture proposes a cross breed air conditioning/dc miniaturized scale network to decrease the procedures of numerous dc-ac-dc or ac-dc-ac transformations in an individual air conditioning or dc system. The half breed matrix comprises of both air conditioning and dc systems associated together by multi-bidirectional converters. Air conditioning sources and loads are associated with the air conditioner arrange though dc sources and loads are fixing to the dc organize. Vitality stockpiling systems can be associated with dc or air conditioning grid. The proposed cross breed network can work in a lattice tied or self-ruling mode. The coordination control calculations are proposed for smooth power exchange amongst air conditioning and dc grid and for stablesystemoperation under different era and load conditions. Vulnerability and irregular qualities of wind speed, sunlight based illumination level, surrounding temperature, and load are additionally considered in system control and operation

2. LITERATURE SURVEY

The insights about Certs microgrid research facility test bed can be clarified from [1] R. Lasseter, J. Eto, B. Schenkman, J. Stevens, H. Vollkommer, D. Klapp, E. Linton, H. Hurtado, and J. Roy, "Certs microgrid research center proving ground, and brilliant loads," IEEE Trans. Control Del., vol. 26, no. 1, pp. 325-332, Jan. 2011. The insights about Distributed Generation can be clarified

from [2] A. Chambers, S. Hamilton, and B. Schnoor, Distributed Generation: A Nontechnical Guide. Tulsa, OK, USA: PennWell, 2001. The insights about Combined system for consonant concealment and receptive power pay can be clarified from [3] A. Luo, Z. Shuai, W. Zhu, and Z. J. Shen, "Consolidated system for symphonies concealment and responsive power remuneration," IEEE Trans. Ind. Electron., vol. 56, no. 2, pp. 418–428, Feb. 2009. The insights about Improvement of force quality utilizing versatile shunt dynamic channel can be clarified from [4] L. H. Tey, P. L. Thus, and Y. C. Chu, "Change of force quality utilizing versatile shunt dynamic channel," IEEE Trans. Control Del., vol. 20, no. 2, pp. 1558–1568, Apr. 2005. The insights around An on-line UPS system can be clarified from [5] A. Nasiri, Z. Nie, S. B. Bekiarov, and A. Emadi, "An on-line UPS system with control figure rectification and electric disconnection utilizing BIFRED converter," IEEE Trans. Ind. Electron., vol. 55, no. 2, pp. 722–730, Feb. 2008. The insights about Robust model after control of parallel can be clarified by [6] M. Pascal, G. Garcer'a, E. Figures, and F. G. Esp'in, "Strong mode following control of parallel UPS single-stage inverters," IEEE Trans. Ind. Electron., vol. 55, no. 8, pp. 2870–2883, Aug. 2008.

3. MICROGRID

It is a little scale control supply arrange that is intended to give energy to a little group. It empowers nearby power era for neighbourhood loads. It includes different little power creating sources that makes it exceedingly adaptable and efficient. It is associated with both the nearby producing units and the utility grid accordingly averting power outages. Excess power can be sold to the utility grid. Size of the Micro grid may go from lodging domain to city areas.

4. HIGH POWER QUALITY MICRO GRID WITH CCHP

Micro grid segments must take after distributed and attachment and-play ideas to protect high power quality and viable utilization of waste warmth. Each source is associated in a distributed manner with a restricted control conspire actualized for every part. This game plan expands the unwavering quality of the system in contrast with having an ace slave or brought together control plot. On account of ace slave controller design the disappointment of the ace controller could bargain the operation of the entire system. Fitting and play ideas permit us to grow the micro grid to meet the necessities of the site without broad re-designing. This suggests the micro grid can keep working with loss of any part or generator. With one extra source, (N+1), we can safeguard finish usefulness with the loss of any source. The attachment and-play demonstrate encourages putting generators close to the warmth loads in this manner permitting more successful utilization of waste warmth without complex warmth appropriation

systems, for example, steam and chilled water funnels. Dispatch capable micro sources, for example, little factor speed inside burning (IC) motor driving a synchronous generator or a micro turbine require an inverter interface. Sources require a quick reaction vitality stockpiling module to limit the effects of source elements on the micro grid operation.

The capacity can be batteries or super capacitors that are associated with the dc transport of each source. DC stockpiling has a few points of interest over air conditioning stockpiling. Initially, the dc stockpiling decouples elements of a source from those of the micro grid. Second, the dc stockpiling elevates shared ideas, where each source has the vitality stockpiling required for a quick element reaction and is not reliant to a focal air conditioning stockpiling system. This separately advances high dependability since loss of one stockpiling module does not altogether affect the operation of micro grid. Conversely, the passing of a focal AC stockpiling system can extraordinarily decrease the usefulness of the micro grid. High power quality micro grids have been effectively learned at the AEP/CERTS Micro grid Test offices

5. PROPOSED CONCEPT

The idea of micro grid has offered purchasers with expanded unwavering quality and decrease in absolute vitality misfortunes, and has turned into a promising option for conventional influence dispersion system. One territory of study for the association of a micro grid to the dissemination grid is the effect of force quality (PQ) issues on the general power system execution. These PQ issues incorporate voltage and frequency deviations in the grid voltage and sounds in the grid voltage and load streams. To overcome the previously mentioned PQ issues, a few power-melding types of gear, for example, dynamic channels uninterruptible power supplies dynamic voltage restorers and brought together PQ conditioners are normally utilized by buyers to ensure their loads and systems against PQ unsettling influences in the appropriation arrange.

Nonetheless, these devices are generally introduced at the purchaser sides and the PQ issues that they are fit to deal with are typically constrained. This venture proposes an adaptable air conditioning dissemination system device for the micro grid that is acknowledged utilizing a mix of arrangement and shunt voltage source inverters (VSIs). The proposed device is introduced at the purpose of basic coupling (PCC) of the dispersion grid that the micro grid and other electrical loads are associated with. The proposed hotspot for the dc-connect voltage of the adaptable air conditioning dissemination system device comprises of a photovoltaic (PV) exhibit and a battery to store the abundance vitality produced by the PV cluster and to give control amid sunless hours.

The device is outfitted with the capacity to enhance the PQ and unwavering quality of the micro grid. Moreover,

amid islanded operation of the micro grid, the device can give genuine and responsive energy to the micro grid. The proposed controller depends on a recently created display prescient control (MPC) calculation to track occasional reference signals for quick inspecting straight time invariant (LTI) systems that are liable to information requirements. This control strategy controls the info signs of the VSIs and breaks down the control issue into consistent state and transient sub issues which are advanced independently. Along these lines, the computational circumstances can be incredibly decreased. In what takes after, this venture gives an exhaustive answer for the operation of the adaptable air conditioning conveyance system device for a micro grid in view of a multi-input-multi-yield (MIMO) state-space demonstrates. The device will achieve the accompanying undertakings all the while:

- 1) compensating for harmonics in the grid voltage and load currents;
- 2) real and reactive power control for load sharing during peak periods and power factor correction at the grid side;
- 3) maintaining PQ despite slight voltage and frequency variations in the grid voltage; and
- 4) Momentarily dispatching real and reactive power to the microgrid when it becomes islanded.

6. SYSTEM DESCRIPTION

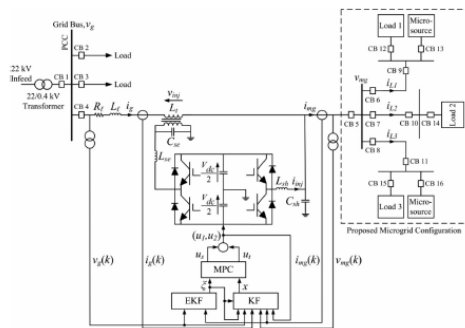


Fig. 1. Overall configuration of the proposed flexible ac distribution system device and the microgrid architecture with EKF denoting the extended Kalman filter and KF denoting the Kalman filter for the plant.

The setup of the microgrid considered in this venture for execution of the adaptable air conditioning conveyance system device is appeared in Fig.1. The proposed microgrid comprises of three spiral feeders (1, 2 and 3) where feeders 1 and 3 are each associated with an appropriated era (DG) unit comprising of a micro generator, a three-stage VSI, and a three-stage LC channel. Feeder 2, in any case, is associated with an electrical load. The adaptable air conditioning circulation system device is worked in two modes: 1) PQ remuneration and 2) crisis operation. Amid grid-

associated operation, the micro grid is associated with the appropriation grid at the PCC. In this mode, the two DG units are controlled to give neighborhood power and voltage bolster for loads 1-3 and thus lessen the weight of era and conveyance of force specifically from the utility grid

The adaptable air conditioning circulation system device capacities to adjust for any sounds in the streams drawn by the nonlinear loads in the micro grid so that the music won't engender to whatever remains of the electrical loads that are associated with the PCC. The device likewise capacities to make up for sounds in the grid voltage that are brought about by other nonlinear loads that are associated at the PCC. The empowerment of huge loads and quick changes in the load request may likewise bring about voltage and frequency varieties in the grid voltage.

Consequently, the device is likewise outfitted with the capacity to deal with such voltage and frequency varieties. At the point when a blame happens on the upstream system of the grid, the CBs work to disengage the micro grid from the grid. The DG units are presently the sole power sources left to direct the loads. For the situation when the era limit of the micro generators can't take care of the aggregate load demand, the adaptable air conditioning circulation system device travels to work in the crisis mode and capacities to immediately accommodate the deficiency in genuine and receptive power. In Fig. 3.2, the definite setup of the three stage adaptable air conditioning dispersion system device is appeared.

7. FLEXIBLE AC DISTRIBUTION SYSTEM DEVICE MODEL

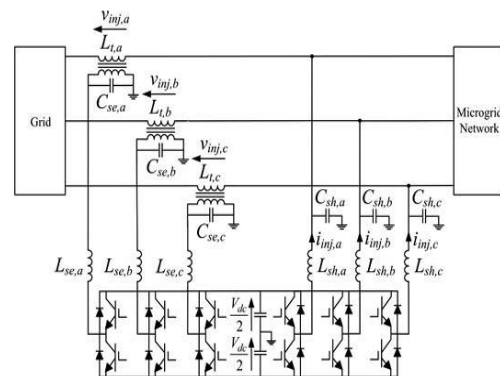


Fig. 2. Configuration of the three-phase flexible ac distribution system device.

The single-phase representation of the flexible ac distribution system device is shown in Fig. 3.3. The distribution grid voltage at the PCC and the total current drawn by the microgrid are modelled as v_g and i_{mg} , respectively. With the proliferation of power electronics equipment being connected to the distribution grid and the microgrid, both v_g and i_{mg} could be distorted due to

the presence of harmonic components. Therefore, v_g is modelled as a source consisting of its fundamental v_f and harmonic v_h .

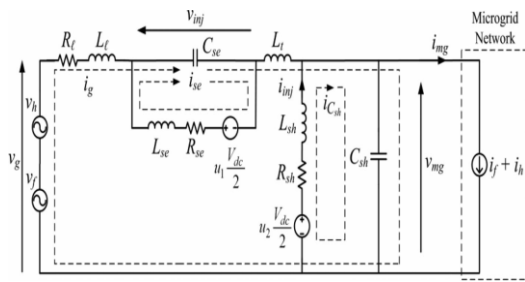


Fig. 3 Single-phase representation of the flexible ac distribution system device

8. CONTROL DESIGN

With the scientific model displayed, this paper proposes another MPC calculation for the adaptable air conditioning conveyance framework gadget. The proposed calculation is an expansion of an as of late created MPC calculation in, which is particularly intended for quick examining frameworks like the proposed adaptable air conditioning appropriation framework gadget to track occasional signs. This calculation deteriorates the MPC streamlining into two sub problems: a consistent state sub problem and a transient sub problem, which are tackled in parallel in various time scales, consequently diminishing the computational loads. Notwithstanding, the MPC calculation in accept that the occasional signs have a settled and known frequency. In this paper, the calculation is reached out to permit an obscure frequency with the goal that it will likewise be reasonable for following frequency varieties.

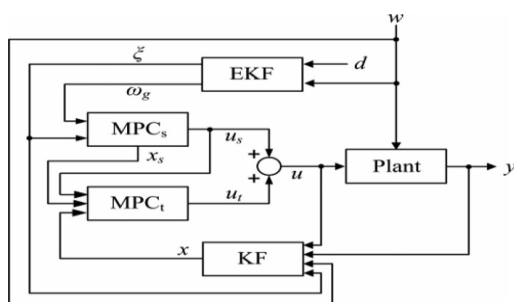


Fig. 4. Overall MPC controller for the flexible ac distribution system device

9. PROPOSED HYBRID SOURCE FOR DC-LINK VOLTAGE

The proposed technique for the dc-connect voltage of the adaptable air conditioning dissemination framework gadget comprises of a PV exhibit and a battery as appeared in Fig. 3.5. The PV exhibit and the battery are associated with the VSI of the gadget through a lift

converter and a buck-boost converter, individually, to encourage charging and releasing operations for the battery and to manage the dc-interface voltage at the coveted level.

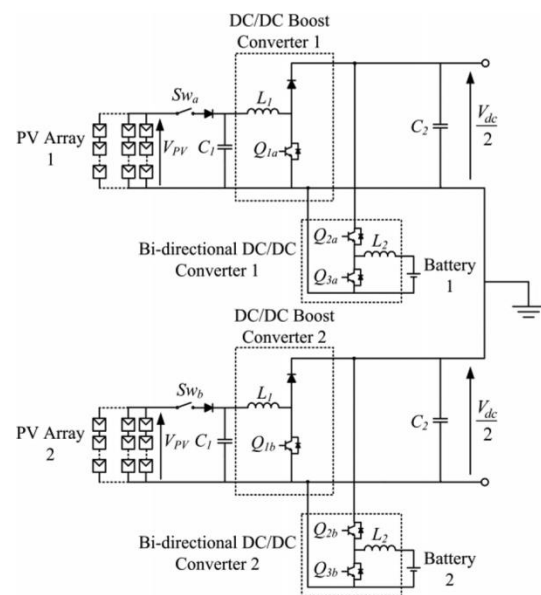


Fig. 5. Proposed PV/battery system for the device.

To keep up the dc-interface at the reference voltage $V * dc/2$, a double circle control conspire which comprises of an external voltage circle and an inward current circle for the bidirectional converter, is actualized to adjust for the variety in the yield voltage $V_{dc}/2$ of the dc/dc support converter. In this segment, the operation of the PV/battery framework is quickly clarified. At the point when there is sufficient daylight, the PV exhibit is controlled by the dc/dc support converter to work in the MPPT mode to convey its most extreme dc control P_{pv} at $V_{dc}/2$, which initiates a voltage blunder $(V * dc/2 - V_{dc}/2)$ at the dc-connect. The mistake is passed to a PI controller, which delivers a reference battery current $i^* b$ for the internal current circle to work the battery in either the charging mode for a positive blunder or releasing mode for a negative mistake. At the point when the battery is in the charging mode, the bidirectional converter works as a buck converter by turning turn Q_{3a} OFF and applying the control motion from the controller to switch Q_{2a} ON as appeared in Fig. 6. Then again, when the battery is in the releasing mode, the bidirectional converter works as a lift converter by turning turn Q_{2a} OFF and applying the control motion from the controller to switch Q_{3a} ON as appeared in Fig. 7. Figs. 6 and 7 represent the charging and releasing operations of Battery 1, in order to keep up the upper dc-interface voltage at a fancied esteem. The same charging and releasing operations are connected to Battery 2 with the end goal that the dc-interface voltages for both the upper and lower dc-connect capacitors are kept up at $V * dc/2$. At the point when the PV exhibit is liable to delayed time of sunless hours and the condition of-charge of the

battery falls underneath a preset utmost, a self-charging strategy from the grid can be fused into the plan of the gadget. The plan of this self-charging procedure is itemized.

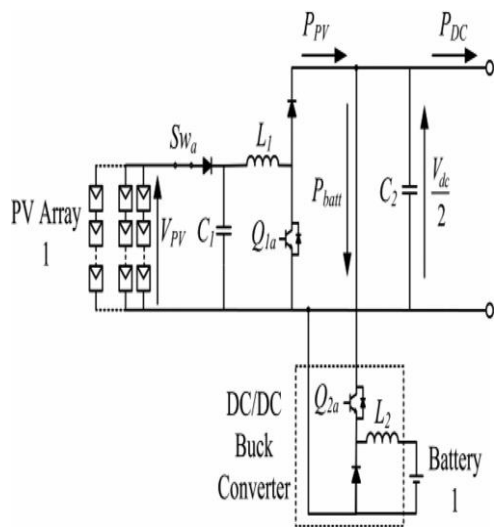


Fig. .6. Equivalent circuit during charging operation.

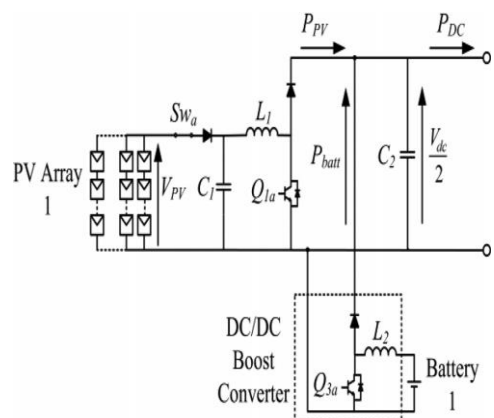


Fig. 7. Equivalent circuit during discharging operation.

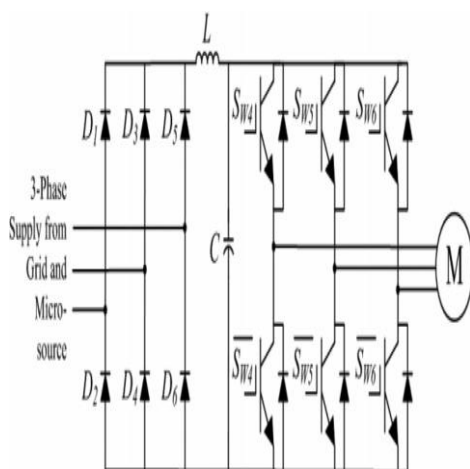


Fig. 8. Configuration of a 15kVA three-phase ASD.

10. SIMULATION RESULTS:

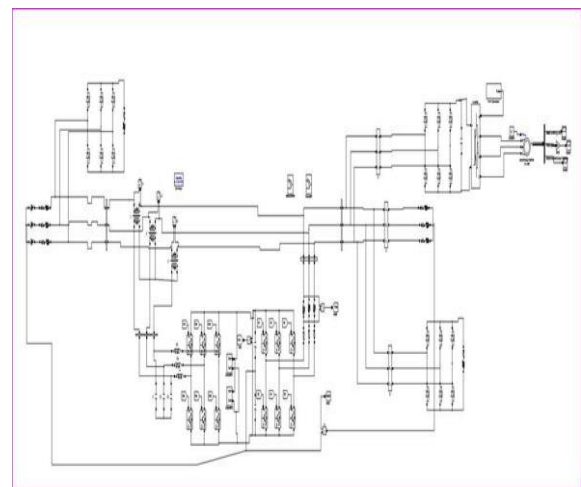


Fig.8 Harmonic compensation and power factor correction during study case operation with load Sharing

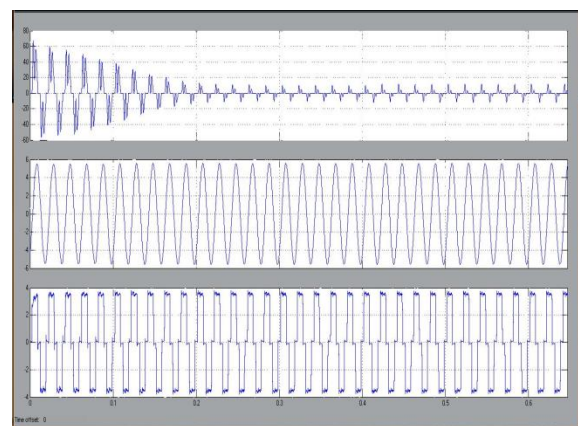


Fig. 9 per-phase currents drawn by feeders 1,2 and3

The proposed gadget is tried under various case situations utilizing MATLAB/Simulink to assess its ability to enhance the PQ and unwavering quality of the conveyance organize that the microgrid is associated with. Diverse sorts of loads comprising of direct and nonlinear loads for the microgrid are considered in these experiments. For load 1, a 15kVA three-stage PWM adjustable speed drive (ASD) with its design as appeared in Fig.4.6 is utilized. Load 2 is comprised of a three-stage straight load and load 3 comprises of a three-stage dimmer load which is nonlinear in nature. The per-stage streams i_{L1} , i_{L2} , and i_{L3} drawn by the feeders 1, 2, and 3 are appeared in Fig. 4.7. The framework parameters are given in Table I. The impedance of the circulation line is Fig. 9. Per-stage streams drawn by feeders 1, 2, and 3. acquired by. The DG inverter misfortune resistance has been coarsely assessed in light of the fact that it is not decisively known practically speaking.

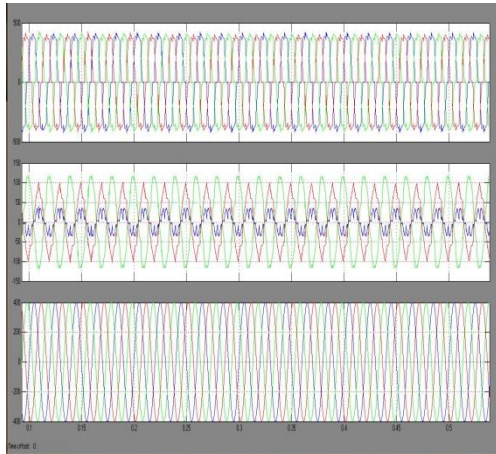


Fig.10 Grid voltage, injected voltage and micro grid voltage

In the primary experiment, the capacity of the adaptable air conditioning conveyance framework gadget to perform consonant pay for grid voltage v_g (because of nonlinear loads associated with the grid transport) and micro grid current i_{mg} (because of the nonlinear loads associated with the micro grid) and in addition control consider adjustment amid steady state operation is illustrated. The gadget is additionally controlled to convey genuine energy to the micro grid amid pinnacle periods when the cost of era from the grid is high. Thusly, the power required from the grid is diminished and crest shaving is accomplished. Thusly, the gadget is entrusted to convey 20% and 40% of the genuine energy to the micro grid for $0 \leq t < 0.16$ s and $0.16 \leq t < 0.32$ s, individually, while the grid conveys 80% and 60% of the genuine energy to the micro grid.

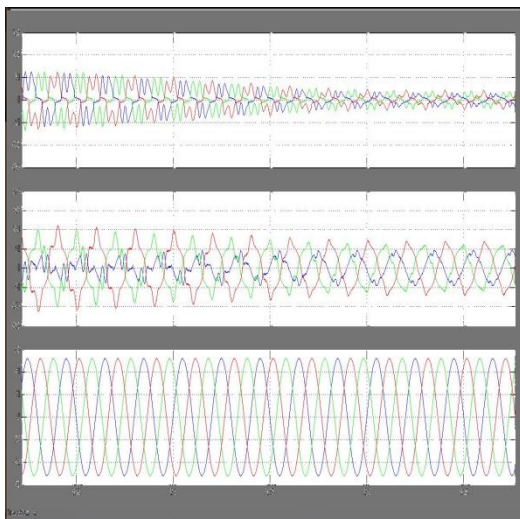


Fig.11 Micro Grid current, injected current and grid current

The voltage and current waveforms under this experiment are appeared in Figs. 8 and 9, individually. Amid enduring state operation, the aggregate consonant

contortion (THD) estimations of v_g and i_{mg} are 18.39% and 42.1%, respectively. With the gadget infusing the voltage and current sounds as appeared in the center waveforms of Figs. 9 and 10, the THD estimations of v_{mg} and i_g are enhanced to around 1.5% and 0.4%, individually as appeared in the base waveforms. To accomplish control figure rectification at the grid side, the gadget is additionally controlled to give the responsive part $i_{f,q}$ of the micro grid current i_{mg} as given in (4). A nearby up waveform for v_{mg} (the voltage has been downsized by a component of 0.25 for correlation) and i_g for $0.1 \leq t < 0.14$ s is appeared in Fig. 4.10. It can be watched that the waveform of i_g is in stage with that of v_{mg} to accomplish control figure redress.

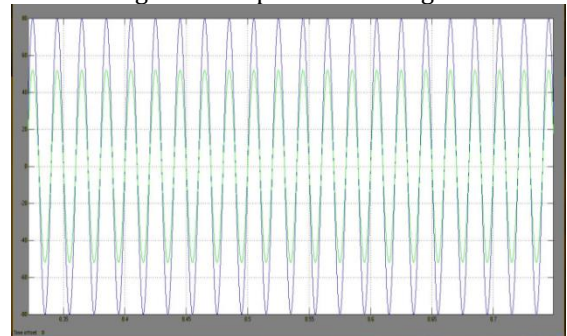


Fig.12 wave forms of microgrid voltage and grid current

The aggregate genuine and responsive power conveyed to the micro grid is around 32 kW and 19kVAR as appeared in Fig

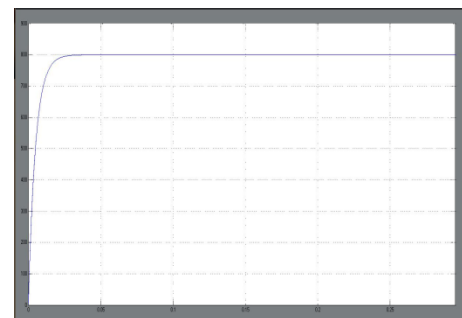


Fig.13 DC-Link voltage of the flexible ac distribution system device

The genuine power dispatched by the gadget is 6.4 kW (20% of the genuine power conveyed to the microgrid) for $0 \leq t < 0.16$ s and 12.8 Kw (40% of the genuine power conveyed to the microgrid) for $0.16 \leq t < 0.32$ s, which outlines the capacity of the gadget to dispatch the required power. The gadget additionally conveys all the receptive force of 19kVAR required by the microgrid to accomplish solidarity control figure at the grid side. As appeared in Fig. 16, the genuine power conveyed by the grid for $0 \leq t < 0.16$ and $0.16 \leq t < 0.32$ s are 80% (25.6 kW) and 60% (19.2 kW) of the aggregate genuine power conveyed to the microgrid and the receptive power

provided by the grid is zero bringing about solidarity control calculate at the grid side.

Test Case 2: Sags and Swells in the Grid Voltage

In the second experiment, the adaptable air conditioning dispersion system device is controlled to adapt to droops and swells in vg. In this experiment, a 30% list for $0.12 \leq t < 0.24$ s and a 30% swell for $0.36 \leq t < 0.48$ s in vg are recreated while the genuine and responsive power required by the microgrid is kept consistent all through the whole interim. The voltage waveform for $0 \leq t < 0.48$ s. It can be watched that vmg can in any case be managed to the wanted waveform despite the fact that the hang and swell cause a transient in vmg which goes on for around three cycles.

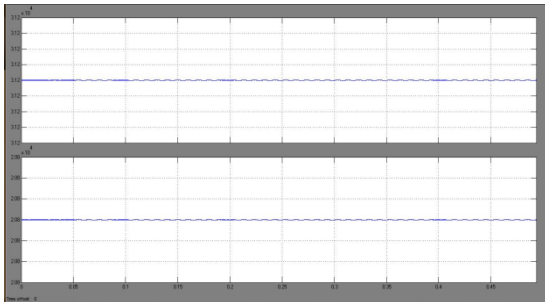


Fig 14 Real and Reactive power delivered to micro grid

This can be achieved because dv mg has been decoupled from vg after the initialization.

Frequency Variations in the Grid Voltage

In the third experiment, the capacity to deal with slight frequency varieties in vg is exhibited and two working situations are introduced. The voltage waveforms for $0 \leq t < 0.32$ s. In both test situations, the re-enactment starts with vg working at the ostensible frequency of 50 Hz for $0 \leq t < 0.16$ s. The frequency of vg then reductions to 49 Hz in the main test situation as appeared in Fig. 18 (top) and increments to 51 Hz in the second test situation as appeared in Fig. (centre) for $0.16 \leq t < 0.32$ s. The genuine and responsive power required by the micro grid in both test situations stay consistent. It ought to be noticed that in both test situations, the adaptable air conditioning circulation framework gadget capacities to keep up vmg at 50 Hz and in the meantime guarantees that the frequency varieties. (Best) Grid voltage vg and (base) micro grid voltage vmg amid grid voltage list and swell.

Grid voltage vg when frequency reductions to (main) 49 Hz and increments to (centre) 51 Hz and (base) micro grid voltage vmg . vg don't bring about any stage move in vmg . It is additionally seen from Fig. 18 (base) that the frequency varieties in vg under both test situations just aim a flitting unsettling influence to vmg which goes on for about a large portion of a cycle and vmg is then managed to its ostensible working frequency of 50 Hz. This is accomplished as the impact of slight frequency varieties has been incorporated into the enlarged exogenous model of (16)–(19) and an EKF has been actualized to track for any frequency varieties

Islanded Operation (Emergency Mode)

In the fourth experiment, the adaptable air conditioning circulation framework gadget is utilized to quickly give genuine and responsive energy to the micro grid when it gets to be islanded. The genuine and receptive power waveforms conveyed by the grid and gadget are appeared in Figs. 19 and 20, individually. The reproduction starts with the micro grid working associated with the grid for $0 \leq t < 0.16$ s. The grid is providing the genuine power request of 32 kW to the micro grid as appeared in Fig.. As appeared in Fig. 20, the gadget is providing zero genuine energy to the micro grid while conveying the receptive power request of 19kVAr to the microgrid with the end goal that solidarity control element can be accomplished at the grid side. At $t = 0.16$ s, a separation is endless supply of a blame on the upstream system of the grid and CB 1 opens to disengage the microgrid from the grid (see Fig. 1). It can be seen from Fig. 19 that the CB figures out how to completely segregate the microgrid from the grid in about a large portion of a cycle, bringing about zero genuine and responsive power conveyed by the grid for $0.16 \leq t < 0.52$ s. With just the microgrid providing for the loads, the power unevenness brings about a lessening in the framework frequency as appeared for $0.16 \leq t < 0.36$ s. To keep up the soundness of the microgrid amid islanded operation, the proposed gadget is entrusted to dispatch genuine force of 32 kW at $t = 0.36$ s by the microgrid vitality administration framework while the receptive force of 19 kVAr to the microgrid is still kept up with the end goal that the aggregate era from the microgrid and the gadget can take care of the load demand. A deferral of 0.2 s is presented between the islanding of the microgrid and the start of the gadget to provide food for frequency homeless people in the framework. As appeared in Fig. 21, for $t \geq 0.36$ s, the frequency is bit by bit re-established to its ostensible estimation of 50 Hz. This experiment exhibits the ability of the gadget to supply all the genuine and receptive energy to the microgrid when it is islanded from the grid.

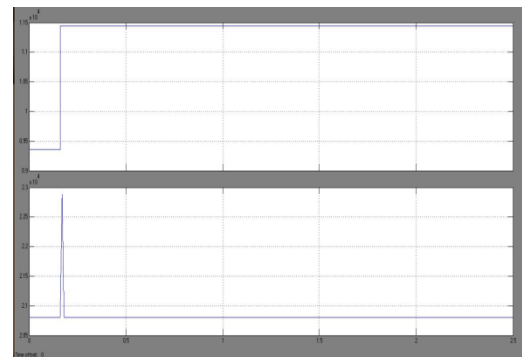


Fig.15 real and reactive power delivered by the device

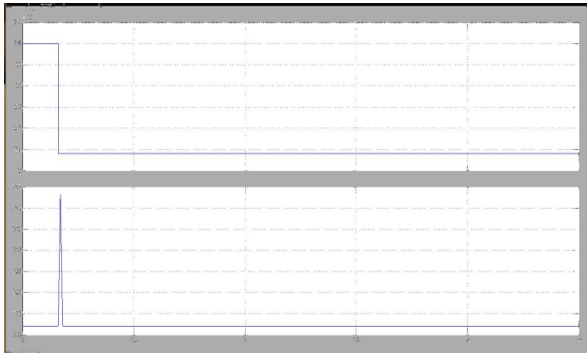


Fig.16 real and reactive power delivered by the grid

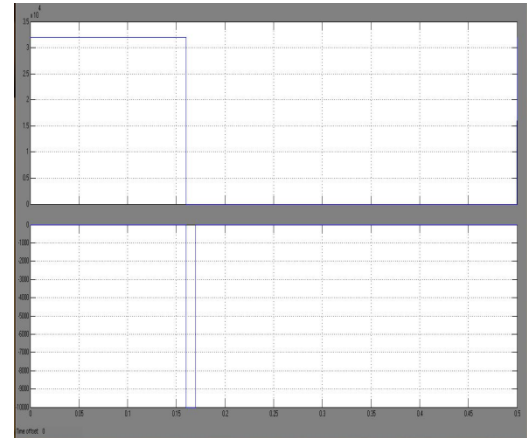


Fig.20 real and reactive power delivered by the grid

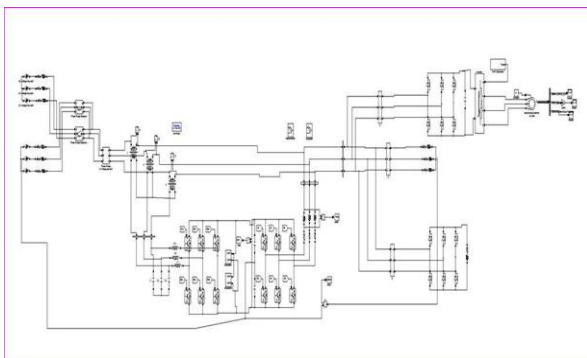


Fig 17 frequency variations in the grid voltage

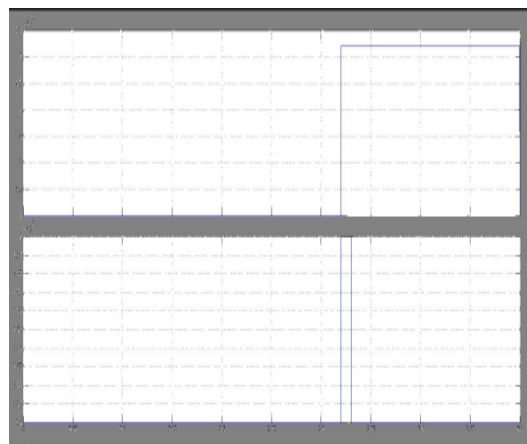


Fig.21 real and reactive power delivered by the device

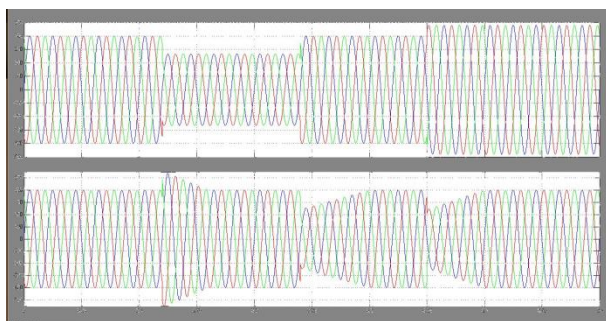


Fig.18 grid voltage and microgrid voltage during voltage sag and swell

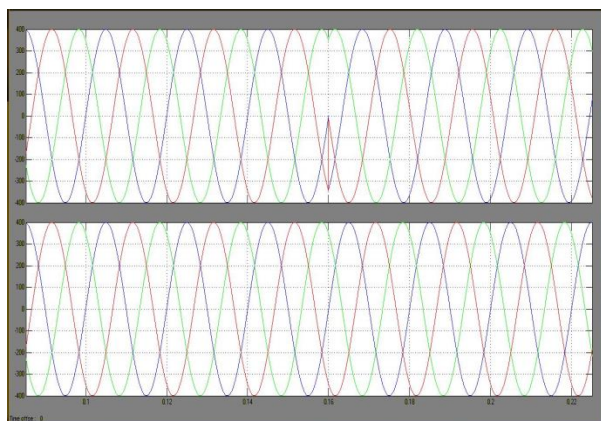


Fig.19 grid voltage when frequency decreases to 49HZ and increases to 51HZ

11. CONCLUSION

In this project, a flexible ac distribution system device for microgrid applications has been presented. The proposed solution integrates EKF into the control design for frequency tracking and to extract the harmonic spectra of the grid voltage and the load currents. The device is installed at the PCC that the microgrid and other electrical networks are connected to and is designed to tackle a wide range of PQ issues. It also operates as a DG unit to perform load sharing when the cost of generation from the grid is high such that peak shaving is achieved and also during islanded operation of the microgrid.

The design concept has been tested under several case scenarios and the results obtained verified that the device can handle a wide range of PQ issues, thus increasing the overall PQ and reliability of the microgrid. The simulation results obtained in this project and the current analysis serve as a fundamental step toward the design of control circuits for hardware implementation of the device in the future.

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