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Fuzzy Based Grid Synchronization Scheme for Integration of Renewable Energy Sources

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ABSTRACT

Micro-grid is a promising area that might provide a solid solution for more and more stress on the utility supply and transmission line. Generally micro-grid comprises of renewable energy sources such as photovoltaic (PV), wind, fuel cell (FC) stack etc., as small-scale framework includes sustainable power sources which have a fundamentally extraordinary dynamic conduct, different creating limits and problematic impacts, for example, voltage plunges and changes, recurrence variety, and symphonies contortion are taken care of through brought together observing in conjunction with various leveled control. The unwavering quality and supportability of the subsequent complex small-scale framework synchronization is guaranteed through the proposed reconfigurable control and power system of the micro-grid, supported by a comprising fuzzy controller area network. The proposed design is fortified by an extra controller that backings long haul streamlining of small scale network task under typical conditions and oversees interim role assignments to control layers during crisis. Micro grids are increasing broad prevalence as they have all the Fundamental properties to constitute a noteworthy building square of the imagined shrewd lattice. The unfavorable impacts of high infiltration of sustainable power sources (RES) like sun powered photovoltaic (PV), winds, and so on. On the stability of the existing grid network has been raising a major concern. This paper proposes a highly reliable controller i.e. FUZZY LOGIC CONTROLLER to reduce the source THD. Minimizing the time required for GS of the complete micro grid. Simulation results related to this paper are presented.

Keywords

Micro grid (MG), Synchronization, Renewable Energy Sources, Fuzzy Logic Controller

1. INTRODUCTION

Introduction to Micro grid: -A few years prior, micro grids turned into the most encouraging answer for the issues of the present power framework. Micro grids represent a vision for the future of power distribution in which islanding detection, control, dispatch strategies, grid integration and energy storage systems are major challenges. This study explores how to provide increased, cost-effective and environment friendly energy for local loads. Micro grids are power dissemination frameworks containing Loads and dispersed vitality assets, (for example, appropriated generators, stockpiling gadgets, or controllable burdens) that can be worked in a controlled in with utility grid or while islanded.
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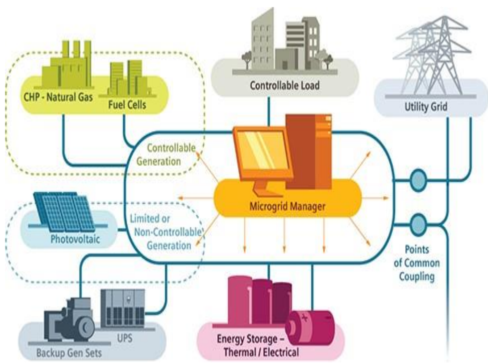

Fig 1.1 Micro Grid Examples

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Micro grid Key Components: -Micro grids usually consist of distributed energy resources, power conversion equipment, communication system, controllers and energy management system to obtain flexible energy management. The customer is another key component for micro grid to be promoted and implemented involves distributed generator (DG) and distributed storage and provides energy to meet energy demand.

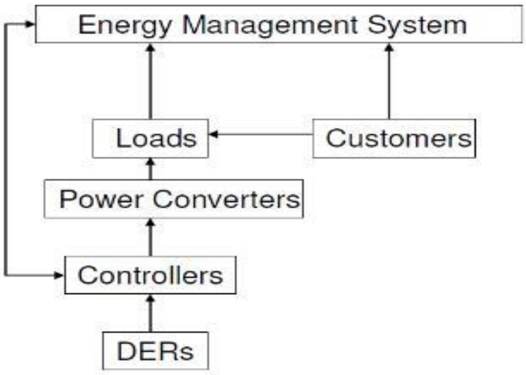

Fig.1.2 Micro grid key components

Modes of Connection of Micro Grid:-Depending in the interaction level between a micro grid and the main grid,A micro grid could be classified as autonomous or grid-connected. Synchronization: Parallelization of two synchronous frameworks requires coordinated activity with a specific end goal to limit surges and power oscillations. A smooth association is accomplished when the voltage sat the two transports to be associated are incidental in extent and phase. Also, recurrence must be minimal. If a flawless parallelization is come to, no power flow will be seeing at the coupling electrical switch (CB) immediately after its activity (Fig. 2.6), which implies that the synchronization control is invalid. Then again, if the sync power is high, harm to the generators may happen. For example, the pole may be fissured or even break due to the unreasonable tensional exertion.

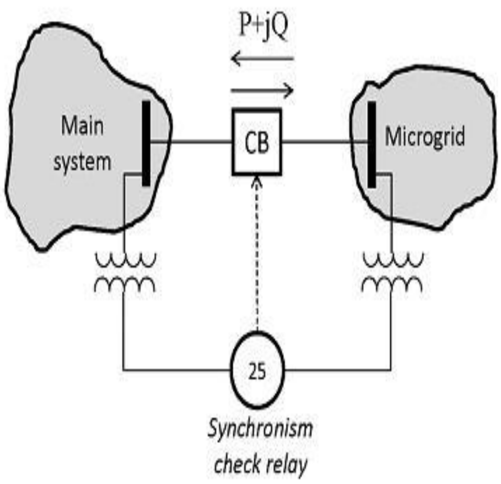

Fig1.3 Parallelization of Two Systems

This paper proposes a straightforward, minimal effort, and solid GS technique in light of controller territory organizes (CAN) correspondence. CAN is a hearty blame tolerant multiport serial communication arrange fit for giving 1 Mb/s information rate. The proposed conspire depends on CAN communication between the micro grid ace controller (MMC), neighborhood controllers (LC), stack controller and network synchronization systems appeared in Fig.1.4.
The figure

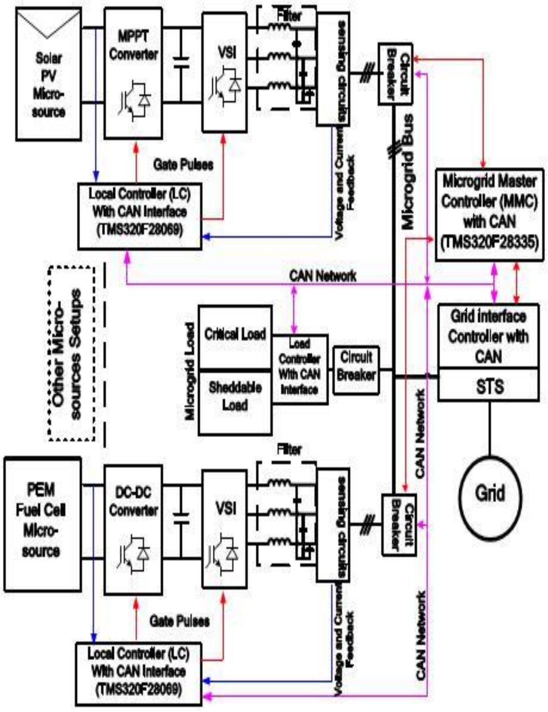

Fig1.4 Micro Grid Configuration with CAN Communication Interface.

The nearby controller for the most part deals with the operation and insurance of the voltage source inverter combined by each MS. In the proposed plot, synchronizing matrix framework taps the lattice voltage information at fast and transfers it on the CAN organize. The MS nearby controller gets the network format information with little however known clear time latencies. This enables the MS to all the while empower in synchronization with the framework while as yet

Working in islanded mode. This encourages simple GS of the considerable number of sources, by limiting the time required for GS of the entire micro grid. Every one of the proposed conspire are introduced in the accompanying sections of this paper The proposed concept is to the controller associated with the grid will taps the grid voltages at high speed and the data is send to the local controller through CAN network thus the micro source local controller receives this information and sets the reference values to that level and always corrects the voltage values while operating in the islanded mode. This enables the faster error compensation in local controller by the proposed controller and once the voltages are matched then the total micro grid is swathes from islanded mode to the grid tied mode this enables the smooth transition from island mode to grid tied mode and vice versa.

GS Technique→	Zero cross detection	Open loop GS techniques	Closed loop GS techniques
Method	1. Zero Crossing Detector ▪ *Analog* ▪ *Digital* ▪ *Software based* 2. Filtered Zero Crossing Detection	1. Low pass filter (LPF) 2. Space-vector filter (SVF) techniques 3. Kalman filtering (KF) techniques 4. Weighted Least Squares Estimation (WLES) techniques	a) SRF-PLL b) Adaptive PLL c)Discrete Fourier transform d) SRF-PLL with filters *i)LPF ii)Adaptive notch filter iii)Resonant filter* e) PLL with filters in Static frame *i)Kalman filter ii)Multivariable filter* f) Instantaneous symmetrical components *i)Decoupled double synchronous reference frame PLL ii)Neural Network based iii)Orthogonal components based*
Advantage	Simple	Less complex than closed loop techniques	Good grid voltage disturbance rejection and frequency tracking
Disadvantages	Poor performance under grid voltage distortion, Filtering delay	Steady state errors possible and no frequency tracking	Amplitude Dependency

Table 1.1: Classification of GS Methods

2. Gridsynchronizationtechniques: -

For the 3-φ VSI-based appropriated age framework, the usually researched and executed GS methods [4], [8], [28] can be comprehensively named by the Table 1.1. These techniques are suitable to be used to control one MS with VSI to accomplish the framework synchronization. ZCD is a straightforward however low-quality lattice voltage makes it a conflicting and wrong strategy for GS. Most of alternate strategies require critical and complex counts/changes, which request fast advanced signal processors (DSP) for execution. This increases the cost and complexity of execution [4]. These strategies primarily use the recurrence and stage data of the detected grid for voltage vector. The issue emerges when micro grids with multiple MS with various dynamical attributes (e.g. solar PV, energy unit, wind, and so forth.) should be framework synchronized.

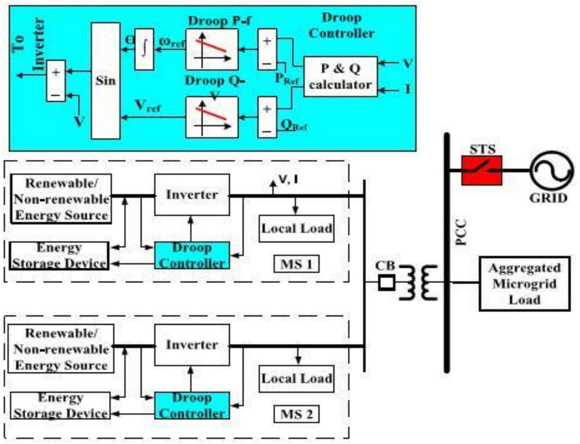

Fig.2.1 Droop Controller

Fig.2.1 demonstrates a case of a micro grid with two sources bolstered by a vitality stockpiling framework (ESS) for transient and unfaltering state go down. The controllers utilized for booths depend on hang control. The hang Controller based on feedback of micro grid transport voltage and the current and the droop attributes, chooses the new working condition interns of the point ø (time fundamental of rakish frequency) and Vref which is then utilized for producing the beat width balance (PWM) control motion for inverter. This is the great hang control. The droop control despite the fact that straightforward for execution, it innately needs in giving precise control that having poor dynamic response because of poor bandwidth. In micro grids with brought together control upheld with appropriate correspondence engineering, the genuine and responsive power control amid the island method of activity is generally managed through the master–slave arrangement. In such micro grids which are all around outfitted with fast correspondence organize, the correspondence helped GS (CAGS) methods can be favored.

Grid Synchronization Method:

As appeared in Fig.1.4, the LCs comparing to variorums, the MMC, the heap controller, and the framework synchronizer they are totally interconnected with each other by a CAN bus. CAN is a message communicate correspondence with nondestructive transport intervention. CAN give a hearty correspondence because of its multi method blunder identification highlight. In this paper, a disconnected CAN transport utilized for the micro grid control task is worked around CAN trans-recipient ISO1050.The CAN information is communicated to all hubs at the same time.

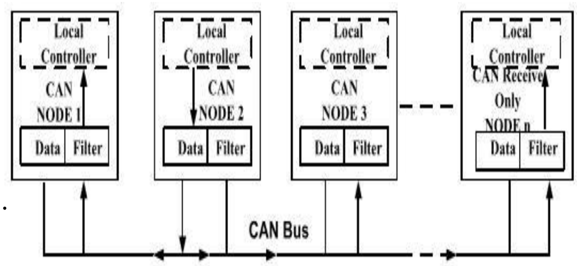

Fig.2.2. CAN Nodes Transmission and Reception of Data

Fig.2.2 shows the data broadcasting on a CAN node from the CAN bus. All CAN nodes receive the broadcasted messages and they can react or cannot react on those messages. This allows the grid synchronizer block to send the short messages to all the nodes. The nodes make their own decision whether to act on the message or not this is the big advantage of the CAN network of broadcasting the messages. The total block diagram of the proposed controller and the communication interface with the micro source fuel cell is shown in fig 2.3 the same applies to the remaining micro sources with interfaces each other. To synchronize total micro sources with each other to form the single bus bar to connect with the same main grid, it is compulsory that every micro source should receive the same grid voltages as fast as possible.

In the proposed scheme, the grid synchronizer block is designed to implement the synchronously rotating frame PLL (SRF-PLL) with capability to adopt unbalanced grid voltage and harmonic contamination. The instantaneous phase angle information of the grid voltage which is the output of the SRF-PLL and the voltage amplitude of the grid supply is communicated on the CAN network to all the LCs simultaneously. In smaller networks, the network time delays are insignificant and can be neglected. Hence, each of the LC is in a position to generate the reference grid voltage template to drive

The VSI to get grid synchronized voltage output. The outer voltage control loop implementation makes sure to maintain the operating voltage same for each of the MS. Thus, the voltage, frequency, and phase synchronized MS are ready to be connected with the grid. The grid synchronizer block continues data broadcasting on CAN bus during the synchronization process, thus enabling each of the sources to accurately track the grid voltage and phase changes. The communication interface designed with the CAN plays a vital role in switching the control between standalone and grid connected modes, allowing smooth synchronization as well as islanding of the micro grid.

After closing STS, on receiving confirmed message from the CAN interface, it is switched over to current control mode allowing export or import of the power to or from the main grid. This allows easy GS of all the MS, minimizing the time required for GS of the micro grid. To understand the proposed control scheme with SRF-PLL and its modeling, basic details are provided next. The proposed control scheme implementation allows the MS power to be modulated by VSI to regulate the micro grid bus voltage and Frequency (v, f) during standalone mode of operation, which exists between the formation of the micro grid bus and its synchronization with the main grid. In the grid connected mode, the real and reactive power (P, Q) is controlled.

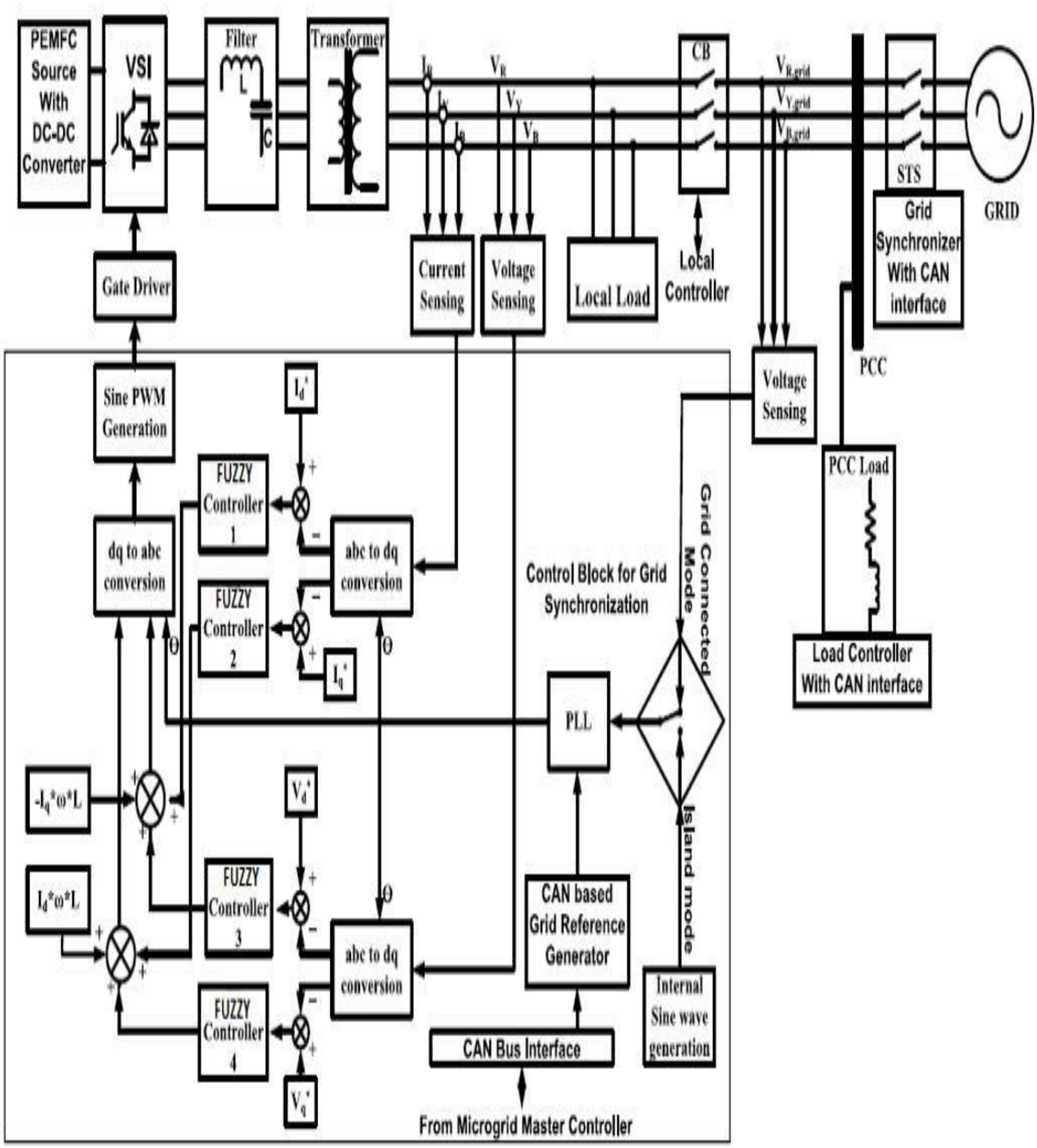

Fig.2.3. Detailed MPC Control for the Implementation with Power Devices and CAN Network

In fig 2.3 represents block diagram of the detailed view of controller previously the controller used here is paranormal integral controller and this has certain disadvantages like slower response for the error compensation and having THD level is not minimal so here fuzzy logic controller is used for faster response in error compensation and THD level is minimized to certain extent

Fuzzy Logic Controller:

Fuzzy logic controller is based up on the approximation it is not based up on the true or false usually the traditional controller is based on (1 or 0). Generally, the Boolean logic which is (0 or 1) modern computer is used.

Linguistic Variables		Fuzzy Variables (Linguistic Quali-fiers)	
Speed error	(SE)	Negative large	(NL)
Position error	(PE)	Zero	(ZE)
Acceleration	(AC)	Positive medium	(PM)
Derivative of position error	(DPE)	Positive very small	(PVS)
Speed	(SP)	Negative medium small	(NMS)

TABLE 2.1 Fuzzy and Semantic Factors

Table 2.1 shows how the error is classified and determined for the faster error response and approximation. The error is divided in to 3 parts negative, zero, positive further it is divided in to negative low, negative high, positive high, positive low and zero as usual

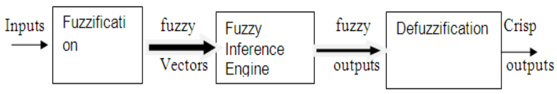

Fig.2.4 Fuzzy inference system.

Fuzzy logic controller basically works on fuzzification, fuzzy interface and after all computing defuzzification.

Fuzzification:
Fluffy rationale utilizes etymological factors rather than numerical factors. In a control framework, mistake between reference flag and yield flag can be doled out as Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (ZE), Positive little (PS), Positive Medium (PM), Positive Big (PB). The triangular participation work is utilized for fuzzifications. The procedure of fuzzification change over numerical variable (genuine number) to an etymological variable (fluffy number).

Defuzzification:
The guidelines of fluffy rationale controller create required yield in a semantic variable (Fuzzy Number), as per true prerequisites; etymological factors must be changed to fresh yield (Real number). This determination of technique is a bargain amongst precision and computational force.

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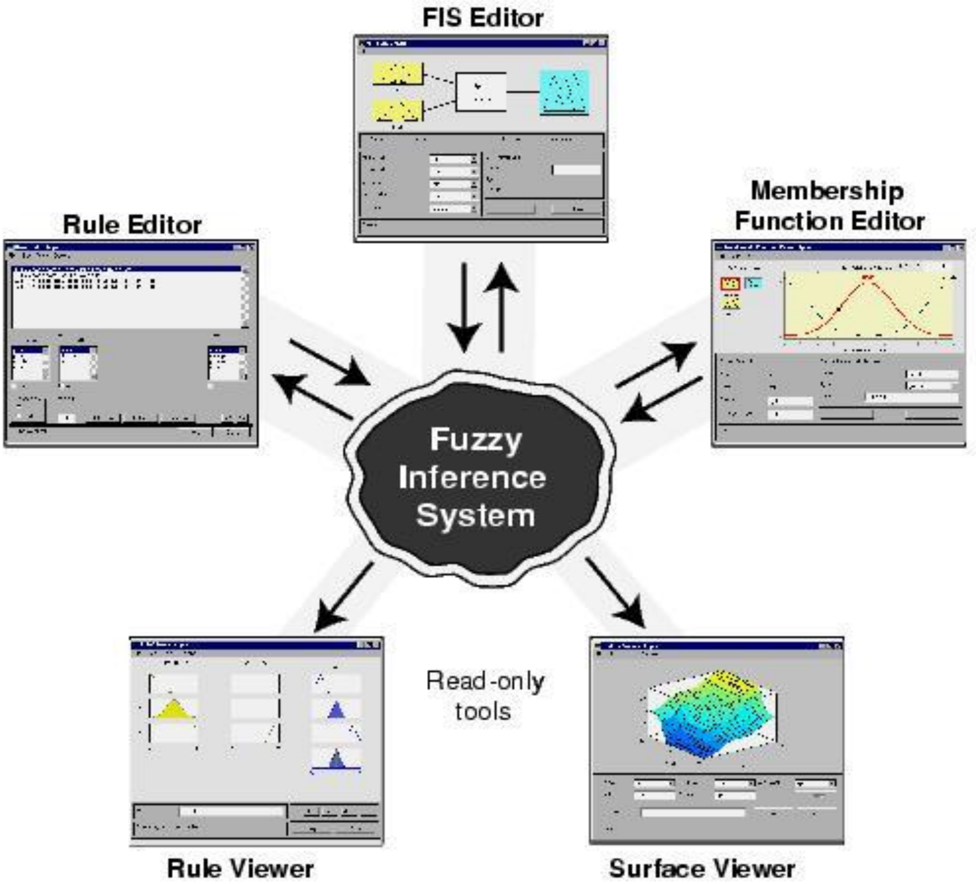

Fig.2.5 Fuzzy Interface System

The FIS Editor handles the abnormal state issues for the framework: as what number of info and yield factors utilized, and their names. The Fuzzy Logic Toolbox doesn't constrain the quantity of information sources. Be that as it may, the quantity of data sources might be constrained by the accessible memory of your machine. On the off chance that the quantity of information sources is too vast, or the quantity of participation capacities is too enormous, at that point it might likewise be hard to dissect the FIS utilizing the other GUI instruments. The Membership Function Editor is utilized to characterize the states of all the enrollment capacities related with every factor. The Rule Editor is for altering the rundown of tenets that characterizes the conduct of the framework The Rule Viewer and the Surface Viewer are

Utilized for taking a gander at, instead of altering, the FIS. They are entirely perused just apparatuses. The Rule Viewer is a MATLAB-based show of the fluffy surmising graph appeared in fig2.5.Utilized as an analytic, it can indicate which rules are dynamic, or how singular participation work shapes are affecting the outcomes. The Surface Viewer is utilized to show the reliance of one of the yields on any maybe a couple of the data sources that is, it creates and plots a yield surface guide for the framework. The five essential GUIs would all be able to associate and trade data. Any of them can read and compose both to the workspace and to the circle. The read-no one but watchers can at present trade plots with the workspace and additionally the circle.

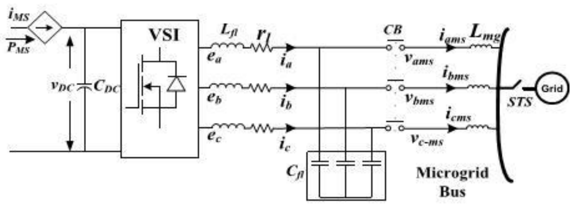

Fig.2.6 Equivalent circuit of power electronic system with LC filter

Fig.2.6 shows the equivalent circuit of a MS interconnected with the main grid through a power conditioning unit followed by an LC filter. Here the MS is represented as a controlled current source, I (ms) which supplies the real powerPmsinto thedc link capacitor at voltage VDC. LC filter comprising Lfl-Cflis used to filter out the high frequency switching components and micro grid line inductance (Lmg) is neglected being very small [30].The local controller senses the VSI side and MG bus side parameters likeiabc, vabc_MS, iabc-MS, VDC, etc., to modulate the VSI to control the real power reactive power or micro grid bus voltage and frequency depending on the operational mode. Synchronously rotating reference frame transformations used to realize the VSI control. Model of VSI can then be expressed as [30]

$$L_{fl}\frac{d_{id}}{dt} = -\eta i_d + L_{fl}\omega i_q + e_d - v_d$$

$$L_{fl}\frac{d_{iq}}{dt} = -L_{fl}\omega i_d - \eta i_q + e_q - v_q$$

Where id, iq, vd, vq and ed, eq are the transformed variables of voltages and currents.

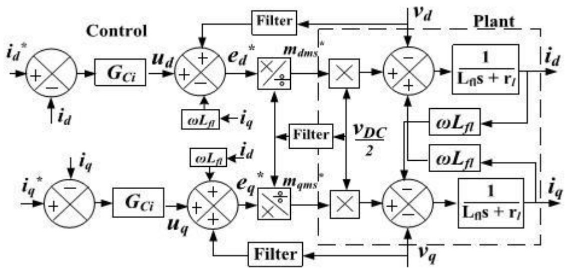

Fig 2.7 VSI inner current loop for PQ control in grid connected mode

The micro grids ac voltage regulation model is given as

$$C_{fl}\frac{d_{vd}}{dt} = C_{fl}\omega v_q + i_d - i_{Ld}$$

$$C_{fl}\frac{dv_q}{dt} = -C_{fl}\omega v_d + i_q - i_{Ld}$$

.
Similarly, all other MS power electronic interfaces are modeled. In standalone mode, the outer voltage mode control is

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Volume 05 Issue 15
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Dominantly active as the MMC controls the id and Iq reference values.

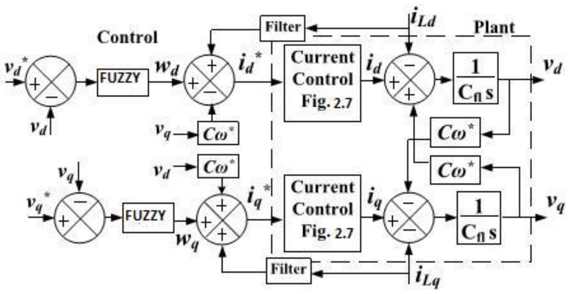

Fig 2.8 VSI outer voltage control loop for micro grid bus voltage regulation in standalone mode

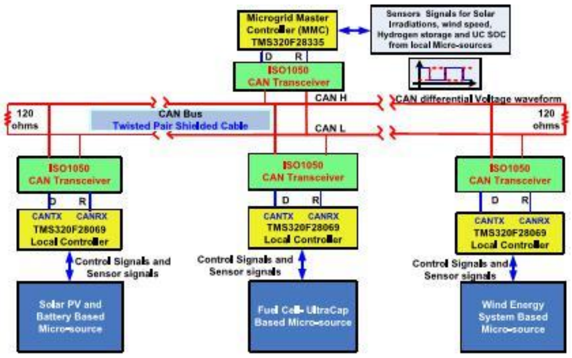

Fig.2.9 CAN communication network implementation

The control system works in co-appointment with CAN interface between the lattice synchronizer, MMC, and LCs.Fig.3.10shows the schematic of the CAN-based communication network for the micro grid under investigation. The LC is interfaced with Texas Instrument's ISO1050 CAN handset through contorted match link with 120termination resistors [33]. The functionality of network synchronizer, LC and MMC are realized on DSP with worked in CAN modules. These controllers bolster 1 Mb/s information speed on CAN transport, encouraging high speed and vigorous correspondence inside the micro grid. Would protocol be able to accompany a high insusceptibility? To electrical impedance amiability to self-analyze and repair information errors? The programming for CAN convention is produced on Texas Instrument's Code Composer Studio (CCS 4.2.1) platform. The programming code is advanced to limit successful time for transmission and gathering of information over all the LCs, grid synchronizer, and MMC

3. MATLAB AND SIMULINK MODEL:

MATLAB

MATLAB was first developed in the year 1970 for studying the straight polynomial mathematics. Then next it was further developed and create awareness about it by mathworks.com MATLAB is a software that performs all scientific researches and their related problems

MATLAB software is interfacing with programs that written in different languages, including C, C++, Java, FORTRAN and Python.

MATLAB is basically for numerical calculations by using a separate tool kit by using the MuPAD emblematic motor, creating access for figuring capacities. Extra software, Simulink software, which includes graphical reproduction and model-based plan for dynamic and inserted frameworks.

SIMULINK

Simulink also created by the mathworks.com it is additional software representing the graphical programming. Simulation is done in multiple domains and it should have a graphical square along with it. Simulation flexible very tight mixture by remaining content in the MATLAB conditions simulation is used for programming controls and multi domain and model-based designs.

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Simulation software is simple and quick to learn and practicable. C codes can be created from Simulink software models for installing applications and fast prototyping of control systems

Simulink and Its Relation to MATLAB:

The MATLAB and Simulink software's are converted as one-unit element so that MATLAB Simulation Diagrams

It flexibility creates user can verify and create changes by critical thinking. They can be used as intelligent devices. It gives successful operations for designers and researchers.

1This software is mainly used in the industries and business, aviation researches, and so many companies and it can be used for so many different applications.

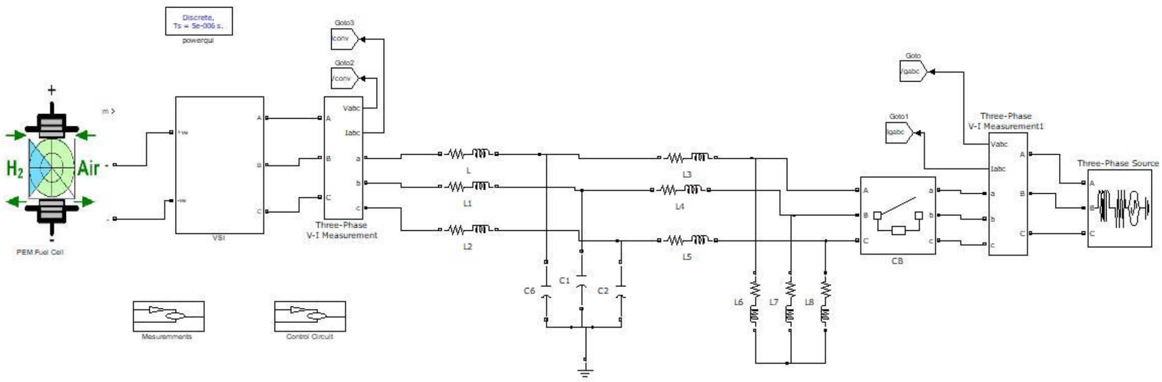

Fig 3.1 Simulation Model of the System

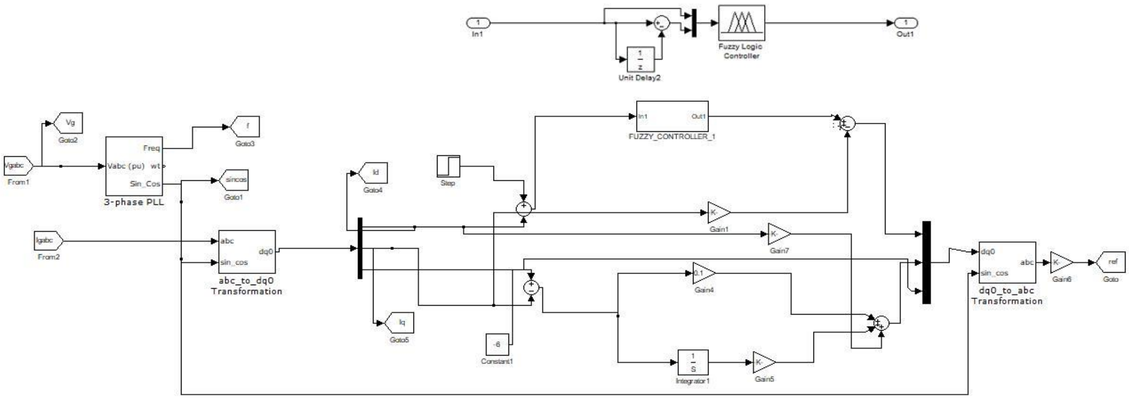

Fig3.2 Sub System of the Controller

Simulation Results

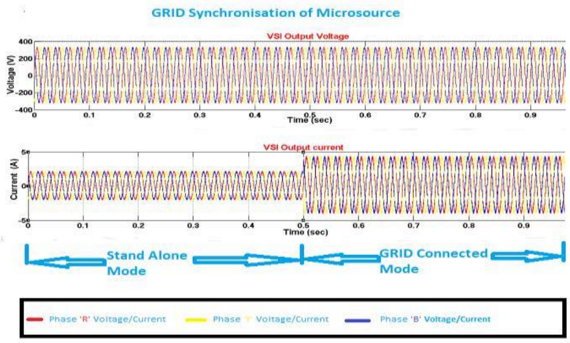

Fig.3.3 Voltage and current waveforms in standalone mode and grid connected mode

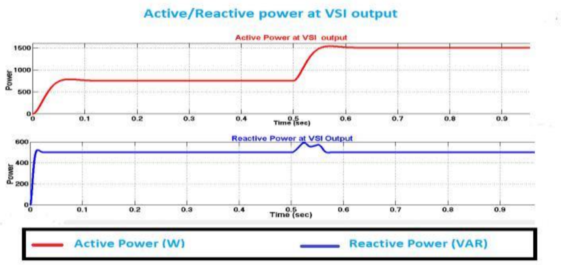

Fig3.4. Active power and Reactive power at inverter

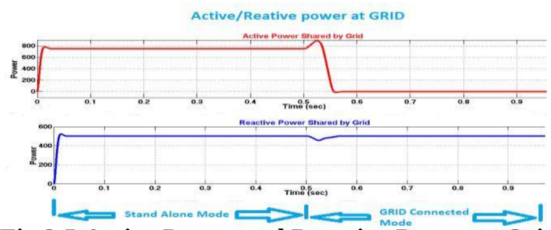

Fig.3.5 Active Power and Reactive Power at Grid

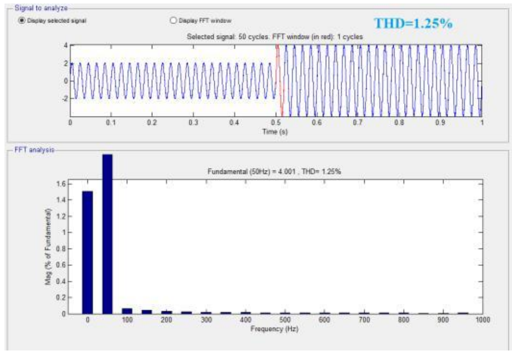

Fig3.6 thd at fuzzy logic controller

4. ACKNOWLEDGEMENTS

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Contribution of others who might have given suggestions or review comments.

5. CONCLUSION AND FUTURESCOPE

The mode progress administration of a micro grid, dominated by RES is very unpredictable, particularly while changing from islanded mode to framework associated mode. The non-dispatch able nature of the majority of the RES makes the undertaking more troublesome. In order to limit the progress drifters, it is fundamental to synchronize all the MS all the while with the principle grid. This project demonstrates that its utilization can be stretched out further to provide strong GS conspire with no extra cost. The reproduction comes about affirm the change in the execution of the control unit. Using fuzzy controller, the yield current sounds are diminished and the controller execution is upgraded. Using fuzzy controller, the output current harmonics are reduced and the controller performance is enhanced and THD

Content is reduced. Along these lines**,** the controller execution is upgraded empowering it to be utilized for lattice synchronization of micro grid applications. General power quality in the framework is moved forward. New control scheme for power electronic interface of micro grid with grid system using artificial intelligence can be developed for utility interactive operation. In future Storage systems can be added along with the micro grid to store energy in absence of grid

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