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Power Quality Improvement with a Hybrid PID & Fuzzy Logics Controller for a Single Phase Grid Connected For a Voltages Source Invertors

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ABSTRACT:
Ever growing demand of electrical energy has resulted in the development of distributed generation system. The main objective is coordinating the DG to the utility grid. PWM voltage source inverters are mostly meant for synchronizing the utility grid to the distributed generation system. In this paper fuzzy logic controller is proposed to enhance the power quality by diminishing current error. An analysis of hysteresis controller is studied for providing control of a grid connected inverter.

1. Introduction of Integration of DG system with the grid:-
There are distributed generation resources would be interconnected to the same transmission grid as central stations. Various technical and economic issues occur in the integration of these resources into a grid. Technical problems arise in the areas of power quality, voltage stability, harmonics, reliability, protection, and control. Behaviour of protective devices on the grid must be examined for all combinations of distributed and central station generation.

Electrical Grid: - An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of the economies of scale. . As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

Power System Efficiency: -The efficiency of a power system is maximized when the total combined load is purely resistive.When the system efficiency is maximized (i.e., minimum power required to serve all loads), Two significant benefits are realized:
1) Power losses are minimized.
1.1 2) Extra capacity

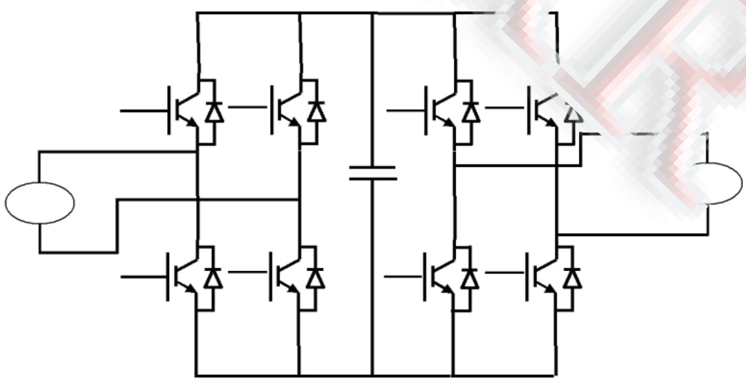


Fig.1 **Structure of the back-to-back Voltage Source Converter**

Unidirectional Power Converter: -The diode rectifier is the most common used topology in power electronic applications. For a three-phase system it consists of six diodes. The diode rectifier can only be used in one quadrant, it is simple and it is not possible to control it. It could be used in some applications with a dc-bus.

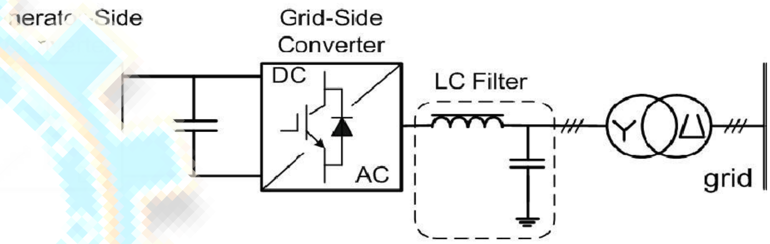


Fig.2 **Full scale power converter**

General Structure of Voltage Source Inverters:-This topology requires only a single dc source and for medium output power applications the preferred devices are n-channel IGBTs. 'V_{dc}' is the input dc supply. Needless to say that physical layout of positive and negative bus lines is also important to limit stray inductances. Q1, Q2, Q3 etc. are fast and controllable switches. D1, D2, D3 etc. are fast recovery diodes connected in anti-parallel with the switches. 'A' and 'B' are output terminals of the inverter that get connected to the ac load. A single-phase inverter has only one pair of load terminals. The VSI consists of single phase IGBT bridge inverter.

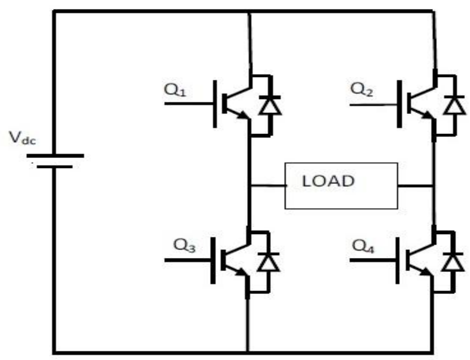


Fig.3 Topology of a 1-phase VSI

3.7.1 Fuzzification

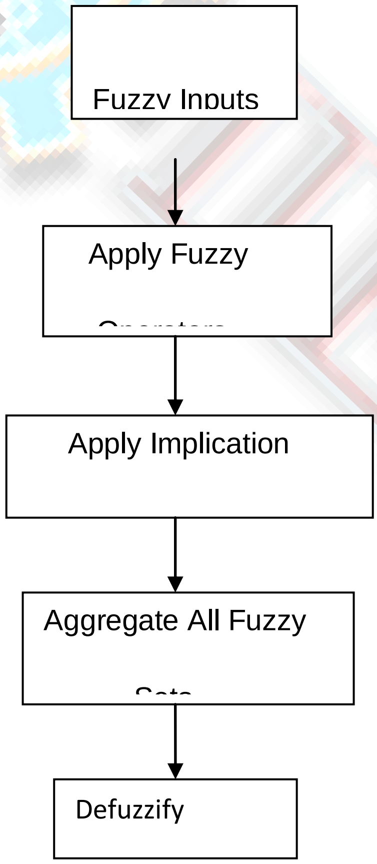
In this stage the crisp variables of input e (ts) and ce (ts) are converted into fuzzy variables. The fuzzification maps the error and change in error to linguistic labels of fuzzy sets. Membership function is associated to each label with triangular shape which consists of two inputs and one output. The proposed controller uses following linguistic labels NB, NM, NS, ZE, PS, PM, PB. Each of the inputs and output contain membership function with all these seven linguistics.

Step1: Fuzzy Inputs: The first step is to take inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions.

Step2: Apply Fuzzy operators: Once the inputs have been fuzzified, week now the degree to which each part of the antecedent has been satisfied for each rule.

Step3: Apply the Implication method: The implication method is defined as the shaping of the output membership functions on the basis of the firing strength of the rule.
Step4: Aggregate all outputs: Aggregation is a process whereby the outputs of each Rule are unified. Aggregation occurs only once for each output variable. The input to the aggregation processes the truncated output fuzzy sets returned by the implication process for each rule.

Step5: Defuzzify: The input for the defuzzification process is a fuzzy set (the aggregated output fuzzyset), and the output of hte defuzzification process is a crisp value obtained by using some defuzzification method such as the centroid, height, or maximum.



Flow chart for fuzzy inference

Defuzzification

A fuzzy inference system maps an input vector to a crisp output value. In order to obtain a crisp output, fweneede fuzzification process. The input tko the defuzzification process ia a fuzzyset (tje aggregated pit[it fizzuset), and the output of the defuzzification process is a single number. Many defuzzifecation techniques have been proposed.

1. Mean of maximum method
2. Centroid of area method
3. Bisector of area method

This stage introduces different methods that can be used to produce fuzzyset value for the output fuzzy variable ΔT. Here the centre of gravity or centroid method is used to calculate the final fuzzy valueΔT(ts)

Operation with FLC

Fuzzy logic is a branch of artificial intelligence that deals with reasoning algorithms used to emulate human thinking and decision making in machines. These algorithms are used in applications where process data cannot be represented in binary form. Fuzzy logic requires knowledge in order to reason. This knowledge, which is provided by a person who knows the process or machine (the expert), is stored in the fuzzy system. The FLC in which the error & rate of change of error is fed to FLC to control the current error and voltage. The error is the difference of actual current from the reference current. The stages of FLC are as follows:

4.1 Simulink Model

In last given modal we shown proposed model with
(a) ysteresiscontroller
(b)PIDController
c) Fuzzy Logic Controller
d) Combination of these.

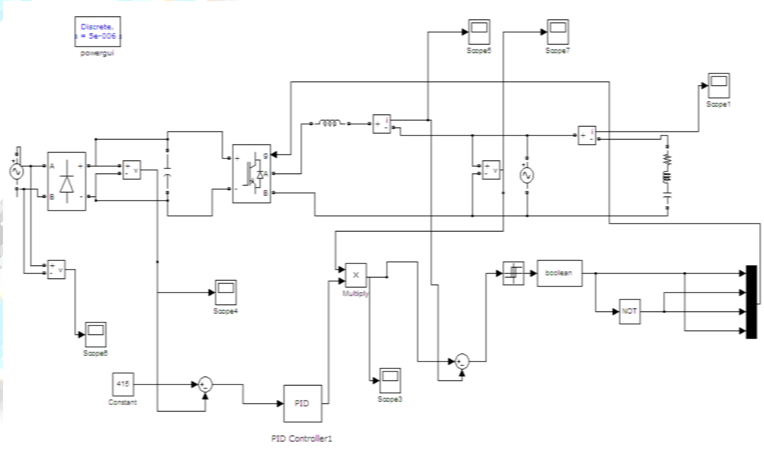


Fig. 7 **Simulink model of control strategy for grid connected inverter using Hysteresis.**

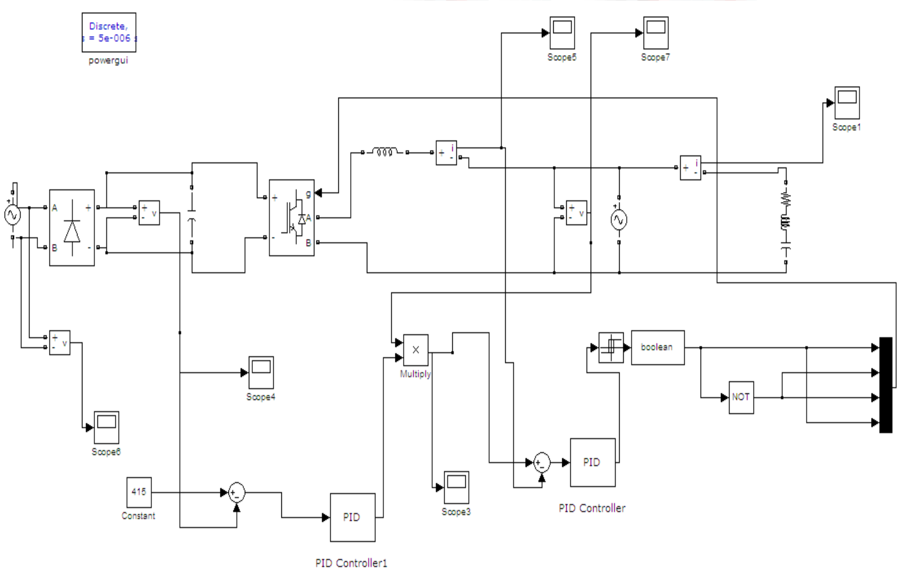


Fig.8 Simulink model of control strategy for grid connected inverter using PID controller.

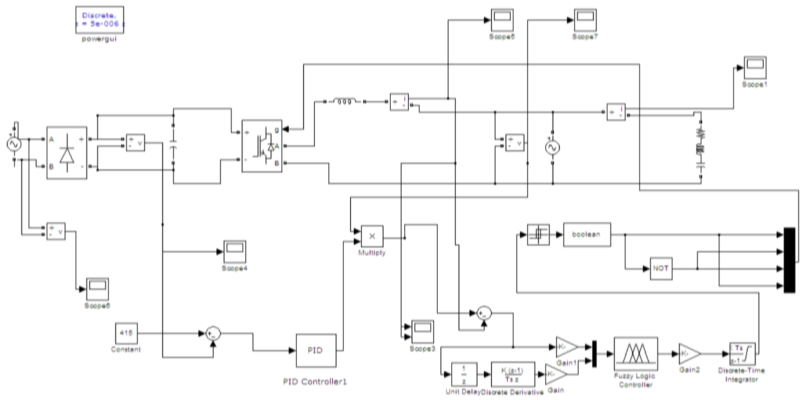


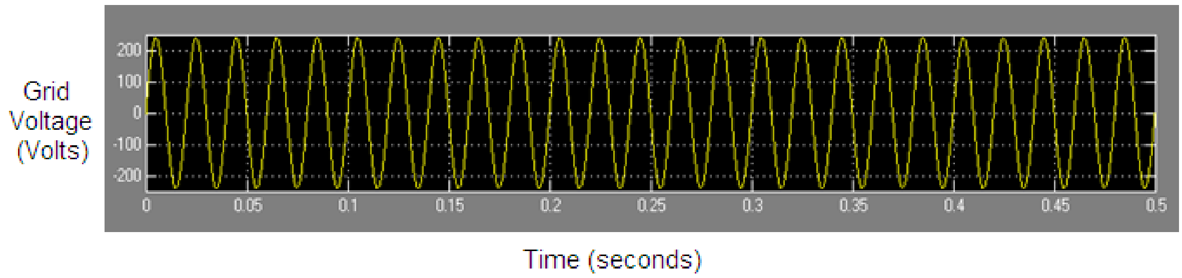
Fig. 9 Simulink model of control strategy for grid connected inverter using Fuzzy controller.

Performance evaluation of control strategy for grid connected inverter.

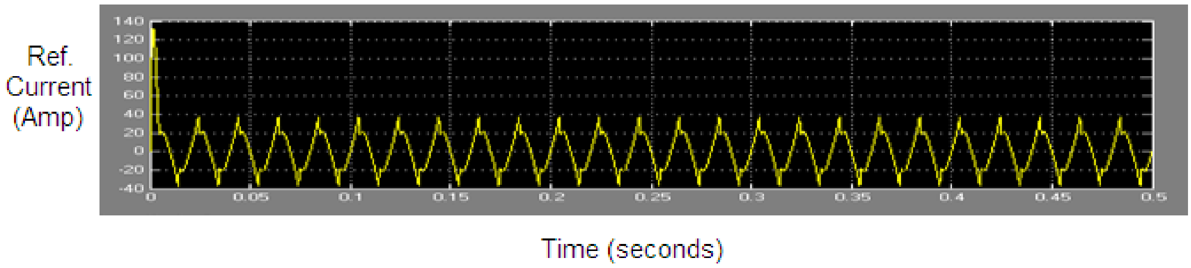
4.3.1 Analysis using hysteresis band

In Fig. 4.5 the grid voltage, source current and load current is shown for a geid connected PWM inverter when cotrolled using a Hysteresis controller only. The load current shows higher content of harmonics.

Grid Voltage:



Reference Current:



Load Current:

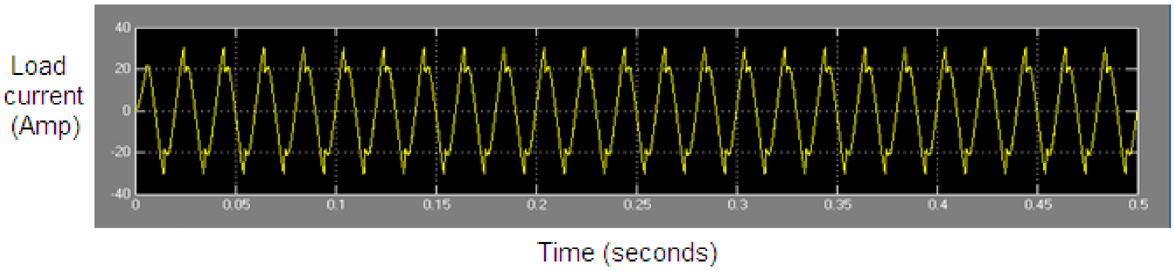


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Fig.10 Grid voltage, Reference current and load current are shown for a grid connected PWM inverter when controlled using a Hysteresis controller.

Analysis of harmonic content

The performance of grid connected PWM inverter through different controller is studied by analyzing the to talhar monic Distortion (THD) of the source current. Two cases are observed.

a) When $V_{grid} > V_{source}$

Calculation of THD using hysteresis controller:

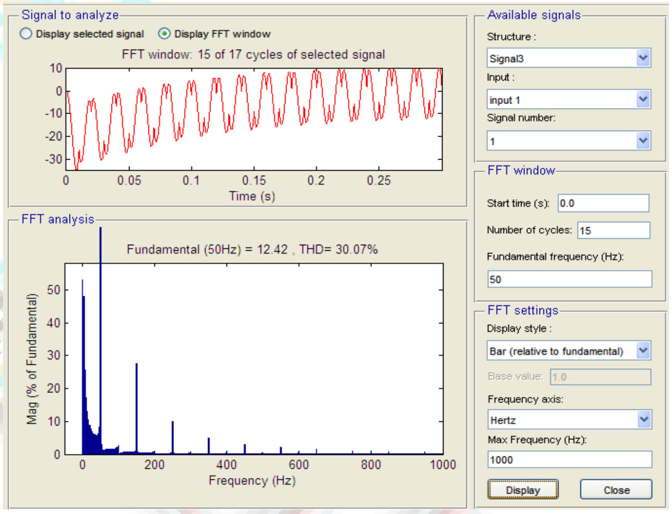

Fig.11 **THD for grid connected inverter using hysteresis controller.**

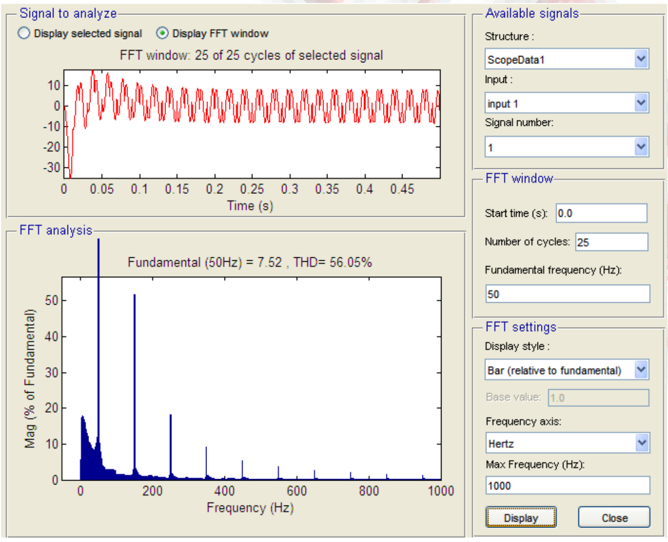

Fig.12 **THD for grid connected inverter using PID controller.**

Table 1: Survey of Various Control Techniques

S.No.	Authors	Control Technique	Max. Frequency (Hz) on X axis	Magnitude of Harmonics at Fundamental Frequency (%)	THD
1.	Satyaranjan Jena et al.	Adaptive Hysteresis Band	2500	19.95	1.24%
2.	Satyaranjan Jena et al.	Fuzzy Controller	2500	10.76	1.66%
3.	GuoXiaoqiang	Proportional Resonant Controller	-	-	3.737%
4.	Satyaranjan Jena et al.	Hysteresis + PI controller	1000	11.89	1.56%
5.	Sharad W. Mohodet.al	FFT	2000	716.5	9.14%

Proposed Work:

Table 2: Comparative Study of Various Control Techniques

S No.	Control Technique	Max. Frequency (Hz) on X axis	Magnitude of Harmonics at Fundamental Frequency (%)	THD
1.	PID Controller	1000	2.27	4.28%
2.	Fuzzy controller	1000	2.174	4.56%
3.	PID + Fuzzy	1000	2.26	4.21%

CONCLUSION

A grid connected PWM voltage source inverter using PID controller, Fuzzy controller and combination of these along with hysteresis controller in the control loop is presented through this work and for the same simulation in MATLAB/Simulink is carried out. From this study we observed that, combination of these controllers (PID + Fuzzy) with hysteresis current controller is able to enhance the power quality of the grid system as it has the capability to reduce the switching frequency even if the bandwidth is increased without any significant increase in the current error. The performance of the (PID + Fuzzy) controller is superior to that of other (PID or Fuzzy) controller as it has been observed that (PID + Fuzzy) controller is able to get steady state current in lesser time with reduced error. As a result, the THD level of grid current is considerably reduced as compared to other controller. Moreover, switching frequency of the inverter system has been reduced, in that in turn, switching losses are also reduced to certain extent.

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