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Optimization Based Reactive Power Control Of Photovoltaic Inverter

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***Abstract*— The power electronic devices may lead to power quality problems which can be overcome by power conditioning techniques. This paper proposes power conditioning scheme based on fuzzy logic for load side inverter. In this configuration a single-phase cascaded multilevel inverter is worn to control the reactive power. The DC output from PV panel is applied to 5-level inverter topology. This is configured using two capacitors and six switches. The power quality issues of this inverter output can be analyzed and controlled by using rule based process in fuzzy controller. Fuzzy control is implemented with the help of FPGA. The design and performance of fuzzy controlled multilevel inverter strategy are verified through numeric simulation.**

Index Terms— Power quality, Reactive power, Fuzzy logic, Multilevel inverter.

I. Introduction

The demand of renewable energy has accrued drastically over the years due to insufficiency of fossil fuels and greenhouse result. Amid various sorts of renewable sources PV plays a serious leaning in many applications as they need reward of being upholding and pollution free power sharing through the world. PV inverters become a lots of rampant at intervals each non-public and industrial circle. In power grid operation, minimizing the real power loss in transmission lines Associate in nursing the voltage deviation at the load buses by dominant the reactive power flow is an necessary task. This ensures for secured operation of power systems with reference to voltage stability and economics of operation due to loss minimization.

Since the reactive power cannot be transferred or transported over long distances, voltage control has to be effected by using special devices located through the system which possess difficulties in keeping sufficient levels of voltage in the power system network. Electric power systems all over the world are moving towards deregulated electricity markets. Reactive power plays an important role in supporting the real power transfer by maintaining voltage stability and system reliability. The reactive power optimization problem has a significant influence on secure and economic operation of power systems. The additional current flow associated with reactive power can cause increased losses and excessive voltage sags.

Since the reactive power can't be transferred or transported over long distances, voltage management has got to be accomplished by exploitation special devices situated through the system that possess difficulties keep decent levels of voltage within the power grid network. wattage systems `everywhere the planet ar moving towards deregulated electricity markets. Reactive power plays a vital role in supporting the $64000 power transfer by maintaining voltage stability and system dependableness. The reactive power optimization drawback features a vital influence on secure and economic operation of power systems. The further current flow associated with reactive power will cause exaggerated losses and excessive voltage sags.

II. Proposed Mechnaism

The proposed technique is to bind the run off reactive power. In order to get better efficiency, Hybrid cascade multilevel inverter is used. Reactive power is optimized by using Fuzzy logic. At the same time THD also reduced.

Multilevel inverter is a power electronic system that synthesizes a desired voltage from several levels of direct current voltage as inputs. Among the Multi-level inverter topologies, a cascaded inverter topology, fed by photovoltaic (PV) source is proposed in this project. Due to the depleting nature of fossil fuels, efficient use of renewable energy resource such as solar is focused here. The DC power generated directly from the Photovoltaic cells and is fed into the converter which is then converted into AC, using a Cascaded Multilevel Inverter to feed an AC load.

A Multi-Level Cascaded voltage source converter is developed to synthesize a high sinusoidal output voltage and it is interfaced with PV source. Multi-level inverter is a high power inverter with comparatively high volt-ampere rating, than the other topologies. It works as an uninterruptible power source that is able to feed a certain minimum amount of power under all conditions. The hardware implementation of this circuit is done after carrying out the simulation test, to ensure proper results. Reduction of power ratings of power devices, low cost, compact structure and high reliability are the important advantages of this system.

A. Block Diagram

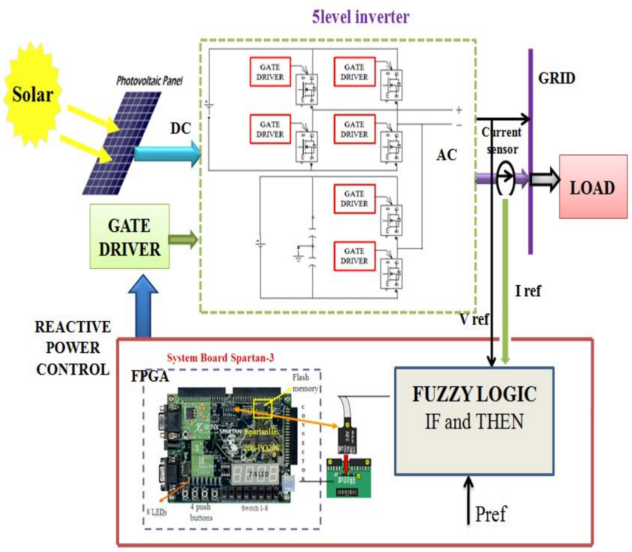

Fig 1. Block diagram of Proposed Mechanism

B. Inverter and its topologies

Multilevel voltage source inverter is recognized as an important alternative to the normal two- level voltage source inverter especially in high voltage application. The concept of a multilevel converter to achieve high power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Using multilevel technique, the amplitude of the voltage is increased, stress in the switching devices is reduced and the overall harmonics profile is improved.

C. Concept of Multilevel inverter

Multilevel inverters are significantly different from the ordinary inverter where only two levels are generated. The semiconductor devices are not connected in series to for one single high-voltage switch. In which each group of devices contribute to a step in the output voltage waveform. The steps are increased to obtain an almost sinusoidal waveform. The number of switches involved is increased for every level increment.

D. Hybrid Cascade Multilevel Inverter

The cascaded multilevel inverter consists of a full-bridge inverter, capacitor voltage divider, an auxiliary circuit comprising four Sic diodes and a Si MOSFET switch. The inverter produces output voltage in five levels: zero, 0.5Vdc, Vdc, 0, -0.5Vdc and -Vdc. The advantages of the inverter topology are:

- Improved output voltage quality.
- Smaller filter size.
- Lower EMI.
- Lower THD compared with conventional three-level PWM.
- Reduced number of switches compared to the conventional

TABLE I. Topologies of Multilevel Inverter.

S. No	Types of Multilevel inverters	No of Switches	No of Diodes	No of Capacitors
1.	Diode clamped	8	12	4
2.	Flying capacitor	8	-	10
3.	Cascade H-bridge	8	-	-
4.	Hybrid cascade	6	-	2

E. Operation of an Inverter

The word main inverter is used to refer to the two-switch single phase inverter and the word auxiliary inverter is referred to four-switch H-bridge inverter. Since the low switching losses during PWM operation is required, the main inverter will operate on square wave mode and auxiliary inverter will operate on PWM mode. The number of switches depends upon the number of required output voltage levels.

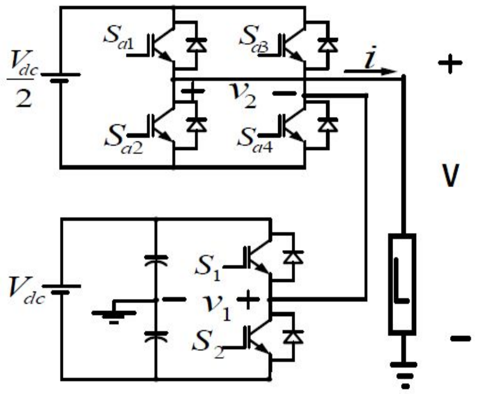

Fig 2. Hybrid Cascade MLI

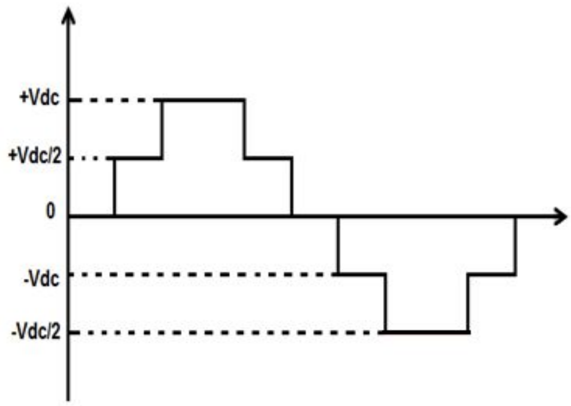

Fig 3.Fivel level inverter output

III. Fuzzy Logic Control

Fuzzy logic control is a control algorithm based on a linguistic control strategy, which is derived from expert knowledge into an automatic control strategy. Fuzzy logic control doesn't need any difficult mathematical calculation like the others control system. While the others control system use difficult mathematical calculation to provide a model of the controlled plant, it only uses simple mathematical calculation to simulate the expert knowledge. Although it doesn't need any difficult mathematical calculation, but it can give good performance in a control system. Thus, it can be one of the best available answers today for a broad class of challenging controls problem. Fuzzy logic controller is capable of determining the instantaneous value of the error signal without considering the change of the rise and fall of the error, which in mathematical terms is the derivative of the error denoted as $\Delta\varepsilon$.

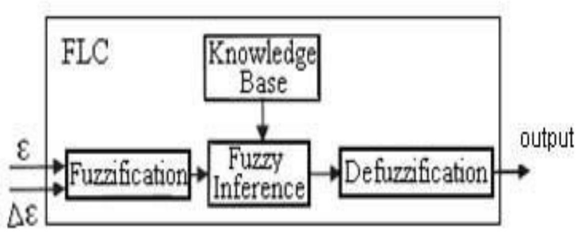

Fig 4.Fuzzy Block Diagram

The scaling is very important because the fuzzy system can be retrofitted with other devices or ranges of operation by just changing the scaling of the input and output. The decision-making-logic determines how the fuzzy logic operations are performed (Sup-Min inference), and together with the knowledge base determine the outputs of each fuzzy IF-THEN rules. Those are combined and converted to crispy values with the defuzzification block. A typical fuzzy logic controller is composed of three basic parts: input signal fuzzification, a fuzzy engine that handles rule inference, and defuzzification that generates continuous signals for actuators such as control valves. Fig depicts such a fuzzy logic controller.

The fuzzification block transforms the continuous input signal into linguistic fuzzy variables such as small, medium and large. The fuzzy engine carries out rule inference where human experience can easily be injected through linguistic rules. The defuzzification block converts the inferred control action back to a continuous signal that interpolates between simultaneously fired rules. Owing to defuzzification, fuzzy logic is sometimes referred to as continuous logic or interpolative reasoning. The resulting relation is actually a nonlinear functional relationship rather than a logic relationship.

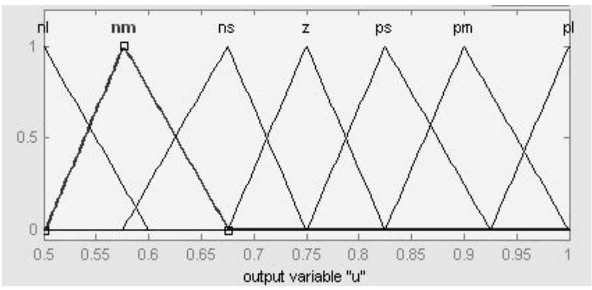

Fig 5. Membership function of fuzzy

IV. Simulation Results

The circuit models for this control are developed by simulation studies in MATLAB.

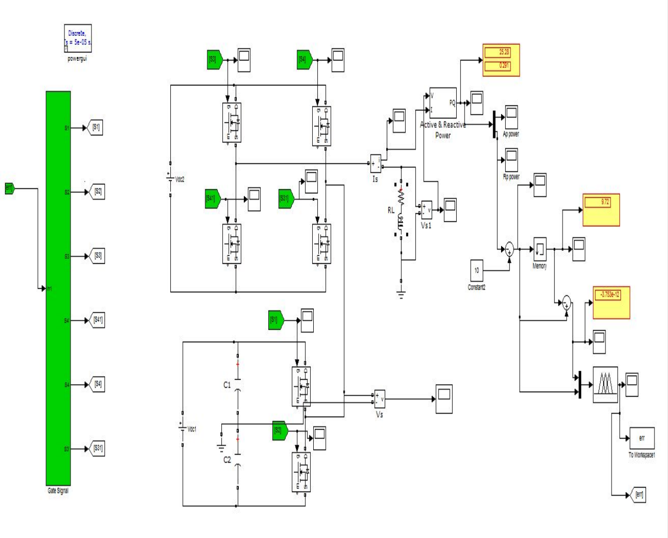

Fig 6. Simulation Circuit For Reactive power control

By using Fuzzy Logic control the reactive power exist in the inverter is reduced to 0.15 and the THD is limited from 73.09 to 54.85 using this strategy.

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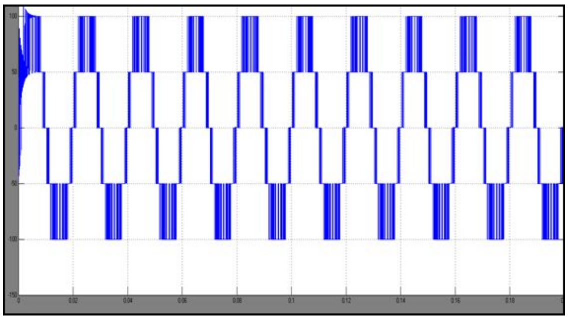


Fig 7. Five level inverter output.

For further verification, a single phase fuzzy controlled five level Hybrid cascade multilevel inverter prototype was built and tested. The switch ratings are for the MOSFET are different.

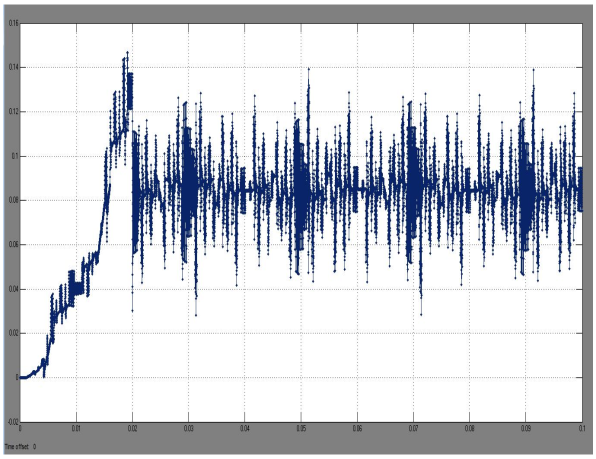


Fig 8.Reactive power output after using Fuzzy

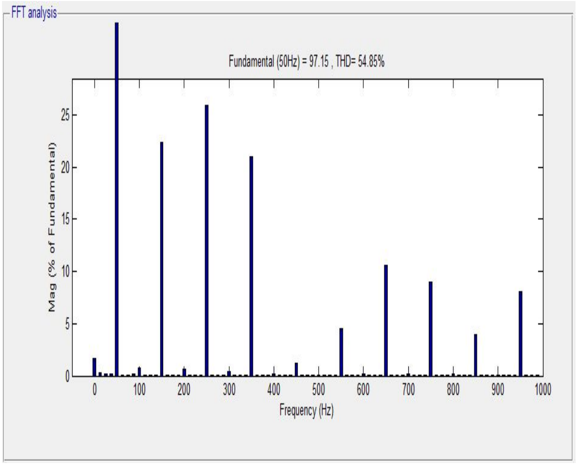
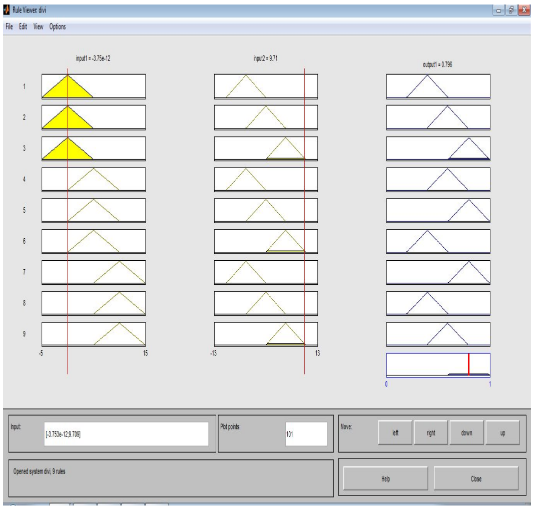


Fig 9. THD Analysis

A. Rules and Surfaces

Many types of curves can be used, but triangular or trapezoidal shaped membership functions are the most common because they are easier to represent in embedded controllers. Fig 10 shows a system of fuzzy sets for an input with trapezoidal and triangular membership functions. Each fuzzy set spans a region of input (or output) value graphed with the membership. Any particular input is interpreted from this fuzzy set and a degree of membership is interpreted. The membership functions should overlap to allow smooth mapping of the system. The process of fuzzification allows the system inputs and outputs to be expressed in linguistic terms so that rules can be applied in a simple manner to express a complex system.



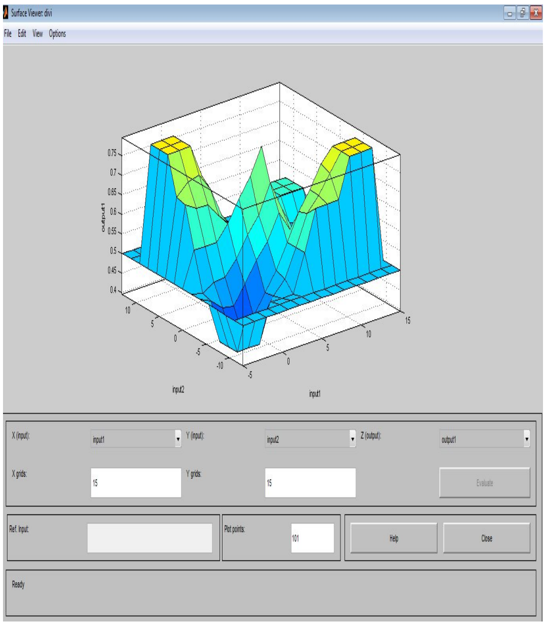


Fig 10.Rules and Surfaces of Fuzzy based on output

V. CONCLUSION

The proposed control technique was based on Fuzzy logic to control the reactive power in the load side inverter. It can reduce the THD and switching stress. The mechanism was cost effective with lower computational burden provided by the circuit. Finally, the simulation and experimental results are to verify the performance of proposed control strategy.

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