A Novel Control Method for Improvement of Voltage Utilization Factor in Three-Phase Multilevel Inverter Considering the Input Voltage Fluctuation

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Abstract

In This paper wind, solar and fuel cells based stand alone cogeneration systems are presented for remote area utilities applications. This type of co generation system output voltages are not constant or stable in always. The generated output voltages are directly connected to the loads, without battery bank or energy storage devices. The PI, fuzzy control method was proposed in this paper using svpwm, such that the output voltage of converter circuit is constant even though input voltages are fluctuation conditions. A three phase multilevel inverter with static and dynamic load was examined to validate for proposed work in MATLAB environment.

Index terms— space vector PWM; PI-controller; FUZZYcontroller; cogeneration systems; cloosed loop control system.

1 Introduction

he last decades growth in the production of electric energy from renewable energy sources has led to an increased focus on power electronics. Renewable energy sources like photovoltaic, wind and wave energy are relying on power converters in order to exchange power with the grid. Anyone who wants to produce power for the grid has to make sure that their facilities are complying with national grid codes. The grid codes has strict regulations when it comes to the voltage quality, including limits for rapid voltage variations, flicker and harmonic distortion. Rapid voltage variations and flicker are matters of control of the inverter system, but harmonic distortion is created by the pulse width modulated switching of the converter. Different filters topologies can be used in order to reduce the harmonics generated by the switching action in the converter.

The technology growth in the recent years, most of the electrical and electronics equipments are playing the major role in the social growth. Accordingly more and more amount of power demand has an increased. One solution that to meet the power demands in rural and remote area are cogeneration systems, witch an includes hybrid renewable energy sources. In case of the system power generation with natural energy and fuel cell, comparatively large amount of fluctuation is generated at the DC voltage.

The circuit wich converts the DC power in to AC power using multilevel inverter circuit was implemented considering the input dc voltage fluctuations. However the space vector pulse width modulation method was applied in order to improve the voltage utilization factor and stabilization of output voltage.

In this paper, the new control method which an introduced the control of the output voltage feedback control is proposed. It applied to the control circuit, multilevel inverter and operational principle with are explained.

2 II.

3 Diode Clamped Multilevel Inverter

The diode-clamped inverter provides multiple voltage levels through connection of the phases to a series bank of capacitors. According to the original invention, the concept can be extended to any number of levels by increasing the number of capacitors. Early descriptions of this topology were limited to three-levels where two capacitors are connected across the dc bus resulting in one additional level. The additional level was the neutral point of the dc bus, so the terminology neutral point clamped (NPC) inverter was introduced. However with an even number of voltage levels, the neutral point is not accessible, and the term multiple point clamped (MPC) is sometimes applied. Due to capacitor voltage balancing issues, the diode-clamped inverter implementation has been mostly limited to the three level. Because of industrial developments over the past several years, the three level inverter is now used extensively in industry applications. Although most applications are medium-voltage, a three-level inverter for 480V is on the market.

The three phase 3-level diode clamped multilevel inverter is the common multilevel inverter used for various applications. A three phase 3-level diode clamped multilevel inverter is adopted in this project. It is obtained from a configuration of twelve switching devices and six clamping diodes as shown in figure **??** The pairs Sa1 Sa1', Sa2 Sa2', Sb1 Sb1', Sb2 Sb2', Sc1 Sc1' and Sc2 Sc2' are complementary. Therefore, Sa1'=1-Sa1, Sa2'=1-Sa2, Sb1'=1-Sb1,Sb2'=1-Sb2,Sc1'=1-Sc1 and Sc2'=1-Sc2. There are twelve active combinations were taken using these switching states which produce twelve active voltage vectors. The nonzero voltage vectors are from V1 to V12.

The sector is identified from three phase reference voltage and the corresponding voltage vector is selected from the switching table to generate the gating pulses for the inverter. The vector sequence is V1, V2 , V3 , V4 , V5 , V6 ,V7 , V8 , V9 , V10 , V11 , V12 , V1 each for 30 o .

The angle of reference is found using equation It represent the combined generation systems of the solar energy, wind power and fuel cell systems are consider for the input source to the inverter circuit, these are generated power is not constant in always. In such cases output voltage suffers from its input. In this paper we developed a control circuit with PI, Fuzzy controller logic which absolves the output voltages, generates the equalant correction signal to the pwm circuits.=

4 III.

5 Space-Vector Pwm

One of the features of two parallel connected inverters is the ability to obtain three levels of voltage (phase to neutral) P = VDC, H = Describing system in the meaning of three voltage levels provides similarity to Three-Level Neutral Point Clamped Inverter. This similarity allows to approach Space Vector Modulation in the same way like for Neutral Point Clamped Inverter [1].

The large vectors divides the plane into six sectors. Each of these sectors can be split into four regions as it is depicted in Fig. 3. Combination of vectors which should be used to synthesize Vref is based on its position. For example, when Vref is in region four of sector I, V2, V7 and V14 are used. where:V14 = 2 3 VDC?? ?? ? 3 ?? ?? ? 3 ; V7 = 2 3 VDC?? ?? ? 6 ;V2= 1 3 VDC?? ?? ? 3 ; 2 3 [cos(? 3)+jsin(?**3**)]?? ?? + ?3 3 [cos ? ? 6 ? + ????????(? 6)]?? ?? + 1 3 [cos(? 6

)+jsin(? 6)]?? ?? = ???????? ?????? [cos(?"¨)+jsin(?"¨)]?? ?? (2)

And splitting into real and imaginary part: b) Real1 3 T a + 1 2 T b + 1 6 T c = Vref VDC cos(?"¨)?? ?? (3) c) Imaginary ?3 3 ?? ?? + ?3 6 ?? ?? + ?3 6 ?? ?? = ???????? ?????? sin (?"¨)?? ??**(4)**

d) Together withT a + T b + T c = T s**(5)**

a set of equations real and imaginary can be created to calculate dwell times: Ta, Tb, Tc. The dwell times for every region in sector I are presented in Table1.

Table **??** : Switching pattern for sectorSECTOR -1 Segments 1 2 3 4 1 [OOO] [HOO] [HOO] [HHO] 2 [HOO] [HHO] [POO] [PHO] 3 [HHO] [PHO] [PHO] [PPO] 4 [HHH] [PHH] [PHH] [PPH] 5 [HHO] [PHO] [PHO] [PPO] 6 [HOO] [HHO] [POO] [PHO] 7 [OOO] [HOO] [HOO] [HHO]

O-lower switching, H-upper switching, P-both upper and lower switching.

IV.

6 Pi Controller

PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on speed of the response and overall stability of the system. Thus, PI controller will not increase the speed of response [5]. It can be expected since PI controller does not have means to predict what will happen with the error in near future **??**1] [2]. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller. PI controllers are very often used in industry, especially when speed of the response is not an issue. A control without D mode is used when a) Fast response of the system is not required b) large disturbances and noise are present during operation of the process c) There is only one energy storage in process (capacitive or inductive) d) There are large transport delays in the system The pi controller basic mathematical equation isU = Kp?? ?? + ???? ? ?? ?? + ?? 0 ?? ?? =0 (6) ?? ?? = ? ????????(?? ? ????????) ????????(?? ? ????????) ? Kp=proportional coefficient Ki=integral coefficient ?? ?? =K-th sampling time ?? 0 =initial value V.

7 Fuzzy Controller

The most commonly used fuzzy inference technique is the so-called Mamdani method, as the very first attempt to control a steam engine and boiler combination by synthesizing a set of linguistic control rules obtained from experienced human operators. Their work was inspired by an equally influential Interest in fuzzy control has continued ever since, and the literature on the subject has grown rapidly [2]. In this model the fuzzy implication is modeling by Mamdani's minimum operator, the conjunction operator is min, the t-norm the working with this model of FLC will be considered the example. Where a simple two-input one-output problem that includes three rules is examined Rule 1 : IF x is A3 OR y is B1 THEN z is C1 Rule 2 : IF x is A2 AND y is B2 THEN z is C2 Rule 3 : IF x is A1 THEN z is C3.

Step 1: Fuzzification The first step is to take the crisp inputs, x0 and y0, and determine the degree to which these inputs belong to each of the appropriate fuzzy sets. According to Similarly, in order to evaluate the conjunction of the rule antecedents, the AND fuzzy operation intersection is applied.µA?B(x) = min{µA(x), µB(x)} (**9**)

The result is given in this Figures

Figure **??** : Rules evaluation Now the result of the antecedent evaluation can be applied to the membership function of the consequent. The most common method is to cut the consequent membership function at the level of the antecedent truth; this method is called clipping. Because top of the membership function is sliced, the clipped fuzzy set loses some information. However, clipping is preferred because it involves less complex and generates an aggregated output surface that is easier to defuzzify. Another method, named scaling, offers a better approach for preserving the original shape of the fuzzy set [3] A reasonable estimate can be obtained by calculating it over a sample of points. This fuzzy logic controller is 3-level system so it has two inputs, n-level system has (n-1) inputs and (?? ? 1) 2 rules are used so in this fuzzy logic controllers. From fig.no.12(c) we can observe that 0sec. to 0.4sec. input DC is constant, output voltage is maintain constant magnitude. From 0.4sec. to 0.62sec. the input DC voltage is decreases. in this case the output voltage magnitude is small decreased. Than after time scale from 0.62sec. to 0.8sec.the output voltage has increased to meet the rated value of magnitude. after 0.62sec. to 1sec. DC voltage is 20% lesser than the applied voltage magnitude even through this period output voltage magnitude is reached the rated voltage and remains constant voltage magnitude. Using SVPWM method which is helps to improve the output voltage magnitude to maintain rated voltage with fast switching cycles.

8 Conclusion

From table 2. Comparison of PI and FUZZYcontrollers, The advantage of PI controller is less THD than fuzzy. The advantage of Fuzzy -controller is taking the less number of cycles to reach the rated output voltage magnitude considering input dc voltage flutuation. Fuzzy control is 22% of voltage fluctuation more DC voltage utilization and dynamic, static load response is very smooth manner than the PI control. So that fuzzy-control method is an effective one considering dc voltage fluctuation cases to improve the output voltages of converters with very fast response time, low THD value, and the supporting results are an examined in this paper with 6Kw resistive and 5HP induction motor loads.

9 VIII.

10 Feature Scope

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Figure 1: Figure 1 : 3 -Figure 2 :

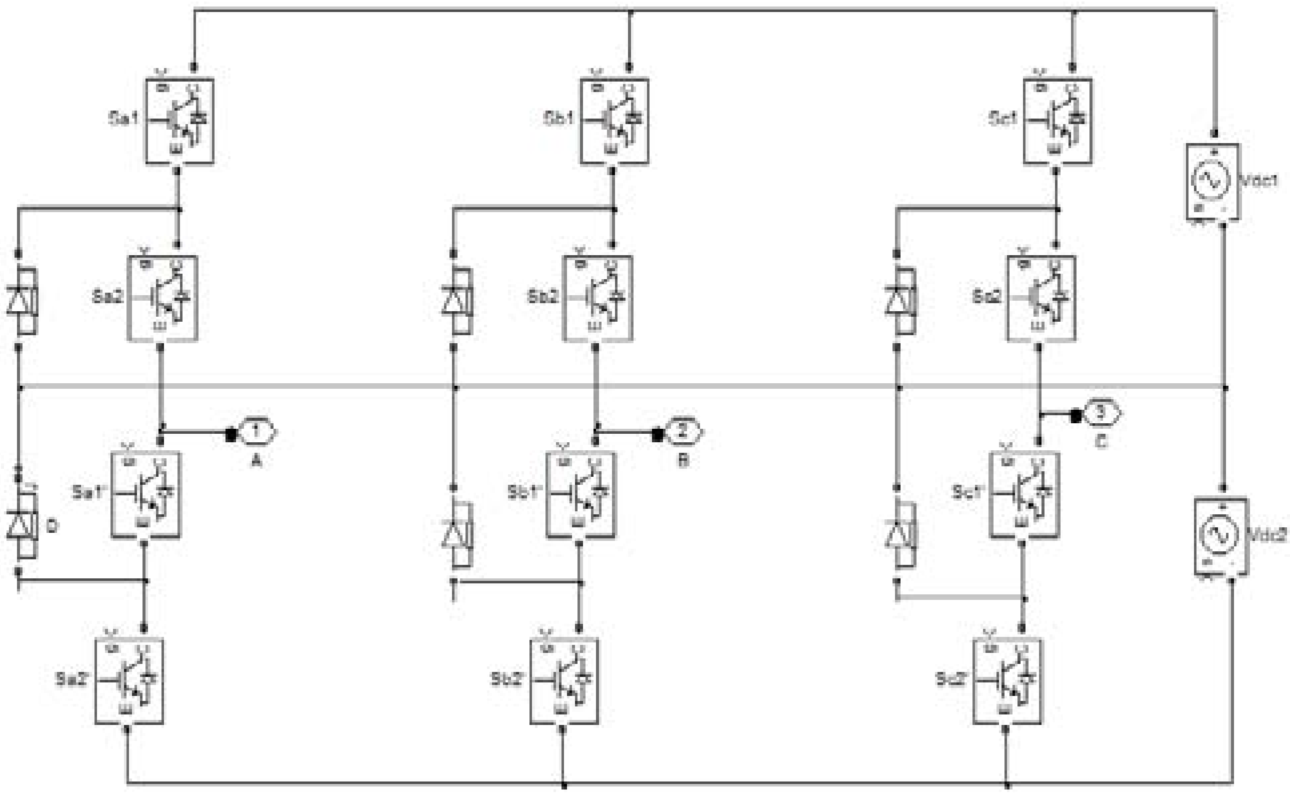

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Figure 2: Figure 3 :

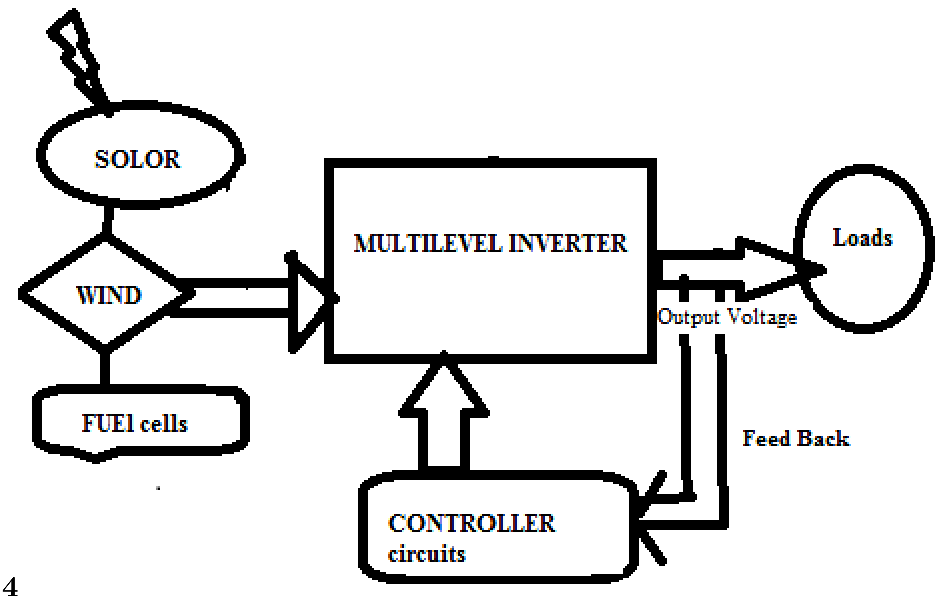

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Figure 3: Figure 4 :

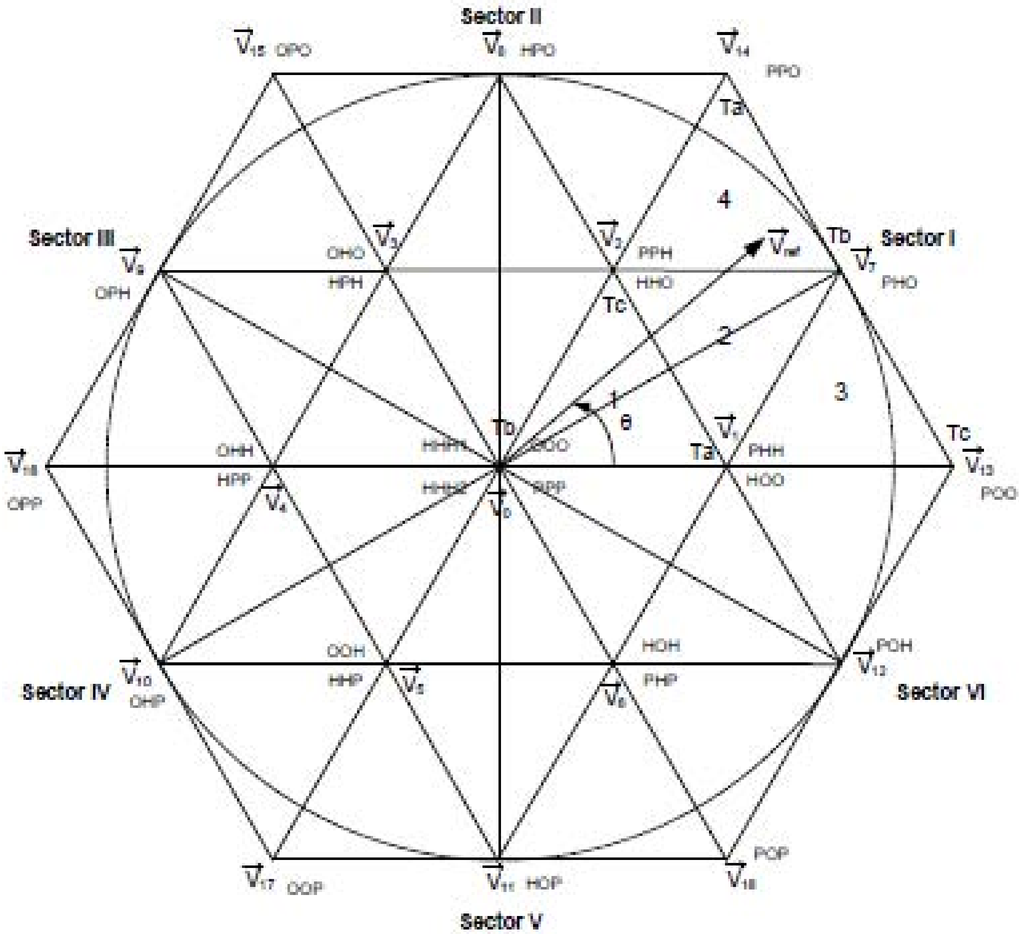

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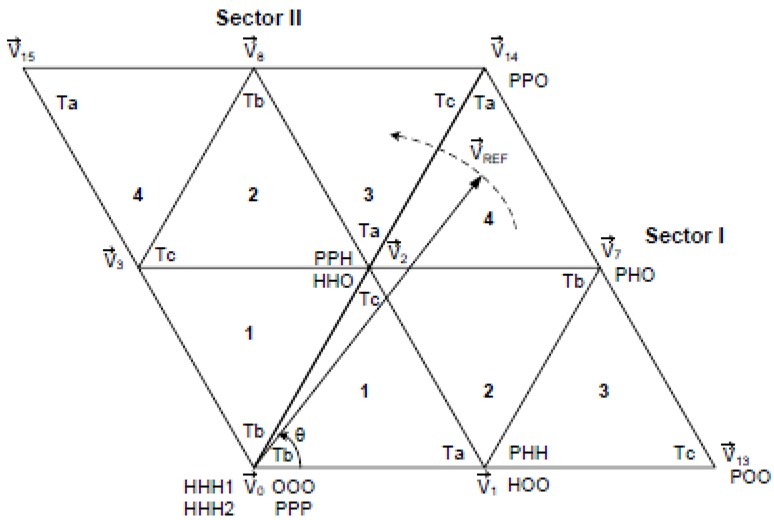
Figure 4: 7)Figure 5 :



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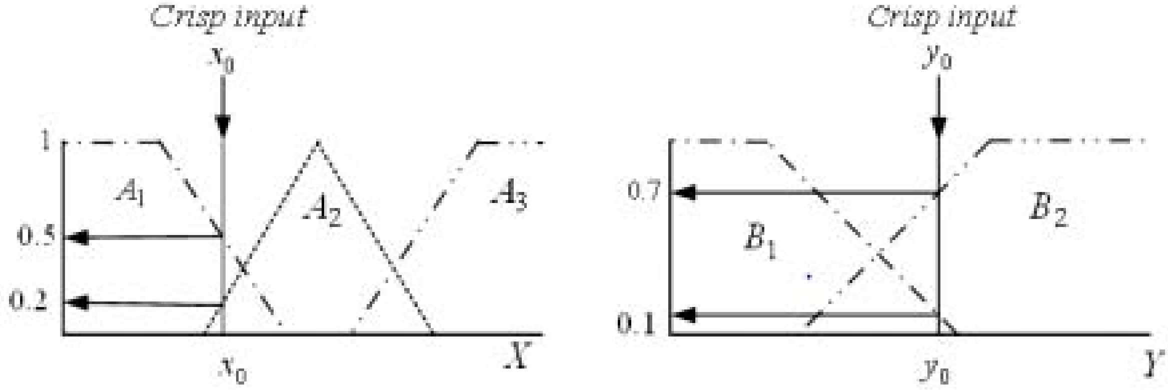

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Figure 6: Figure 7 :

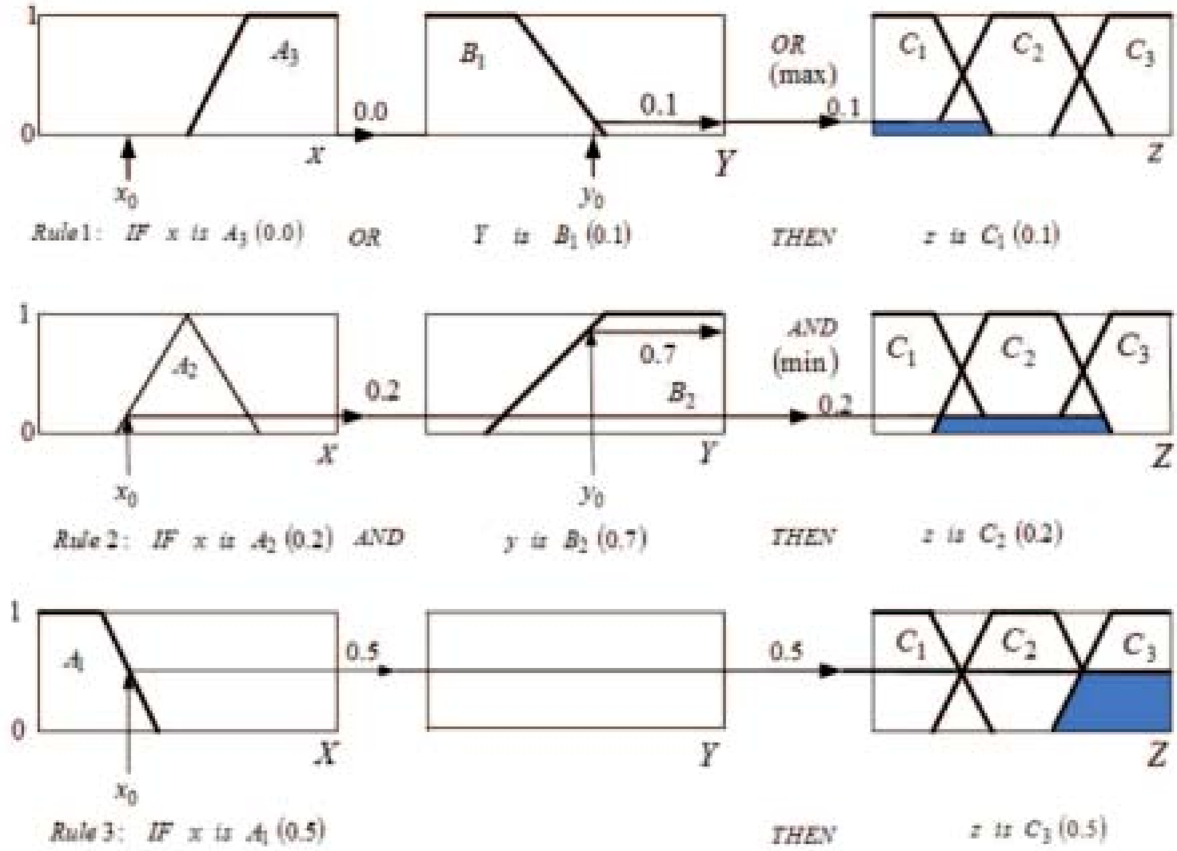

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Figure 7: Figure 8 :

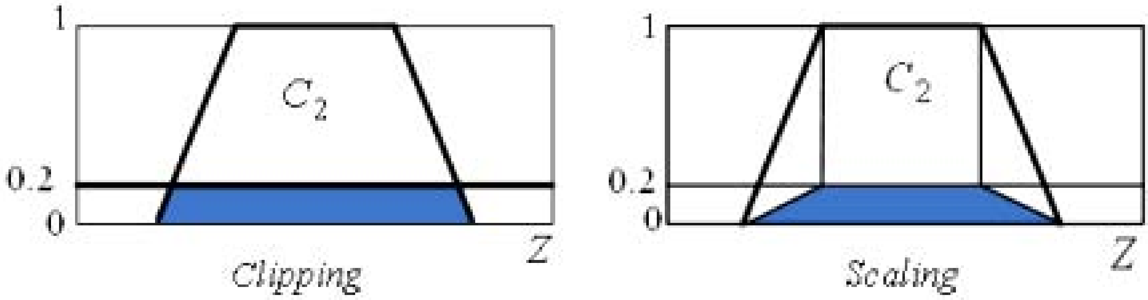

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Figure 8: © 4 FeFigure 10 :

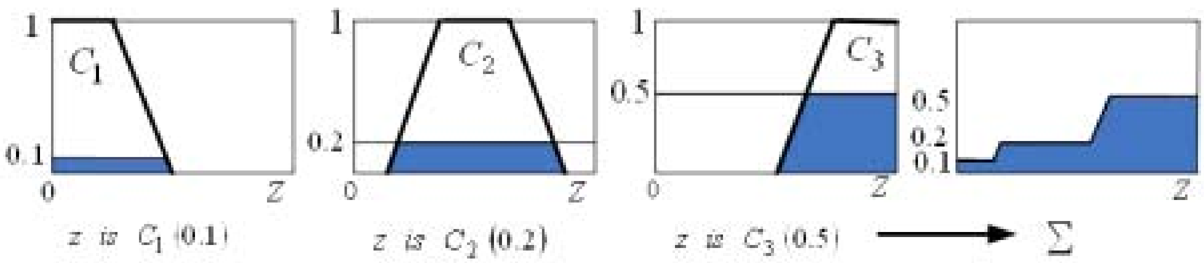

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Figure 9: Figure 11 : 5 2015 FFigure 9 :

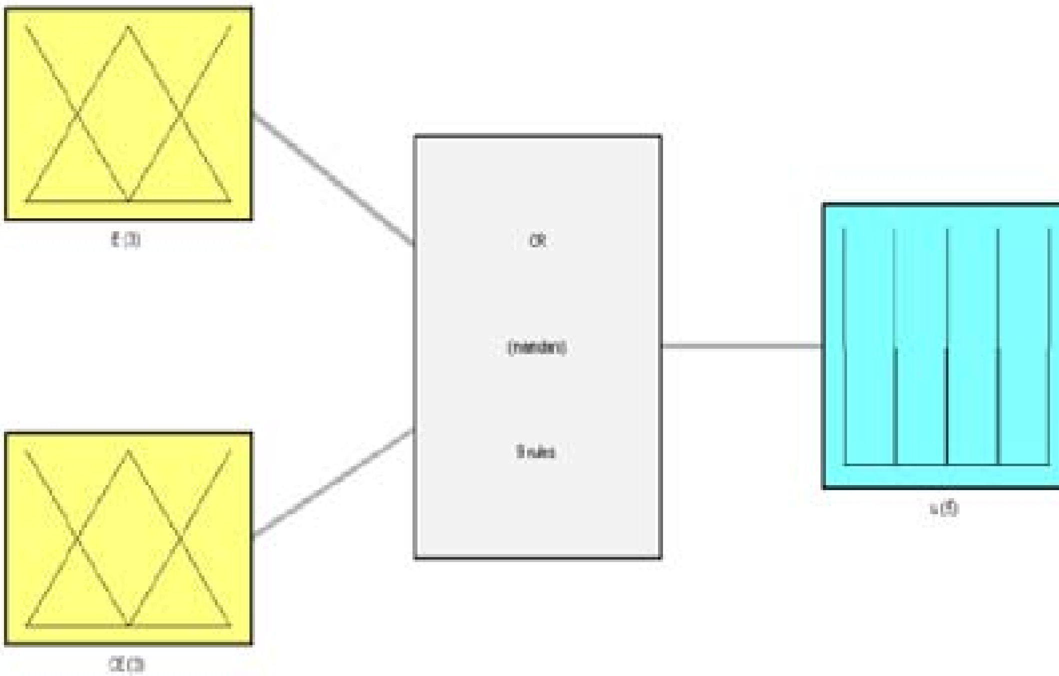

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Figure 10: Figure 13 :Figure 14 : 7 2015 FFigure 21 :

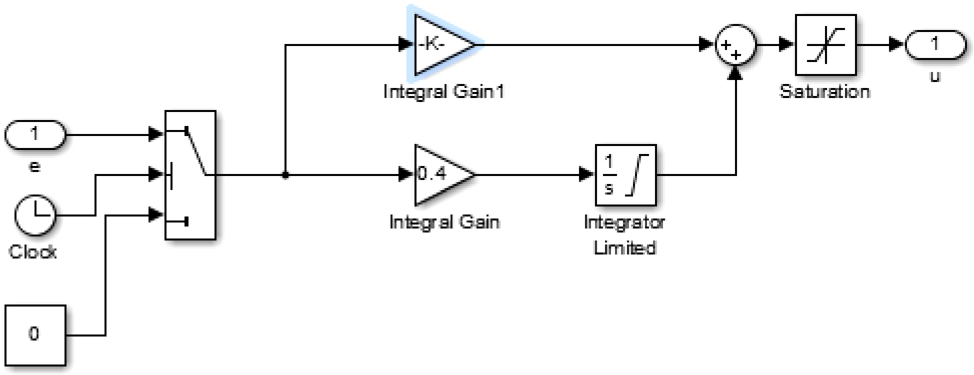

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Figure 11: Figure 23 :

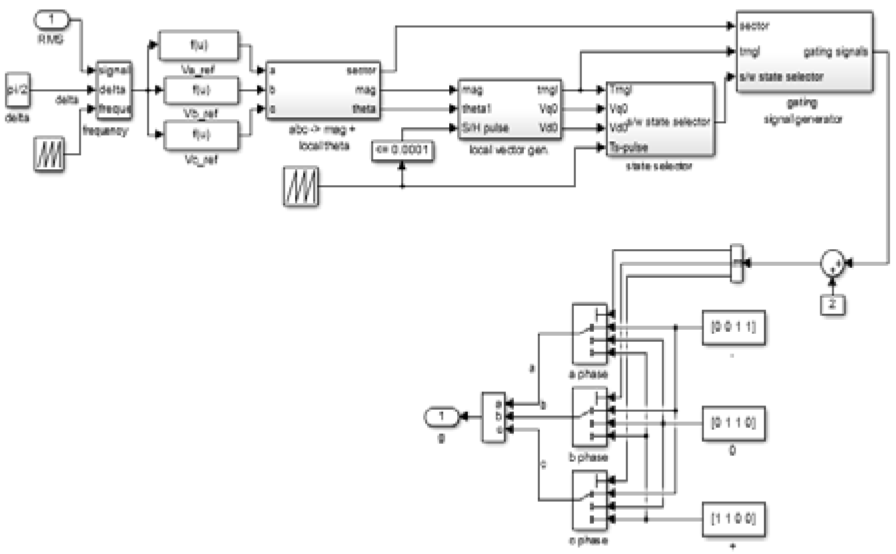

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Figure 12: Future 8 Fe

?? ???? ?? ???? ? .

Figure 13:

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Input DC voltage fluctuation (%)	and Fuzzy controller Control methods with Load	Total Harmonic Distortion (%)	No. of cycles to reach rated voltage
20	PI with Resistive	0.12	12
20	PI with Induction motor	0.21	12
22	Fuzzy with Resistive	0.20	8
22	Fuzzy with Induction motor VII.	0.20	8

Figure 14: Table 2 :

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