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Design and Development of 7-swithced multilevel inverter 15 Level Using Fuzzy logic Algorithm

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ABSTRACT:-

Harmonics cause the power quality of solar photovoltaic (PV) energy conversion systems to deteriorate. In order to address this problem, this article looks into how Fuzzy Logic (FL)-based controllers can reduce harmonics in a solar system with a cascaded 15-level inverter. Recently, interest in multilevel inverters has grown as a result of their capacity to produce output waveforms of excellent quality at low switching frequencies. They are therefore incredibly desirable for high-power applications. By removing some of the lower order dominant harmonics, the output waveform's quality can be improved. It is suggested to use a modern multilayer inverter with fewer power switches. This novel cascaded H-bridge architecture multilevel inverter. This study lowers overall harmonic distortion (THD). In this study, a novel idea for switching frequency with fewer switches is put forth. Compared to previous multilevel inverters, this idea aids in reducing the complexity of switching. A straightforward linear load is used to verify a proposed multilevel inverter with fifteen levels of output. Simulation has been used to validate the suggested concept.

INDEX WORDS: Harmonics, multilevel inverter, photo voltaic, Fuzzy Logic Controller

I. INTRODUCTION

Multilevel inverters are widely used today due to the diversity of voltages at which they operate and perform. The multilayer inverter produces the necessary output by fusing together a number of various, independent sources of dc power. The inverter voltage output waveform is created by combining an increasing number of dc sources with a switching frequency, resulting in a waveform that is roughly sinusoidal [1]. This system has a large number of dc sources, which leads to low voltage stress and minimum switching losses. Due to its many benefits, MLI has recently attracted a lot of attention. Converting power in discrete voltage steps is MLI's main objective. Devices with low voltage specifications and increased efficiency benefit from the tiny voltage steps' reduction of switching losses and harmonic distortion. Also It raises the likelihood that low speed power semiconductor devices will be adopted and reduces the voltage demands placed on the load. Efficiency is raised and with this MLI topology, the output filter's size can be greatly reduced. The main job of a multilayer inverter is to convert a finite source of DC input voltage into the appropriate AC output voltage. Three basic forms of multilevel inverters can be generically categorised: cascade H-bridge MLIs [4], flying capacitor MLIs [3], and diode clamped converters [2]. When we aim for greater levels, balancing the voltage across the capacitor gets more difficult since a flying capacitor inverter needs more and more capacitors. When we progress to higher levels and require more clamping diodes, the system gets more challenging when using a diode clamped type. Hence, cascaded H-bridge multilevel inverters are applicable to get around the aforementioned limitations [5] [6]. These converters are frequently used because they are straightforward and versatile. Symmetrical converters and asymmetrical converters are the two categories into which the cascaded H-bridge multilevel inverters are divided. Whereas symmetrical topologies use equal-voltage dc sources for each H-bridge, asymmetrical topologies use voltage sources that are not equal in value. With less power-hungry components, the innovative asymmetrical MLI architecture developed in this work can provide more levels in the output waveform [7]. Figure 1.1 below illustrates it. As a result, switching losses are decreased, increasing the inverter's efficiency. Many sinusoidal pulse PWM techniques can be used to extract the proper staircase output voltage waveform from the various DC input voltage sources.

II. SOLAR ENERGY

Renewable energy is used to describe life that depends entirely on natural resources. Many renewable energy sources, such as sunshine, Nature contains the elements of air, water, biomass, and geothermal heat. The scope and potential for renewable energy resources are vast over a particular geographic area, in contrast to conventional energy sources like fossil fuels, which are constrained and focused to specific locations. Rapid adoption of renewable energy sources would increase energy security, efficiency, and economic growth while minimising adverse environmental effects. Improvements in healthcare, a decline in newborn death rates as a result of fewer environmental effects, and countries spending millions less on healthcare are all included in this [8]–[9]. While creating electricity, renewable energy frequently takes the place of conventional energy sources. Services for getting about, moving, and heating water in rural areas (off grid). As a result, it is realistic to anticipate that rural areas will have better and increased access to renewable energy sources [10]. Solar energy from the sun is captured via PV technologies, solar heating, concentrated solar power, and concentrated photovoltaics. Depending on how information is gathered, transformed, and distributed, it is frequently broken down into various categories. They come in active and passive varieties. Using the photoelectric effect, a PV system transforms light into electrical energy. A variety of silicon semiconductors are used in the PV system to transform photons into electrons.

The produced DC is subsequently converted to AC using converters. To maximise the amount of solar energy harvested, specialised MPPT technology must be used. For this, solar panels that track the sun are typically used. The sun-tracking PVs accomplish this by adjusting their solar energy collection to produce the most electricity at a constant voltage in response to variations in the amount of solar insolation experienced across the world. Efficiency is measured by a solar array's ability to convert light into electricity, which is a highly specific consideration when choosing the right PV panel. Solar PVs can be successfully incorporated into the main power supply as a dependable RE source the solar energy system has a number of problems due to the discrepancy between the amount of electricity the solar panels generate and the amount required.

This is mostly caused by PV's unpredictable generation. Voltage regulation is one of the many problems it causes. When compared to other multilevel inverters, the CMLI generates the same number of voltage levels with the fewest number of components. The need for separate DC sources for use in real power conversions is the CMLI's only flaw. Yet this flaw can be fixed by using solar PV as its input. In light of this, the study describes ways to improve power quality and streamline voltage regulator control in a solar power circuit. The second section examines several methods for controlling voltage. The suggested course of action for the proposed system is discussed in section 3, the findings are covered in section 4, and the research is wrapped up in section 5.

III. PROPOSED CASCADED MULTILEVEL INVERTER FOR 15 –LEVEL

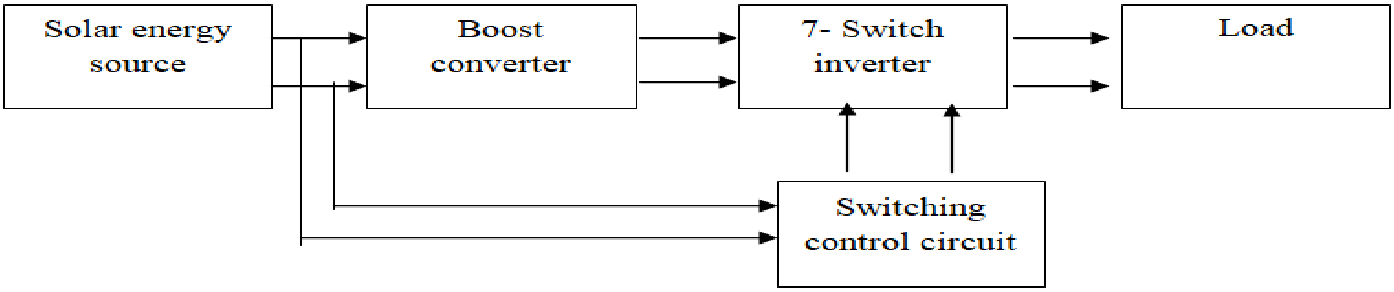


Fig. 1 Proposed Block diagram

Three PV sources are used in this multilayer inverter. Each source provides the voltage needed by each switch. Unlike the inverter circuit, which needs 48 volts of power, the driving circuit only needs 12 volts. DC current is changed into AC current by the inverter circuit. For the load (the power-consuming device) to create a waveform that is as even as is practical, the PWM switching frequency must be significantly greater than what would affect the load. Depending on the load and application, the power supply's switching frequency can vary significantly.

IV. CONTROLLER MODELLING

The bulk of renewable energy sources, including solar PV, are connected to the inverter, which functions similarly to and analogously to a synchronous machine or generator on a grid (Distribution System). As a result of the PV panel's solar radiation absorption, the power production varies throughout the day. The rated voltage can therefore vary between 20% and 20%. Power electronic circuits can be used to maintain a consistent DC voltage in the PV. The continuous because the grid delivers voltage in AC, DC voltage is then inverted to AC. In order to sustain a 48V, 7A solar panel with a maximum variation of 1%, the suggested experiment uses an inverter with sufficient accuracy.

A. Fuzzy Logic Controller

Lofti A. Zadeh developed fuzzy logic, which differs fundamentally from boolean algebra. The values state must always be either 1 (ON) or 0, which is one of fuzzy logic's distinctive characteristics (OFF). Fuzzy logic is different from Boolean logic in that it accepts two or more values between true and false. It simply allows true or false, in contrast to Boolean logic. Fuzzy logic makes it less difficult to derive specific conclusions from ambiguous, dubious, and false evidence.

The Cascaded H Bridge Multilevel Inverter Fuzzy Logic Controller (FLC) design for a Solar PV-fed inverter is shown in Figure 2. Here, the output voltage (Vo) of a fifteen level inverter is compared to the reference voltage. The inverter must achieve this recommended voltage in order to comply with grid requirements. The FLC's input parameters are the subsequent error, e = Vref Vo, and the rate of error change de/dt. There are five significant block sets that make up the FLC. They include the defuzzifier, fuzzifier, inference system, rule foundation, and database. Membership functions convert the provided data into degrees of membership using fuzzy logic. The commanding signal (or control signal) Cs is then contrasted by the FLC.

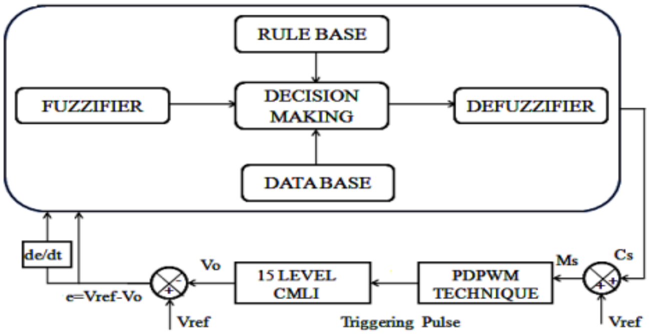


Fig. 2 framework for fuzzy logic control

The modulating signal Ms needed for PWM (pulse width modulation) production is made using Vef to produce the gating signals for the semiconductor switches in the inverter power circuit. The issue is formulated using the error and its derivative MF (membership function). The MF for the false signal is shown in Figure 3. In this graph, N, P, and Z stand for negative, positive, and zero values, respectively. The letters B, M, S, and E stand for big, medium, tiny, and error, respectively, in a manner similar to this. Figure 4 displays the MF and derivatives of the error signal for the fuzzy logic controller's input.

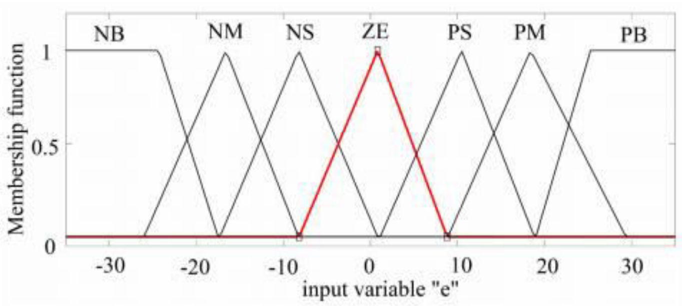


Fig.3 Membership function

For a warning of an error figure 4 shows how fuzzy logic produces the signal that a membership function produces as a reference. The rule table's rule matrix, which has one Output and two inputs (the error and its derivative signal), is shown in Table 1. The fuzzy value is subsequently converted to crisp value usinga defuzzification approach.

TABLE 1
FLC rule matrix

e Ce	NB	NS	NM	ZE	PB	PS	PM
NB	PB	PB	PB	PB	ZE	PM	PS
NS	PB	PM	PB	PS	NM	ZE	NS
NM	PB	PB	PB	PM	NS	PS	ZE
ZE	PB	PS	PM	ZE	NB	NS	NM
PB	ZE	NM	NS	NB	NB	NB	NB
PS	PM	ZE	PS	NS	NB	NM	NB
PM	PS	NS	ZE	NM	NB	NB	NB

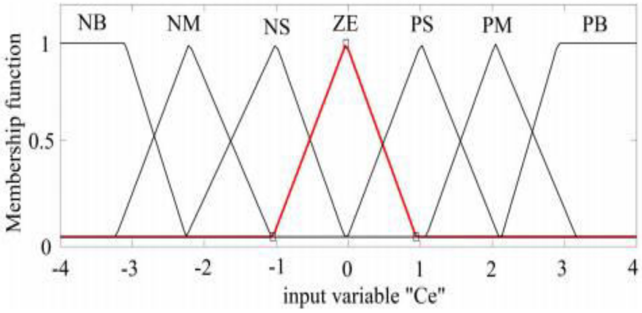


Fig. 4 MF in case the error signal changes

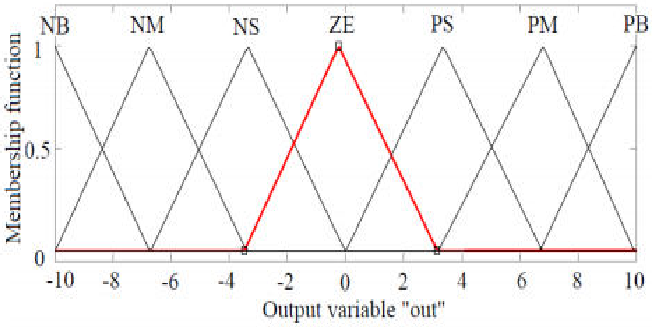


Fig. 5 MF for the reference output

B). Harmonic Elimination for Cascaded Multilevel Inverter

The output waveform's harmonic content needs to be reduced in order to improve the output power's quality. To minimize the harmonics, a number of methods have been devised, including Sinusoidal PWM, Space Vector PWM, space vector modulation, and selective harmonic removal. Selective harmonic removal is one of the best methods for getting rid of harmonics (SHE). Switching losses will be reduced to a minimum since SHE uses low frequency switching. SPWM and space vector PWM cause significant switching losses and call for massive filters as high frequency switching draws near. The harmonic content of the output voltage signal will be constrained by this type of modulation control approach.

V. SIMULATION AND ANALYSIS

To allow for the independent regulation of each string's potential voltage and MPP tracking, multilevel converters feature a large number of DC links. A system that uses an open-loop system is a 15-level inverter powered by solar energy without VR. Each CMLI stage has a separate connected panel with varied irradiance intensity. Seven cascaded H-bridges that are connected one after the other in succession connect the fifteen floors. A carrier signal and a reference signal are contrasted for the pulse generation. To create a comparison is made between a pulse signal, a reference sinusoidal carrier, and a triangular carrier. The pulses are made using the bipolar PDPWM technique. On one leg, a triangular wave and a positive sinusoidal signal are contrasted.

We contrast the triangle wave's opposing pulse sequence negative sinusoidal signal leg. Figure 7 uses a PV panel model with different irradiance levels to show how an inverter output voltage varies. Figure 6 depicts the solar PV modules' output voltage waveform under various irradiance and partially shaded conditions. This results in an unbalanced voltage state because of the uneven output voltage distribution. VR methods can be used to account for these unequal movements.

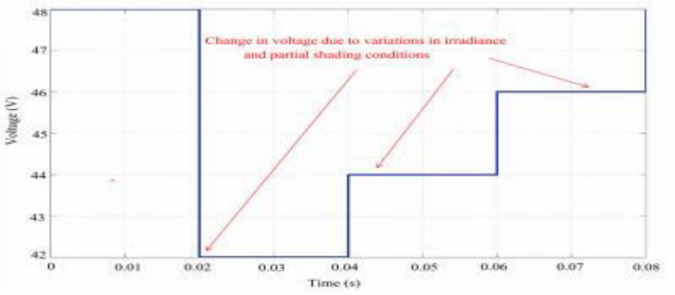


Fig. 6 output voltage irradiance relationship fluctuation

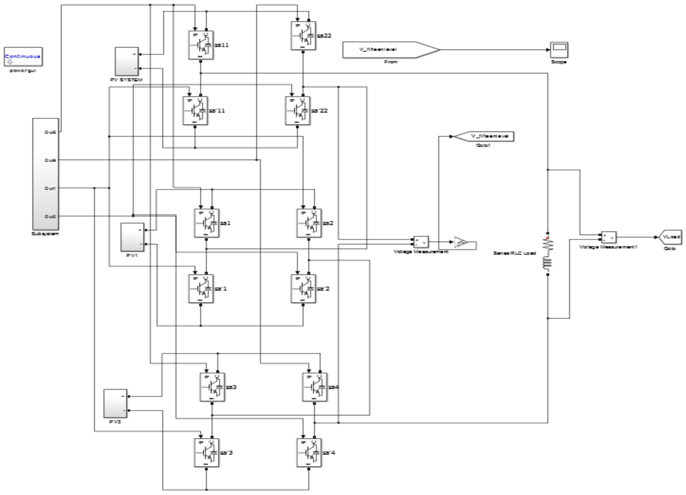


Fig.7 An illustration of a simulated 15-level inverter circuit

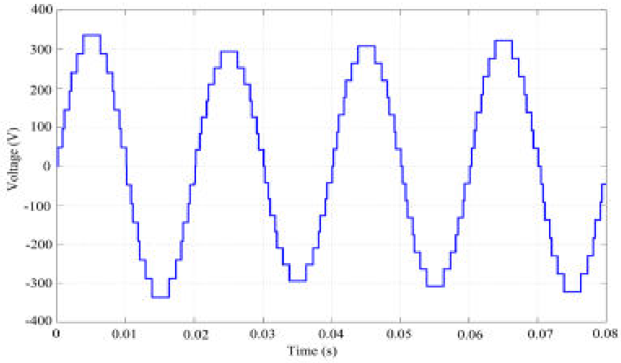


Fig. 8 FLC-controlled output voltages at the fifteenth level

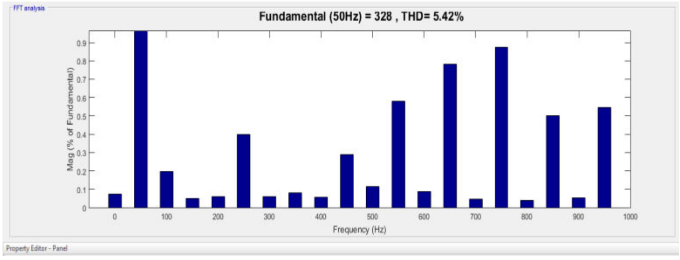


Fig. 9 Based on FLC, FFT analysis for voltage regulation

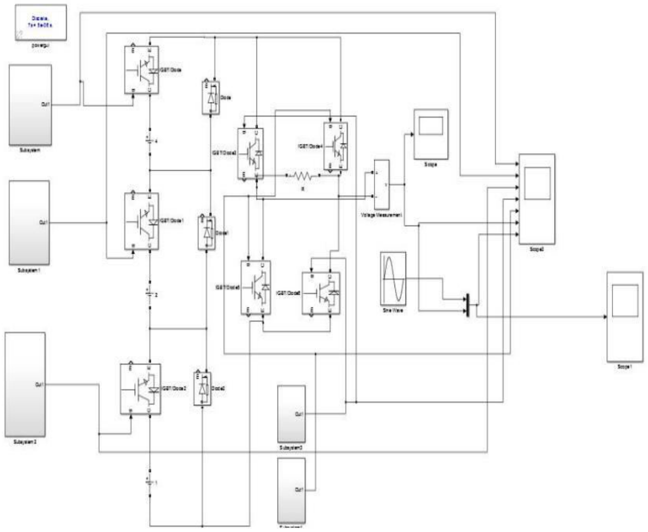
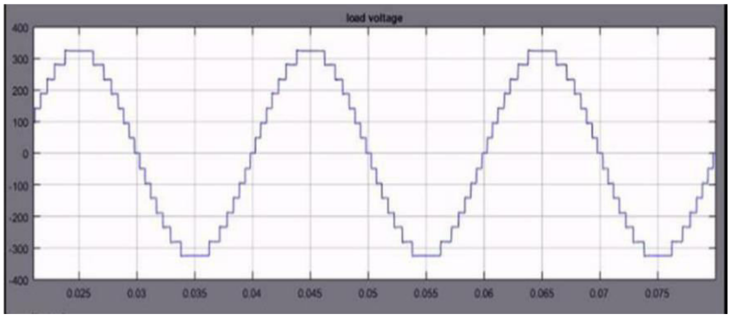
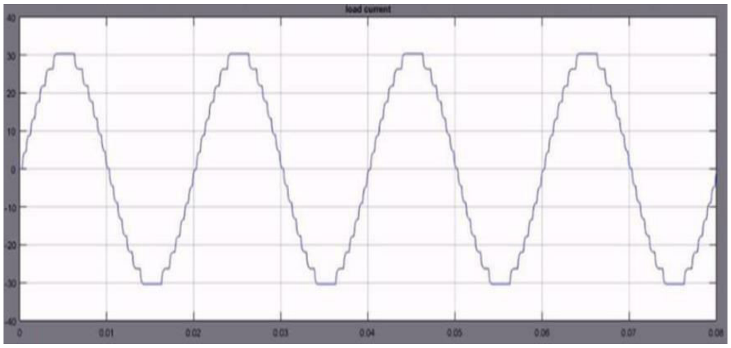


Fig. 10 An illustration of a simulated 15-level inverter circuit

Using the FLC method, PWM method, and the MATLAB/Simulink programme for equal switching angles, the suggested seven-switched multilevel inverter is simulated. In order to meet the need good for grid-connected applications for 220V RMS at the output voltage, the inverter's input DC voltage sources are 45V, 90V, and 180V in magnitude. The findings of each of the aforementioned simulations have been carefully scrutinized, and the effects of a resistive load are considered. After careful comparisons, conclusions about There have been diagrams showing overall harmonic distortion, circuit complexity, and voltage stress on devices.



(a) Load voltage



(b) Load voltage

(c)

Fig. 11 simulation results of 7- switches

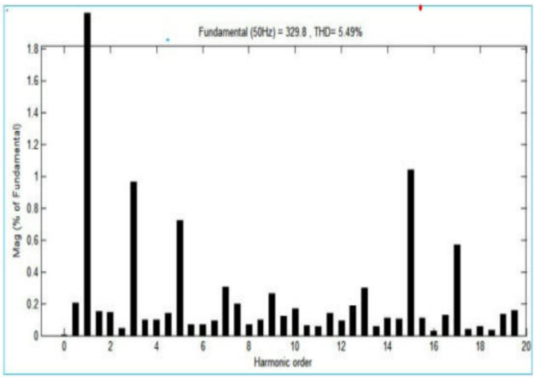


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Fig. 12 FFT analysis for 7-switched based voltage regulation

C. Fifteen Level Inverter with Fuzzy Logic Controller

Finding patterns and drawing conclusions are done via fuzzy inference. The error and derivate error signals are the two input signals that are utilized to frame the membership function. A triangle membership function is employed in the controller. The membership function sends a modulating output signal to the PWM generator. The error and derivative error both have 7 membership functions. Many regulations have been developed and are being used to improve voltage regulation. The displayed controlled output voltage and related FFT analysis, respectively, in Figures 10 and 13. It is possible to compare the simulation results for the 7-Switch Multilevel Inverter that was achieved using the different methods.

VI. CONCLUSION

The simulation configuration for a 15-level inverter fueled by solar power takes into account and implements both the voltage regulation structure and the improvement of power quality. According to the findings, FLC provides better VR outcomes when solar PV input changes are taken into account. FLC is still seen as appropriate for the nine-level despite this; however, the installation is finished using a DC power supply rather than solar power. When the power is low and the

MLI topology is at lower levels, the alternative approaches are used. Investigation into The practical application of MLI with a constant output voltage demonstrates the efficacy of the suggested strategy. Those that require grid interaction and power quality improvement can employ this strategy. A close match to IEEE specifications, this design generates an almost sine-wave-like ac waveform for the voltage output with a total distortion caused by harmonics of 5.5%.

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