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Comparative analysis of NPC and Cascaded Inverter connected to Induction motor drive with Utilization of PV-Battery Standalone System and Total Harmonic Distortion Analysis

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***Abstract*— This paper presents the control of a multi level inverter supplied by a Photovoltaic (PV) panel and a batteries bank. It is well known that the power quality of multilevel inverter signals depends on their number of levels. Three, nine and fifteen-level converters are studied. The harmonics content of the output signals are analyzed. A simplified Pulse Width Modulation (SPWM) method for a multilevel inverter that supplied an induction motor is developed. The controller equations are such that the SPWM pulses are generated automatically for any number of levels. The effectiveness of the propose method is evaluated in simulation. MATLAB /Simulink is used to implement the control algorithm and simulate the system.**

The rapid evolution of semiconductor devices manufacturing technologies and the designer's orientation has enabled the development of new structures of converters (inverters) with a great performance compared to conventional structures. So, these new technologies of semiconductor are more suited to high power applications and they enable the design of multilevel inverters. The constraints due to commutation phenomena are also reduced and each component supports a much smaller fraction of the DC-bus voltage when the number of levels is higher. For this reason, the switches support more high reverse voltages in high-power applications and the converter output signals are with good spectral qualities. Thus, the using of this type of inverter, associated with a judicious control of power components, allows deleting some harmonics

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***Index Terms*—** api, ipd pd pod she svpwm.

I. INTRODUCTION

Multilevel inverter supplied by a Photovoltaic (PV) panel and a batteries bank. It is well known that the power quality of multilevel inverter signals depends on their number of levels[1]. The rapid evolutions of semiconductor devices manufacturing technologies and the designer's orientation have enabled the development of new structures of converters (inverters) with a great performance compared to conventional structures. A simplified Pulse Width Modulation (SPWM) method for a multilevel inverter that supplied an induction motor is developed. The controller equations are such that the SPWM pulses are generated automatically for any number of levels [2]. The effectiveness of the proposed method is evaluated in simulation. MATLAB SIMULINK is used to implement the control algorithm and simulate the system. A cascade of H-bridge cells has been used to obtain a multilevel conversion structure. The front-end rectifier should absorb current with low harmonic content to eliminate disturbances on the communication equipments and, more in general, to reduce electromagnetic pollution. Additional specification is the elimination of the transformer such as to reduce encumbrance and cost. A similar H-bridge cascade has been used in the motor side. In fact, supplying the motor by multilevel voltages greatly reduce the current harmonic distortion, enhancing induction motor performance, and the switching frequency, improving efficiency and extending component life[3]. In this paper the design of the converter has been described with the help of theoretical analysis and simulations, moreover some first partial experimental results.

Cascaded H-Bridge multilevel Inverter

The cascaded H-bridge multilevel Inverter uses separate dc sources (SDCSs). The multilevel inverter using cascaded-inverter with SDCSs synthesizes a desired voltage from several independent sources of dc voltages, which may be obtained from batteries, fuel cells, or solar cells. This configuration recently becomes very popular in ac power supply and adjustable speed drive applications. This new inverter can avoid extra clamping diodes or voltage balancing capacitors. Again, the cascaded multilevel inverters are classified depending on the type of DC sources used throughout the input[4].

Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, $+V_{dc}$, 0, and $-V_{dc}$ by connecting the dc source to the ac output by different combinations of the four switches, S_1, S_2, S_3 and S_4. To obtain $+V_{dc}$, switches S_1 and S_4 are turned on, whereas $-V_{dc}$ can be obtained by turning on switches S_2 and S_3. By turning on S_1 and S_2 or S_3 and S_4, the output voltage is zero [5],[6]. The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs. The number of output phase voltage levels m in a cascade inverter is defined by m = 2s+1, where s is the number of separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure 1.1. The phase voltage $v_{an} = v_{a1} + v_{a2} + v_{a3} + v_{a4} + v_{a5}$ [7][8].

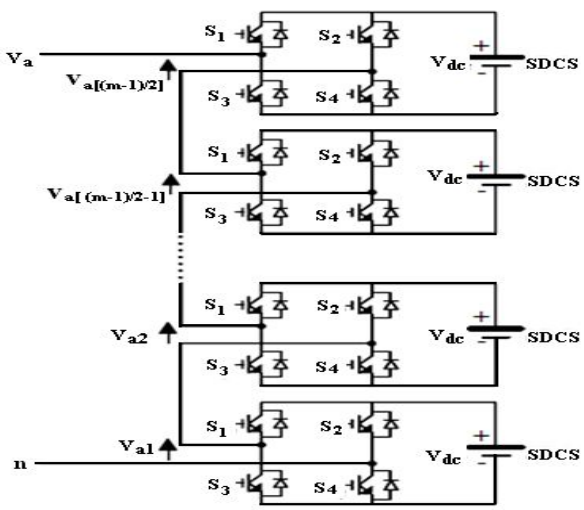

Fig.1.1: Single-Phase Structure of a multilevel cascaded H-bridge inverter

II. PV Battery Standalone System

A number of models for modeling and simulation of a stand-alone photovoltaic (PV) system with a battery bank verified against a system installed at Rise National Laboratory. The work has been supported by the Danish Ministry of Energy, as a part of the activities in the Solar Energy Centre Denmark. The model of the stand-alone PV system is made up by blocks in order to facilitate the modeling of other structures of PV systems. Many photovoltaic systems operate in a stand-alone mode. Such systems consist of a PV generator, energy storage (for example a battery), AC and DC consumers and elements for power conditioning as sketched in Figure 2.1. Per definition, a stand-alone system involves no interaction with a utility grid. A PV generator can contain several arrays. Each array is composed of several modules, while each module is composed of several solar cells. The battery bank stores energy when the power supplied by the PV modules exceeds load demand and releases it backs when the PV supply is insufficient. The load for a standalone PV system can be of many types, both DC (television, lighting) and AC (electric motors, heaters, etc.). The power conditioning system provides an interface between all the elements of the PV system, giving protection and control[9][10]. The most frequently encountered elements of the power conditioning system are blocking diodes, charge regulators and DC-AC converters

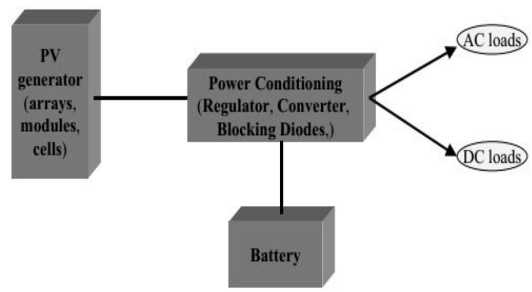

Fig.2.1: Elementary scheme of the components of a stand-alone photovoltaic system.

2.1 Component models for standalone PV system

The main purpose of this section is to describe the models for the elements of a standalone PV system: PV generator, battery, controller, inverter and load. The modeling of the PV system is based on modular blocks, as illustrated in Figure 2.1.1 The modular structure facilitates the modeling of the other system structures and replacing of elements, for instance a DC load instead of an AC load.

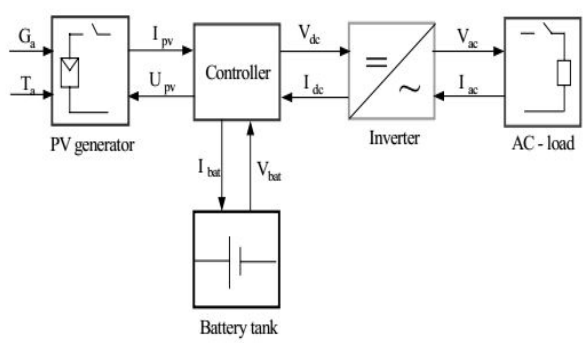

Fig.2.1.1: Block diagram for the stand-alone PV system

III. MATLAB/SIMULATION RESULTS

3.1. MATLAB / Simulink model of Inverter

Figure 3.1 Shows the MATLAB/Simulink Model of 3-Level NPC Inverter Fed Induction Motor, Figure 3.2 Shows the MATLAB/Simulink Model of 3 - Level

NPC Inverter Fed Induction Motor Voltage waveform ,Fig 3.3. Shows the THD of 3-Level NPC Inverter.

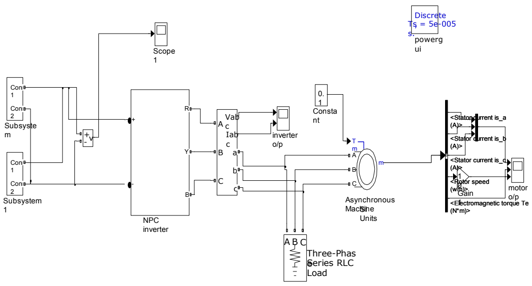

Fig 3.1: MATLAB / Simulink model of 3-level NPC Inverter Fed Induction Motor.

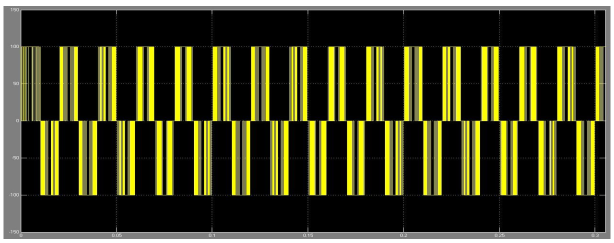

Fig.3.2: Voltage Waveform of a three level Inverter

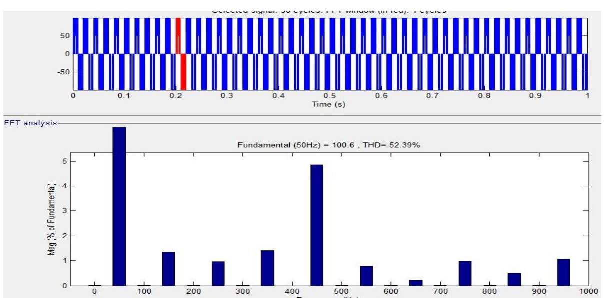

Fig 3.3: THD of a Three Level Inverter

Fig.3.3. Shows the THD of a 3-Level NPC Inverter.

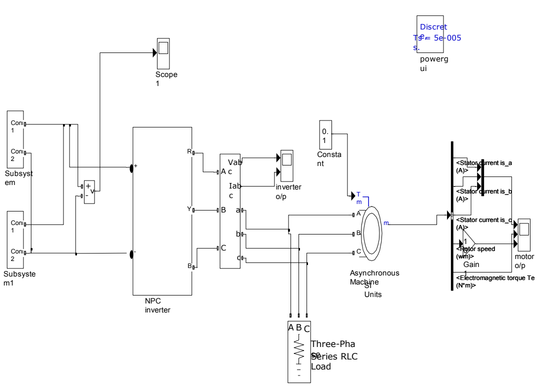

Fig3.4:MATLAB / Simulink model of Nine level NPC inverter fed Induction Motor.

Fig.3.4 shows MATLAB/Simulink model of Nine Level NPC Inverter Fed Inudction, Fig 3.5 Shows the Voltage Waveform of 9-Level NPC Inverter, Fig.3.6 Shows the THD of Nine Level Inverter.

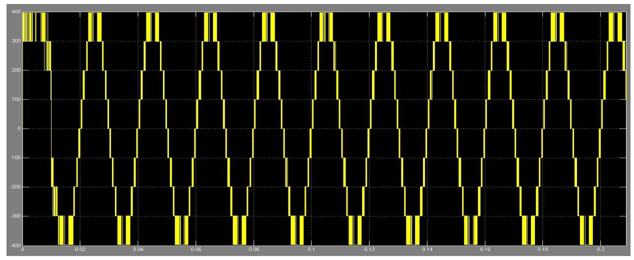

Fig.3.5: Voltage Waveform of a Nine level Inverter

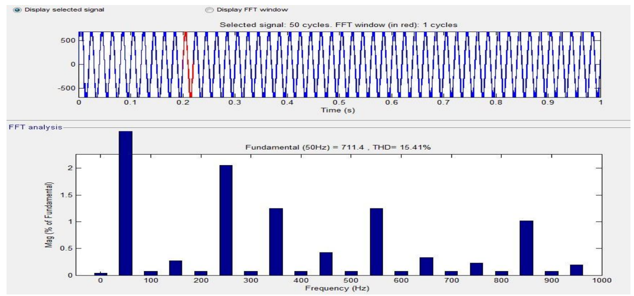

Fig 3.6: THD of a Nine Level Inverter

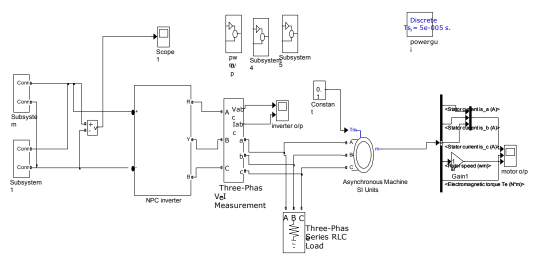

Fig.3.7:MATLAB / Simulink model of Fifteen level NPC inverter fed Induction Motor.

Fig.3.7 MATLAB/Simulink Model of 15-Level NPC Inverter Fed Induction Motor, Fig. 3.8 Shows the Voltage Waveform of 15-Level Inverter , Fig.3.9 Shows the THD of a 15-Level NPC Inverter.

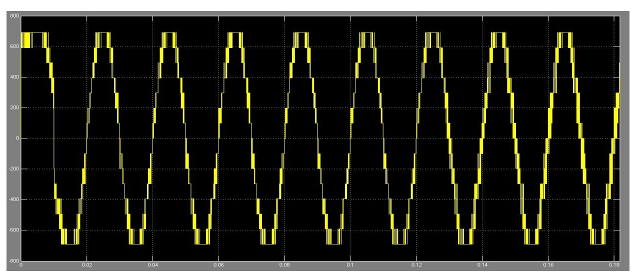

Fig.3.8: Voltage Waveform of a fifteen level Inverter

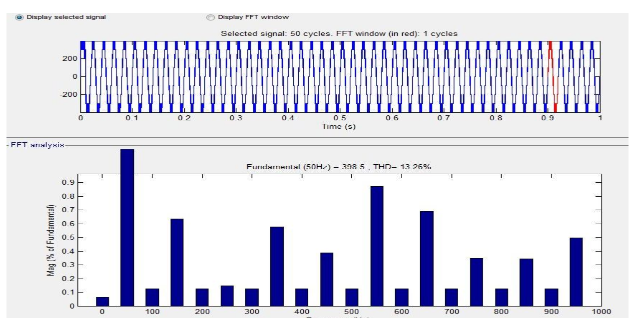

Fig 3.9: THD of a fifteen Level Inverter

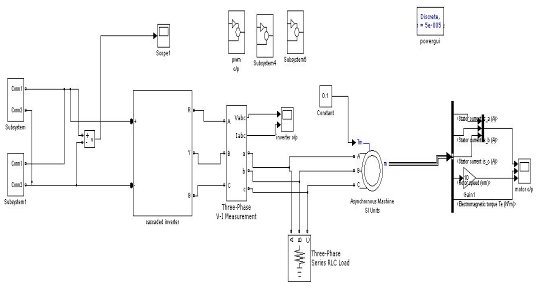

Fig 3.10: MATLAB / Simulink model of three levels Cascaded inverter fed Induction Motor

Fig. 3.10. MATLAB/Simulink Model of 3-Level Cascaded Inverter fed Induction Motor, Fig.3.11 Voltage Waveform of a 3-Level Inverter, Fig.3.12 THD of a 3-Level Cascaded Inverter.

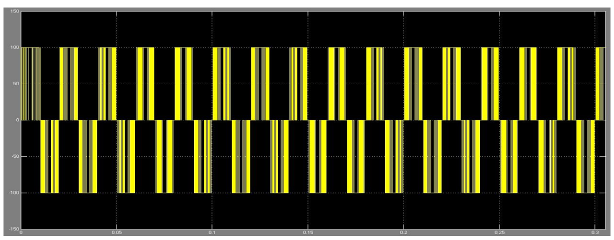

Fig 3.11: Voltage Waveform of a three level inverter

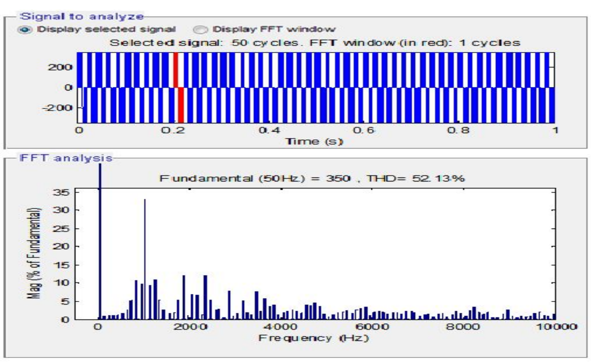

Fig 3.12: THD of a three Level Inverter

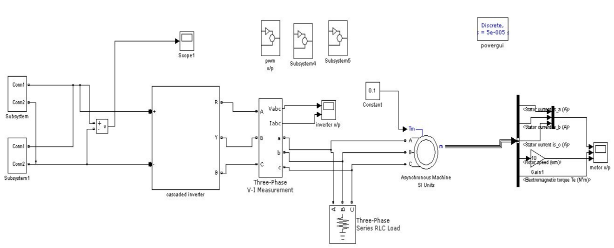

Fig 3.13:MATLAB / Simulink model of nine level Cascaded inverter fed Induction Motor

Fig.3.13 Shows the MATLAB/Simulink Model of 9-Level Cascaded Inverter fed Induction Motor, Fig.3.14 Voltage Waveform of a 9-Level Cascaded Inverter, Fig.3.15 Shows theTHD of a9-Level Inverter.

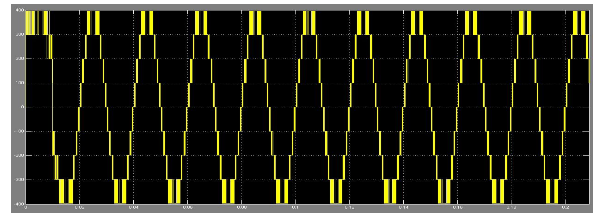

Fig 3.14 : Voltage Waveform of a nine level inverter

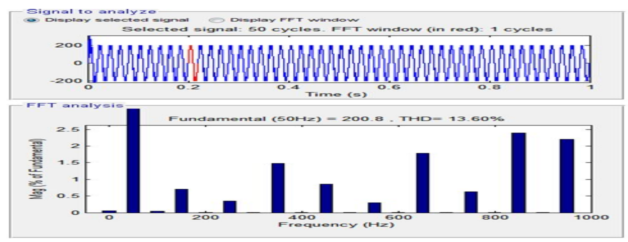

Fig 3.15:THD of a Nine Level Inverter

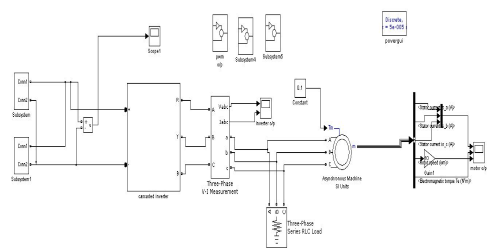

Fig 3.16: MATLAB / Simulink model of Fifteen level Cascaded inverter Fed Induction Motor.

Fig.3.16 Shows the MATLAB/Simulink Model of 15-Level Cascaded Inverter fed Induction Motor , Fig.3.17 Shows the Voltage waveform Cascaded 15-Level Inverter, Fig.3.18 Shows the THD of 15-Level Inverter.

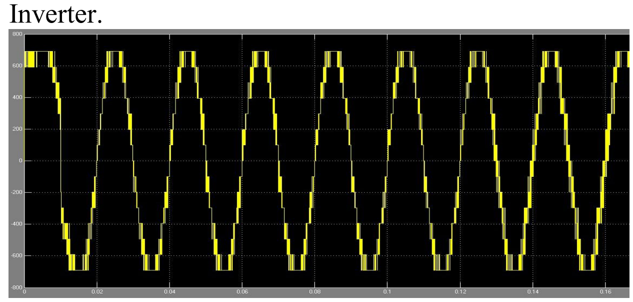

Fig 3.17: Voltage Waveform of Fifteen level inverter.

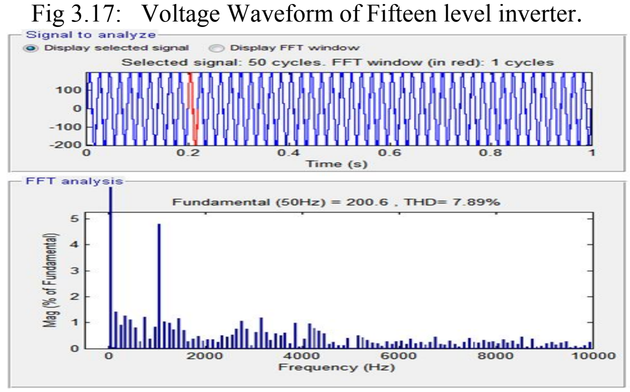

Fig3.18: THD of a Fifteen Level Inverter

CONCLUSION

In this Paper a general multilevel SPWM control algorithm for 3,915-level inverter has been modeled and simulated using MATLAB/SIMULINK Compare to these two inverters (NPC & Cascaded) cascaded is better because the level of inverter increases the THD get reduced. This algorithm can generate automatically SPWM pulses for any level of inverter by changing only a parameter 'n' which is the number of inverter level. Simulation of Three, Nine, and Fifteen level inverter connected to induction motor has been performed and the generated signal THD is analyzed. The system is supplied by a PV panel and batteries bank. That gives energy autonomy to the system. Simulation results give a better quality of stator current in terms of low harmonics, thus reducing the adverse effects on of the machine life and eventually the electrical network which supplies it. Base to THD analyses for three different index of modulation, we have also highlighted that at fifteen-level, the harmonics are very low.

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