PERFORMANCE EVALUATION OF SEVEN LEVEL REDUCED SWITCH ANPC INVERTER IN SHUNT ACTIVE POWER FILTER WITH RBFNN BASED ON HARMONIC CURRENT GENERATION

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ABSTRACT

In this project, a modified seven level boost Active-Neutral-Point-Clamped (7LB-ANPC) inverter is utilized as a Shunt Active Power Filter (SAPF). Another vital aspect of this work is to retain the link voltage across the capacitor, which is accomplished through a PI controller tuned with an Adaptive Neuro-Fuzzy Inference System (ANFIS). An adaptive instantaneous p-q theory is instigated in the direction of extracting reference current and the harmonic extraction is carried out by using Radial Basis Function Neural Network (RBFNN). Gating sequence of inverter is generated for the outputs, which are attained from ANFIS and RBFNN and thus the opposite harmonics are injected to the Point of Common Coupling (PCC) by which current harmonics are eliminated with reactive power compensation. The 7Lb-ANPC inverter has a minimized number of switching devices with low switching losses and high boosting ability. By RBFNN based reference current generation, the source current THD of 0.89% is achieved. The proposed methodology is simulated through MATLAB/SIMULINK Software.

INTRODUCTION

Presence of Harmonics in output sine waveform are major problem in power converter. In medium and small industrial applications, square waveform are used. Whereas ideal sinusoidal are preferred for large applications in industries but it is problematic to achieve less distorted sinusoidal wave due to presence of THD, it resembles as major problem in converter, these harmonics effects in overall efficiency of the system by drawing more current and heating of conductor results in failure of insulation and maintaining cost increases. Hence harmonics has to be reduced in sine wave as much as possible. Multilevel Inverter helps to overcome voltage limiting ability of semiconductor devises. MLI were introduced in late 1975 advancement in semiconductor helps in maintaining good power quality with reduced switching losses, yet there are still novel technologies coming up to discover in emerging zones of application which makes MLI,s more attractive[1]-[3]. These inverters proposals several advantages than Two-level converters (2L) which generate AC source with input of DC source generating 2 voltage levels +Vdc & -Vdc across load with harmonics in output waveform. Classic multi-level inverter (MLI's) topologies includes flying capacitor inverter (FC), Neutral point clamped inverter (NPC) and CHB inverters are different types of MLI. Phase leg of 3L-NPC is easy to control with simple PWM technique, but it has unequal loss distribution between the semiconductors and difficulty of capacitor voltage balancing considered as major drawback [4]. Number of switches required in NPC is less but balancing of capacitor is a major problem [5] However Flying capacitor balances the load & distribute losses equally but controlling is difficult due to its increased number of capacitors [6]. New FCMI structure makes full DC input available by using low frequency two switches & generates double RMS which helps to increase amount of output but number of power switches used is more and THD is about 6.26% [7]. Author has combined 5 level ANPC inverter and HBBB to form nine level ANPC to obtain better quality of voltage and current waveform, advanced method of controlling is required and implementation is complicated [8]. In neutral point clamped T-type inverter a nine step voltage waveform are generated but the number of components used is more [9]. In this paper a seven level output voltage is generated using 8 power switches which uses PWM to control but THD is 2.7%

PROJECT OUTLINE

CASCADED H-BRIDGE MULTILEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER:

In a Cascaded H-Bridge inverter, separate H-bridges are connected in series in each phase depending on the number of levels that are desired at the output. The three-phase structure of a Cascaded H-bridge inverter is shown in Figure 1.3. Separate DC sources are connected to each single-phase full-bridge inverter. The AC output of each level is then connected in series such that the overall output voltage waveform of the multilevel inverter is the sum of the individual inverter output [8].

From the knowledge of single-phase full-bridge inverters, each inverter level with V_{dc} as the DC voltage for each full-bridge can generate three different voltage outputs; $+V_{dc}$, 0 and $–V_{dc}$ and in case of the inverter represented in Figure 1.3, all the levels from $-2V_{dc}$ to $+2V_{dc}$ are present constituting 5 levels for the phase. This is made possible by connecting the DC sources (or capacitors) sequentially to the AC (output) side via the four power switches present in each cell. When communication by pulses was introduced, the amplitude, frequency and pulse width become possible modulation options. In many powers electronic converters where the output voltage can be one of two values the only option is modulation of average conduction time.

Cascaded inverters have been proposed for use as the main traction drive in electric vehicles where the inverter could serve as a rectifier/charger for the batteries of the vehicle when it is connected to an AC supply. For a vehicle that uses regenerative braking, this inverter can act as a rectifier.

Three-phase Cascaded H-Bridge Multilevel Inverter:

Fig: Three-phase Cascaded H-Bridge Multilevel Inverter

FLYING CAPACITOR MULTILEVEL INVERTER:

The Flying Capacitor multilevel inverter came into existence in 1992. The three phases of the three-level Flying Capacitor inverter are shown in Figure 1.5. The three phases of the inverter share a common DC bus. Similar to the three-level Diode-Clamped multilevel inverter, the Capacitor-Clamped multilevel inverter has two series-connected capacitors,

C1 and C2, dividing the DC bus voltage into three levels; namely V2dc, 0 and V2dc. These voltage levels appear at the output of each phase of the inverter by appropriate switching of the power semiconductor devices. In place of the “clamping diodes” present in the Diode-Clamped multilevel inverter, the Capacitor-Clamped multilevel inverter consists of “clamping capacitors”. Each clamping capacitor clamps the device voltage to one DC-link capacitor voltage level. Field-

Oriented Control of PMSM

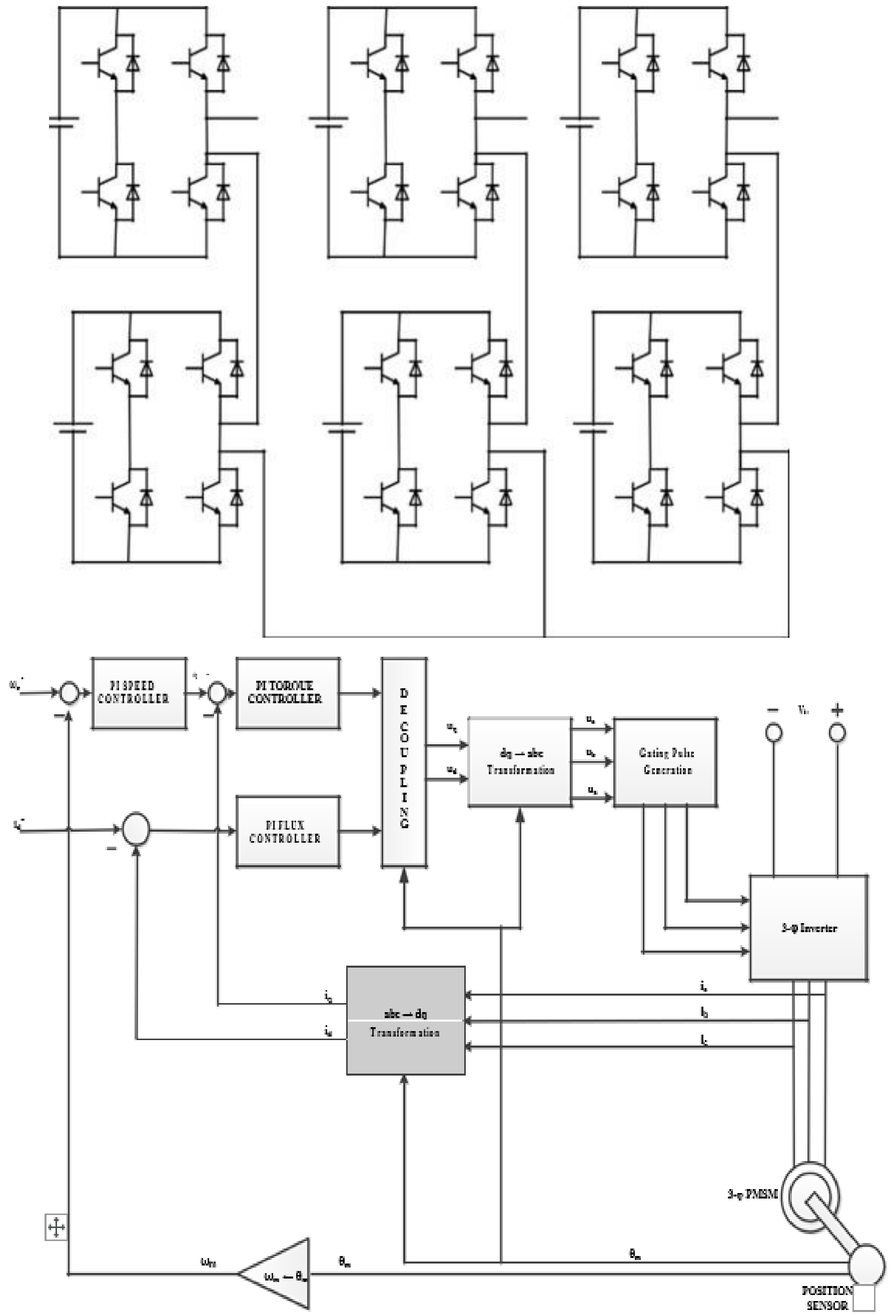


Fig 1: Field-Oriented Control of PMSM

FLOW CHART FOR SPACE VECTOR PULSE WIDTH MODULATION OF TWO AND THREE-LEVEL INVERTERS:

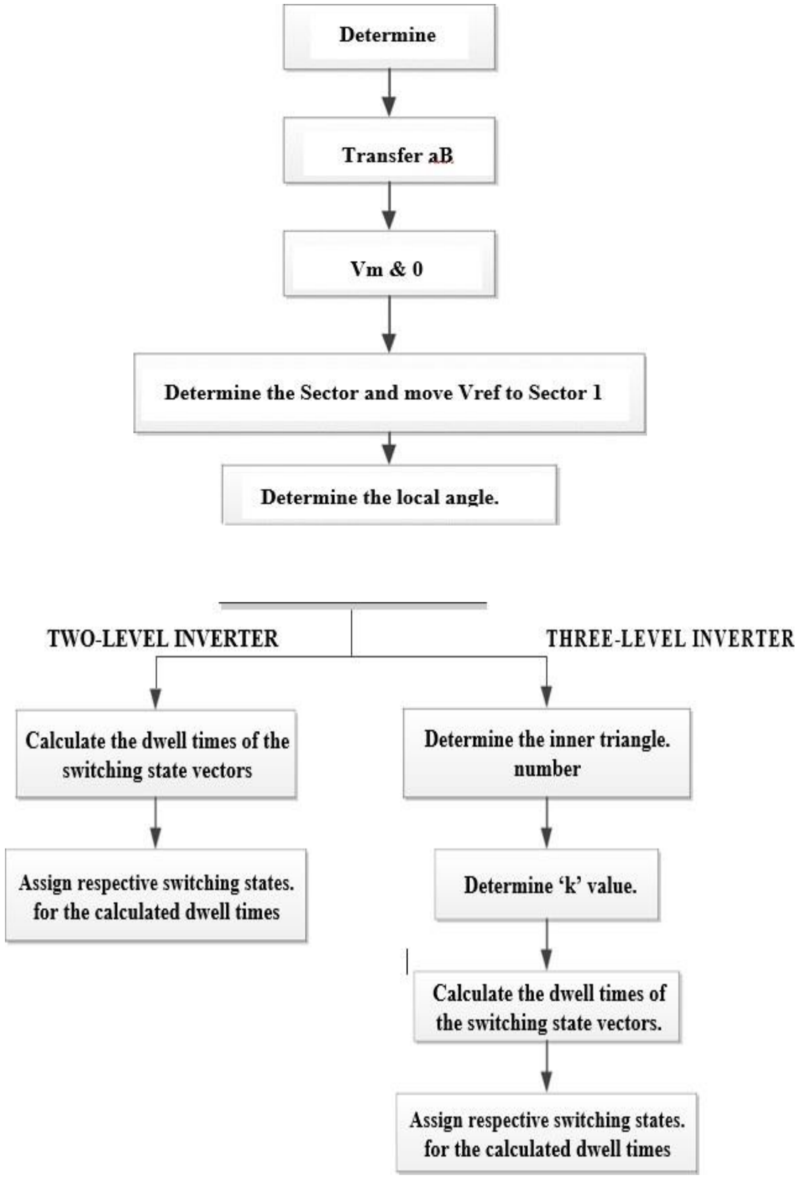


Fig 2: Flow Chart for SVPWM of Two and Three-level Inverters

THD COMPARISON FOR TWO AND THREE-LEVEL INVERTERS

To have further reduced total harmonic distortion of line-to-line voltage especially in the case of a three-level inverter, Space Vector Modulation method has been employed with neutral-point voltage balancing in the present chapter. The total harmonic distortion of the line-to-line voltage for the two and three-level inverters using the Space Vector Modulation technique have been presented. Therefore, one can observe a reduction in the total harmonic distortion of about 57% when SVM is used as the modulation scheme. However, these are the procedures and guidelines that one can follow to make a performance comparison based on different criteria.

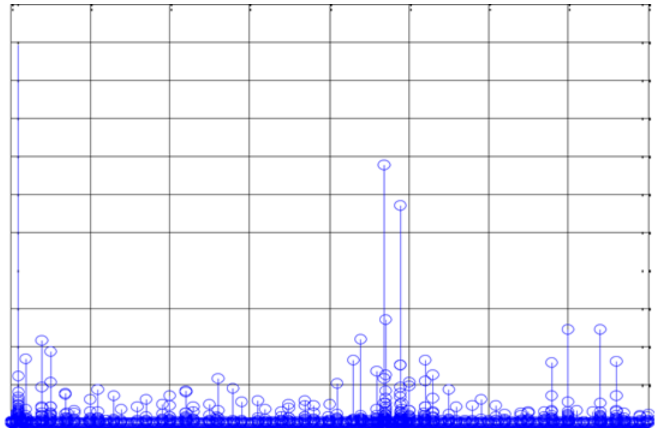


Fig 3: Two Level Inverters

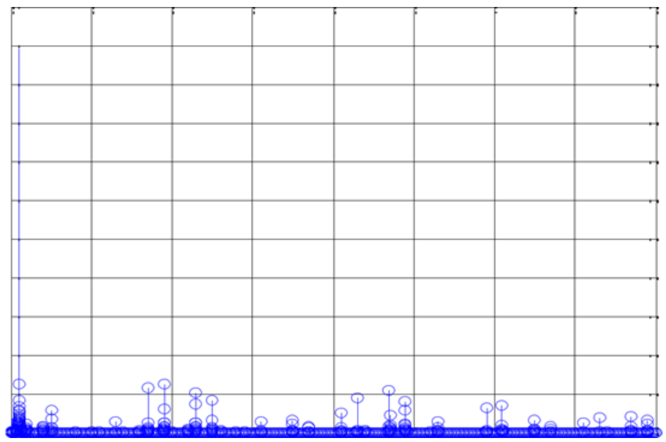
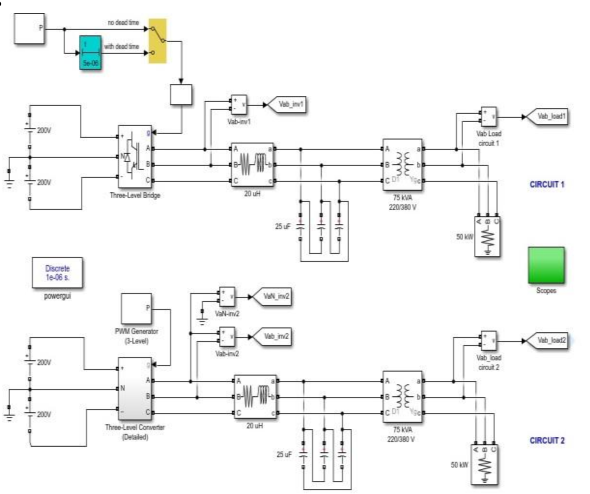


Fig 4: Three Level Inverters

SIMULATION LINK:



Harmonic Distortion of Load Voltage

Dead time (us)	Vab (Vrms)	THD (%)	H5 (%)	H7 (%)	8 kHz (%)
0	380	1.27	0.21	0.13	0.74
5	359	1.99	1.25	0.73	0.81

Fig 5 : Simulation Link

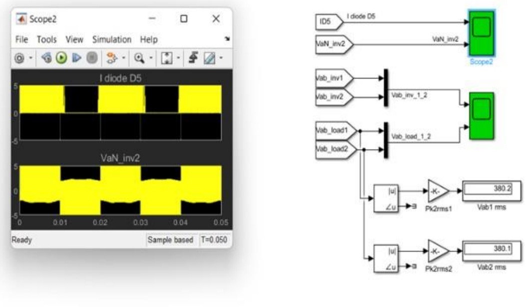


Fig 6 simulation PWM scope

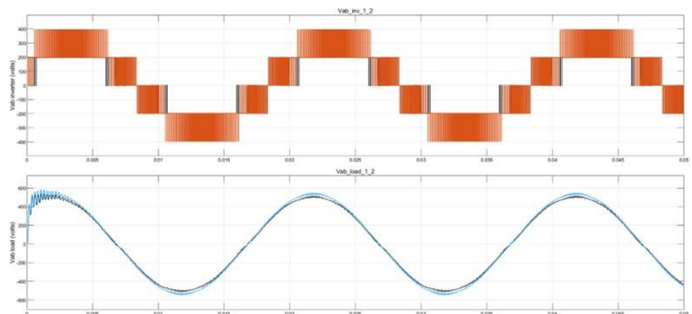


Fig 7: Output Waveform 1

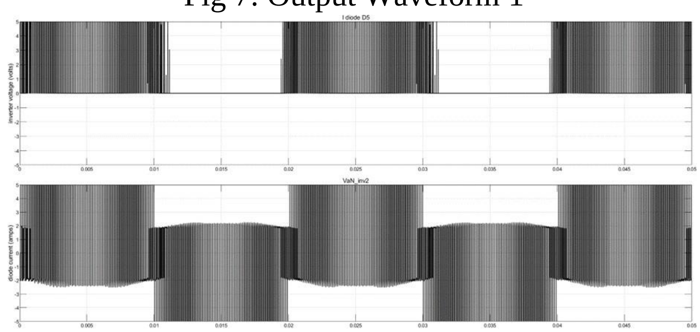


Fig 8: Output Waveform 2

CONCLUSION:

With efficiency becoming increasingly important in Power Electronics, it is the goal of every industry to take up initiatives for reduced energy consumption and improve the performance. Chapter 2 proposes the design of PI controllers for the control of speed and torque for a closed-loop PMSM drive with Field-Oriented Control approach. From the comparison of the two and three-level NPC inverters in Chapter 3, with respect to losses, efficiency, junction temperature and switching frequency for an entire range of speed and torque of an electric vehicle PMSM drive; three-level NPC inverter stands out as a better candidate.

The present thesis, therefore, offers a detailed approach with designs, calculations and validations using MATLAB / SIMULINK and Microsoft Excel VBA platforms.

It can therefore be concluded that the three-level NPC inverter is a better candidate with varied advantages for the chosen application in the automotive industry employing PMSM drives.

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