Design of Multi-Level inverter Using SPWM technique

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Abstract

Multilevel inverter have drawn a tremendous interest in the power industry nowadays ,a multilevel inverter is as converter used to obtain ac voltage of desired magnitude and frequency waveform from separate dc source. In recent decade multilevel inverters have been usedfor high power and medium voltage energy control application. These also improves the overall performance of the system as these produces lower harmonics as the number of level increases the quality of voltage waveform is also increases. In this paper design of three phase three level multilevel inverter has been carried out in MATLAB/SIMULINK using sinusoidal pulse width modulation technique, analysis of THD content for output voltage as well as output current is done .

Keywords: *Multilevel inverter cascaded, SPWM, Simulink, and THD.*

I. INTRODUCTION

During the past few years, power electronics engineers have paid great attention to multilevel inverter as the new kind of power converter.Present day word is facing enormous increase in energy consumption. Multilevel inverter is an important technology in the field of power electronics. For industrial applications multilevel inverter fed a.c. drive gives quality performance and is best option for energy saving. Multilevel inverter uses medium voltage semiconductor devices, sources and produces high output power. Sources like batteries, super capacitors, solar panels can be used as medium voltage sources. This technology is showing popularity for multi megawatt industrial drive application. As compared to conventional two level inverter, in which harmonics contents can be reduced by raising switching frequency, multilevel inverter has many advantages such as output voltage waveform can be generated at low switching frequencies thereby reducing switching losses, more efficiency, low harmonics distortion and near sinusoidal output. There are less voltage stresses on power switches and low electromagnetic interference. However, this multilevel technology requires more number of switches which makes the control circuitry complicated. The term multilevel begins with three level inverter. In 1975 multilevel concept has been first introduced, by proposing Neutral Point Clamped converter. Here to synthesize a staircase ac output voltage, separate dc. Sourced H bridges were connected in series. The elementary concept of multilevel inverter is to attain higher power. For this series of power semiconductor switches and dc sources with low magnitudes are used. There exist three popular commercial called c1assical topologies of multilevel voltage-source inverter. They are Neutral Point Clamped (NPC-MLI) or Diode Clamped (DC-MLI), Flying Capacitor (FC- MLI) and Cascaded H-Bridge (CHB-MLI).

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II.PROPOSED MULTILEVEL INVERTER

TOPOLOGY

The cascaded H-bridge inverter is a cascade of H-bridges, or H-bridges in a series configuration. The basic power circuit of single H-bridge inverter is shown in Fig.1.There are four active devices in each cell and can produce three levels 0, +Vdc and –Vdc.

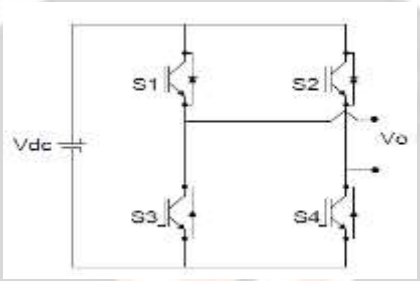

Fig.1: Configuration of single-phase H-bridge inverter

To synthesize a multilevel waveform, the ac output of each of the different level H-bridge cells is connected in series. The synthesized voltage waveform is, therefore, the sum of the inverter outputs. An m level cascaded H-bridge inverter consists of series connected (m-1)/2 number of cells. Each cell consists of single-phase H-bridge inverter with separate dc source... As the number of voltage level m grows the number of active switches increases according to 2× (m-1) for the cascaded H-bridge multilevel inverters. In three-phase, each phase is 120° out of phase with each other.

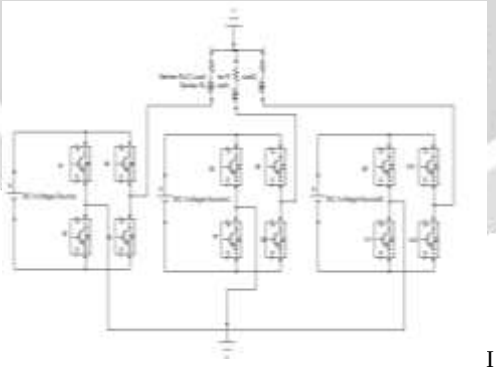

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Fig 2: Three phase circuit arrangement for three level star configurations.

III. ADVANTAGES OF MULTILEVEL INVERTER

1. **Common mode voltage:**

The multilevel inverters produce common mode voltage, reducing the stress of the motor and don't damage the motor.

2. **Input current:** Multilevel inverter can draw input current with low distortion.
3. **Switching frequency:** The multilevel inverter can operate at both fundamental switching frequencies that are higher switching frequency and lower switching frequency. It should be noted that the lower switching frequency means lower switching loss and higher efficiency is achieved.
4. **Reduced harmonic distortion.** Selective harmonic elimination technique along with the multilevel topology results the total harmonic distortion becomes low in the output waveform without using any filter circuit.
5. **Staircase waveform quality:** Multilevel inverter not only can generate the output voltages with very low distortion, but also can reduce the dv/dt stresses; therefore electromagnetic compatibility (EMC) problems can be reduced.

IV.APPLICATIONS

- Industry up to multi-MW Range in Tractions and naval systems.
- High power propulsion systems.
- STATCOM, FACTS, UPFC Active power filters, etc.
- A green energy source with photo voltaic cells.
- Storage battery charger where high power and efficient energy conversion are required with improved power quality.

V.SYSTEM CONFIGURATION

The proposed three level inverter with RL load, which consists of voltage source inverter. The inverter model connected to the RL load is controlled to produce the staircase voltage and sinusoidal current. Three levels PWM based on constant carrier frequency for three level inverter systems is proposed to reduce the harmonic contents in the output voltage and decrease the voltage rating of the power device.

VI.CONTROL TECHNIQUE OF THREE LEVEL INVERTER

The sinusoidal pulse-width modulation (SPWM) technique produces a sinusoidal waveform by filtering an output pulse waveform with varying width. A high switching frequency leads to a better filtered sinusoidal output waveform. The desired output voltage is achieved by varying the frequency and amplitude of a reference or modulating voltage. The variations in the amplitude and frequency of the reference voltage change the pulse width patterns of the output voltage but keep the sinusoidal modulation. A low-frequency sinusoidal modulating signal is compared with a high frequency triangular signal, which is called the carrier signal. The switching state is changed when the sine waveform intersects the triangular waveform. The crossing positions determine the variable switching times between states. In three-phase SPWM, a triangular voltage waveform is compared with three sinusoidal control voltages (Va, Vb, and Vc), which are 120° out of phase with each other and the relative levels of the waveforms are used to control the switching of the devices in each phase leg of the inverter. This paper work also presents a comparative analysis of the harmonics generated in the output waveforms of 3-phase H-bridge cascaded multi-level inverter and proposed topology using Sinusoidal Pulse Width Modulation (SPWM) techniques. The Alternate Phased Opposite Disposition- Pulse Width Modulation (APODPWM) is one of the best SPWM schemes in achieving reduction in the Total Harmonic Distortion (THD), which is the major parameter often used to assess the suitability of an inverter. However, due to the closely set carrier arrangement, the APOD-PWM produces high THD especially at switching frequencies above 1-kHz. Therefore, a Gapped APOD-PWM is proposed. The switching sequence is similar to the APOD-PWM technique, but it has smaller switching angle. This reduces the switching overlap at boundary positions and hence the THD. The technique was simulated using the MATLAB-SIMULINK toolbox.

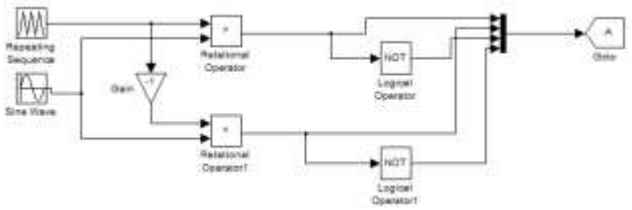


Fig.3: Control Signal Generation for SPWM

VII.SIMULATION RESULTS

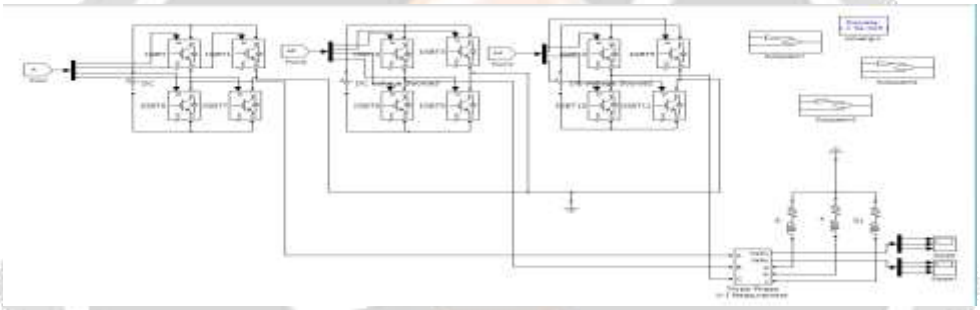


Fig.4: Configuration of three-phase three levels proposed multilevel Inverter

The performance of proposed cascaded multilevel inverter is simulated on MATLAB and the Simulink model is shown in Fig 4. For each dc source of 100V, switching frequency fs=50Hz and resistive load R=5Ω,L=15mH fc=6khz the simulation result of three-phase nine level proposed inverter is shown in Fig.7 shows the FFT analysis for the inverter.

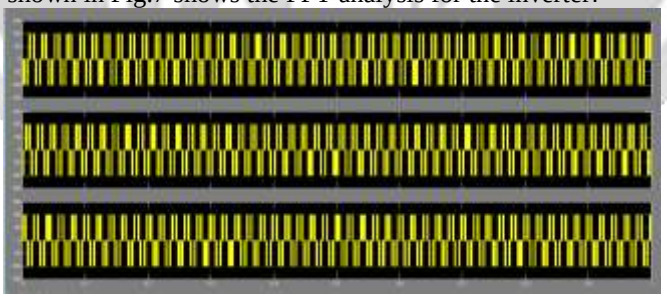


Fig5: Three phase 3level output phase voltage waveform

Fig6: Three phase 3level output line to line voltage waveform

Fig 7: Three phase 3level output current waveform

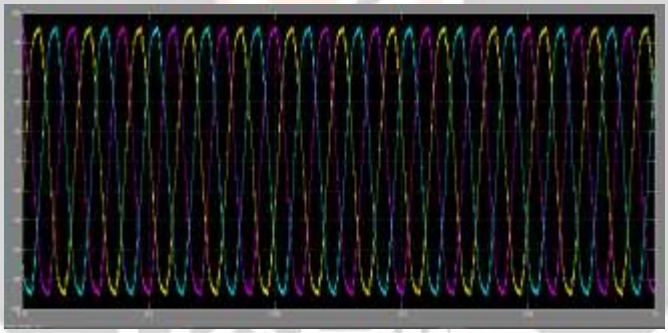


Fig8: Three phase three level output current waveform

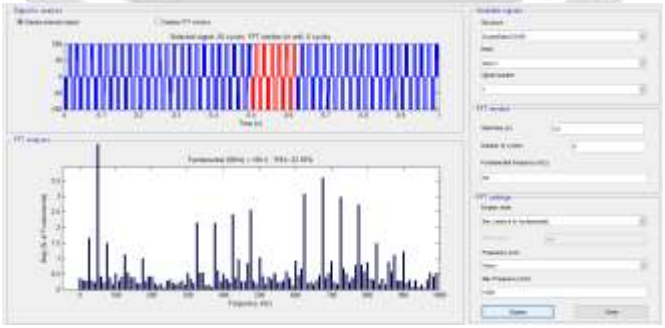
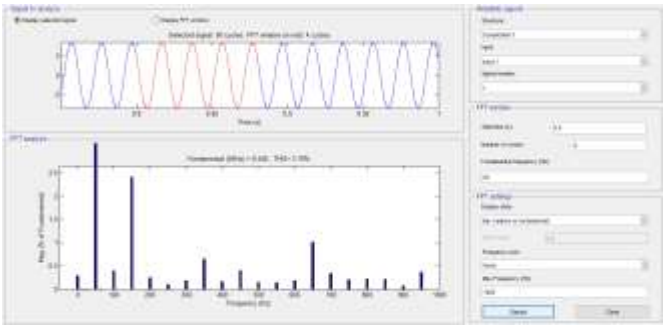


Fig: 9: FFT spectrum of 3-level proposed inverter for voltage using SPWM technique .THD=22.93%



Fig; 10: FFT spectrum of 3-level proposed inverter for current using SPWM technique.THD=0.55%

VIII.CONCLUSION

In this paper, simulation of 3Phase3 level inverter with RL load has been proposed. Future work will be towards the implementation of 7, 9 and 11 level inverters. As the levels of output increases, nearly sinusoidal waveform will be obtained, these results in reduced THD. So the benefits of multilevel inverter include, lower transient power loss due to low-frequency switching, less THD, reduced ac filters, It can be concluded that, in order to maintain the good quality of power, it is necessary to replace the conventional drives with 2 level inverters by multilevel inverters.

IX. REFERENCES

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