Three Phase Inverter Switching Losses at Ambient Temperature Conditions

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Abstract- **The environmentally friendly power sources are drawing in everybody because of zero carbon content discharge. Inverters will have a significant impact to defeat the difficulties connected with the environmentally friendly power sources. It is perceived as an electrical gadget that changes DC power to AC power at the ideal result voltage and recurrence level. A model of inverter has been created utilizing MATLAB and switching losses of the inverter has been determined by carrying out simulation**

Index Terms- **Multiphase Inverter, Output Power Losses, Temperature, Simulation**

I.INTRODUCTION

An inverter is basically a DC-AC converter. Inverter circuits might be profoundly convoluted; subsequently the objective of this strategy is to show a portion of the inverters' inward activities without getting derailed exhaustively. The expression inverter in power gadgets alludes to a class of circuits worked by a source of dc voltage or a dc current source and changed into ac current or ac voltage. While the contribution to an inverter is a dc source, this dc comes from an ac source, for example, a utility ac supply. Thus, the main source of input power, for example, may be a "converted" utility-ac-tension supply which is "converted," then "inverted" back to a dc-converting device using an inverter. Here, the ultimate output may vary from the input ac of the utility supply [1] to a different frequency and magnitude. Typical applications such as UPS, industrial (induction motor) drives, HVDC traction. A power electronics circuit is most often accepted since the circuit truly uses electrical energy rather than information. In classifying a circuit as a power circuit, the actual power level is not really relevant. One the most vital of all performance considerations of power electronics circuits, like inverters, is their energy conversion efficiency. The main reason for high efficiency demands is that enormous volumes of heat are removed from power supplies. The intelligent use of energy is, of course, equally paramount, especially if the inverter is fed from batteries such as in electric cars. For these reasons, inverters operate the power devices, which check the flow of energy, as switches. Ideally in the switching event, there would be no power loss in the switch since either the current in the switch is zero (switch open) or the voltage of the whole switch is zero (switch closed). In reality, there are two mechanisms that do create some losses, however; these are on-state losses and switching losses

A. *Multi Inverter Level*

Many industrial applications in recent years have started to need greater power equipment. Some medium voltage engines and utilities need medium and megawatt power levels [2]. It is difficult to connect a single power semiconductor switch directly to a medium-voltage grid. As an alternative in high and medium power settings, a multi-level power converter structure was created [5]. In addition to achieving high energy ratings, a multi-level converter allows to use renewable energy. Photovoltaic, fuel cells and wind energy sources may readily be interconnected with a multi-level converter system that is high power application [3]. Since 1975, it was presented the notion of multilayer converters. With the three-stage converter the phrase multi-stage originated. Subsequently, several multilevel converter topologies have been developed. However, the basic idea for a multi-level converter in order to generate more power is to employ a number of power semiconductor switches with various lower voltage dc sources to synthesize the waveform of the stepper voltage. Multiple dc voltage sources can be employed with capacitors, batteries and renewable energy sources. The power switch commutations add these many dc sources to produce high output voltage, however the rated voltage of the semiconductor switches only depends on the rate of the dc voltage sources to which they are attached[6].While multilevel converters were created in order to attain higher voltage, the additional switches and dc sources offered by dc-link condensers were able to provide various voltage levels, enabling the development of step-mounted waveforms with reduced harmonic distortion, decreasing dv/dt and conventional-modified voltages, before being constrained by semi-conductor restrictions. These features have popularized them for medium voltage high power applications in these inverters, but a significant number of semi-conductor switches results in both of them being reduced reliability and efficiency of the drive. Therefore, many power electronic researchers have done a lot to develop multilevel inverters with the same benefits and fewer numbers of semiconductor devices [7].

B.Three-Phase Inverters

A three-phase inverter, In today's motor drives, this is the most popular topology. The circuit is essentially an extra leg to an H-bridge-style single-phase inverter. The control technique is identical to that of a single-phase inverter, with the exception that the reference signals for the various legs are phase shifted by a factor of two 120° instead of 180° for the single-phase inverter. Due to the odd triplen harmonics of the reference waveform for each leg are removed from the line-to-line output voltage due to this phase shift. If the waveforms are pure AC, as is frequently the case, the even-numbered harmonics are also cancelled. For linear modulation, the amplitude of the output voltage of a three-phase rectifier supplying the DC bus is decreased by a factor determined by the input voltage as given in Equation 1.

$$\frac{3}{\left(2\cdot\pi\right)}\cdot\sqrt{3}=82.7\% \qquad (1)$$

To compensate for this voltage reduction, the fact of the harmonics cancellation is sometimes used to boost the amplitudes of the output voltages by intentionally injecting a third harmonic component into the reference waveform of each phase leg.

II.DESCRIPTION FOR INVERTER

The proposed model of Multi Phase Inverter has been developed for multiphase inverter. Supply variable power to a distribution power grid, a 400 kW three-phase three-level inverter was modeled. The three-level leg of the inverter is made up of three industrial half-bridge IGBT units. The anti-parallel diodes were used as neutral clamping diodes in this experiment. Two PI regulators (one PQ regulator and one current regulator) are used in the control system to produce the inverter pulses required to attain the reference output power.. Three Half-bridge IGBT with Loss Calculation blocks make up the Phase-A leg. In a thermal network, all switching and conduction losses are measured and injected. The achievable output power versus switching frequency for the three-phase, three-level inverter is seen in the simulation performance. Two IGBT/Diode blocks are used to model the half-bridge. An active pulse generator pulses the upper and lower IGBT/Diode blocks. The damage measurements were made using the manufacturer's data sheets as a guide.

The inverter's cumulative losses are divided into two categories: IGBT losses and diode losses. The energy losses of IGBTs are calculated using the pre-switching value of the voltage around the circuit, the post-switching value of the current flowing through the device, and the junction temperature. This energy is transformed into a power pulse and pumped into the thermal network. Further, the energy losses are calculated using the pre-switching value of the current flowing through the device, the post-switching value of the voltage around the device, and the junction temperature. The energy is transformed into a power pulse and pumped into the thermal network in the same way. And conduction loss determines the saturation voltage through the IGBT based on the current flows in the system and its junction temperature. The energy losses of diodes are calculated using the pre switching value of the current flowing into the circuit, the post switching value of the voltage around the device, and the junction temperature. The energy is transformed into a power pulse that is then pumped into the thermal network. The on-state voltage across the diode is determined by the conduction loss, the value of the current flowing in the circuit, and the junction temperature. The losses pumped into the thermal network are then calculated by multiplying the voltage by I_f.

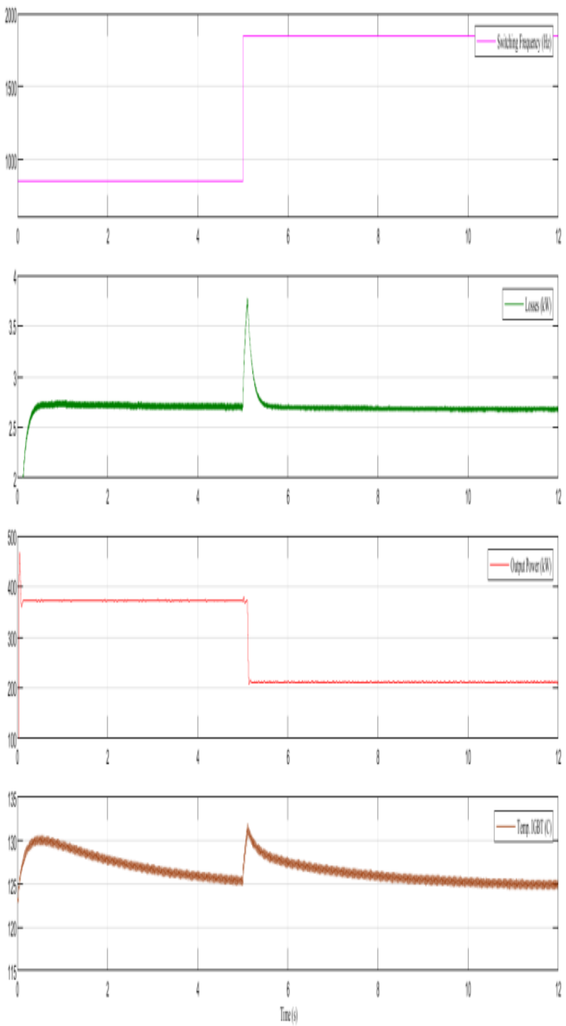

Figure 1 Comparison of different parameters

III.RESULTS

From initial time to five seconds the inverter outputs 372 kW and the power factor equal to 0.85. The cumulative losses of the converter will exceed 2.7 kW, and the IGBT module has the maximum junction temperature of 125 °C. Afterward, from time five seconds to twelve seconds the inverter outputs 210 kW and the power factor is similar. The maximum losses i.e. 2.7 kW are observed at highest junction temperature at 125 °C on IGBT module.

Table 1 Different Values observed after Simulations

Total Losses Inverter	2.67 kW
Output Power Inverter	211.73 kW
Junction Temperature	124.46 C

IV.CONCLUSION AND FUTURE SCOPE

In this paper a study of multi level inverters has been presented. A model of multi level inverter has been developed using MATLAB and switching losses of the inverter has been calculated by carrying out simulation. Graphical representation of the various obtained parameters such as output power losses in kW, losses in inverter and variation of temperature of IGBT has been presented in the results. The mathematical values of total power losses is 2.67 kW, output power is 2.73 kW and junction temperature is 124 °C observed by simulating the model of multi phase inverter. From the results it has been concluded that the higher IGBT temperature results in maximum power losses. Investigation about different modulation strategies to improve the performance of multi phase inverter may be area of interest in future.

REFERENCES

[1] G. Sinha, T.A.Lipo, "A Four Level Rectifier Inverter System for Drive Applications" ,IEEE IAS Annual Meeting, pp 980-987, 1996.

[2] Samir Kouro, Jaime Rebolledo and J.Rodriguez, "Reduced Switching Frequency Modulation Algorithm for High Power Multilevel Inverters," IEEE Trans on Industrial Electronics, vol.54, no.5, Oct 2007.

[3] Akagi, H., "New Trends In Active Filters For Improving Power Quality," Proc. of International conference on Power Electronics, Drives and Energy Systems for Industrial Growth Vol. 1, pp. 417 - 425,January 1996

[4] K. Ding, K. Cheng, S. Wang, D. Wang, and Z. Shi, "Five-level cascaded multilevel motor driver for electrical vehicle with battery charge management," in Power Engineering Conference, AUPEC '08. Australasian Universities, dec. 2008, pp, 1 –6.2008.

[5] F. Lacressonniere and B. Cassoret, "Converter used as a battery charger and a motor speed controller in an industrial truck," in Power Electronics and Applications, 2005 European Conference, pp. 7 pp. – P.7, 2005.

[6] X. Zou, X. Du, G. Wang, Y. Yang and Y. Ji, "The single equivalent inverter admittance model of three-phase grid-connected inverter system considering frequency coupling," *IECON 2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society*, Beijing, pp. 4994-4999, 2017.

[7] H. Matsumori and T. Shimizu, "EE shape low loss three-phase AC filter inductor design for three-phase PWM inverter," *IECON 2017 - 43rd Annual Conference of the IEEE Industrial*

Electronics Society, Beijing, pp. 1119-1124, 2017.

[8] X. Li, L. Qu, W. Ren, C. Zhang and S. Liu, "Controllability of the three-phase inverters based on switched linear system model," *2016 IEEE International Conference on Industrial Technology (ICIT)*, Taipei, pp. 287-292, 2016.

[9] A. Boglietti, R. Bojoi, A. Cavagnino and A. Tenconi, "Efficiency Analysis of PWM Inverter Fed Three-Phase and Dual Three-Phase Induction Machines," *Conference Record of the 2006 IEEE Industry Applications Conference Forty-First IAS Annual Meeting*, Tampa, FL, pp. 434-440, 2006.