International Journal of Research in Engineering, Science and Management
Volume-2, Issue-1, January-2019
www.ijresm.com | ISSN (Online): 2581-5792

Reduced Switch Count Topology for Power Loss Minimization

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***Abstract*: This thesis proposes novel methods and comprehensive analysis for power loss calculation using three-level three-phase voltage source inverters (VSIs). A novel method of MOSFET voltage rise- and fall-time estimations for the switching power loss calculation is developed. The estimation accuracy is significantly improved by the proposed method. In order to provide a reference for thermal management design, inverter power loss analysis is presented. Using the parameters obtained from the semiconductor device datasheets and inverter operating conditions, power loss calculations using three leg inverter with thermal condition are discussed. The conduction power loss calculations for these three devices are straight-forward; and, the switching power loss of MOSFETs can be obtained from the energy losses given by datasheets. However, many MOSFET datasheets do not provide the switching energy losses directly. Therefore, to acquire MOSFET switching energy losses, switching transient times must be estimated as accurately as possible. The impacts of inverter anti-parallel diode reverse recovery on the DC-link current and voltage ripples are investigated. The impact of diode reverse recovery on the voltage ripple is negligible, while the RMS value of current ripple is intended by both diode reverse recovery and inverter switching frequency. A novel method is developed to calculate the ripple current RMS value and the estimation accuracy is significantly improved. Depending on the calculated current and voltage ripples, DC-link capacitor selection is introduced. Generally speaking, failures in the DC-link capacitors take place more frequently than the failures in other parts of the inverter system, and plenty of research has been focusing on minimizing the required DC-link capacitance. As a result, the accurate estimations of DC-link current and voltage ripples are vital in the optimization methods. In addition, with the accurate estimations, the over-design in the DC-link capacitance could be reduced. Finally, the design of a practical bus bar is presented. The DC current distribution is acted by the numbers and locations of the DC input tabs, while the AC current distribution is intended by the numbers and locations of the installation holes for DC-link capacitors and semiconductor devices. Furthermore, parasitic parameters of the bus bar, especially the stray inductance and voltage spikes caused by this inductance during switching turnoff transients, are also discussed from the angle of the design rules and correlation between the parameters and bus bar geometry structure.**

***Keywords*: Power Losses; MOSFETs, Converters, DC-Link**

1. Introduction

In the past two or three decades, about two thirds of the world's electrical power is converted into mechanical power by electrical motor drive systems, in which AC power supplies play an important role. Additionally, uninterruptible power supplies are vital to some critical loads as AC sources, such as in hospitals. Due to the limited supply and global climate change issues of the fossil fuels, renewable energy became the trend in power generation. DC power is usually generated by most renewable energy sources, which leads to demands for DC-to-AC power converters. As a result, three-phase DC-to-AC voltage source inverters are widely utilized DC voltages are converted to AC voltages by inverters that are commonly utilized to interface DC sources to loads Meanwhile, the amplitude and frequency of output AC voltages can be regulated depending on the demands of loads. Inverter is now commonly used equipment in our engineering application and also in daily life. In Electrical engineering inverter means an electronic device or circuitry that changes dc power to an ac power at a desired output voltage and frequency. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter design generally includes several steps:

- Semiconductor device selection;
- Power loss calculation and thermal management system selection;
- DC-link current and voltage ripple estimation and DC-link capacitor selection;
- Bus bar design and analysis.

Various inverter design methods can be implemented to achieve different objectives to increase power density of an inverter system; some methods are developed for size and weight the implementations of most optimization methods rely on the accurate estimations of the inverter performances. Therefore, the estimation accuracies of power loss, DC-link current and voltage ripple, and bus bar performances are crucial in inverter design. However, there are still improvements that are demanded in those estimations.ht minimization the inverter does not produce any power; the power is provided by the DC source. Power Loss Calculation and Thermal Management Selection. Power loss calculation of semiconductor devices and inverters is important since it predicts the inverter efficiency and provides a reference for the thermal management system selection. Unnecessary over-design can be avoided by accurate power loss estimation. Once a certain semiconductor device is selected, the inverter power loss and thermal management system can be calculated and selected depending on the parameters provided by device datasheets and operating conditions of the inverter. Both conduction power losses and switching power losses should be considered. Power loss calculation for inverter and three types of commonly used semiconductor devices, i.e. MOSFETs, IGBTs and diodes, is introduced. Utilizing the information given in datasheets, such as on-state resistance and switching energy losses, the conduction and switching power losses can be calculated according to the inverter operating conditions. Nevertheless, different from the switching power loss estimation of IGBTs and diodes, most MOSFET datasheets provide inherent capacitances instead of switching energy losses; thus, switching time. Calculations are needed to obtain the MOSFET switching energy and power losses. An existing method is provided in for estimation of the MOSFET switching transient times. The estimation accuracy of voltage rise and fall-time is restricted by the nonlinear variation of MOSFET inherent capacitances. Therefore, a method is proposed in this chapter to improve the estimation accuracy. In this chapter, power loss calculations for semiconductor three devices, namely MOSFETs, IGBTs, and diodes,

A. MATLAB Simulink Model

The Simulink model in MATLAB provides a graphical user interface, users can call the standard library module from where the necessary blocks and components are selected and are properly connected to form the dynamic system model. There is a Dialog box for changing the properties of each individual component used in the module and also the system parameters as well as the configuration parameters for the type of simulation desired. For system modeling, address parameters and numerical algorithms are selected we can start the simulation program Simulation of the system. Scopes are used to get the output waveform of voltages and current and workspace is also used for the same.

2. Results and discussion

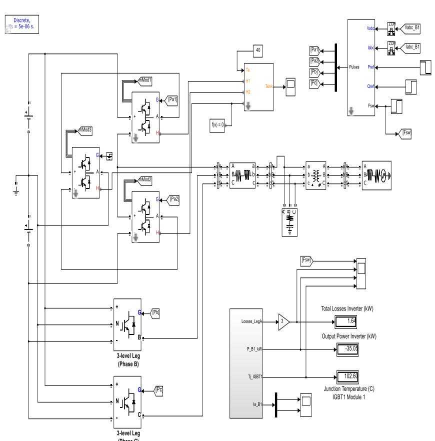

Fig. 1. Simulation diagram of proposed system

The proposed method is implemented using MATLAB 2013b and tested for Distribution system. Fig. 1 shows the overall diagram of the Distribution system With Three Phase Three Leg Inverter. In this system, PWM firing circuit is used to trigger the MOSFET Switches. 420 Volt Grid Connected to Inverter Circuit to analysis the system losses.

Fig. 2 shows the output power in kw also represent the switching frequency and power losses occur in the system during proposes. Fig. 3 Shows the Heat Conductance effect on system power Losses.

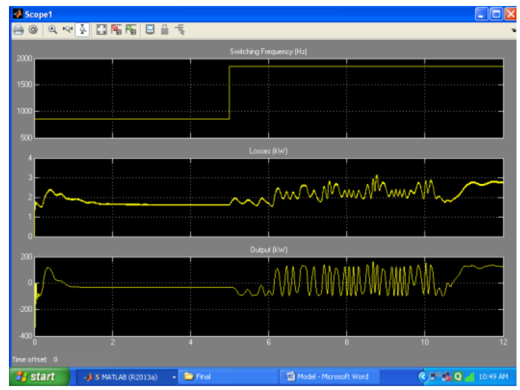

Fig. 2. Output waveform of losses and switching frequency

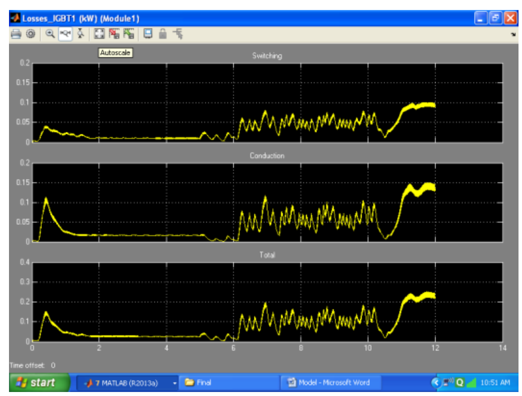

Fig. 3. Heat Conductance effect on system power Losses

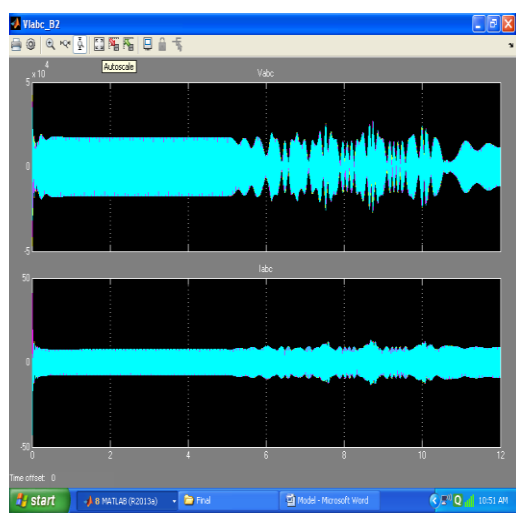

Fig. 4. Output voltage and current of the inverter

Fig. 4 and 5 shows the current and voltage output of the system across the load and simultaneous Line current and present harmonics distortion in the system.

Conclusion: In this Paper, three phase three leg inverter connected to distribution system. The effects of the power losses are calculated at different condition. From the result it is clear that there is the power loss of the system is minimum at the three leg topology of inverter using MATLAB 2013b and tested for power distribution system. This is shown in Figure the power losses of the system found at 2 KW at all Physical conditions like Temperature are considered. Thus there is a reduction by about 20 % of total power losses in the system.

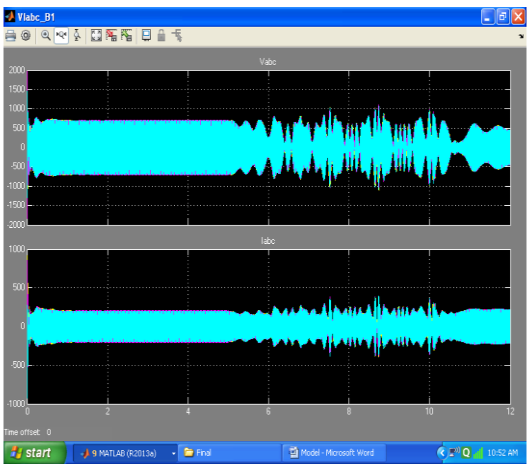

Fig. 5. Output waveform of the voltage and current at bus 1

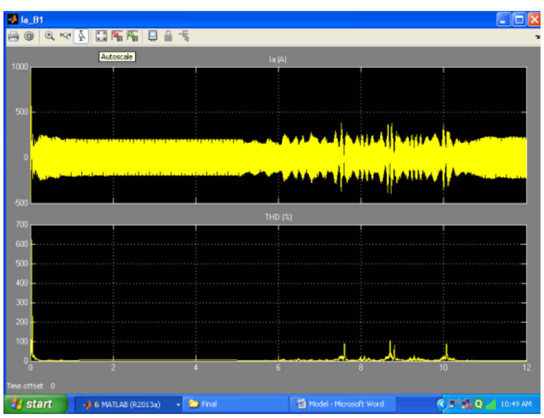

Fig. 6. Total harmonic distributions

Fig. 6 represent the final system operating condition in terms of THD. The result shows the 2 to 5 % harmonics present in proposed model and the power losses of the system is maintaining at permissible limit.

3. Conclusion

In this paper, design and simulation of three phase three leg converter is designed. The effects of the significant parameters have been shown. From the result it is clear that there is optimal enhancement in the system parameters. The proposed method is implemented using MATLAB 2013b and for MOSFET Switches for converter designing. Which is shown in Figure the power losses of the system found at 2 KW at all Physical conditions like Temperature is considered. Thus there is a reduction by about 20 % of total power losses in the system. The result shows the 2 to 5 % harmonics present in proposed model and the power losses of the system is maintaining at permissible limit.

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