Design and Analysis of a Transformer-less Single Phase Inverter

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Abstract - The Primary objective of the paper is to design an efficient, reliable and low cost inverters without the use of transformers.The present day inverters with transformer are bulky making them tougher to transport and to install. There has been an increasing interest in transformerlessinverter due to low cost,high efficiency, light weight, etc.But unfortunately, a leakage current flows through the system. The experimental results show that the proposed topology can inject reactive power without any additional current distortion and leakage current. Proposed circuit structure and detail operation principle are presented in this paper.The proposed inverter topology is simulated by MultiSim software to validate the accuracy of the theoretical analysis.

Keywords - Boost-Buck Converter, MOSFET switches, H-Bridge, leakage current, T-LCL filter

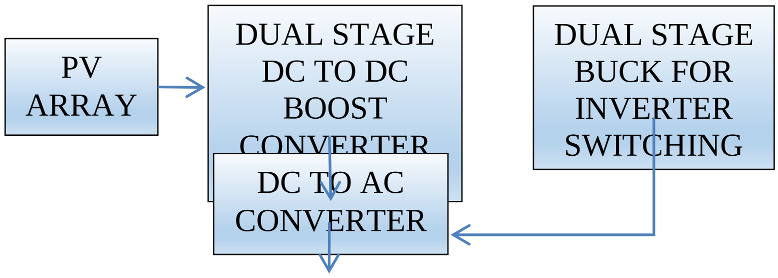
1. INTRODUCTION

In the present scenario people are concerned with use of machines that are capable of providing more efficient output with the available input. Recently, the photovoltaic power generation system has been focused as one of the most significant energy sources due to the rising concern about global warming, and the increase of electrical power consumption. In addition, the PV module has no moving parts, which have made it very robust, long lifetime and low maintenance device. Energy losses can reduce system efficiency so much that achieving a target outputpower becomes impossible, so limiting losses often determines practical implementation of converter.Transformer converters increases the cost and the powerlosses, so the efficiency of the system is reduced. Hence, transformer-less inverters are nowadays one of the most popular power electronic devices used to connect green energy sources. This project mainly focuses on designing of transformerless inverter using MOSFET's. Some of the problems associated with proposed transformerless inverter topology are: The stray capacitance between PV arrays andground can cause leakage current .Capacitive current will be produced due to alternating voltageof polarities.Leakage current further causes higher losses andelectromagnetic interference issues.Due to absence of Galvanized isolation, security is at risk.

2. OBJECTIVES

The main goal is to design a transformer-less inverter with high reliability and maximum efficiency greater than that of presently available configurations by overcoming their problems and to reduce leakage currents. In order to avoid injection of DC current and to suppress the leakage current within thepermissible level, certain converter structures and modulation methods have been proposed. In this project, a new transformer-less topology is modeled, analyzed and validated by simulation. The main objective of the proposed transformer-less inverter is to address two key issues: One key issue for a transformer-less inverter is that it is necessary to utilize super junction MOSFETfor all switching devices to achieve high efficiency.Another key issue is that the inverter configuration should not have any shoot-through issues for higher reliability.

3. PROPOSED SYSTEM



The input from the PV Panel is first fed to the DC-DC Boost converter where the 24VDC is converted to 312VDC in two stages (24V-86V and 86V-312V). The buck converter input is taken directly from the grid and the conversion here is from RMS 220V to 5V in two stages (220V-33V and 33V-5V). Both the input from boost converter and buck converter is fed to the DC to AC converter or the H-Bridge Inverter. The switching circuit input is taken from the H-Bridge Inverter and the output of the switching circuit is fed to the grid and suppiled to the necessary loads.

4. ANALYSIS OF PROPOSED DUAL STAGE DC-DC BOOST CONVERTER

A DC-DC converter converts DC from one voltage level to a desired voltage level by storing the input energy and releasing it at different voltage levels. In this type of converter, unregulated voltage is converted to fixed level regulated voltage. This converter is controlled by Pulse Width Modulation(PWM) and applied through transistor. To achieve the desired output the duty cycle of PWM should be very large(72%). In order to achieve this the power conversion is done through 2 stages. The boost converter is used for 24V-312V conversion.

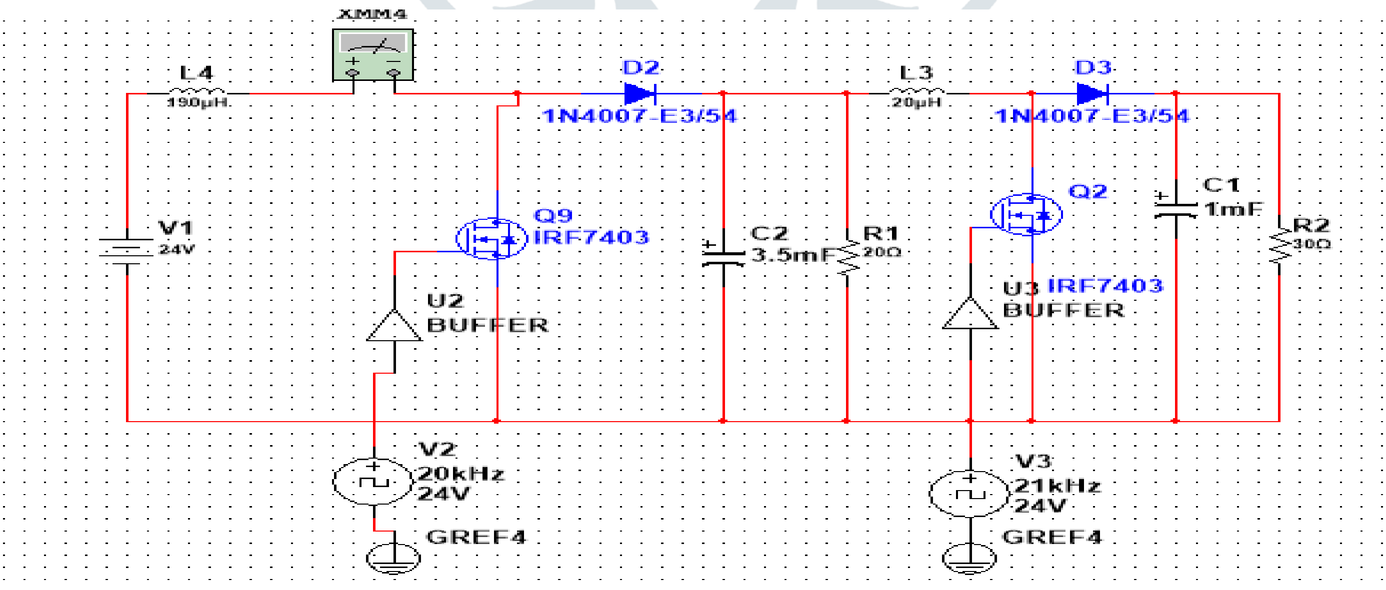


Figure 4.1 Dual stage Boost Converter

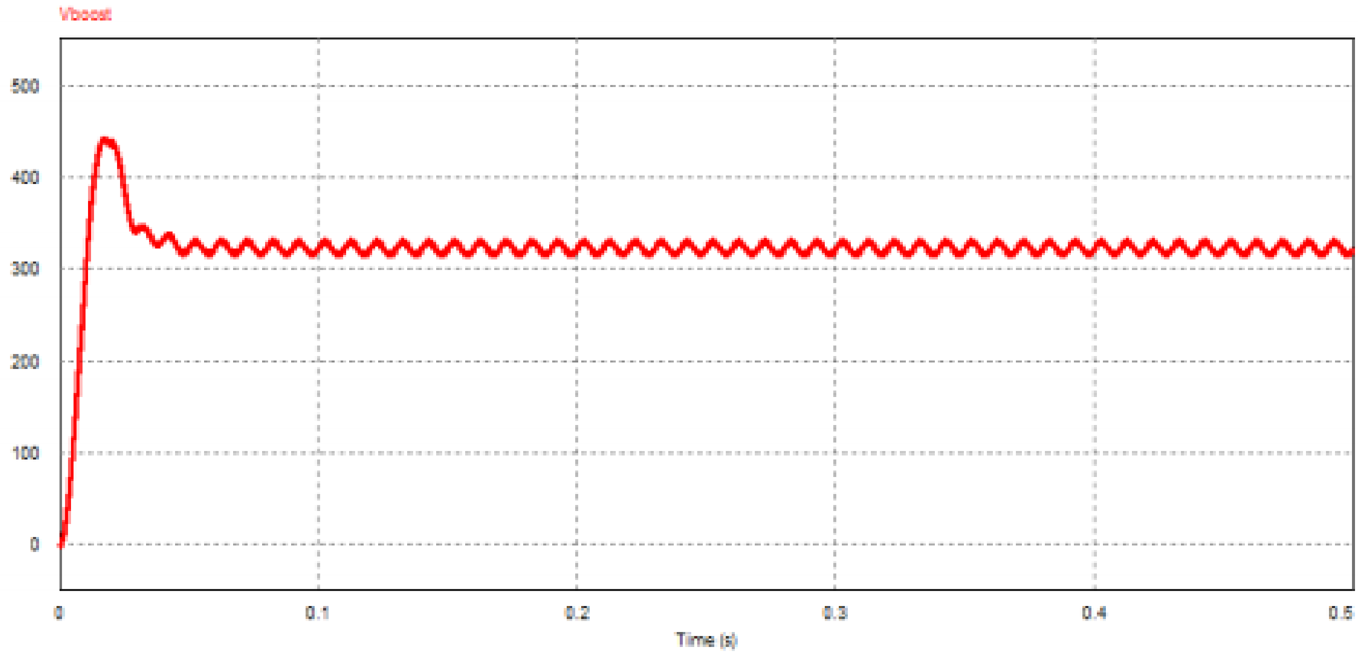


Figure 4.2 Dual stage boost converter output

4.2 DESIGN OF BOOST CONVERTER

Inductor selection:

$$L = \frac{Vin(Vout - Vin)}{\Delta Il \times fs \times Vout}$$

Where Vin is the input voltage

Vout is the output voltage

I_l is the inductor ripple

Fs is the Minimum switching frequency of the converter

Capacitor selection:

$$C = \frac{Iout \times D}{fs \times \Delta Vout}$$

Where Iout is Maximum output current

D is Maximum duty cycle

5. ANALYSIS OF PROPOSED DUAL STAGE AC-DC BUCK CONVERTER

The buck converter takes input from the grid and this AC voltage is converted to pulsating DC voltage through bridge rectifer. This pulsating 220V voltage is converted to 5V DC by buck converter. The duty cycle of Pulse Width Modulation(PWM) should be low (15%) to achieve the desired output. So we use dual stage buck converter to get the desired output. Since the input to the buck is from the grid, the frequency of the inverter output will be same as grid frequency. The buck converter converts RMS 220V to 5V.

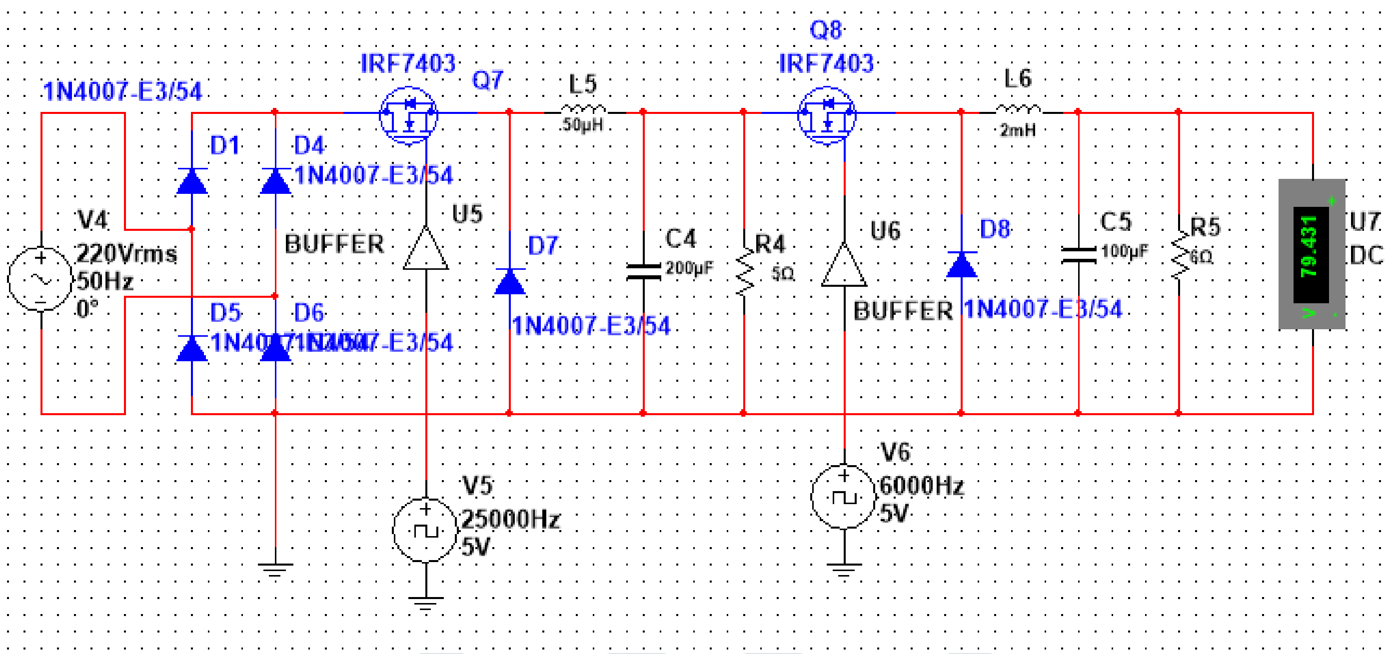


Figure 5.1 Dual stage buck converter

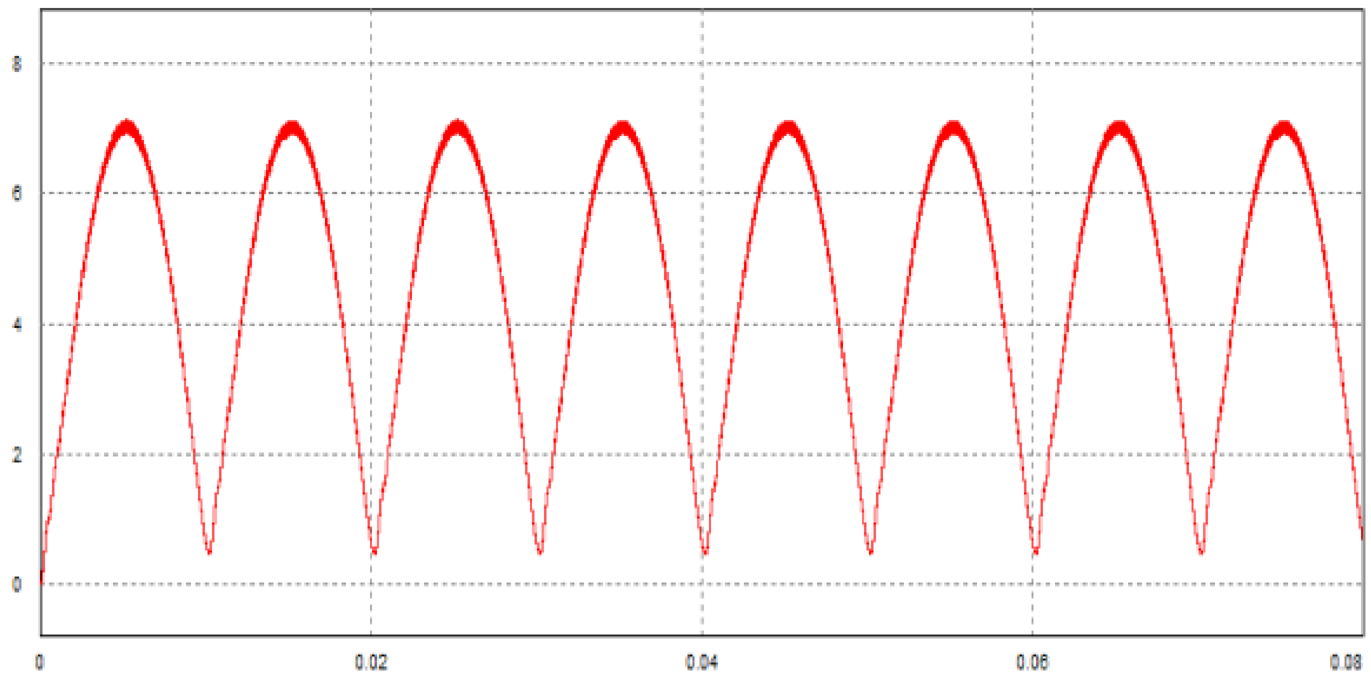


Figure 5.2 Dual stage buck converter output

5.2 DESIGN OF BUCK CONVERTER

Inductor selection:

$$L = \frac{Vout(Vin - Vout)}{\Delta Il \times fs \times Vin}$$

Capacitor selection:

$$C = \frac{\Delta Il}{8 \times fs \times \Delta Vout}$$

6. ANALYSIS OF PROPOSED SINUSOIDAL PULSE WIDTH MODULATION

In this type of inverter instead of using one type of switching signal to switch the inverter, we use a combination of SPWM and square wave. The purpose of using this kind of combination is to reduce switching losses across the switches of the inverter due to switching frequency. The sinewave for the proposed inverter will be sampled from the grid by using buck converter to convert 220V to 5V. The output frequency will be same as the grid frequency. A high frequency triangle wave is generated by the analog oscillator of frequency 10kHz.

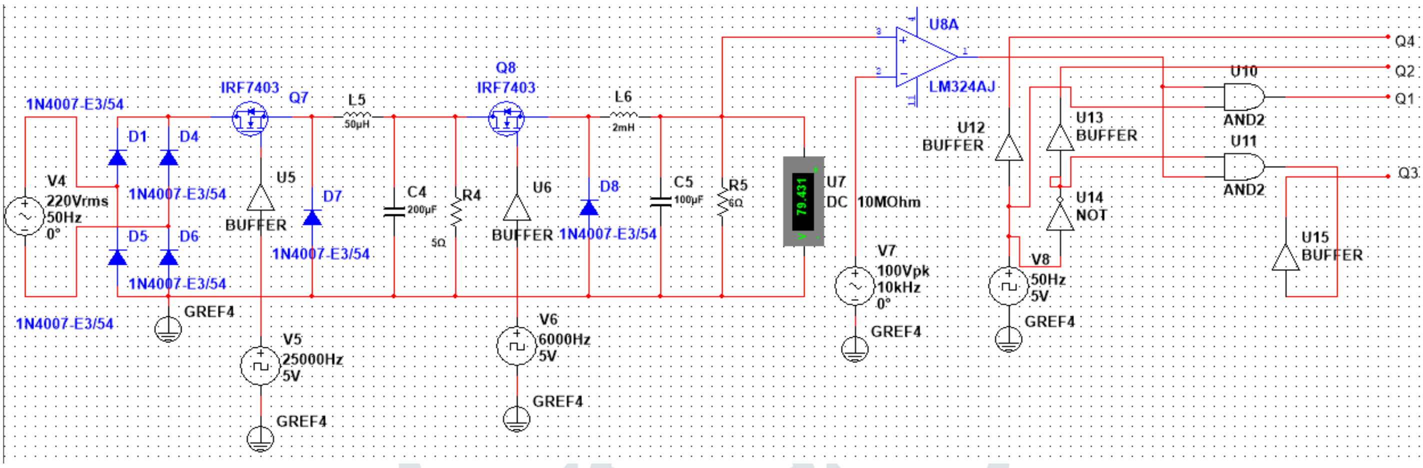


Figure 6.1 Buck converter with Switching Circuit

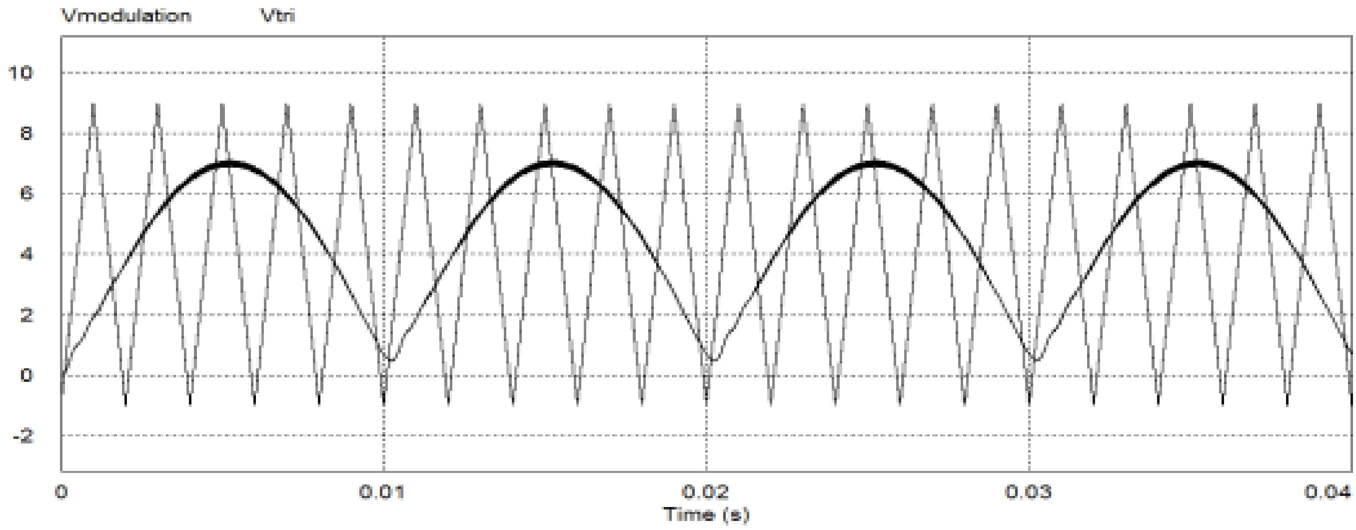
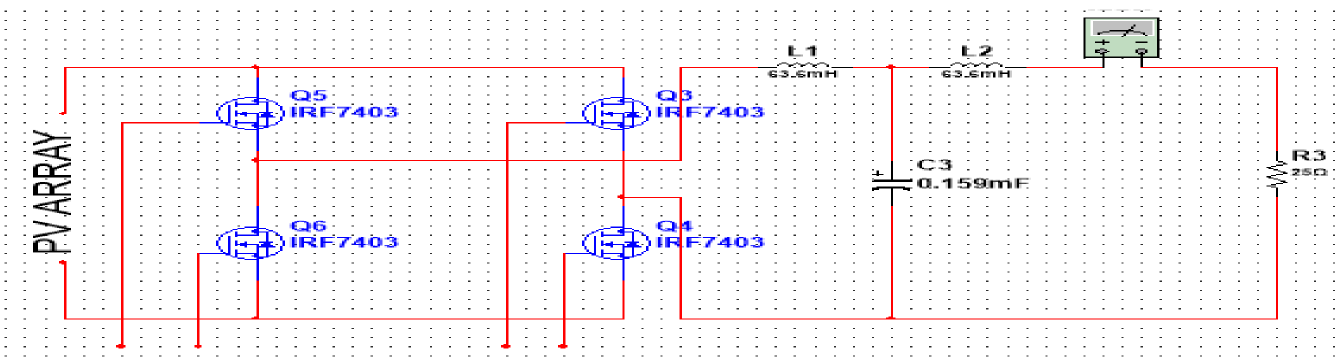


Figure 6.2 Sinusoidal Pulse Width Modulation Generation

7. ANALYSIS OF PROPOSED H-BRIDGE INVERTER AND FILTER CIRCUIT



A DC-AC Converter is called an inverter. The input is a DC voltage and the output is a sinusoidal AC voltage. The H-Bridge inverter has high efficiency, low stress and can be easily interfaced with RES such as PV panel. In H-Bridge Q3 and Q4 is one group and Q5 and Q6 is one group. When one group is turned one the other is forced to turn off and vice-versa.

The T-LCL filter topology has less than 4 reactive elements hence they are used extensively. It is an Impedence-Admittance converter i.e., the impedence is converted to admittance. The input impedence is directly proportional to the load and the output current is proportional to the source voltage and vice-versa. The filter also reduces the harmonic distortion to produce a pure sinusoidal output and also maintains the output current constant.

7.2 Design of T-LCL Filter

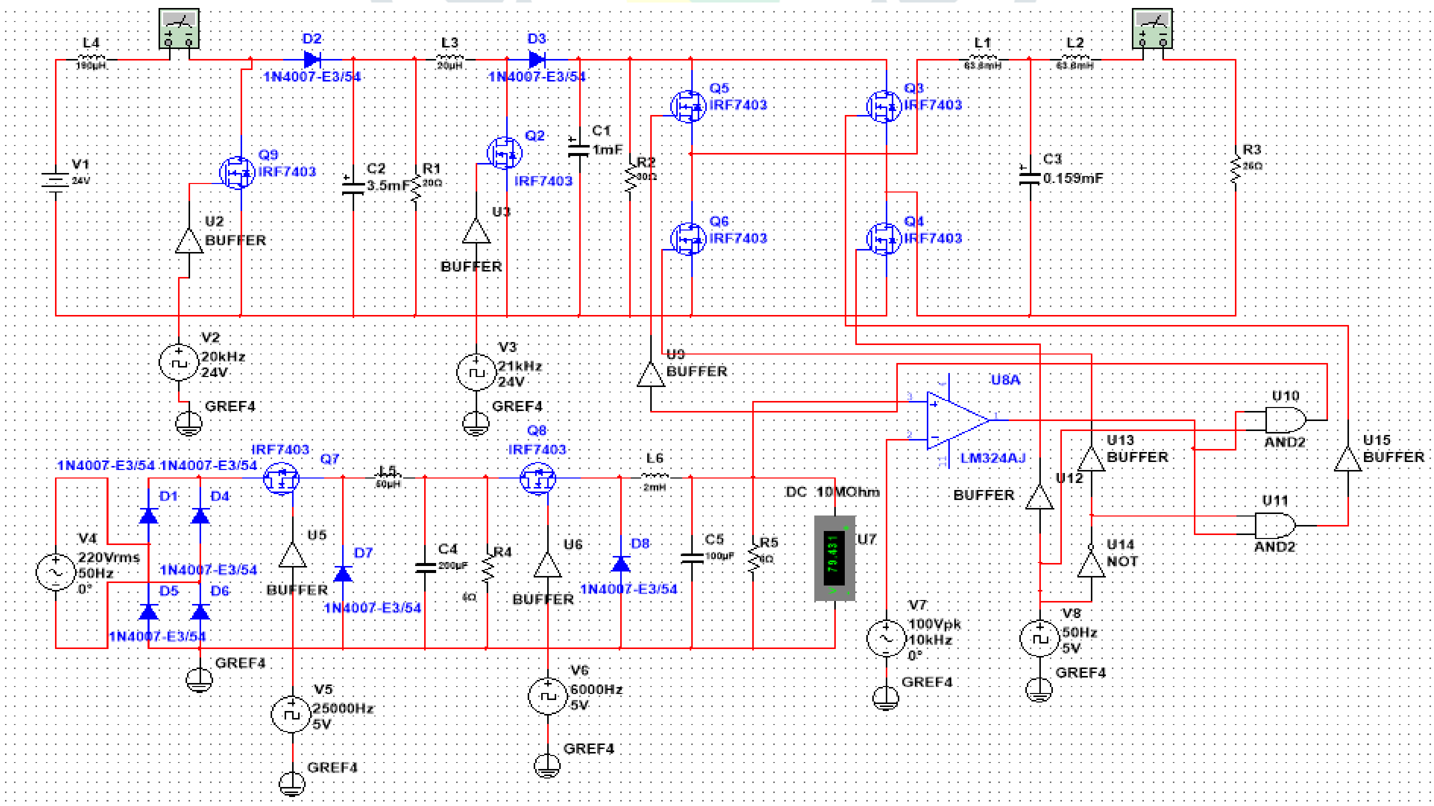
$$C = \frac{1}{2\times\Pi\times fc\times R}$$

$$L = \frac{.....R}{2\times\Pi\times fc}$$

$$Z = \sqrt{\frac{L}{C}}$$

$$f = \frac{.....1}{2\times\Pi\times\sqrt{LC}}$$

8. CIRCUIT OF PROPOSED TRANSFORMERLESS INVERTER



Conclusion

The outcome is to design an inverter without transformer that is more efficient and more reliable. The design of transformerless inverter is done using SPWM and dual stage boost and buck converter. The simulation results obtained were more efficient and satisfactory. The proposed topology is suitable for both constant load and dynamic loads. As losses are observed in case of transformer inverters which effects their efficiency, it is seen that the losses are reduced to gain maximum efficiency and is very much cost effective.

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