3 PHASE INVERTER AND FILTER FOR HIGH TEMPERATURE APPLICATION

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Project Summary

This project consisted of designing and improving the efficiency of 3-phase inverter and filter at extreme high temperatures. The temperature range was up to 25-150°C. A simulation was generated for the inverter using PSIM software. A DC input of 24[V] was used as a source and a 3-phase motor was used as a load. The design plan consisted of using a DC source followed by a filter, which was needed to filter out harmonics. The filter was then connected to a microcontroller which controlled the inverter switches. A 3-phase motor was used as a load.

Problem and Need

An inverter is a device which is used to convert DC (direct current) to AC (alternating current). Inverters are used in field engineering and many petrochemical projects as well. Sometimes these inverters can be exposed to extreme high temperature conditions such as oil drilling or electric cars. This causes the inverter to lose efficiency or stop functioning as the parts degrade with increase in temperature. The focus of this project was to investigate the effects of high temperature on the equipment. The increasing temperature created unwanted harmonics which hindered the performance of the inverter. Due to unwanted harmonics the cutoff frequency of the filter changed because the capacitors and inductors lose their characteristics as temperature increases. The frequency values changed exponentially as temperature changes.

Significance

Extreme temperature power electronics have become possible with the recent availability of silicon carbide MOSFET. This material, compared with other wide-bandgap semiconductors, can operate at temperatures above 500 °C, while silicon is limited to 150–200 °C. Lots of work is still needed to design and build a stable power system that is able to operate in harsh environmental conditions (high temperature and deep thermal cycling). In addition to drilling, motors in electric vehicle may need to operate at temperatures close to 150 degrees Celsius. With the advent of electric cars, stable power electronic systems that can function at high temperatures are a necessity. For our project, we believe that it will benefit any applications of power electronics at high temperature.

Goal

Simulations were done using PSIM, a engineering design software, to generate models of the functionality of the embedded inverter and the filter that was designed. During the simulation process we experienced some issues simulating the thermal module for the capacitor and inductor along with choosing the correct values for them. The filter was designed with the purpose of mitigating the harmonics coming from the load when exposed to high temperatures. Proper filter materials and components were chosen to withstand the high temperatures we dealt with. Next the microcontroller was programmed and calibrated with the three-phase motor using code composer and control suite to run at ten-thousand kilohertz. In the second phase, the Spring semester of 2018, we tested the filter after connecting it to the microcontroller on a hot plate to test whether the harmonics where mitigated at high temperatures.
Customer/User Analysis

Our project was intended to be used in the power electronic field, such as oil drilling operations for petrochemical companies and electric automobiles. The voltage quantities used in the research were reduced to ensure safe work practices. To test the circuit components at varying temperatures, a hot plate was used to heat up the circuit to mimic the effect of ambient temperatures in oil drilling operations. Some experience requirements include basic knowledge of DSP and AC motor calibration as well as power electronics and signal processing.

Deliverables

The deliverable was to model and simulate a 3-phase inverter that can function between 25–200 °C. The materials for the filter were selected that can handle high temperature. The testing of the inverter circuit was done on a hot plate from 25–200 °C.

Terminal Objective

Target objectives included: the design and simulation of a 3-phase DC-AC inverter in PSIM which enabled variations of speed and temperature; the research of materials and specifications for the design of a suitable 2nd order low-pass filter for the 3-phase inverter; understanding the different voltage/current/temperature sensing options for the system; and identifying the best way to connect all sub-modules together for the system with a thermal plate.

Overview Diagram

![Circuit Diagram of Filter and 3-Phase Inverter](image)

Fig. 1. Circuit Diagram of Filter and 3-Phase Inverter

References (if applicable)