Commissioning and evaluation of an inverter box

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1 Introduction

In a world where the interest for environmentally friendly, so called hybrid, vehicles is growing the technology of power electronics is becoming an important part of vehicle construction. For future technologies for propulsion of vehicles, power electronics will play an important role when fuel cells and an increasing use of batteries will become reality. This technology will give the opportunity to reduce the need for fossil fuels and make countries less dependent of oil producing states.

This article describes commissioning procedure and evaluation of a construction of a DC/AC inverter. The function of the inverter is to supply a fan motor located in military vehicle called SEP. The aim of this article is to describe a section of the commissioning process and how the power electronic devices act.

Figure 1: The rubber band version of SEP.

SEP (Splitterskyddad Enhetsplattform or Modular Armoured Tactical System) is a newly developed armoured vehicle by BAE Systems Hägglunds and Sweden's defence material administration. The vehicle is based on a modular concept where it will meet demand for different purposes such as troop transport, working as a radar station or as a weapon equipped tank. One of the advanced feature of SEP is the electrical drive. Instead of conventional mechanical propulsion an electrical motor is integrated in each wheel, or in the front in the rubber band version. Electrical propulsion has many advantages such as less weight and volume and a more flexible manoeuvring of each wheel independently.

In the first generation of the vehicle two diesel engines will provide energy to a generator transforming it to 700V on a DC bus. The DC bus provides enough energy for both propulsion and the auxiliary equipment. The now existing prototypes are, to a large extent, equipped with hydraulic systems for energy conversion. It is desirable to replace the hydraulic system with an electrical one. As a part of the development this article will describe an evaluation of a prototype of an inverter for the cooling fan motor.

2 System description

The components of interest in the inverter box are the IGBT module, the DC capacitors, the DC bus and the driver circuit card. The components can be seen in Figure 2. Of course does the inverter box contain more components, but those will not be discussed in this article.

The IGBT module chosen is a 1200V, 50A full bridge module (six transistors). The module transform the 700DC voltage to achieve 400AC voltage by switching the transistors in pairs.

Figure 2: A photo of the inverter box.

It is of great importance to keep the DC bus voltage level stable. This, not to affect other voltage system connected to the same source of supply. For this reason large DC bus capacitors are needed.

It is desirable to minimize the inductance in the circuit. The energy stored in so called stray inductance influence the switching behaviour and can in worst case damage the inverter. For low inductive supply of DC voltage a DC bus consisting of two copper plates is used inside the inverter box.

The main purpose of the driver circuit card is to turn the six transistors on and off by providing the desirable current to the gates.

3 The commissioning procedure

During the commissioning phase it is of utmost importance to have full control of the entire system. A plan for commissioning was developed to be able to in a structured way test all important properties without risk of hazardous situations. The DC bus capacitors hold a large energy, enough for risking a person's health. These were disconnected during almost the entire process.

To assure that no short circuit on the DC bus occurs, an isolating layer between the copper plates is necessary. The isolation properties on the layer has to be tested to assure that no partial discharge occur, i.e short circuiting between the plates. The applied voltage across the DC bus during operation in the vehicle is set to 700V. During the evaluation of the plastic layers a margin of a more than three times higher voltage is applied (2.5kV). A partial discharge is desirable, this to be able to know how it behaves. A thicker layer replaces the old one and a control that no discharge occurs has to be done.

The function of the driver circuit card was tested. The output signals to the IGBTs have to work in a correct way to not damage components. Some adjustments on the electronic layout were done before it worked satisfying.

When the functions of all components were tested, they were put together and a DC voltage of 50V was applied to investigate if the system behaved as expected. The DC bus voltage was then stepwise raised up to the maximum voltage.

4 Switching behaviour

If the switching behaviour is to poor a snubber circuit could be introduced. A snubber circuit is mainly used for limiting voltage overshoot and to minimize resonance in the circuit.

When a snubber is used it is possible to fasten up the switching behaviour without increasing the level of overshoot. When the switching behaviour is faster the switching losses in the inverter is decreased. That is an important factor because losses produce heat and many devices can not handle temperatures over 125 degrees centigrade.

To design a snubber circuit the stray inductance in the circuit has to be calculate. The energy stored in the stray inductance should be absorbed in a snubber capacitor, this to not influence the switching behaviour. The energy stored in the snubber capacitor has to be discharged, through a snubber resistor. This can be accomplished by different snubber circuits working by the same principal. The value of the resistance can be chosen in different ways depending on how fast the snubber capacitor should be discharged.

An example of the advantage with a snubber circuit can be seen in Figure 3. Two turn-off sequences are compared, one slower without a snubber circuit and one faster with a snubber circuit connected. It can be seen that the overshoot behaviour is the same despite that the rise time is faster for the one with a snubber circuit. It is desirable to not use snubber circuits if not necessary because of economic reasons and volume aspects, but sometimes it is necessary.

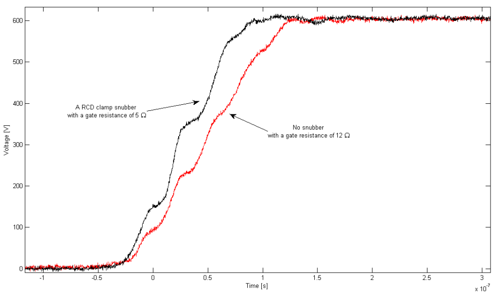

Figure 3: Switching behaviour with and without a snubber circuit.