Development of a Universal Bidirectional Galvanic Isolated Switch Module for Power Converter Applications

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***Abstract* – This paper describes the intention of making the practical implementation of converters easier. It consists of a bi-directional galvanic isolated switch module for power converter applications integrating the bidirectional switch function in current and voltage with fast switching times. It includes a MOSFET or IGBT, a gate driver, galvanic isolation between control and power stages, over-voltage protection devices and a floating voltage power supply.**

***Index Terms*–Floating supply, galvanic isolation, switch module**

1. INTRODUCTION

A semiconductor switch is sometimes used where no terminal is connected to the ground potential and it is thus said to be floating. This causes problems when applying a logic signal that controls when a semiconductor switch must be on and when it must be off. However, a semiconductor switch usually does not accept logic level signals therefore a drive circuit is needed to convert the logic signals to appropriate levels [1].

If the switch is used in an electrical circuit where high voltages and currents (AC or DC) are the norm, these high voltage levels will be disastrous to the control circuit and therefore there must be galvanic isolation between the control circuit and the power circuit [2].

When switches are used in circuits where they are complementary, they may not be on simultaneously or else they will be destroyed [3].

In applications where a common ground cannot be guaranteed, galvanic isolation prevents ground loops from causing circuit damage and offset errors at sensitive nodes [4].

The size of the pulse transformers and the complexity of the modulation circuitry are limiting factors in many applications [5].

One of the most popular and cost effective drive circuit for driving the MOSFETs is an npn-pnp complementary totem-pole circuit, which couples the appropriate floating DC voltage to the gate of the MOSFET to turn it on and off as required [6]. This circuit handles the current spikes and power losses making the operating conditions for the PWM controller more favorable. This drive circuit should be placed right next to the power MOSFET, so that the high current transients driving the gate are localized in a very small loop area, thus reducing the value of parasitic inductances [7]. An interesting property of the bipolar totem-pole drive circuit is that the two base-emitter junctions protect each other against reverse breakdown.

2. RESEARCH AIMS

The aim of the research is to develop a universal bidirectional isolated switch module for converters which will be used to provide galvanic isolation between the control circuit and the semiconductor device. A floating gate drive supply will be used to ensure full gate control for indefinite periods of time.

The switch must be usable in both AC and DC applications. It must provide an interlocking facility to ensure that the two switches do not conduct simultaneously.

Researchers in the fuel cell laboratory at VUT will be able to use the proposed circuit module to implement control algorithms in experimental setups without having any interface problems between the control circuit and the conversion topology. This will shorten the research time by enabling the researchers to focus on their own objectives and not on peripheral issues.

3. WORK DONE AND FUTURE WORK

A research proposal has been submitted and has already been approved. A circuit has been simulated and measurements have been taken on an experimental model.

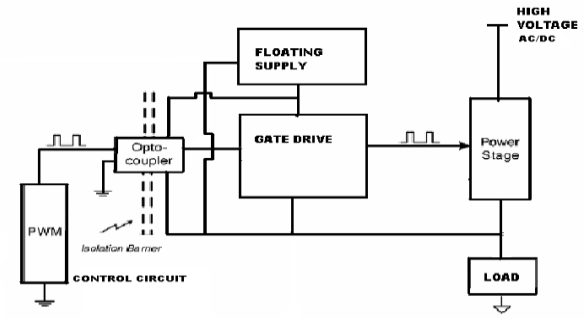

Fig. 1 Power switch module showing the isolation barrier and floating supply voltage

The design is on the breadboard and this module can to switch at 100 KHz without elevated voltages and or spikes. This was proved with the switching waveforms from simulation and measured results fig 2 and 3.

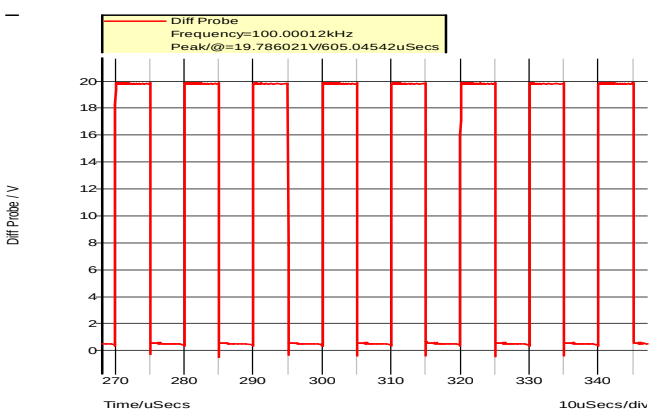

Fig. 2 Switching waveform from simulation

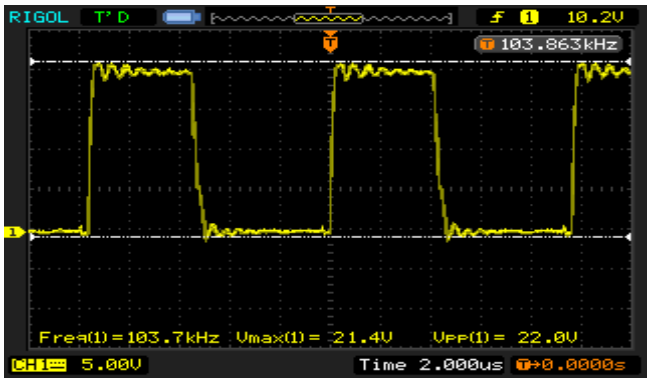

Fig. 3 Switching waveform of the prototype

Figure 4 shows waveforms results of a buck converter design switched with this module. Channel 1 shows a chopped output voltage when the module is switched at high frequency (100 kHz). Channel 2 shows the current through the inductor.

The DC output voltage can be controlled by varying the duty ratio depending on the load.

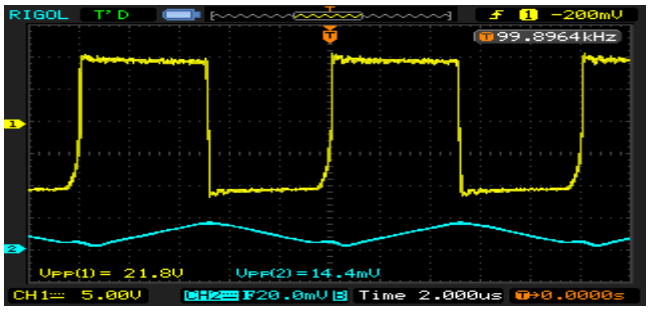

Fig. 4 Voltage and current waveforms of a buck converter

PCB boards for the switch module and a buck converter have been completed and also their design wound components. A measurements are being conducted.

This module will also be tested in other few typical power electronics topologies to verify its universality. It will be tested on a boost converter, a buck-boost converter, a push-pull converter, an H-bridge converter and an inverter to test its working status. And this will include design considerations of their magnetic wound components.

Manufacturing of PCB boards for these converters is in process. Then testing and optimization of the system will be done to verify whether the module meets design specifications.

A final dissertation will then be submitted for examination.

4. CONCLUSION

This paper has highlighted some aspects of the switch module and reported on the progress of the research.

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Mokhalodi Kopano obtained his BTech(Elec Eng) degree from Vaal University of Technology in 2007. He then joined the Fuel Cell Research Group as a Telkom Centre of Excellence student where he is currently working towards his MTech(ElecEng)degree. His research interests include Renewable Energy and Information security.