Isolated gate driver power supply with integrated PCB capacitive coupling communication

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This thesis is part of a bigger project which focuses on the development of an isolated multilevel AC/DC converter for medium voltage AC and low voltage DC grids. In addition to the sizing of the power electronics, there are insulation limits that must be respected to ensure a correct and safe operation. In order to power and control this converter power module boards, an isolated system has been developed.

Context

The AC/DC converter consists of cell inverters mounted in cascade in the medium voltage AC part to ensure the desired voltage. These cells will be connected to modules with an AZCS (Active Zero Current Switching) topology that will ensure isolation and transfer the power to the low voltage DC network. The idea is to develop an interface that both guarantees the isolation and transmits the power and the control signals to the control boards of the power modules.

Goal

The aim of this project is to develop a prototype of an isolated driver that allows the simultaneous transmission of power and the command signals.

Starting point

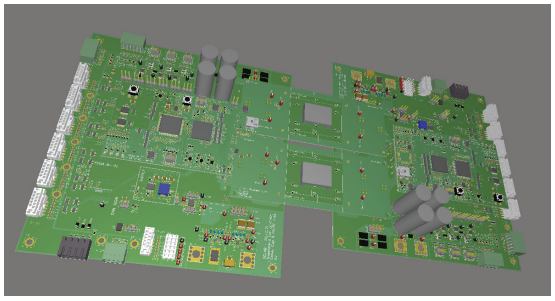
In order to develop the isolation system needed to transmit the signals and the power, it was initially necessary to complete the construction of the AZCS modules developed in the BFH power electronics laboratory. Then a first prototype of the isolated power supply was redesigned to supply the control boards for the AC/DC converter power electronics. Eventually, the isolated communication channel had to be integrated into the power supply through capacitive elements integrated on the PCB.

Implementation

First of all, the operation of the AZCS converter was analysed, in order to complete its hardware. Therefore, the control board for the IGBT power modules was developed. Then, a safety standard zone was conceived to carry out the commissioning and the measurements of the losses of each power element of the AZCS converter.
Based on an existing prototype of an isolated DC/DC converter, it was possible to resize it by redesigning a 500kHz planar transformer to transfer adequate power, 12V/50W, to supply the control boards of the AZCS converter. The transformer was designed to isolate two areas with potential differences of 14.5kV. It included a shield that contained the high electric fields, which was exploited to create an isolated communication channel through capacitive elements integrated on the PCB. Afterwards, it was possible to implement a prototype that consisted of two PCBs interconnected through the transformer with integrated isolated communication. On the two PCBs there was the Layout of the DC/DC converter with a control board (uC+FPGA) that could control the transfer of the power and manage a communication protocol. In order to make the communication channel immune to interference from power electronics, a RLC band-pass filter using the integrated capacitive elements was implemented. The communication protocol applied is of the OOK type.

Results

The development of the AZCS converter has been successful. So far, it has been possible to run initial tests up to a maximum RMS current flowing through the converter of 60A with total losses equal to 1.375% of the rated power estimated during the test of 42kW. An isolated driver prototype has been built and validated by transferring 12V/8W of power at the frequency of 500kHz simultaneously trasmitting a signal with a BaudRate of 25MBit/s under a common mode transient voltage perturbation of 2.85kV/us.



Isolated Driver Prototype Board

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