# Bachelor Thesis

## Design of a High Voltage/High Frequency Measurement Tool with Optical Transmission for Use in Solid State Switches in a Particle Accelerator

TECHNISCHE UNIVERSITÄT DARMSTADT

SRT

Institute for Power Electronics and Control of Drives
Lars Dresel, M.Sc. S3|21/201 lars.dresel@lea.tu-darmstadt.de
Alexander Bode, M.Sc. S3|21/306 alexander.bode@lea.tu-darmstadt.de

### Background

Measuring high voltages is typically done using high voltage probes connected to an oscilloscope. These probes usually have very low parasitic capacitance (1–10 pF when connected to PE). However, in applications such as particle accelerators, high voltages up to 25kV with a fundamental frequency of 1–5 MHz cause significant parasitic currents that cannot be neglected. These additional impedances can interfere with the switch's operation, leading to overvoltages that may exceed the reverse voltage of semiconductors used in the solid-state switch. Even commonly available high voltage differential probes have shown malfunctions when used with high frequencies and high voltages.

For these reasons, it is necessary to design a voltage measurement probe that is completely isolated from the ground (e.g. supplied by a battery) and has very low input capacitance. While many integrated circuits offer galvanic isolation between the input and output signals, their small distances often result in excessive parasitic capacitance. Therefore, the measured voltage data should be transmitted via optical fiber to a receiver to ensure complete galvanic isolation.

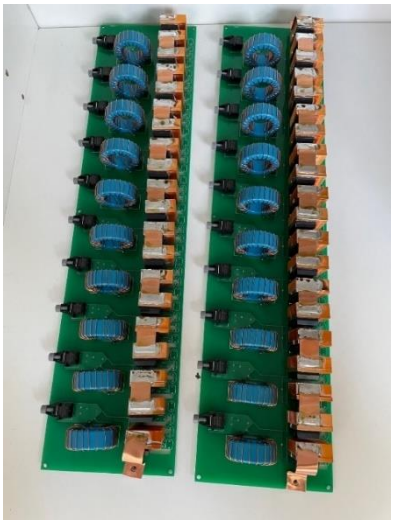

*Fig. 1 High Voltage/High Frequency Solid State Switch*

### Goal of the Master Thesis

Utilizing simulations, this thesis aims to design a voltage measurement probe suitable for high voltage and high frequency applications (4kV, 1-5MHz). The high voltage will be scaled down via a capacitive divider to a low input voltage, which is then converted to a digital signal. This signal is transmitted via optical fibre and decoded at the receiver to plot the voltage on an oscilloscope.

### Tasks

1. Research of relevant Topics.
2. Analysis and Simulation of the capacitive divider, ADC, DAC.
3. Design of a capacitive divider with a ratio that is suitable for the ADC (Sigma-Delta Converter) and the PCB (transmitter and receiver) as well as the transmission system
4. Measuring and evaluation of developed voltage probe under high voltage and high frequency conditions.

**Used Software/Skills**: Plecs, LT Spice, Matlab Simulink, Altium or EAGLE, LateX, Citavi/Zotero

**Lectures relevant to this topic:** ETIT 1, ETIT 2**,** Hochspannungstechnik 1, Messtechnik, Nachrichtentechnik

**Working Language:** German, English