ELECOMP CAPSTONE SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Fiber Optics Design High Voltage Equipment Control System Interface

Fiber Control

PEC

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Project Motivation

Electromagnetic interference (EMI) distorts signal transmission in copper wires. Current power grid substations are rarely shielded from electromagnetic interference, which makes them particularly vulnerable to serious equipment failures, possibly leaving entire cities or counties without power for weeks. Fiber optic cables are immune to EMI and thus, provide a reliable and effective solution to this problem. Fiber provides superb signal quality while not conducting any electricity. Fiber is also resistant to fluctuations in environmental conditions and can be directly placed in water without affecting the signal. Additionally, the glass core makes tampering with fiber optic cables impossible, offering a higher level of security. Fiber optics are a safer, more rugged alternative to copper cabling especially in electrical facilities where strong electromagnetic fields are present. Integrating fiber optics is the next step to modernizing the power transmission and distribution industry and is the motivation for our project.

Key Accomplishments

Serial Communication Protocol: Created a proof-of-concept using two Cmod S6 Diligent breakout boards to implement the serial communication protocol and send/receive data using a low voltage differential signal output. This test proved the protocol could work across some channel between two different Spartan 6 FPGA.

Start Bit Detector: This VHDL entity block served to determine when a "start sequence" was received across the communication channel to the receiving FPGA. As the most complex entity, the start bit detector was essential to the grand design of the serial communication protocol.

Local Control Cabinet (LCC) PCB: Designed schematics and board layout using the CircuitMaker software. The LCC board is a 7 layer board with 3 power planes and 4 signal layers. The LCC board uses 48 ON/OFF checks, 8 main contact checks, and 12 relay control signals to control the state of the high voltage equipment. The board also includes an onboard FPGA with a programming header and separate programmable memory IC. (Refer to Figure 3)

High Voltage Equipment (HVE) PCB: Designed schematics and board layout using the CircuitMaker software. The HVE board is an 8 layer board with 4 power planes and 4 signal layers. The HVE board uses 8 ON/OFF checks, 8 main contact checks, and 12 relay control signals to interface with the LCC and control the high voltage equipment. (Refer to Figure 2)

PCB Power Requirements: We were successful in generating 12VDC from 125VDC and 1.2VDC and 3.3VDC from 12VDC.

FPGA Programming: The FPGA that we chose was the Spartan 6 by Xilinx. We chose the Spartan 6 because of its low power draw, ease of programming, cost effectiveness, and number of I/O pins. A major accomplishment of this project was being able to program and send signals to different components on the board from the FPGA. This showed that the circuits that were designed in the PCB were correct and worked as they were intended to.

ON/OFF/MC Continuity Checks: Programmed the FPGA to send a high signal to one of the Continuity check pins and set a diode on the board to turn on when the return path saw a high signal.

Relay Control: We were able to successfully control the operation of the relays by connecting a load on the output of the relays. Will need to add heat sinking in the future for the 15A load.

Fiber Optic: The boards have fiber optic communication using BiDi transceivers. This allows for serial communication between the High Voltage equipment and the Local Control Cabinet.

Testing: Once the boards were received from the fabricator, they were slowly powered up and a smoke test was performed. Once it was confirmed that the board passed the smoke test and no shorts were found, we began to test the components on the boards. We were able to test each major circuit from the PCB design using a VHDL test code, a multimeter and an oscilloscope to confirm that the signals were being sent to the correct location. We were able to confirm the following: power generation, power generation diodes, status diodes, program the FPGA, MC continuity check, OFF/ON continuity check, LVDS PECL chip, and that the FPGA can switch relays. (Refer to Figure 3)

Anticipated Best Outcome

The anticipated best outcome of this project is to produce two manufactured printed circuit boards to interface via fiber optic cabling. Once connected to their respective cabinets (High Voltage and Local Control) the two boards will be able to effectively communicate back and forth using bidirectional fiber optic transmission. The Local Control Cabinet (LCC) will control the state and position of each disconnect and ground switch in the High Voltage Cabinet (HVC). The cabinet will also have the capability to operate a switch or simply provide information to the user.

Project Outcome

Results towards achieving the Anticipated Best Outcome will be presented at the Summit.

Figures

Figure 1: Local Control Cabinet and High Voltage Equipment field installation

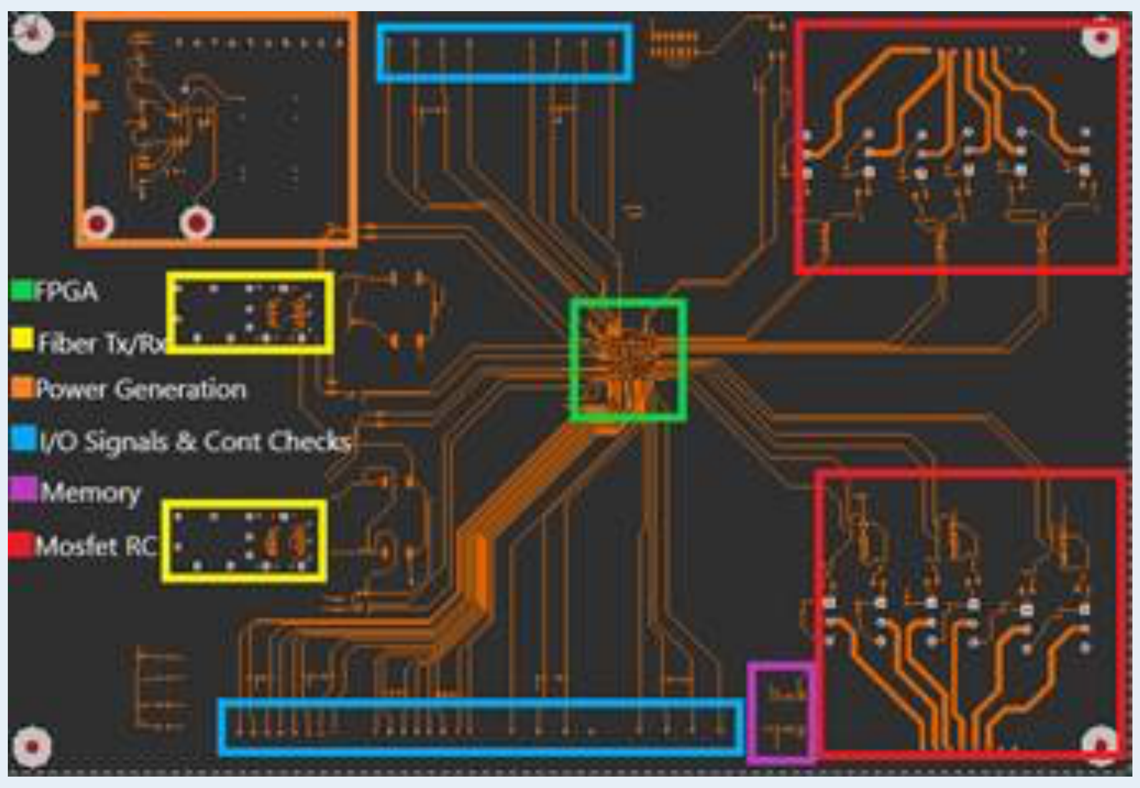

Figure 2: High Voltage Board Layout with each circuit section highlighted

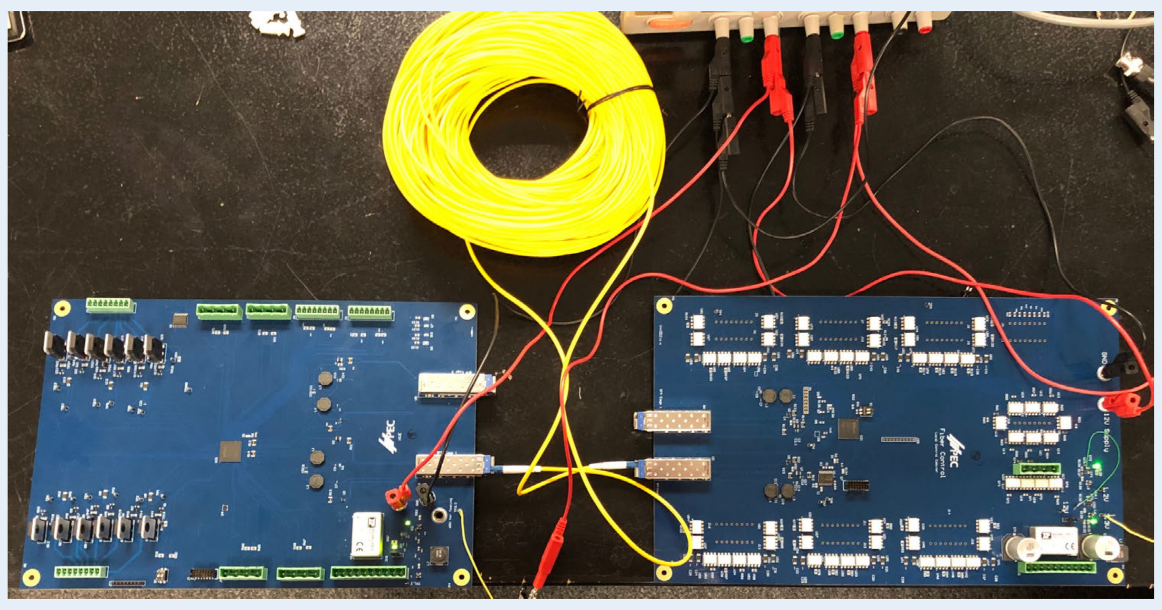

Figure 3: Final Boards High Voltage Board (left) and Local Control Cabinet Board (right) with transceivers and fiber connected

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