FiberControl

Fiber Optics Design High Voltage Equipment Control System Interface

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

Phoenix Electric Corporation
40 Hudson Road
Canton, MA 02021
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WWW.PEC-USA.BIZ

Company Overview:

PEC specializes in developing custom products, systems and solutions for the power transmission and distribution industry.

PEC custom engineers control, protection, and interlocking systems for leading medium and high voltage gas insulated switchgear manufacturers worldwide. These systems provide a reliable, user friendly control interface for SF6 gas-insulated switchgear and generator/transmission power circuit breakers in accordance with ANSI/IEEE requirements. Control systems range in size and complexity from relatively small motor control equipment to large complex substation control and protection installations.

All control philosophies and interlocking protocols conform to US utility standards and procedures for safe, reliable operation. Controls are manufactured using only readily available heavy-duty UL listed components. Provided with the control equipment, complete ANSI drawings facilitate installation, commissioning, testing, maintenance, and troubleshooting.

PEC headquarters and manufacturing facility are located in Canton, MA.

Technical Director:

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Consulting Technical Director:

Mike Smith (URI Class of 2001)
Consulting Technical Director
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Project Motivation:

The present issue is that copper wires are vulnerable to Electro Magnetic Interference (EMI), which is interference in signal transmission or reception caused by the radiation of electrical and magnetic fields. Fiber optic cable can be immune to EMI or RFI caused by equipment/material failure or unwanted attack and is extremely durable and provides a very reliable signal. Fiber does not conduct electricity because its core is made of glass. In glass, optical attenuation is much less than the attenuation of electrical signals in copper. Fiber can be immersed in water without effect and it can be used in much harsher conditions such as power plants, as it is less susceptible to fluctuation in temperature than copper cables. It does not radiate signals and is almost impossible to be tampered with without the system getting corrupted. Unlike copper cables, Fiber optics offer a much higher level of security. Fiber optic cable is also much safer to install and maintain because it is non-conductive. Copper cable attracts lightning and is heavier and harder to maneuver inside conduits and cable trays.

Conducted electromagnetic interference is caused by the physical contact of the conductors as opposed to radiated EMI, which is caused by induction (without physical contact of the conductors). This persists in all conductors and mutual inductance between two radiated electromagnetic fields will result in EMI. For lower frequencies, EMI is caused by conduction and, for higher frequencies, by radiation. EMI through the ground wire is also very common in an electrical facility.

Major accomplishments during 2017/2018:

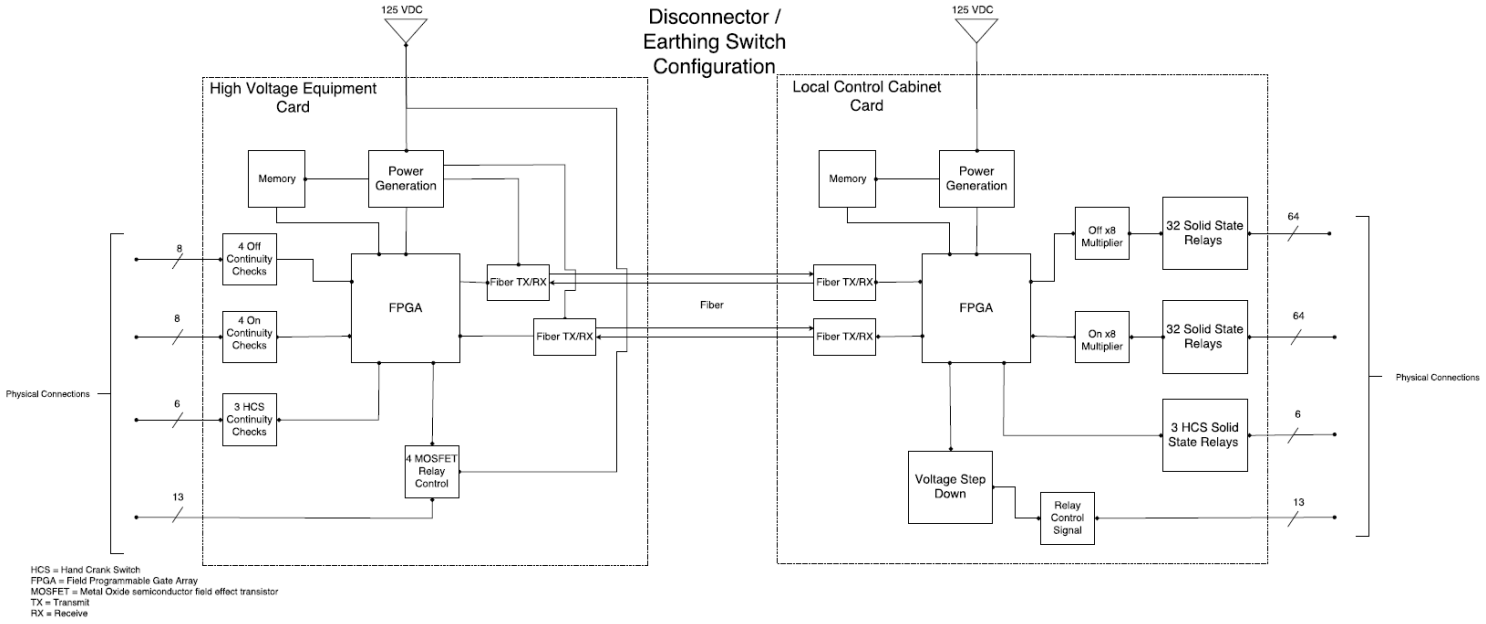
- Simulated Major Circuits
- Generated Schematics for High Voltage Equipment Board
- Generated Schematics for Local Control Cabinet Board
- Design High Voltage Equipment PCB

Further details can be accessed at this link:

https://web.uri.edu/elecomp-capstone/project-details-by-team/pec/

Major accomplishments expected for 2018/2019:

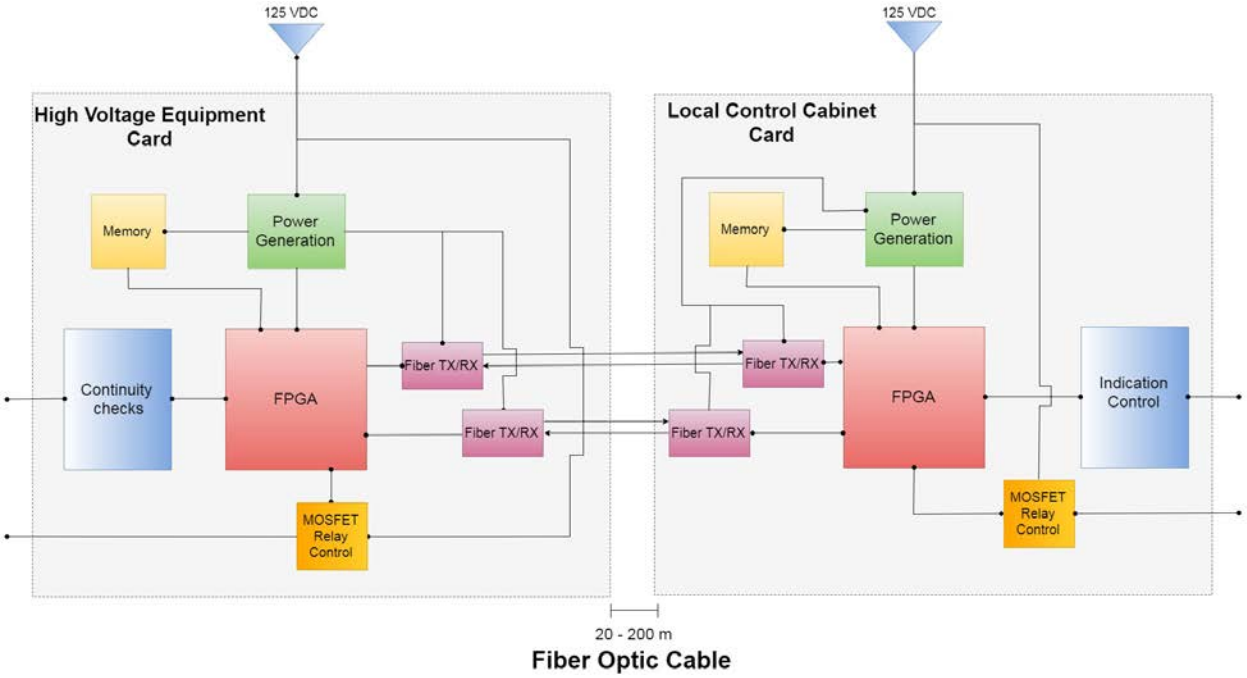
- Design Local Control Cabinet Equipment PCB
- Design VHDL Communication Protocol
- Fabricate and Test High Voltage Equipment PCB
- Fabricate and Test Local Control Cabinet PCB
- Prove that both boards communicate with each other



Fiber Optic System (number of physical connections)

Anticipated Best Outcome:

PEC expectations for April 2019 is to have the team present a functional and working Prototype of a fiber optic interface control system unit that would be functionally equivalent and reliable in comparison to current electrical control, and ultimately electromagnetically immune to outside electromagnetic influences.



Proper design and application of fiber optic control system will lead to a highly secure system. Engineers will choose proper components, design, program and install an appropriate fiber optic cable system, test components selected and the ultimate design to be immune to any interference.

This year (2019), it is expected that the team will work and develop a fiber optic interface control that would be functionally equivalent and reliable in comparison current to electrical control, and ultimately electromagnetically immune to outside influences.

Project Details:

Starting with last year's design, PEC expectations for April 2019 is to have the team present working prototypes of the two fiber optic interface control boards. The two boards have distinct hardware designs and each has FPGA development. The boards themselves will be configurable to be used in different positions. Both the hardware and FPGA designs have common features as well as unique depending on the position.

The basic function of the High Voltage Equipment Card is:

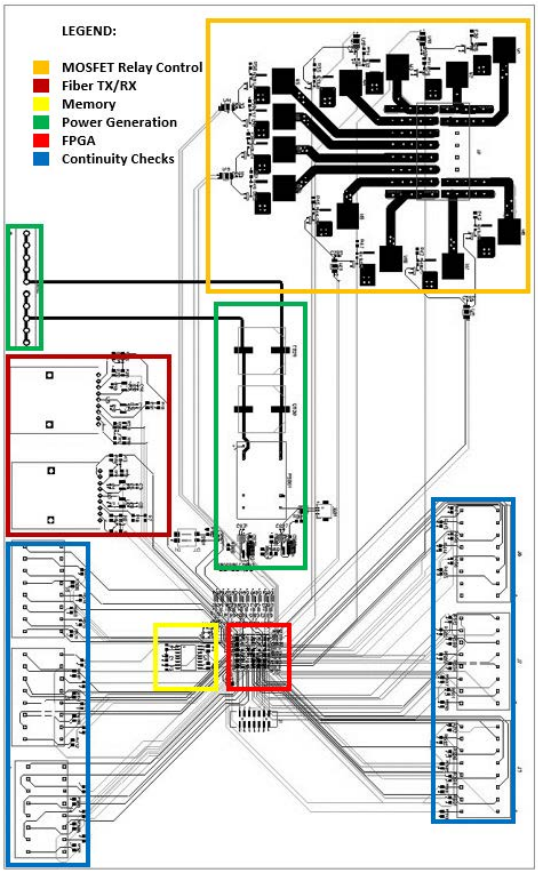
- DC/DC Conversion:
  - 125VDC Input, Generate 12V, 3.3V and 1.2V
- Fiber Optic Interface:
  - FPGA to Fiber Optic Interface Design
  - Multiple Continuity Checks
  - Multiple Load Switches
  - Switch 125VDC at 15A
  - Support Circuitry
  - Mode Switch, Memory, Connectors, etc.

The basic function of the Local Control Cabinet Equipment Card is:

- DC/DC Conversion:
  - 125VDC Input, Generate 12V, 3.3V and 1.2V
- Fiber Optic Interface:
  - FPGA to Fiber Optic Interface Design
  - Multiple Isolated Indication Control
  - Multiple Isolated 125VDC Relay Detection
  - Support Circuitry
  - Mode Switch, Memory, Connectors, etc.

The general functions of the fiber optic interface control system are:

- Transmit and Receive up to 160 wires.
- 200 meters Fiber Length
- Fiber Optic withstand 50 Kilovolts per meter
- Material List to be updated as needed.



High Voltage PCB Layout
(last year's Design)

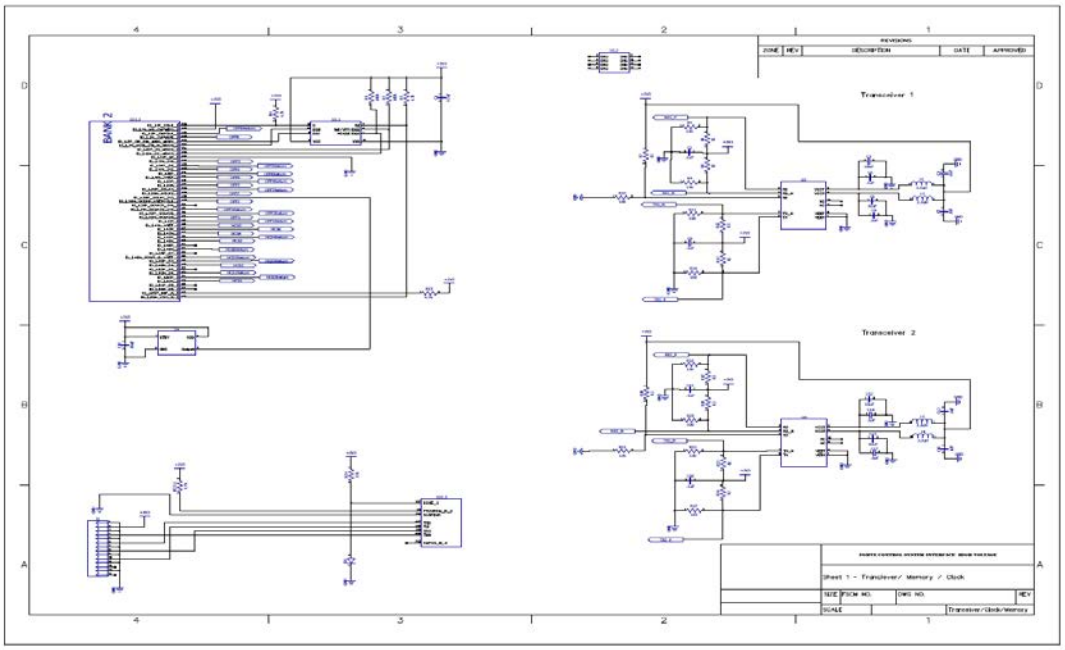
Composition of Team:

Engineering requirement for our proposal will be composed of 2-3 electrical engineers. They should be familiar with testing and debugging electrical circuitry. This will require the use of lab equipment, such as oscilloscopes, multi-meters and soldering tools, along with being able to understand data sheets. The engineers should have knowledge of communications, analog and digital electronics. These team members will be responsible for designing, testing and resolving any related electrical or coding issues.

The team will be supported by PEC Engineers and Mike Smith, Consulting Technical Director. Preference will be given to designers taking the PCB Design Course (ELE391); to be taught by Mike Smith on Thursday evenings.

Skills Required:

- Interest in fiber optics and their diverse applications.
- Strong understanding of VHDL.
- Knowledge in digital and analog Circuits design with Spice simulation experience.
- Interested in PCB layout and design; taking ELE391 simultaneously.
- Knowledge in FPGA Design.



High Voltage Schematic Diagram (last year's Design)

Anticipated Best Outcome's Impact on Company's Business and Economic Impact:

The best outcome for this project is to have two fiber optic interface control units that encodes the level of a signal either higher than the threshold or below the threshold; on or off respectively. The threshold is the industry standard of 125 VDC. The threshold voltage will then then be stepped down to a manageable voltage for the digital circuit board designed.

The expected customer economic impact is large, with the prevention of lost revenue in the order of many millions of dollars. This lost revenue is caused by massive power grid failure lasting many days or weeks as a result of power grid vulnerability due to unwanted electromagnetic interference.

Broader Implications of the Best Outcome on the Company's Industry:

With further development and expansion of our system and circuits, we can see that this would be an alternative for power control system of the future. With fiber optics replacing copper wiring for electrical substation equipment control lines, we would see an increase in grid safety and even municipal safety. We would envision improving the reliability of numerous electrical applications in the power grid workplace, and home for a more reliable and safer electrical supply system.