Fiber Optics Annunciator

ELECOMP Capstone Design Project 2020-2021

PEC is continuing their support of the Program for the 5th consecutive year.

Sponsoring Company:

Phoenix Electric Corporation

40 Hudson Road
Canton, MA 02021
781-821-0200
WWW.PEC-USA.BIZ

Company Overview:

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

PEC designs custom 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 and reliable operation. Controls are manufactured using only readily available heavy-duty UL listed components. In addition to the control equipment, we provide complete ANSI drawings to facilitate installation, commissioning, testing, maintenance and troubleshooting.

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

Technical Director:

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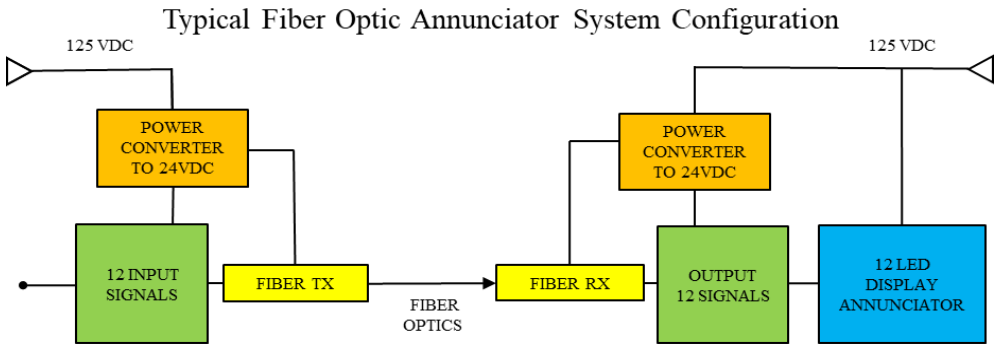
Project Motivation:

Recently there is a higher demand for systems that are immune to Electro Magnetic Interference (EMI). Our controls circuits are monitored by Annunciators that collect data and wealth of our circuits, and display it locally via LED lights, or transmit those signals miles away to the Grid control house. This system collects digital alarm signals, transmit them via fiber optic transmission lines. The fiber optic signals are then converted back to digital and displayed on Annunciator. Presently our typical fiber optic annunciator system is made up of multiple components: 125VDC to 24VDC power converter, Input Card, Converter from digital to Fiber Optic, Converter from Fiber Optic to digital, Output Card and Annunciator.



The more components we use, the higher is the potential for device failures, larger physical space and lower profitability.

Major Accomplishments during 2019-2020 Academic Year:

- Simulated Major Circuits
- Generated Schematics for Signal Converter PCB
- Generated Schematics for Annunciator PCB
- Design input pushbuttons: Test, Reset, Acknowledge
- Programmable delay filters and continuity Checks
- Design VHDL Communication Protocol

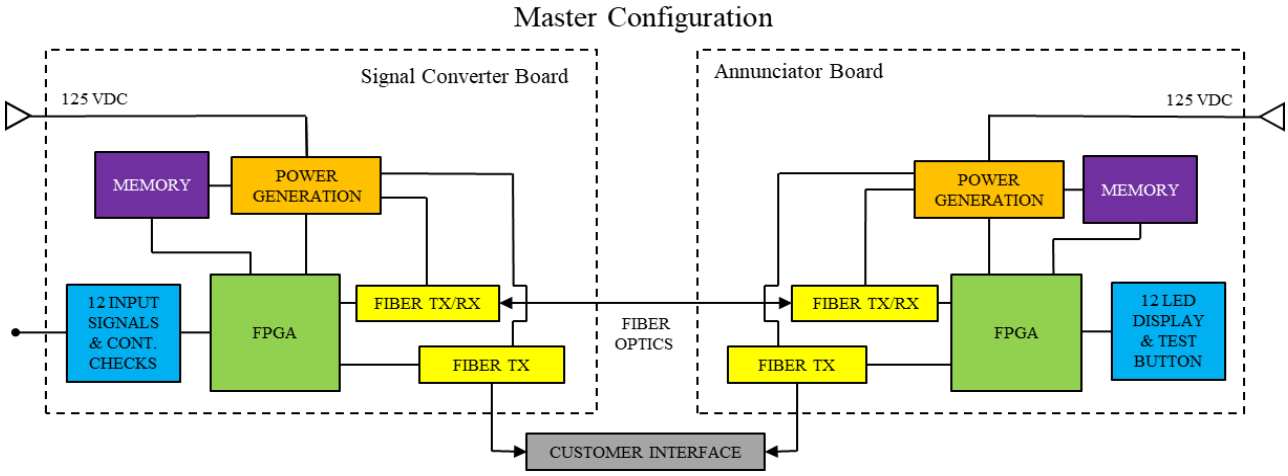
For more details, please see the YouTube video that was submitted by the team at the Virtual Summit: YouTube

Major Accomplishments Expected for 2020-2021 Academic Year:

- Serial port configuration firmware (to be completed)
- Update Power Converter Modules
- Fabricate and Test Signal Converter PCB
- Fabricate and Test Annunciator PCB
- Prove that both boards communicate with each other
- Design Metal Enclosures to protect both Boards (Designed by PEC Mechanical Team)

Anticipated Best Outcome:

Starting with last year's design, PEC's expectation for April 2021 is to have the team present a functional and working Prototype of a Fiber Optic Annunciator System that would be functionally equivalent and reliable in comparison to current electrical control circuit, and ultimately electromagnetically immune to outside electromagnetic influences.



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

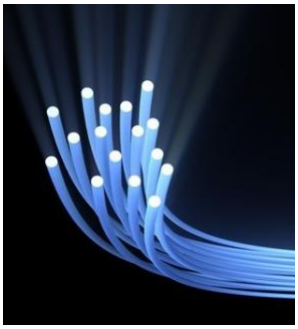
Project Details:

PEC expectations for April 2021 is to have the team present working prototypes of the two fiber optic interface 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 (as well as unique) features depending on the position.

The basic function of the Signal Converter Board is:

- DC/DC Conversion:
  - 125VDC, 48VDC, 24VDC or 120VAC Input, Generate 12V, 3.3V and 1.2V
- Fiber Optic Interface:
  - FPGA to Fiber Optic Interface Design
  - Multiple Continuity Checks
  - Multiple Load Switches
  - Support Circuitry
  - Mode Switch, Memory, Connectors, etc.



The basic function of the Annunciator Board is:

- DC/DC Conversion:
  - 125VDC, 48VDC, 24VDC or 120VAC Input, Generate 12V, 3.3V and 1.2V
- Fiber Optic Interface:
  - FPGA to Fiber Optic Interface Design
  - 12 LED Display
  - Support Circuitry
  - Mode Switch, Memory, Connectors, etc.

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

- Transmit and Receive up to 12 alarm signals.
- Various Fiber Optic cable lengths (3 feet up to 30 miles)
- Fiber Optic withstand 50 Kilovolts per meter

Composition of the Team:

Engineering requirements for our proposal will be **2-3 electrical (ELE) engineers**; preference will be given to one ELE having some CPE skills, as listed below. The ELEs should be familiar with testing and debugging electrical circuitry. This will require the use of such lab equipment 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 Capstone Team will be supported by PEC Engineers and URI circuit Board and component specialists: Mike Smith, Consulting Technical Director.

Skills Required:

- Interest in learning about fiber optics
- Strong understanding of VHDL.
- Knowledge in digital and analog Circuits design with Spice simulation experience.
- Interest or experience in PCB layout and design. (preference given to capstone designers enrollment in Mike Smith's class on PCB Design.)
- Knowledge in FPGA Design.

CPE Skills Required

- Experience with C programming
- UART-based command parsing and response
- Xilinx Microblaze or equivalent experience a plus

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

The best outcome for this project is to have working Fiber Optic Interface Annunciator system 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 is then going to be stepped down to a manageable voltage for the digital circuit board designed.

Customer Major Economic Impact is the prevention of lost revenue, estimated in many millions of dollars. The lost revenue would be 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 developments and expansion of our system and circuits, we anticipate 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.