ELECOMP CAPSTONE
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Fiber Optic Annunciator

A power control system annunciator immune to electromagnetic interference.

Team Members: Maxwell Tyree (ELE), Seth Botelho (ELE), Ethan Ribb (ELE)

Technical Directors: Sandro Silva, Mike Smith

Project Motivation

The power distribution market has a high demand for systems that are immune to Electro-Magnetic Interference(EMI). Currently, Phoenix Electrical Corporation is using traditional Copper Wire systems for their annunciator systems. These copper wire systems are susceptible to EMI which can lead to false positives and unnecessary downtime, both of which waste a companies money and time.Our Goal is to design an annunciator system that is immune to EMI, while still maintaining functional equivalence to PECs current copper wire annunciator systems. The plan is for this system to be easily configurable, reliable, low cost, and adaptable for application in many different industry standards. In order to achieve this we will be using fiber optic cables for communication between our annunciator and input boards since fiber optic cables are immune to EMI.

Key Accomplishments

Development Board Selection: Since the focus of this project is to create a functional prototype of an annunciator system, all work is done on development boards. We selected a Trenz Artix-7 FPGA module and associated carrier board, which features plenty of I/O and an SFP cage for a fiber optic transceiver.

Communication Over Fiber: The first major task was to prove that communication between two FPGAs was possible using SFP transceivers. For this we selected the Aurora 8B10B IP from Xilinx, and started with the reference design. After learning how the IP worked, we were able to use it to send custom data over the gigabit link.

Continuity Check Module: Created a module for the key feature of an annunciator, the continuity checks. This module will test the state of 12 switches, and return a logic value representing their validity. Each channel may be configured to be "normally open" or "normally closed", depending on their desired application.

Programmable Delays: A common feature on annunciators is a programmable delay on each continuity check channel, which serves to filter out false alarms. This delay can be configured to be up to one minute, with a millisecond resolution, depending on the desired application.

LED Display with Input Buttons: A display module serves to take in input from three pushbuttons, while displaying the status of the continuity check channel on a set of 24 LEDs, 12 green and 12 red. Each pushbutton mimics common inputs found on traditional annunciators, such as "Test", "Reset", and "Acknowledge".

Breakout Boards for Switches and LEDs: To assist with testing of the system in hardware, two different PCBs were designed as breakout boards for switches and LEDs needed by each board. The signal collecting "input board", features 12 SPST switches for emulating breakers monitored by the continuity checks. The annunciator board features the 24 LEDs and 3 push buttons required for the display module.

MicroBlaze Core for Serial Port Configuration: We have modified the Vivado MicroBlaze reference design in order to create a basis for serial port configuration. Currently the design has been modified to be able to take in data from the serial port then reprint the data back to the serial port. Additionally we have created a custom constraints file for our FPGA boards and the Microblaze reference design.

Custom IP Packaged as an AXI Peripheral: The annunciator board codes have been packaged as custom IP for use in Vivado with a MicroBlaze core. This was an important step toward finalizing some of the features of our digital system design, and makes it possible to use custom VHDL codes with Vivado's block diagrams.

Test of all Features in Hardware: Tests of every completed feature have been conducted in hardware using our Trenz development boards. The full test setup includes a duplex fiber optic link between each FPGA board, with the continuity check data being streamed from the input board to the annunciator board, and displayed on our custom display PCB.

Schematics of Hardware for Completed Features: Schematic capture was done as various components and modules were proven to integrate well within the overall design. This was a slow process and was worked on bit by bit all year long.

DC/DC Converter Selection: Since a product like this would need to be a versatile tool that can work with various input voltages, which may be country or grid specific, three converters were chosen. One AC/DC two DC/DC converters were selected and cover a wide range of voltages with the ability to step down to 3.3V in order to power the FPGAs.

Anticipated Best Outcome

The Anticipated Best Outcome for this project is to have a fully functional prototype that is equivalent to traditional annunciator systems using 2 FPGA development boards and Fiber Optics. Our system will be capable of monitoring 12 signals being fed into our Input board, and then communicating their continuity status via fiber optic cables to our annunciator board which will display their valid/invalid status to our LEDS.The system will be able to be configured to normally open and normally closed.

Project Outcome

The Anticipated Best Outcome was achieved, and the project is ready to be continued by next year's team.

Figures

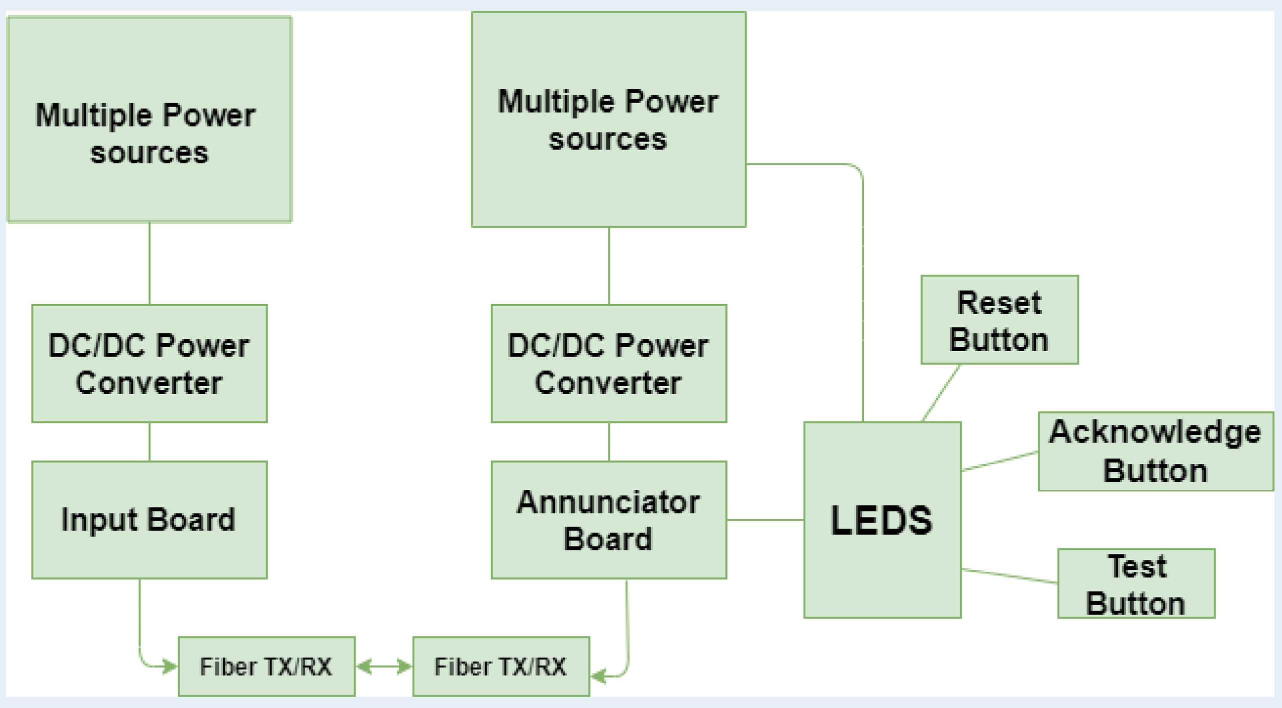

Fig 1: Functional Block Diagram of our entire annunciator prototype.

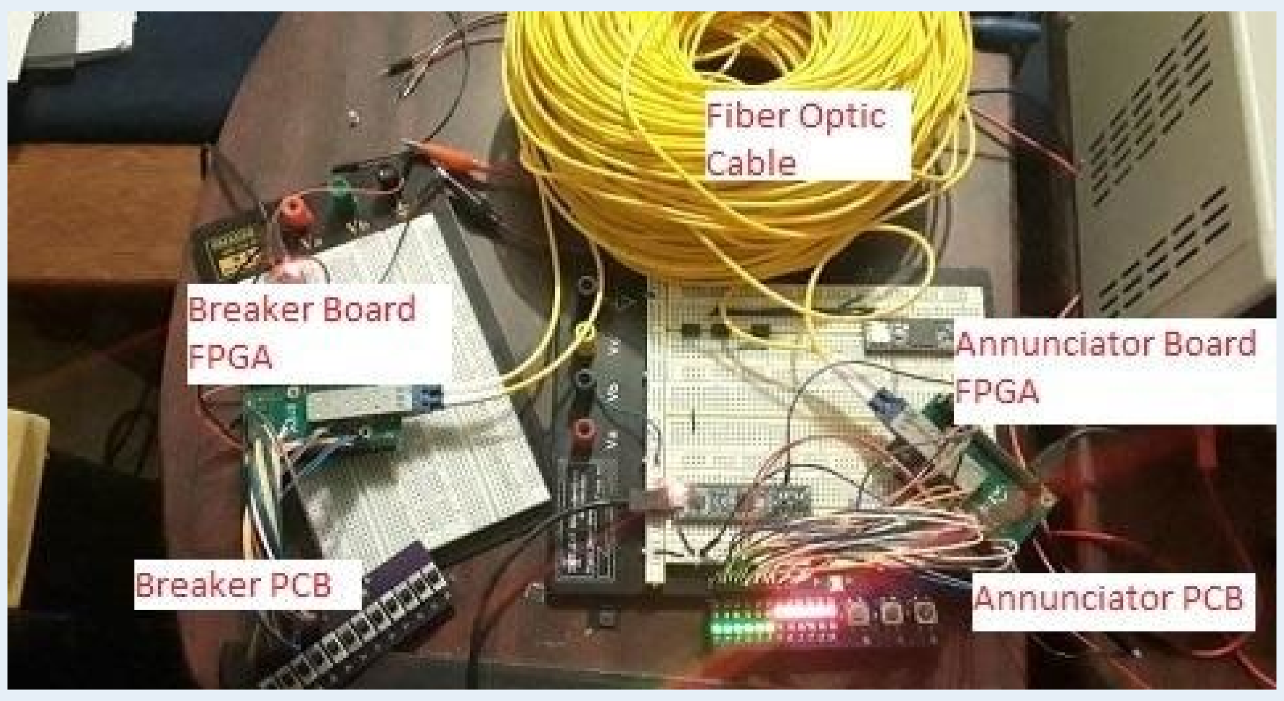

Fig 2: Picture of our Current Functional Prototype.

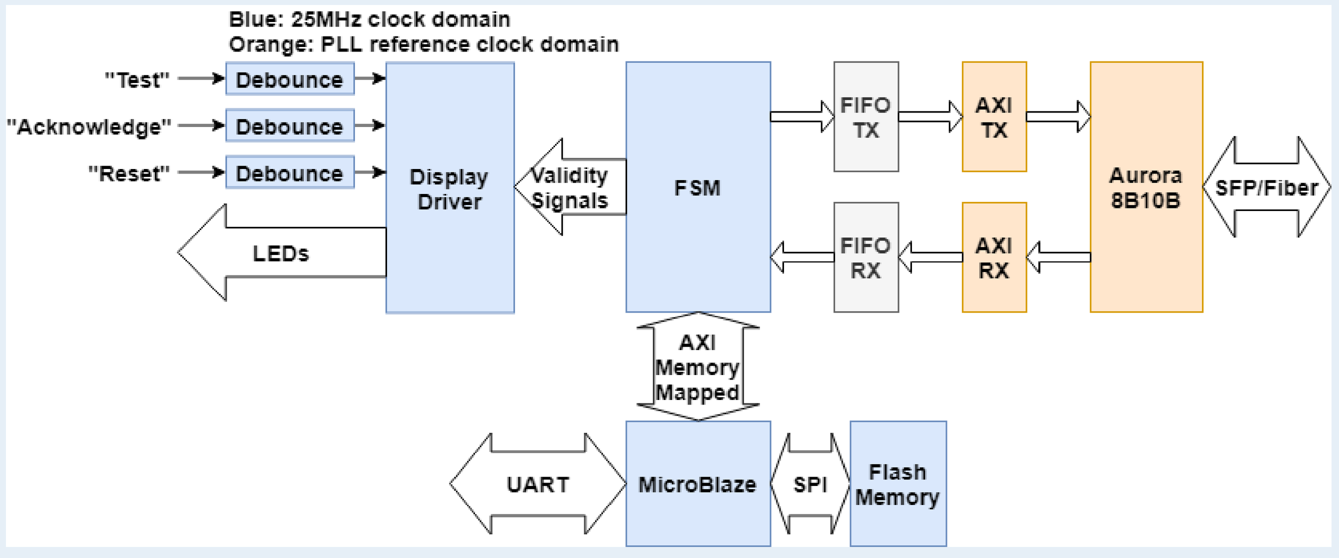

Fig 3: Functional block diagram of our annunciator board, including the planned UART configuration feature.

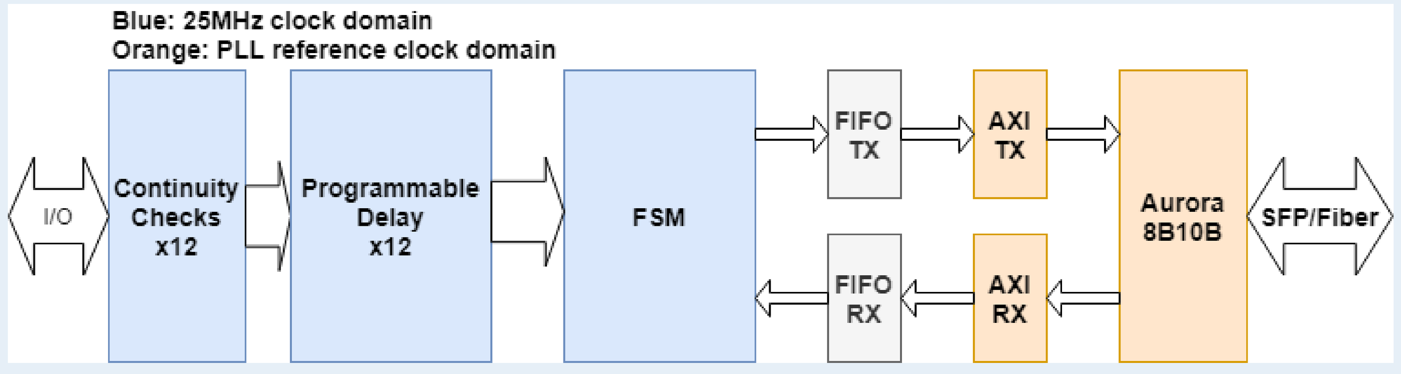

Fig 4: Functional block diagram of our input board.

ELECOMP Capstone Program Director: Professor Harish R D Sunak

email: sunak@ele.uri.edu telephone: 401-874-5859 ELECOMP Website: https://uri.edu/elecomp-capstone