The RF Power Supply Control (RPSC)

- The UW Medical Cyclotron Facility (MCF) features a 50MeV multi-particle accelerator for neutron therapy and cancer research.
- Built in the 1980s, the RPSC handles command, status, and interlock signals for the cyclotron's power supplies.
- Composed of 15 analog, logic, and flip-flop cards.
- Upgrading this system with an FPGA will allow for faster and more reliable control leading to less downtime for repairs.
- Providing documentation for HDL will also enable the MCF team to develop future FPGA designs.

System Overview

Seven PCBs handle the hardware side of the system.
- Motherboard Card: Houses the FPGA and deals with voltage shifting/protection.
- Lamp and Relay Cards: Handles the lamp and relay signals controlled by the FPGA.
- Two Analog Cards: Processes the analog signals of the system.
- Two Isolation Cards: Isolates the power supplies of certain analog signals.

Hardware Design

FPGA Selection:
- Xilinx Spartan-7 XC7S50 System on Module (SOM)
- Provides 114 I/O pins for required parallel connections.
- Industrial SOMs are reliable and can be easily replaced without any solder work.

PCB Design:
- PCB layouts are organized by circuit types with test points to increase maintainability.
- All cards use through-hole components that are stocked by the facility.
- All cards are connected using the facility's Schroff standard for rack-mounted systems.
- Analog Cards: Power supplies' voltage and current levels pass through a 3-stage op-amp ADC for the FPGA.
- Isolation Cards: Uses isolation amplifiers for voltage reference separation.

Future Work and Acknowledgments

- Further system functional testing.
- Integrating EPICS control system protocol over ethernet.
- Manufacture new RPSC enclosure.
- Install and test within the overall RF system.
- Develop second identical RPSC for the parallel RF tower.

Digital Design

- Existing control logic adapted using HDL.
- Follows cyclotron power supply startup sequence.
- Monitors and flags subsystems for faults.
- Indicates correct function by lighting the assigned lamp on the front panel.
- Replaces analog delay circuits with digital equivalents.
- FPGA connects to a ESP32 ethernet module through UART.
- Potential real time system monitoring with the facility's EPICS ethernet control system.

System Validation

- All Verilog modules are simulated with specific fault cases.
- The logic is further validated against existing card behavior.
- Utilize a separate testing FPGA to rapidly verify the overall design.
- Full system input voltage levels (15V and 24V) will be used to test the hardware while using transients to test protection circuitry.

Seven PCBs handle the hardware side of the system. Each PCB contains specific components: Motherboard Card, Lamp and Relay Cards, Analog Cards, Isolation Cards. The Motherboard Card houses the FPGA and deals with voltage shifting/protection. The Lamp and Relay Cards control the lamp and relay signals. The Analog Cards process analog signals, while the Isolation Cards isolate power supplies of certain analog signals.