HIGH FREQUENCY RF PHASE METER

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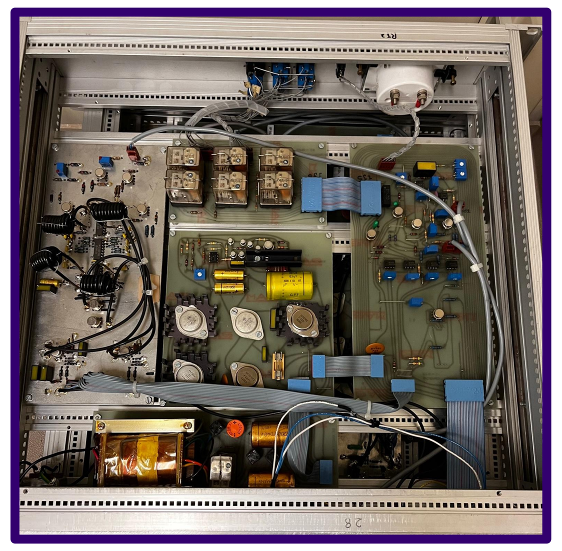
17

CYCLOTRON OVERVIEW

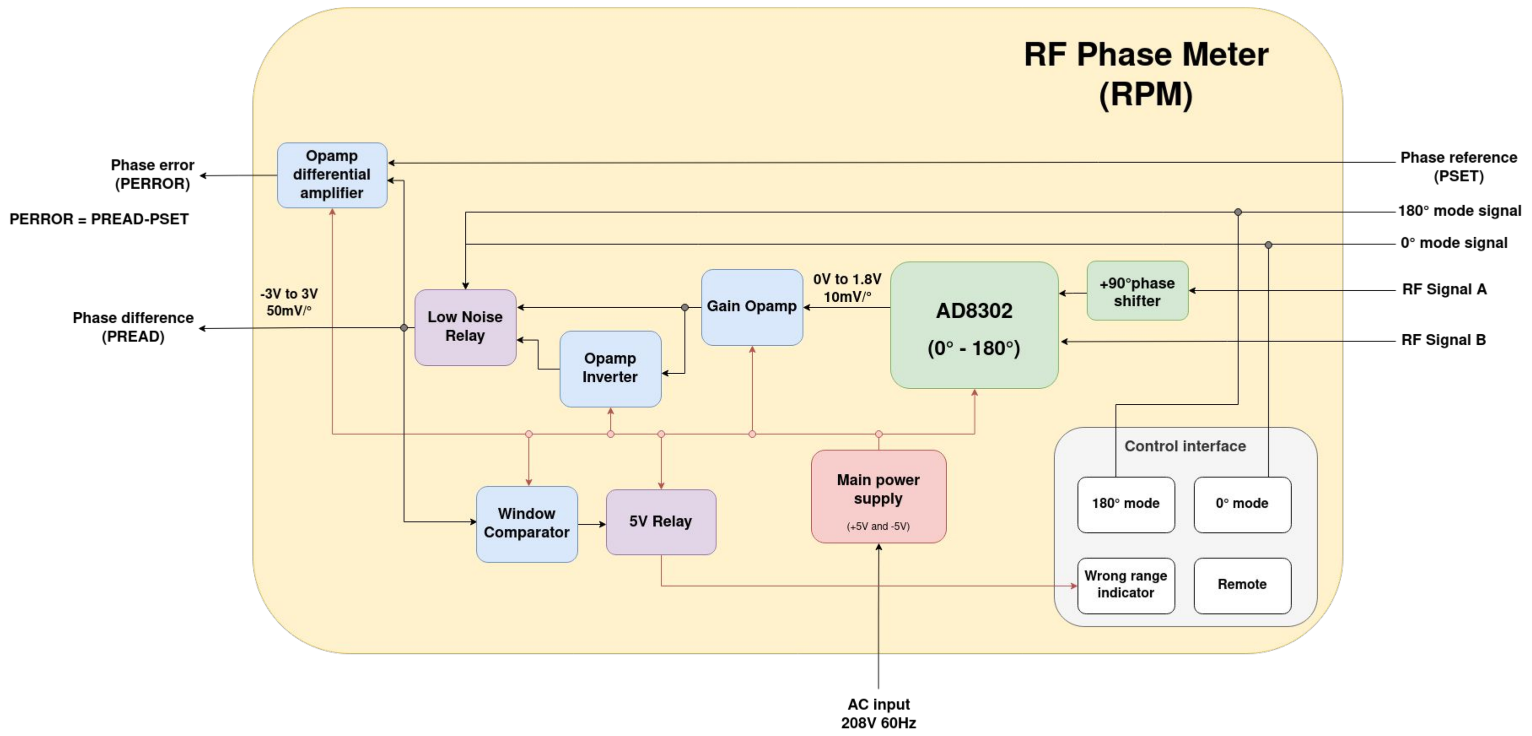
- UWMCF houses the only fast neutron cyclotron particle accelerator being used for cancer treatment and research.
- A combination of a magnetic field and an oscillating electric field accelerate the particle in a circle.
- The two oscillating electric fields must be either completely in phase with each other or completely out of phase for the the particles to accelerate.
- The RF phase meter is a critical component of the control system that measures the phase difference and reports the error.

PROBLEM STATEMENT

- RF Phase Meter a critical component in proton beam extraction and efficiency.
- Current RF phase meter was built in the 1980s. It has outdated components with decreasing reliability and accuracy.
- Goal: upgrade the RF Phase Meter with smaller and improved components and provide thorough documentation for the UWMCF staff.



REQUIREMENTS



- Output a DC voltage with slope 50mV/° centered at 0V.
- Operate at frequencies around 29.5MHz.
- Ability to switch between 0 degree and 180 degree operation modes.
- Accuracy within ±5 mV (± 0.1°) with long term stability.
- System must be self contained within a standard 19" rack.
- Ability to interface with the front pushbuttons and monitoring outputs.
- Provide thorough and accurate documentation for the UWMCF staff.

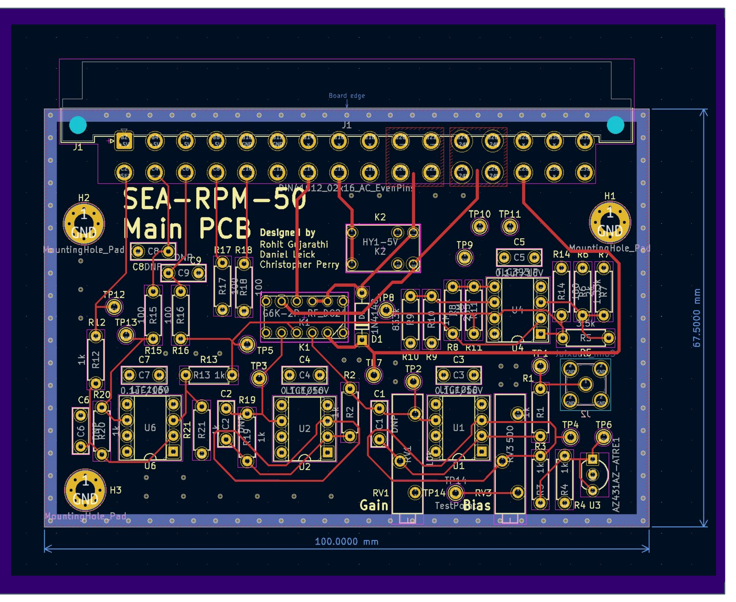
DESIGN PROCESS

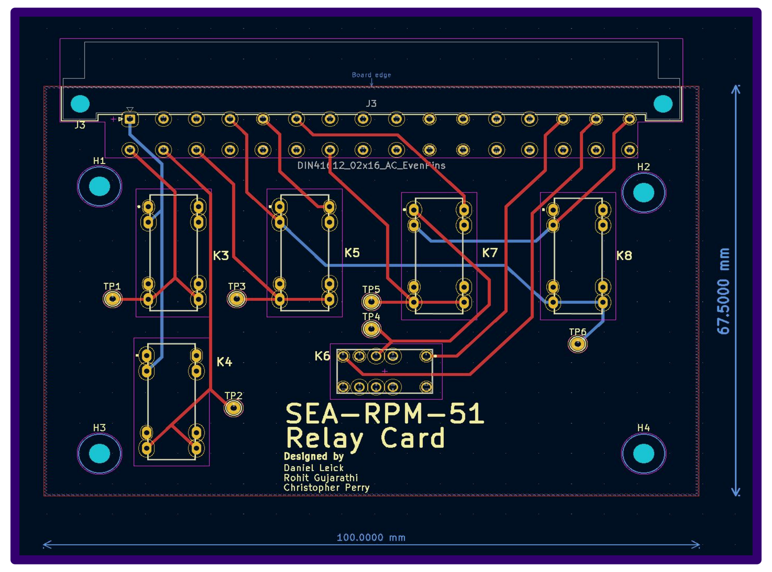
1. Designed and simulated circuits in LTSpice, then prototypes were built and tested on benchtop with function generators.
2. RPM-50 prototype was tested with cyclotron system to ensure accurate phase detection.
3. Two speciality PCBs, RPM-50 and RPM-52 were designed to consolidate circuitry and allow for future upgrades.
4. A 19" rack was built to house power supplies, wiring and allow for interfacing. The two speciality PCBs were integrated into the rack.
5. The RF Phase Meter was tested with the whole cyclotron system. It provided high proton beam extraction power and efficiency.

PCB AND RACK DESIGN

RPM-50

- RPM-50 is composed of four layers and provides signal conditioning to the output of the AD8302 IC. It provides the main system outputs (Phase Set and Phase Error).
- Features: inverting op amp and low noise relay to allow for mode switching, differential amplifier circuit for signal comparison, two trimmers for gain tuning.
- Stitching was incorporated to shield critical signals from EMI.



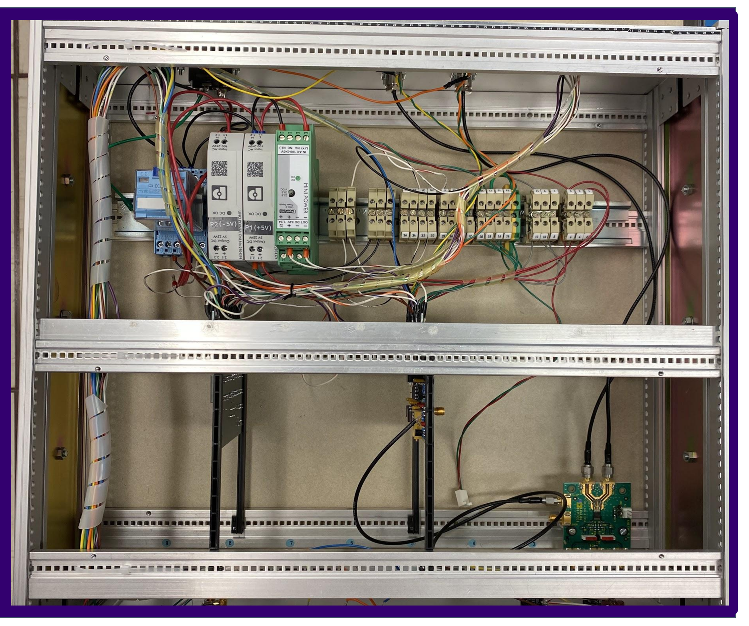


RPM-52

- The RPM-52 is composed of two layers and provides control flow for status interlocking to the cyclotron system.
- Features: multiple relays for signal control, internal/ external power separation through use of double-pole double-throw relays, manual control of operation modes through switching.

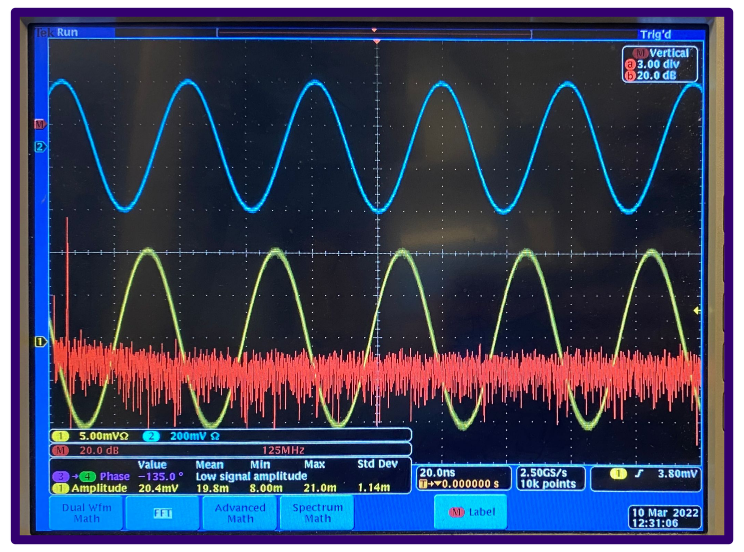
RACK DESIGN

- The RF Phase Meter is completely housed in a 19" rack.
- Features: AC Relay, three DC power supplies, terminal blocks, front and back panel connectors, interfacing for manual control, front panel door for box access.



CONCLUSION AND FUTURE WORK

- A system to detect the phase difference between two RF signals was built, tested and validated.
- The error between the set phase difference and the actual phase difference is measured and output to the RF main controller.
- Maintainability and modularity of the system was given importance so the staff can replace any damaged components with ease.
- Various other subsystems of the cyclotron are also developed in 80s and need to be upgraded.
- Future work consists of upgrading these systems with a more compact and robust design, similar to the work that was done in this project..



ACKNOWLEDGEMENTS AND REFERENCES

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[1] David Cuadrado Calle, José Antonio López Pérez, D. C. Calle, and J. A. López Pérez, "Gain And Phase Detector Based On The Analog Devices AD8302 Chip," INFORME TÉCNICO, Mar. 2012.
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