OAK RIDGE National Laboratory

THE SNS PLC BASED CONTROL SOLUTION FOR STEPPER MOTORS

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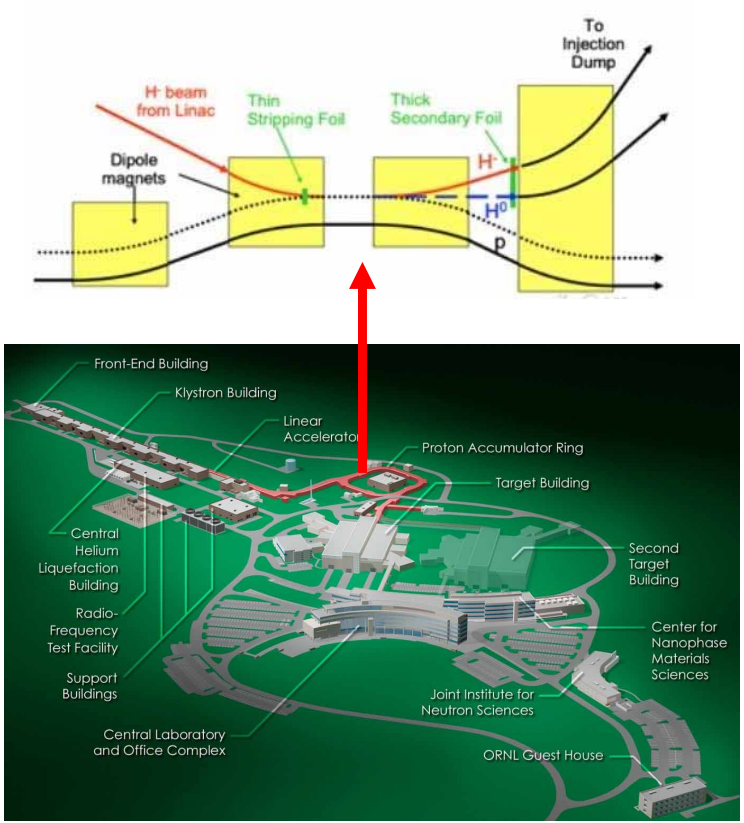
U.S. DEPARTMENT OF ENERGY

Overview of SNS stripping foil systems in the ring

Thin stripping foil in the injection section of the proton accumulator ring



Thick secondary foil in the injection section of the proton accumulator ring

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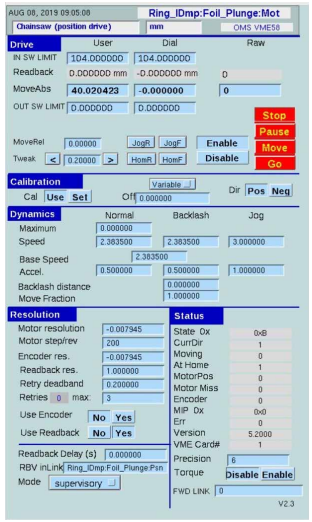
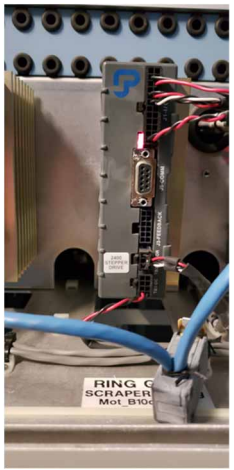
Original foil changer stepper motor controls design

- RING primary and secondary stripper foils was a VME based control system with most components that were obsolete.
- VME IOC
- OMS VME58 stepper control
- VMIVME 2510B (64-Bit TTL input/output board)
- Pacific Scientific Motor Drivers
- Acopian Power Supplies
- EPICS screens allowed operator to change critical motor control parameters that were not well understood



Old foil detail control screen



Pacific Scientific Motor Driver

OMS VME58 stepper control

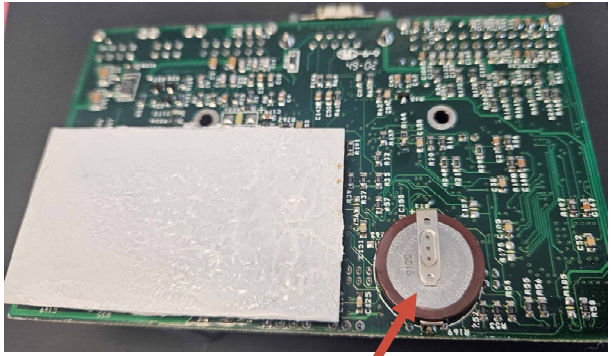

Acopian Power Supplies

Pacific Scientific driver board issues and battery failures

- Over 15 years of operation time the Pacific Scientific driver boards were starting to fail, and spares were running low.
- The Pacific motor driver configuration parameters were stored in the hardware and retained by the onboard battery. These batteries were having end of life failures; when power was lost, the parameters had to be reloaded manually.

Inside look at the Pacific Scientific Motor Driver

Same board underneath view



The battery is soldered onto the circuit board that had to be disassembled for replacement.

Addressing obsolete components and increase sustainability of the control system

The primary building blocks of new control system

- Allen-Bradley Control Logix PLCs

- Application Specific Components
  - "AMCI" Ethernet IP Modules
    - SD4840E2 Stepper Motor Controller

      - AMCI's SD4840E2 Networked Series Stepper Indexer / Driver for Ethernet/IP networks reduces stepper control system costs by eliminating the need for a separate stepper controller in your PLC chassis. The indexer is built into the driver.
    - ANA2 Resolver Input Module

- Sola 24VDC power supplies (SDN20-24-100C)
- SoftIOCs
  - EPICS support for devices already exists (A-B PLC TCP/IP, BACnet, Modbus, VFD TCP/IP, etc.

IFMs for position switches

Stepper Motor Driver / Controllers

New PLC

Power supplies & network switch

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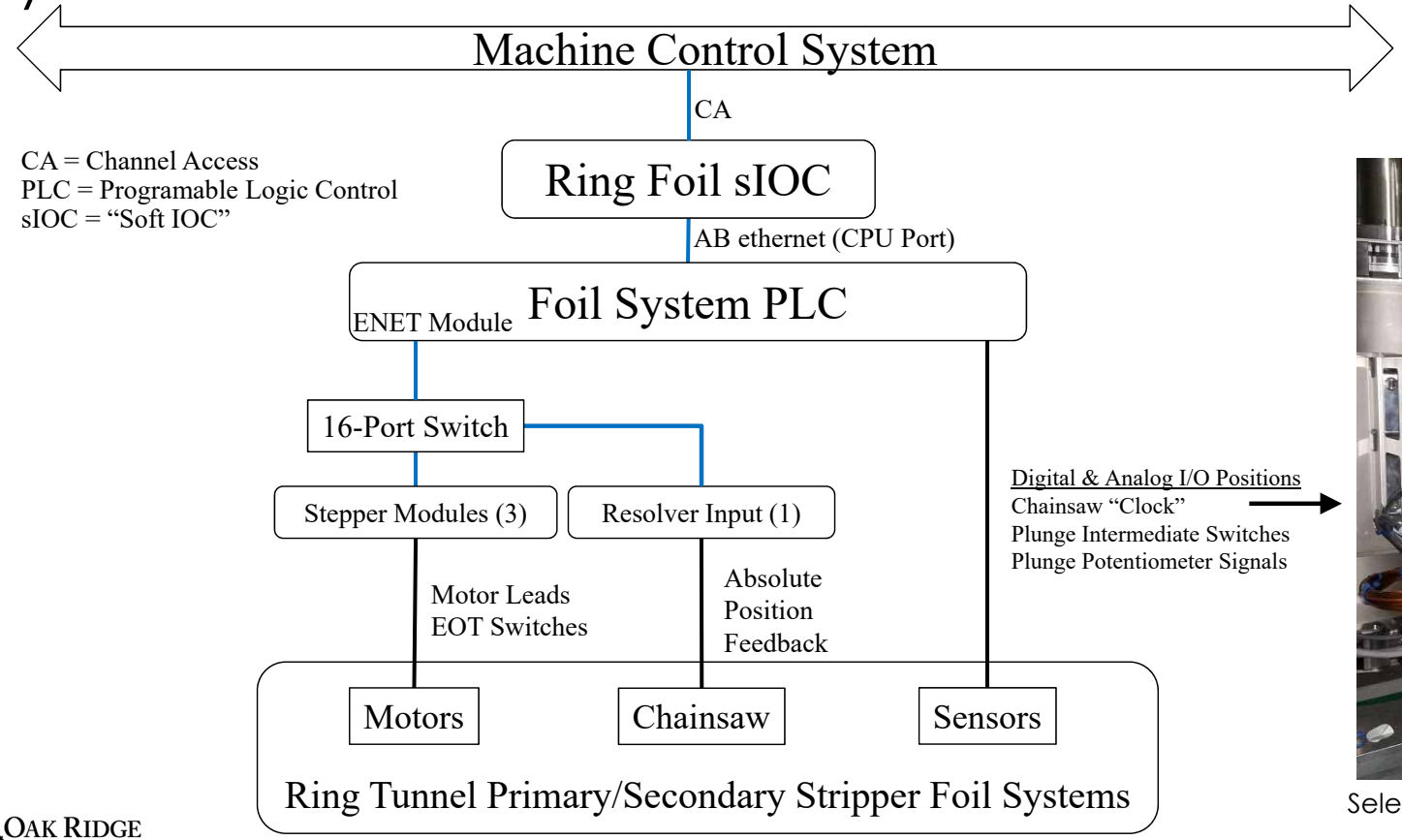
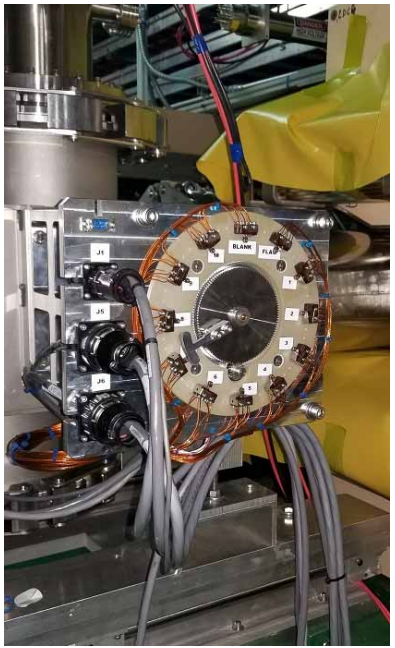
Architecture of the stepper motor PLC based control system





Selection motor limit switches

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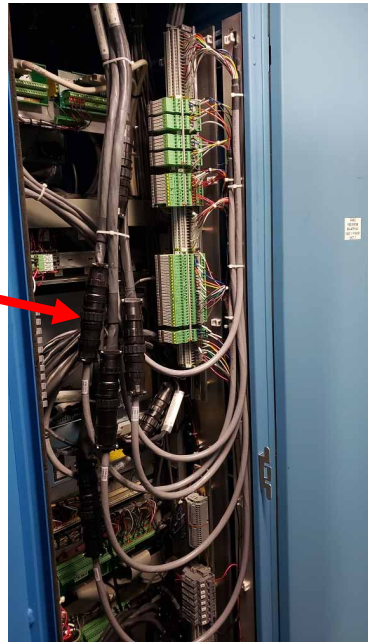
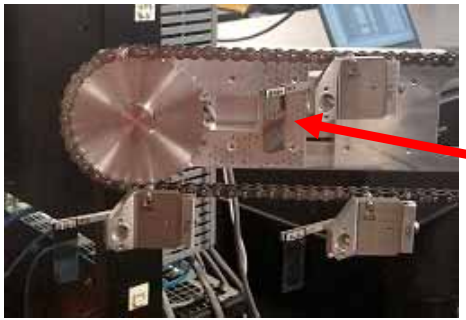
Installation over two 6-week outages with offline testing of the design

- The first outage was utilized to place connectors on the field cables to allow the system to be connected to the old VME based system and to the new PLC based system.
- The second outage the PLC and motor control system was install and commissioned.
- **Old control system was left in place for quick rollback if required.**



The test stand was fitted with a wiring harness and connectorized to mate with the spare foil changer. The test stand uses a PanelView HMI for local control that matched the functionality of the EPICS control screens.

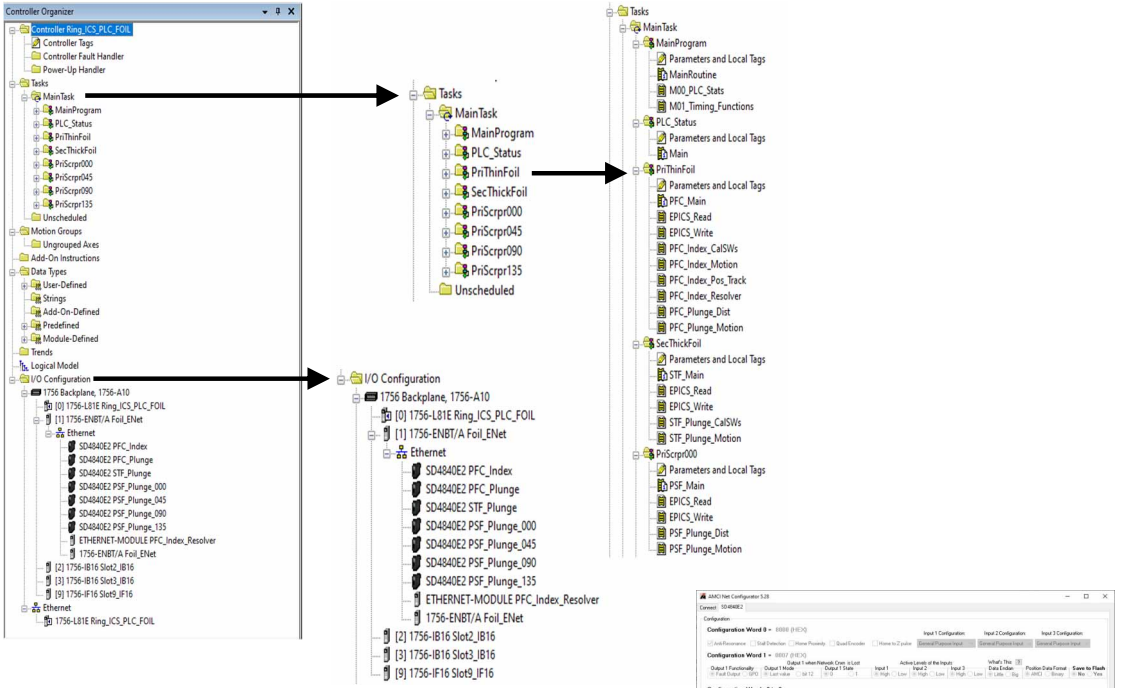


Thin foil on hangers on primary foil changer

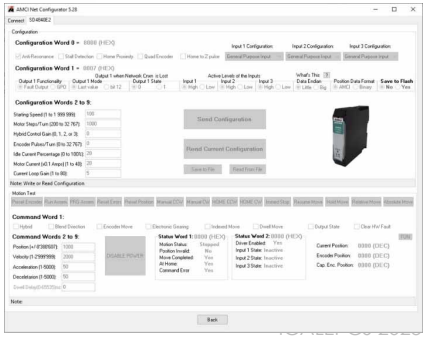
The stepper motor controllers were optimized through testing and measurements by the Alignment Group; the results of each axis were for the primary thin foil; index 0.1501 mm/step and plunge 0.0194 mm/step.

PLC hardware and software configuration in RSLogix 5000

- The programming of the motor controller over the network is easy because it uses the PLC's native software (e.g. Studio 5000). No extra software is required, and you don't need to learn another programming language.
- AMCI's SD4840E2 Networked Series integrates with Ethernet/IP, Modbus-TCP, or Profinet compatible with Allen-Bradley PLC. AMCI provides the EDS file for configuring in the I/O tree, add-on instructions, and sample PLC code.



AMCI provides Ethernet configuration software for the stepper controller. The PLC retains configuration data for each stepper controller. When a controller fails, all that is required is setting the IP address in the replacement controller. Once the new stepper controller is put in place the PLC recognizes and transfers the motor configuration to the controller for quicker recovery time.



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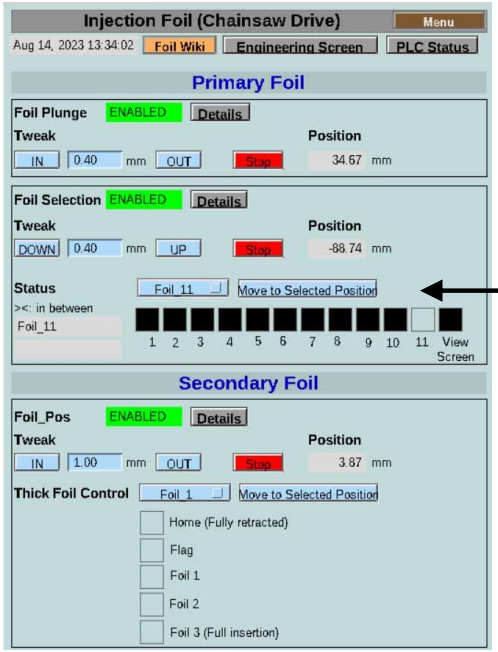
New EPICS control screens for foil changers

Foil overview screen

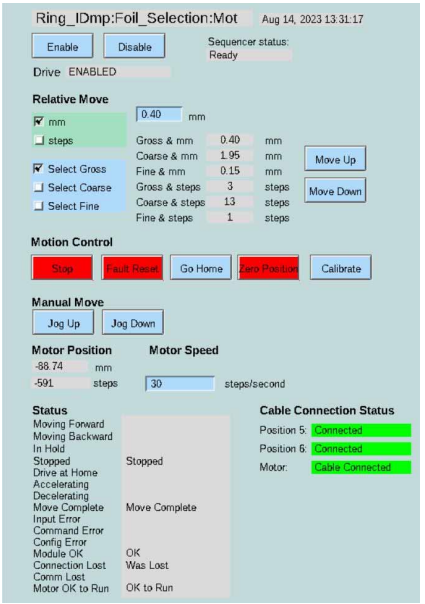


Operator can select relative move size

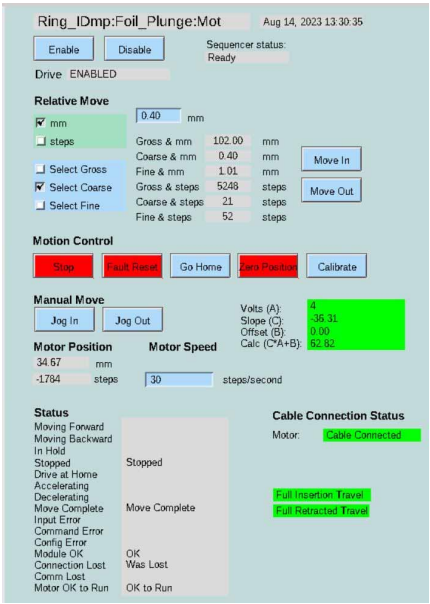
Foil selector control

Motion controller status

Foil selector detail screen



Plunge detail screen



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Conclusion

- The PLC based motor control system upgrade using commercial off-the-shelf (COTS) hardware eliminated obsolescent issues with the VME based system and old motor drivers.
- Streamlining the operator's interface to remove drive configuration parameters, that were not well understood, reduced the possibility of foil damage. Operator's feedback has been very positive!
- The upgrade was a success with improved performance of motion on the foil changer. No control issues that required rollback to the old system have occurred.
- Having the confidence of 1 ½ years of operation without any issues, ensures a path forward to deploying this design to other stepper motor control systems throughout the facility.
- The PPS gamma blocker system was upgraded with same design and plans to upgrade the high energy beam transport (HEBT) scrappers will take place in the 2023-24 long outage.

Primary foil changer in tunnel

Secondary foil changer in tunnel