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EPICS IOC INTEGRATION WITH Rexroth CONTROLLER FOR A T-Zero CHOPPER*

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Abstract

A neutron chopper is not typically used as a filter, but rather as a way to modulate a beam of neutrons to select a certain energy range or to enable time-of-flight measurements. T-Zero neutron choppers have been incorporated into several beamlines at SNS and are operated via a Rexroth controller. However, the current OPC server is only compatible with Windows XP, which has led to the continued use of an XP machine to run both the Indradrive (Rexroth interface) and EPICS IOC. This setup has caused issues with integrating with our Data Acquisition server and requires separate maintenance. As a result, for a new beamline project, we opted to switch to the Rexroth XM22 controller with T-Zero chopper, which allows for the use of drivers provided by Rexroth in various programming languages. This paper will detail the XM22 controller drivers and explain how to utilize them to read PLC parameters from the controller into the EPICS application and its Phoebus/CSS interface.

INTRODUCTION

The Oak Ridge National Laboratory's (ORNL) Spallation Neutron Source (SNS) is a cutting-edge pulsed neutron facility, supported by the U.S. Department of Energy's Office of Basic Energy Sciences. Its primary mission is to investigate the properties and behaviors of materials using neutron scattering techniques [1]. At ORNL, diagnostic instruments adhere to the Network Attached Device (NAD) concept. Each sensor possesses its dedicated resources, including networking, timing, data acquisition, and processing. NADs operate independently, mitigating the fragility commonly associated with tightly integrated systems. The fundamental concept behind a Network Attached Device is to design each instrument as a self-contained networked device with its set of resources [2]. The software suite is built upon EPICS, which facilitates communication through a shared memory interface and serves as the standard control system for the entire SNS facility. One such resource is a T-zero choppers that rotate a large mass through the beam to effectively place a beam stop in the path of the beam and eliminate high-energy neutrons that occur early in the neutron pulse. These choppers must be operated in phase with the production of neutrons so that the energy distribution in each neutron pulse in the instrument remains constant. The chopper controller is designed to couple the phase of the chopper's rotor to the phase command produced by the timing reference generator [3]. ORNL is planning to build a TOF neutron imaging facility at the SNS, called VENUS, located on a decoupled poisoned parahydrogen moderator, which offers the sharp neutron time pulse widths needed for high wavelength discrimination. VENUS is optimized for the measurement of micro-scale structures in radiography (2D) and tomography (3D) modes. The optical components are comprised of a series of selected apertures, T0 and bandwidth choppers, beam scrapers [4]. Few other beamlines at SNS has T0 chopper for which the EPICS IOC was developed a decade ago. But in preparation for the VENUS neutron imaging facility, which demands sharp neutron time pulse widths, a transition to a more integrated control system was required. The legacy architecture utilized Windows XP and an OPC server, leading to compatibility issues and separate maintenance efforts. To address these challenges, the Rexroth XM22 controller with its drivers was adopted, providing a versatile solution for EPICS integration. In the following sections the current methodology will be discussed, followed by the newly implemented IOC for the new controller.

The EPICS control system environment has been a cornerstone of the SNS facility since its implementation in 2006, supporting accelerator operations, and later, beam- lines, and data acquisition systems.

T0 EPICS ARCHITECTURE

Legacy T0 Architecture

This EPICS architecture at SNS consisted of two primary Input/Output Controllers (IOCs): a Serial IOC responsible for managing PVs related to serial communications and other software PVs, and an OPC IOC designed to communicate with the Rexroth OPC server, facilitating communication with the Programmable Logic Controller (PLC) using the Open Platform Communications (OPC) standard. OPC is a widely used software interface standard that enables Windows programs to communicate with industrial hardware devices.

In the legacy system, the primary role of the OPC IOC was to establish communication with the PLC, making it a critical component of the control system.

The Serial IOC scanned various devices, including the Televac vacuum gauge controller, pressure readings for helium, and multiple interlocks such as water temperature, water flow, shaft temperature, bearing temperatures, and tachometers for overspeed interlocks and motor speed/vibration monitoring.

Despite being EPICS IOCs, these components resided on a Windows machine, operating outside the Linux EP- ICS ecosystem, leading to maintenance challenges.

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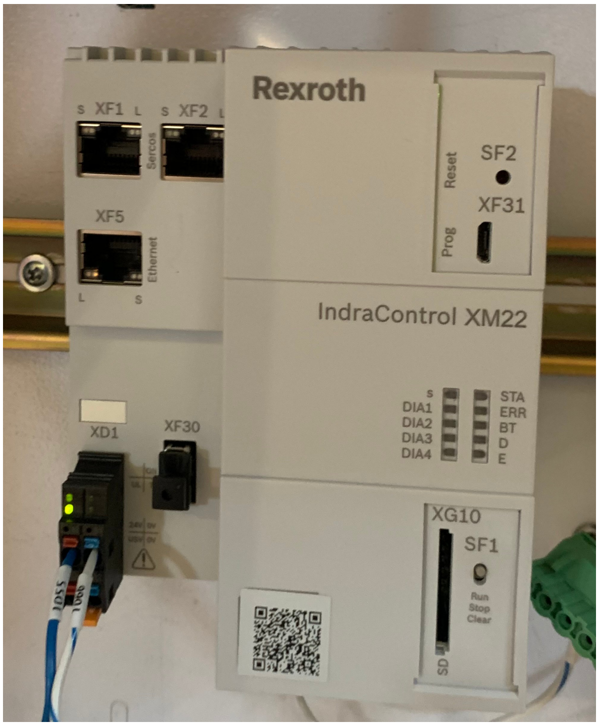

Figure 1: Rexroth XM22 Controller.

New T0 Architecture

To address the maintenance challenges posed by the legacy system, a revamped architecture was implemented, focusing on improved communication, integration, and compatibility within the Linux EPICS environment. In the upgraded system, the Indralogic programming for the register controller in the PLC played an important role. Additionally, the adoption of Modbus Library for EPICS (MLPI) libraries further strengthened the communication between EPICS and the XM22 controller, as depicted in Fig. 1.

The incorporation of asynDriver was pivotal in establishing robust low-level support, enabling seamless interaction with the MLPI libraries. This integration led to the creation of a specialized driver with the capability to both retrieve and update PLC parameters within the Indralogic Interface from Rexroth. The StreamDevice protocol file served as the channel between the driver and the interface, aiding the bi-directional communication required for parameter manipulation.

Figure 2 visually illustrates the transformation, showcasing the elimination of OPC interfaces. This upgrade not only streamlines the system but also enhances its compatibility within the Linux EPICS environment. This simplification significantly reduces maintenance efforts and ensures a more robust and integrated solution for managing alarms and controller communication.

FLOW DIAGRAM

In Fig. 3, the deployment flow diagram illustrates the ease of integrating Rexroth XM 22 controller hardware and various environmental monitoring components into an EPICS application. This straight-forward process also combines seamlessly with other software and will serve as a vital component within SNS's existing alarm system.

IMPLEMENTATION AND TESTTING

The newly enhanced T-Zero architecture and application have been deployed and tested at the VENUS beamline. Initial testing results indicate significant improvements. Specifically, a 350 lbs mass as shown in Fig. 4, is successfully spun

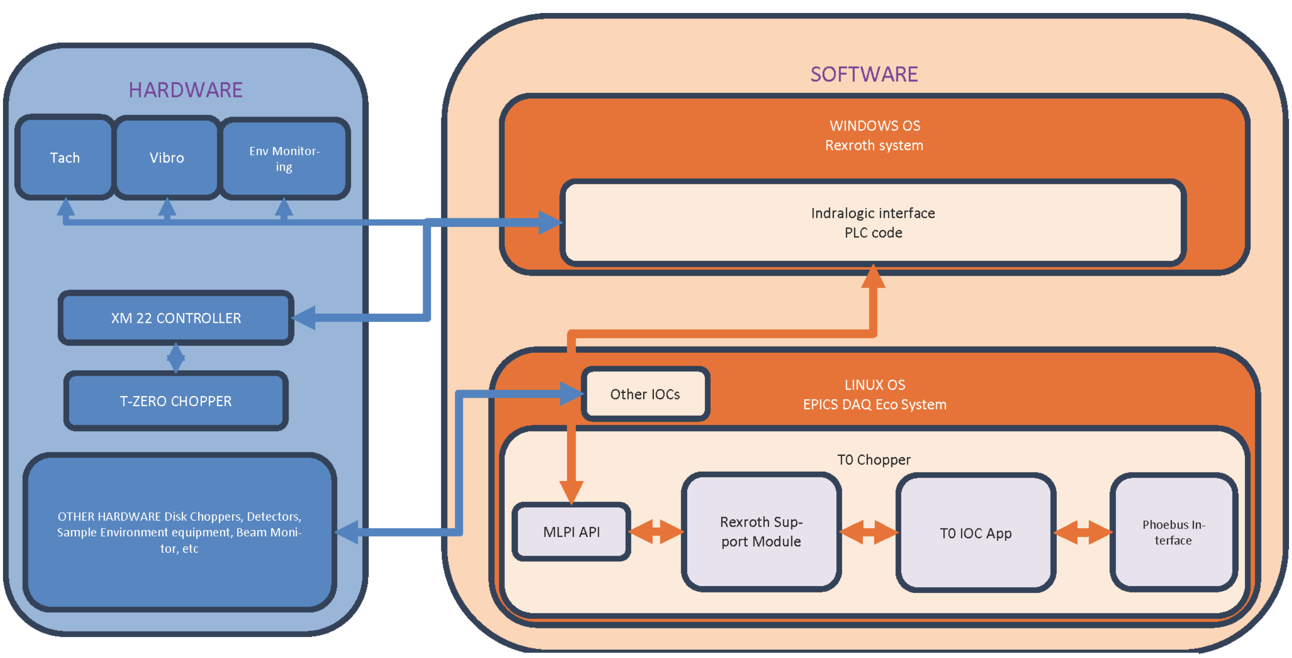

Figure 2: T0 EPICS Architecture.

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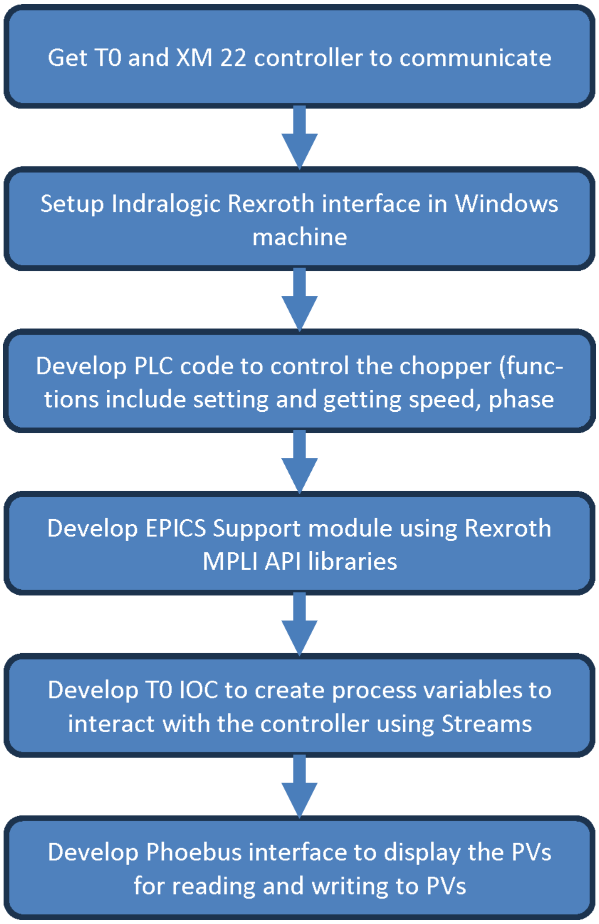

Figure 3: Deployment Flow Diagram.

Figure 4: Rotor on the balancing machine.

at a frequency of 60 Hz, perfectly synchronized with the accelerator pulse, achieving an impressive error margin of only 20 µs. This demonstrates the robustness and effectiveness of the Rexroth XM22 controller and its drivers in the EPICS environment.

CONCLUSION

The transition from a legacy T-Zero neutron chopper control system to the Rexroth XM22 controller has yielded substantial benefits for the Oak Ridge National Laboratory's Spallation Neutron Source (SNS). The new architecture eliminates compatibility issues associated with Windows XP and OPC servers, streamlines operations, and simplifies maintenance.

By adopting Indralogic and MLPI libraries, communication between EPICS and the XM22 controller is enhanced, ensuring a more reliable and integrated solution. Initial testing at the VENUS beamline has yielded promising results, highlighting the success of this transition.

This enhanced control system not only meets the demanding requirements of neutron scattering experiments but also sets a precedent for improved control system implementations at SNS. The Rexroth XM22 controller, in combination with EPICS, paves the way for efficient and reliable instrument control and data acquisition in the pursuit of cutting-edge neutron research.

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REFERENCES

[1] N. Holtkamp, "Status of the Spallation Neutron Source", in *Proc. PAC'03*, Portland, OR, USA, May 2003, paper MOAL003, pp. 11–15. `https://jacow.org/p03/papers/MOAL003.pdf`

[2] W. Blokland, T. J. Shea, and M. Stettler, "Networked Attached Devices at SNS", in *Proc. DIPAC'03*, Mainz, Germany, May 2003, paper PM23, pp. 146–148. `https://jacow.org/d03/papers/PM23.pdf`

[3] R. Merl, R. Nelson, and K. Kupcho, "Design and performance of a DSP based neutron chopper phase controller", in *Proc. PAC'01*, Chicago, IL, USA, Jun. 2001, paper TPAH099, pp. 1438–1440. `https://jacow.org/p01/papers/TPAH099.pdf`

[4] H. Bilheux, K. Herwig, S. Keener, and L. Davis, "Overview of the Conceptual Design of the Future VENUS Neutron Imaging Beam Line at the Spallation Neutron Source", *Physics Procedia*, vol. 69, pp. 55-59, 2015. `doi:10.1016/j.phpro.2015.07.007`