Background Information

Project Overview

This project focuses on developing a real-time data acquisition and synchronization system for integrating motor position data from Harmonic Drive FHA actuators with Spike2 data analysis software. Using a CANUSB adapter, the system will translate CANopen protocol data from the motors into USB format for PC integration. In Spike2, this motor data will synchronize with experimental signals captured by a 1401 ADC/DAC converter, enabling comprehensive, real-time analysis of motor and biological signals.

System Goals

1. **Real-Time Data Synchronization**: Capture, convert, and synchronize motor data with biological signals in Spike2, supporting real-time analysis.
2. **Data Integrity**: Ensure consistent, reliable data transfer across multiple protocols and hardware interfaces.
3. **Usability**: Provide a documented, user-friendly system for straightforward operation and maintenance.

Key Components and Protocols

CANopen Protocol

CANopen is a communication protocol built on the Controller Area Network (CAN) standard, widely used for precise real-time control in automation and robotics. Harmonic Drive FHA motors use CANopen to transmit position, velocity, and status information.

- **Protocol Characteristics**: CANopen's structured data packets allow low-latency data transfer, ideal for real-time motion control.
- **Data Transmission Requirements**: To maintain low-latency data flow into Spike2, the system requires a reliable CAN-to-USB interface with minimal delay.

CANUSB Adapter

The CANUSB adapter translates CAN messages from the Harmonic Drive motors into USB format, enabling data transfer to a computer where Spike2 can process and synchronize it with other experimental data.

- **Considerations**: Timing and data integrity can be affected by high-throughput demands. Effective error handling and precise timing protocols are necessary to prevent data loss and maintain synchronization.

Spike2 Software

Spike2 is a powerful data acquisition and analysis platform designed for biological research. Integrating motor data into Spike2 provides a synchronized view of motor activity alongside neural and other experimental signals, crucial for analyzing sensorimotor coordination in real-time.

- **SDK and Integration**: The Spike2 C++ SDK allows customization for seamless handling of external data sources. By synchronizing CANopen motor data within Spike2, researchers can study precise relationships between sensory inputs, motor outputs, and biological responses.

1401 ADC/DAC Converter

The 1401 ADC/DAC converter records various analog and digital signals, enabling Spike2 to acquire experimental data from multiple sources. Synchronizing motor data with signals recorded through the 1401 provides a unified timeline for analyzing sensory-motor coordination.

- **Capabilities**: The 1401 offers high-speed, high-resolution waveform capture and simultaneous digital output, supporting complex, multitasking experiments that involve precisely timed motor control and sensory feedback.

Project Challenges

1. **Real-Time Data Processing**: Ensuring low-latency data conversion and transfer to support Spike2's real-time analysis capabilities.
2. **Precise Timing Synchronization**: Aligning CANopen motor data with biological signals captured by the 1401, which is essential for experiments examining fine-grained sensorimotor timing.
3. **Error Handling**: Developing robust error-handling mechanisms to manage protocol, USB, and timing errors that may occur during continuous, real-time operation.
4. **Performance Optimization**: Designing a multi-threaded architecture to handle simultaneous data streams without bottlenecks or performance degradation.

Benefits of the Proposed System

1. **Enhanced Experimental Insight**: Real-time synchronization of motor and biological data enables more detailed studies on sensory-motor processing, supporting research into neural control of movement.
2. **Maintainability**: The system's documentation and streamlined architecture ensure straightforward maintenance and potential for future enhancements.
3. **Adaptability**: A robust, scalable design enables future integration with additional hardware and experimental protocols, facilitating research expansion.

This project will deliver a reliable, high-performance data acquisition system that supports Dr. Stay's research on sensorimotor control by providing a unified, real-time view of motor and biological signals.