EUROPEAN SPALLATION SOURCE

ECMC: Open Source Motion Control at ESS

Based on the open source EtherCAT master by IgH (etherlab)

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Outline

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- Previous work
- EtherCAT at ESS
- ECMC (EtherCAT Motion Control):
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EtherCAT Fieldbus

- EtherCAT
  = Ethernet for Control Automation Technology
- Open fieldbus standard originally developed by Beckhoff GmbH [1].
- Maintained by EtherCAT Technology Group [2].
- Hardware requirements:
  - Master: standard computer hardware (NIC)
  - Slaves: dedicated hardware, EtherCAT Slave Controller (ESC)
- Masters: Commercial (e.g. Beckhoff TwinCAT) and open source masters available.
- Slaves: Several 100 manufacturers of slaves (drives, I/O, sensors, robots).
- Topologies: Line, Star, Ring.
- Media: Cat 5 cable, plastic fiber, glass fiber.
- Bandwidth utilization: 80%-97% (100 Mbit/s , Ethernet, Full-Duplex) .
- Supports Distributed Clock (DC) in slaves with a max. of 100ns synch error.
- Cycle times > 50µs.
- Applications: Motion, large or long distance systems, synchronized systems.

Previous work

- Diamond Light source “dls-ethercat” driver [7, 8]:
  - Data acquisition and control
- Paul Scherrer Institute “ecat2” driver [9]:
  - Data acquisition and control
- Other facilities are using EtherCAT as well but based on commercial software / hardware platforms.

We have focused on Motion Control!

EtherCAT at ESS

- Chosen as a medium performance platform for data acquisition and control [3, 4].
- Ideal for Motion Control.

Source: [5]

ECMC: EtherCAT Motion Control

ECMC is an open source motion control framework for EPICS environment [10].

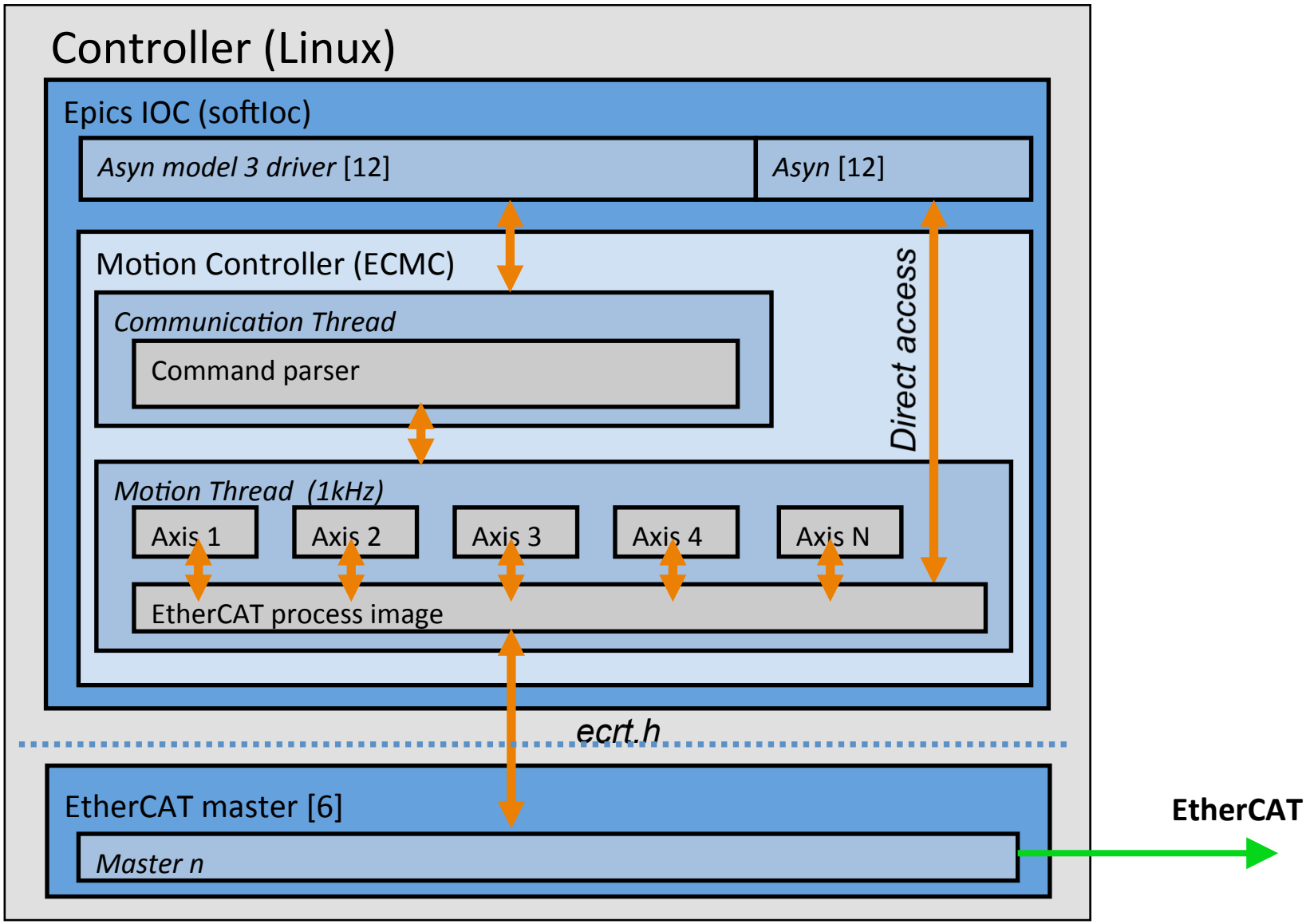
Functionalities:

- Motion (with EPICS Motor Record support):
  - Positioning (absolute, relative)
  - Constant speed
  - Referencing sequences

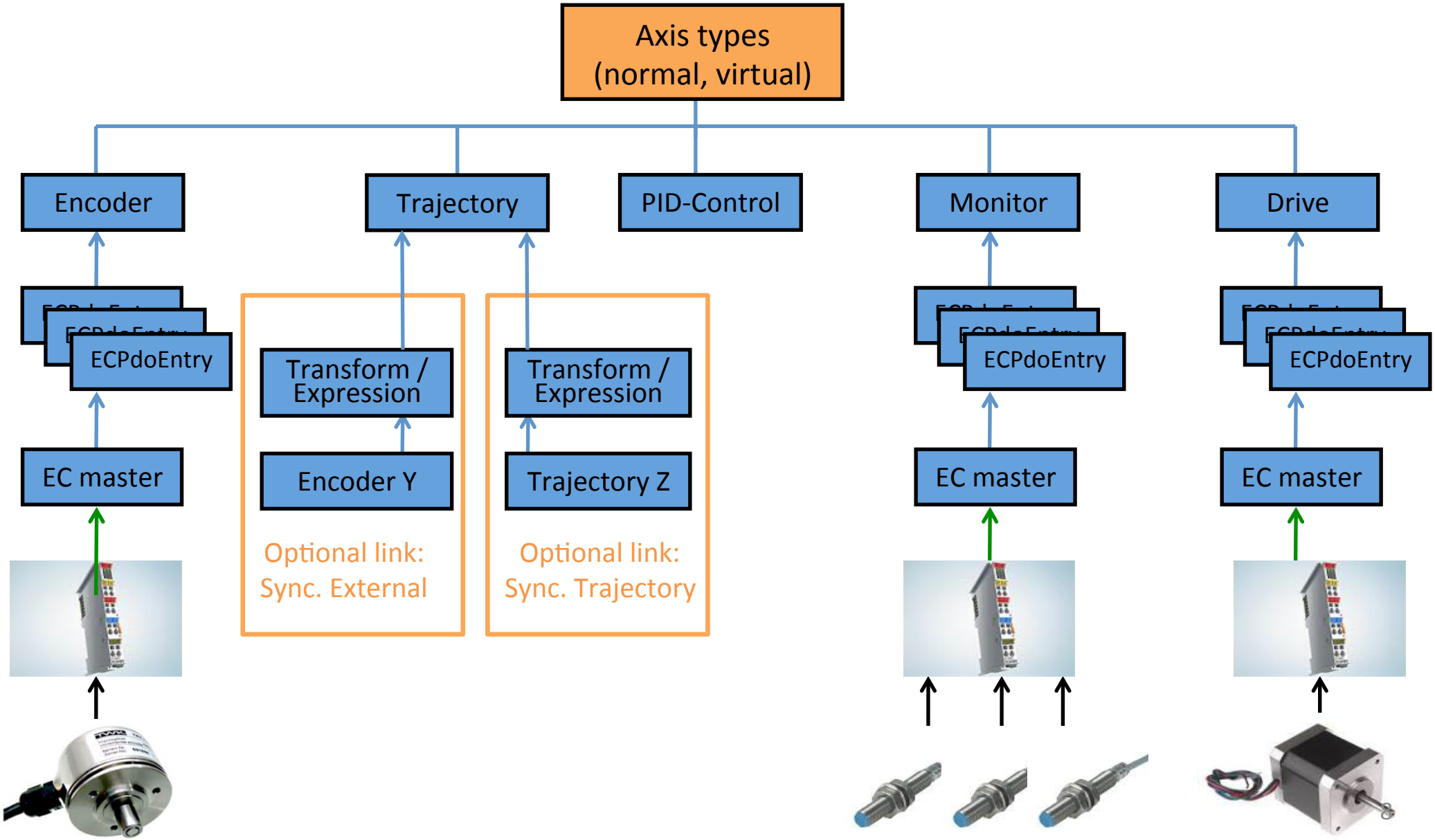
- Motion (extension to Motor Record)
  - Motion interlocks
  - Triggering, latching positions
  - Synchronization axis to axis
  - Synchronisation to external source (timing system)

- General
  - Data acquisition (analogue <100kHz, digital <1Mhz)
  - General I/O + low level control

ECMC: Architecture



ECMC: Axis class



ECMC: Synchronization

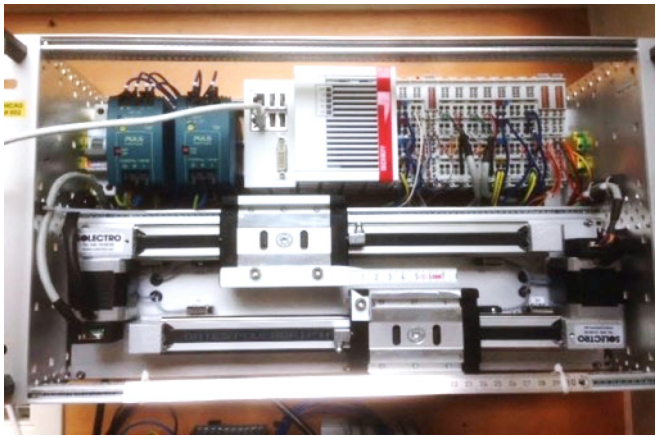
- Synchronization of axes by expressions (exprTk) [14].
  - setPosx = Trajectory generated setpoint for axis x
  - actPosx = Actual position of axis x
  - enx = Enable amplifier of axis x
  - ilx = Motion interlock of axis x (allowed to move if true)
- Update of expression at runtime possible (evaluated in 1kHz).

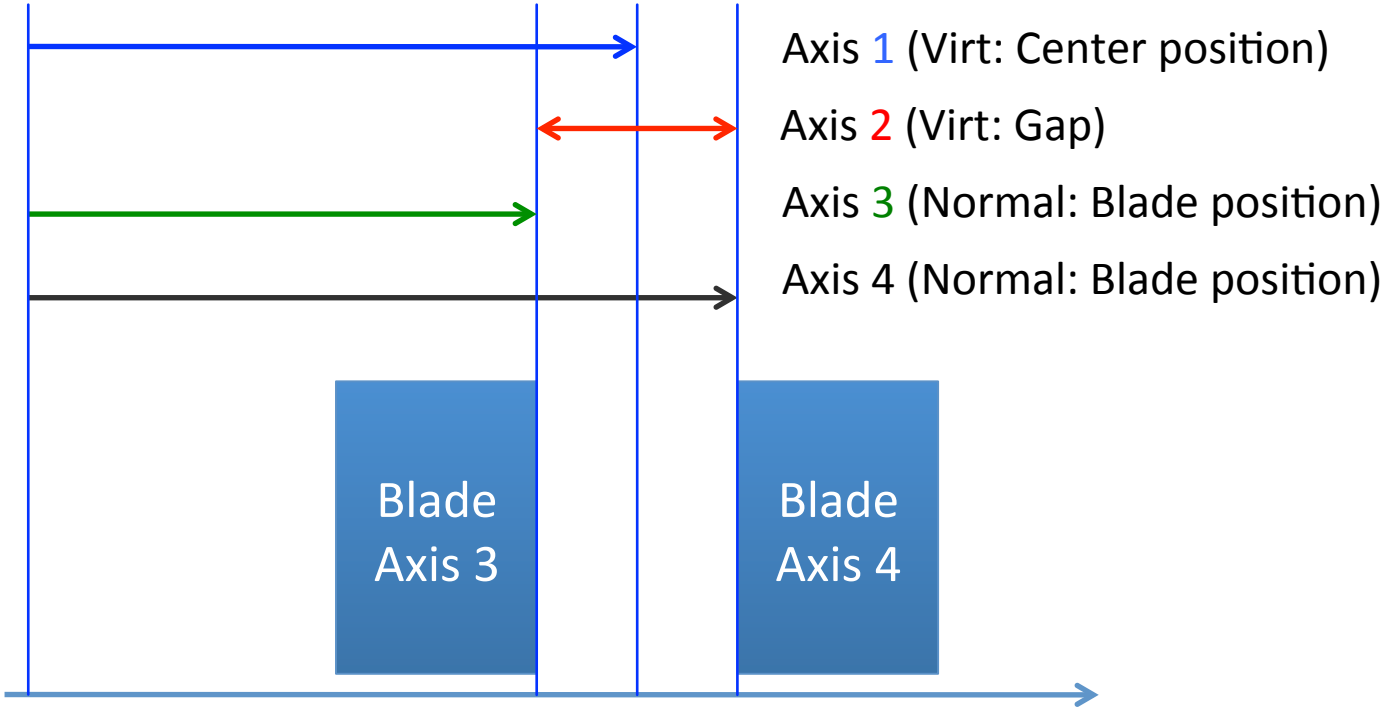
Examples:

Slaving:	setPos2:=actPos1;
Synchronization:	setPos2:=setPos1;
Gearing:	setPos2:=0.5*setPos1;
Phasing:	setPos3:=setPos1+setPos2;
Advanced:	setPos1:=10*sin(setPos2+actPos3);
Interlocks:	il1:=il2 and il5 and actPos4>actPos3;
Enable:	en2:=en1;

ECMC: Example 2-axes slit set

- 2 virtual axes
  - Slit center position
  - Slit gap/opening
- 2 normal axes (blade positions)



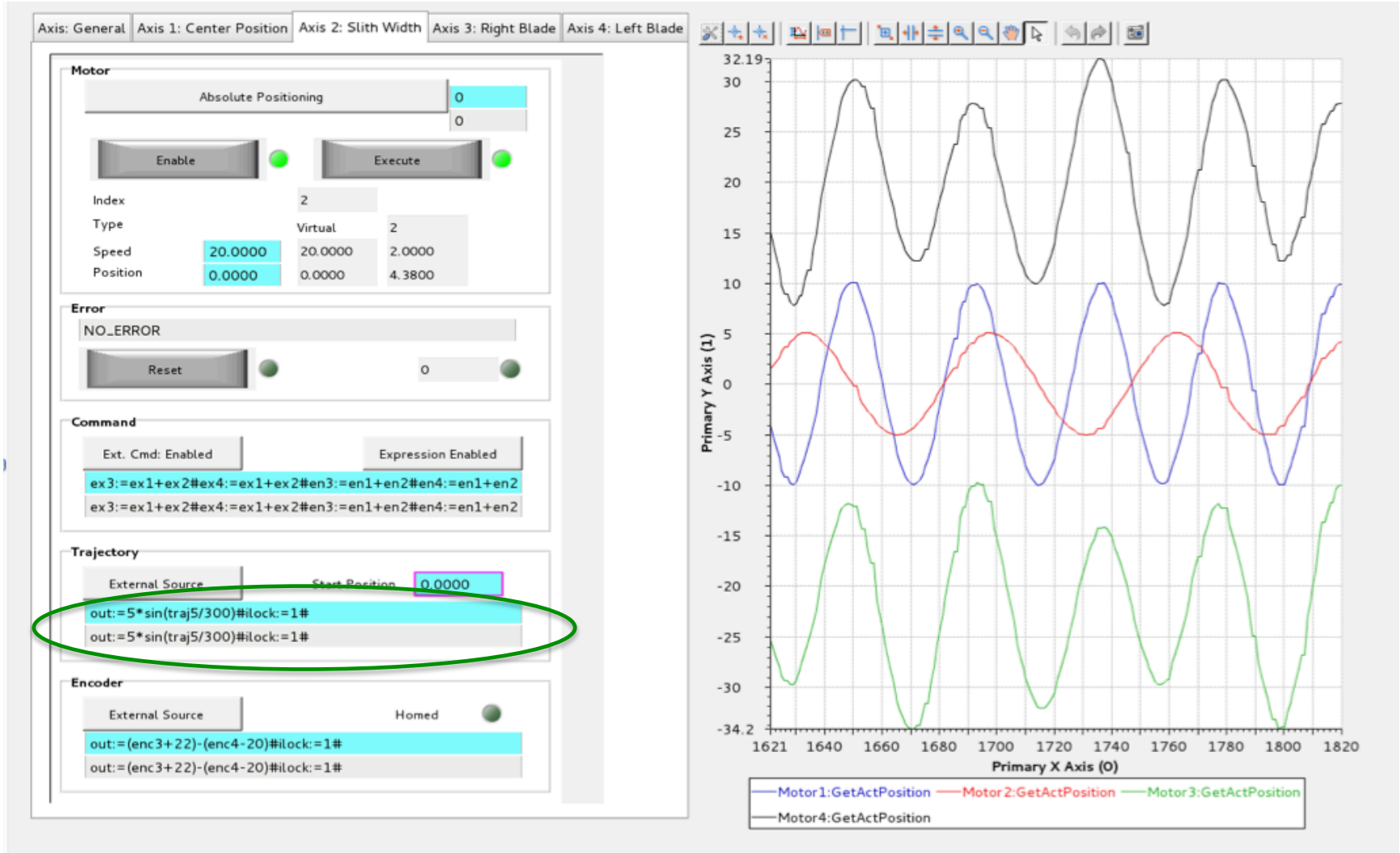


Forward Kinematics:
setPos3:=setPos1-setPos2/2;
setPos4:=setPos1+setPos2/2;

Inverse Kinematics:
actPos1:=(actPos3+actPos4)/2;
actPos2:=(actPos4-actPos3);

Amplifier enable:
En3:=En1 or En2;
En4:=En1 or En2;

ECMC: Example 2-axes slit set



Axis 4

Axis 1 (Centre)

Axis 2 (Gap)

Axis 3

ECMC: Hardware Platforms

- Standard computer hardware (NIC needed for EtherCAT Master).
- Flexible hardware choice:
  - µTCA (not tested yet)
  - Industrial computer
  - DIN rail computer
- Virtually any commercial EtherCAT slave (terminal) can be used, but needs to be evaluated and manually integrated into the framework.

Summary

- A motion control frame work for use within EPICS environment has been presented.
- The frame work utilizes the open source EtherCAT master from IgH Etherlab to configure and communicate with EtherCAT hardware.
- Basic motion functionalities as well as more advanced have been implemented.
- Framework can also be utilized for general control and data acquisition.
- Next steps:
  - Apply the framework to ESS accelerator applications
  - Continue to evaluate hardware and add to the framework

Acknowledgments

- IgH open source EtherCAT master
- EPICS community (base, motor, asyn, stream device)
- Mathematical Expression Toolkit Library (ExprTk)
- ESS Motion Control & Automation Group:

  Paul Barron, Torsten Bögershausen, Thomas Gahl, Kristina Jurišić, Markus Larsson, Federico Rojas.

Questions?

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