Double Crystal Monochromator Control System for the Energy Materials In-Situ Laboratory Berlin

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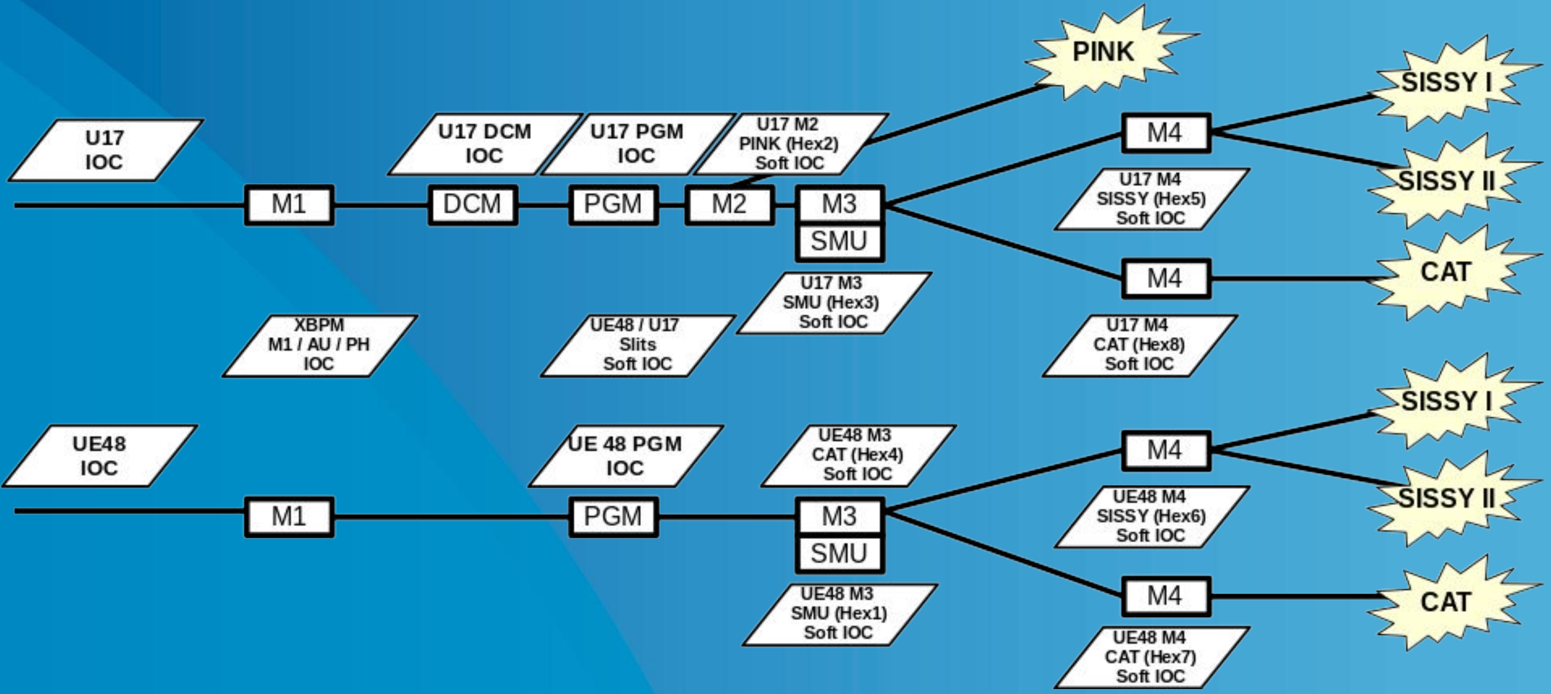
Introduction



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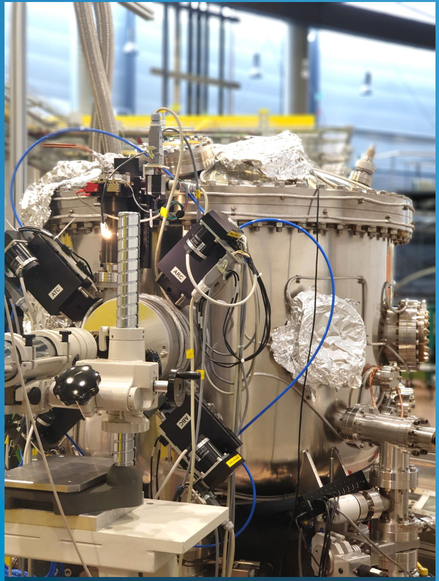
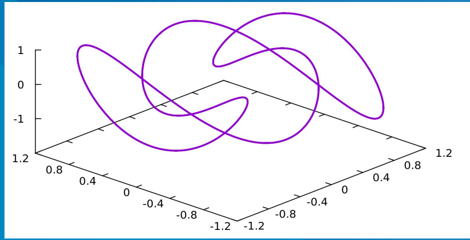
Challenges

- Complex beamline
- Experimental constructions
- >15 EPICS IOCs
- New motion control hardware
- Follow devices on-the-fly or predefined path
- Fast and precise positioning
- Low-level programming on motion controller
- Support of low-level features in higher level software
- Diagnostic tools needed by scientist and software engineers
- Device based framework and adaption to old monochromator control software

Motion Control Hardware



Software Stack



PLC Program

```
. .

if collision
  stop motors
endif

. .
```

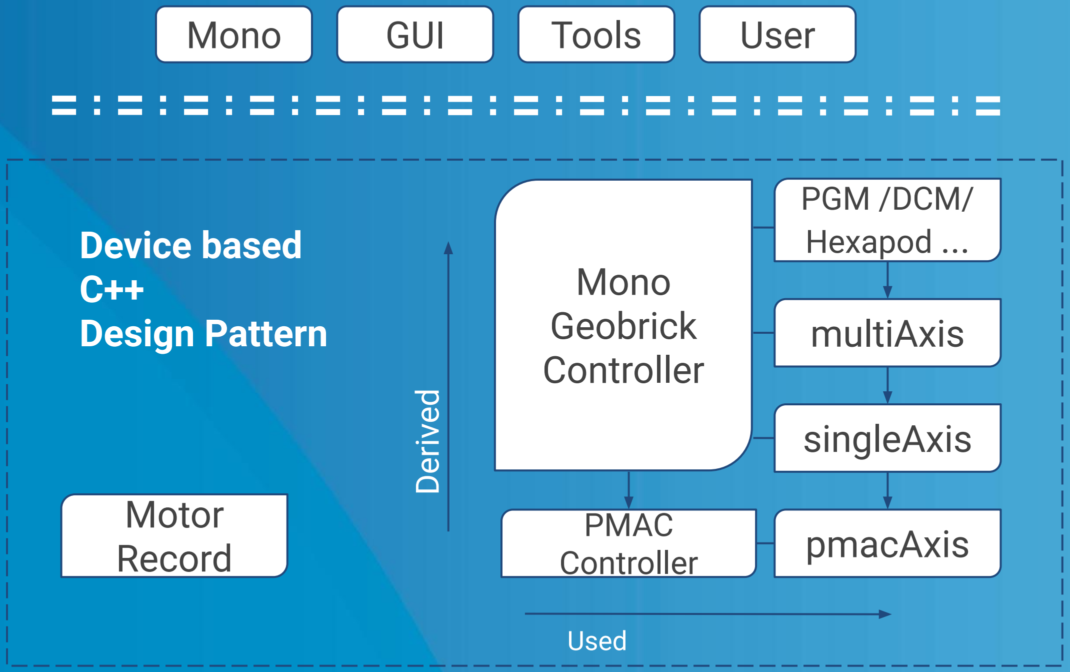
Motion Program

```
SPLINE
X Y Z
X Y Z
X Y Z
M33 == 1
X Y Z
...
```

- EPICS IOC
  - Database
  - C++ Model
    Specific features can be added
- Clients: EMP2, SPEC, LISE, ...
  Evaluating: Bluesky, Phoebus
  - Display Manager
  - Collaborate, Share Code
  - Python/Jython
  - Reduce overall number of programming languages, tools.

EPICS Support

EPICS CA
or DB Access



Filters for encoder positions

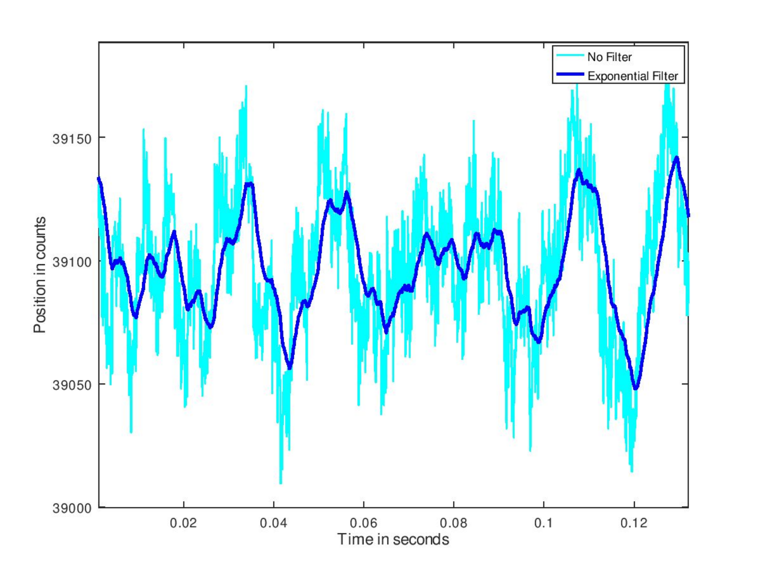


Figure : Exponential filter implementation for encoder readouts.

Types of filters implemented include:

- Exponential filter
- Moving average filter
- Spike detection

Algorithm for smooth on-fly velocity profile generation

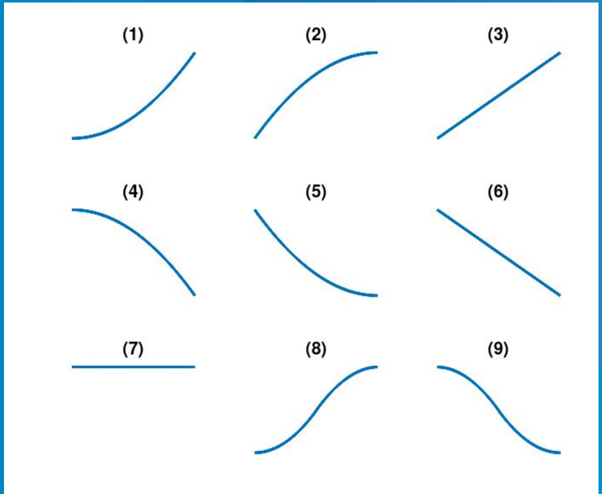
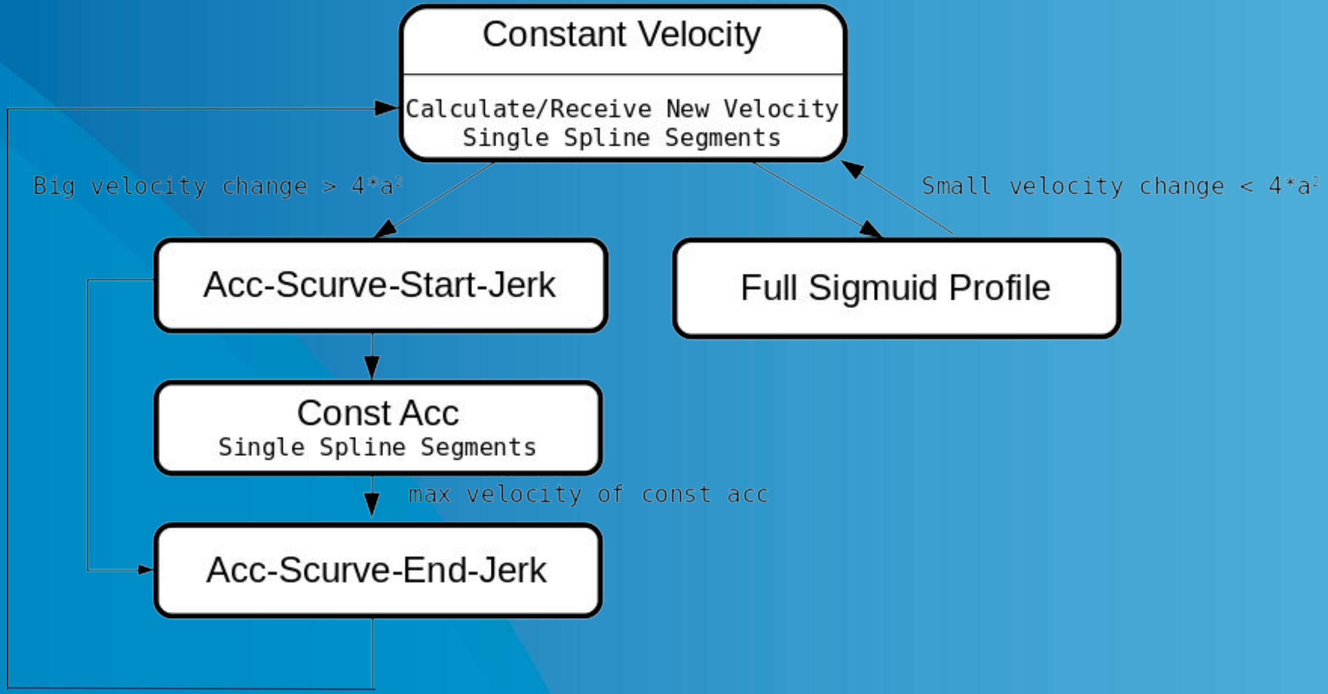


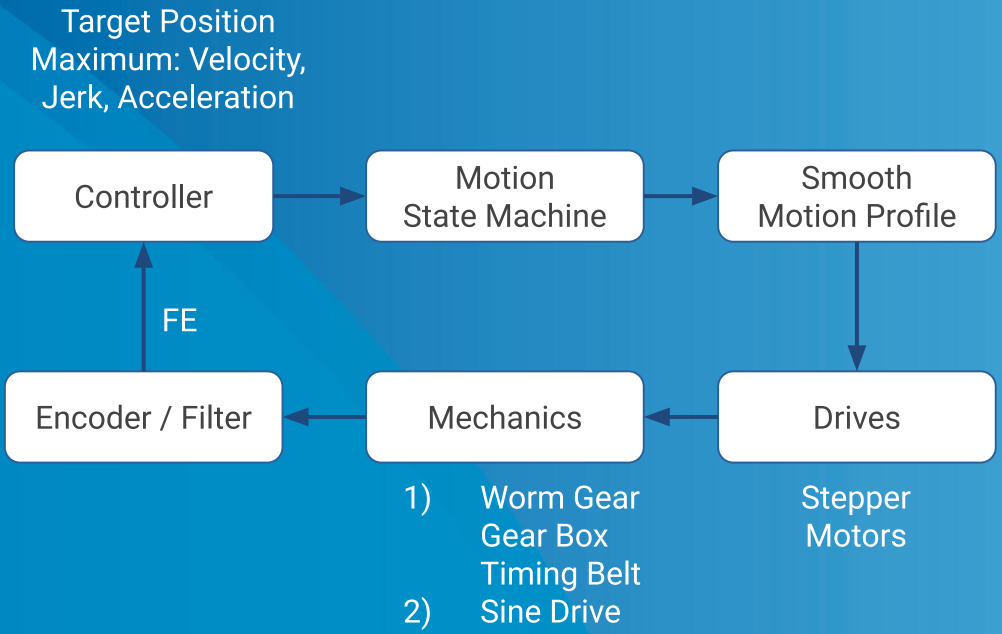
Figure : Spline move building blocks

- Trapezoidal shaped motion not sufficient
- High precision point-to-point moves
- Closed-loop moves
- Multidimensional path
- Jerk limited profile
- Motion profiles continuous in 2nd derivative (acceleration)
- On-the-fly generated path predictable at any point of the trajectory
- Possible triggers in sync with movements

Motion States



CR1/CR2 Controller



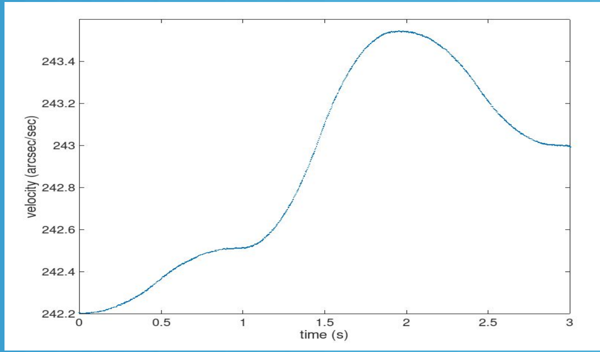


Figure: Motion state machine output.

Long Range Spline Moves

DCM

1 Axis closed-loop
PID Vff
+ Programmed velocity profile

PGM

Continuous mode

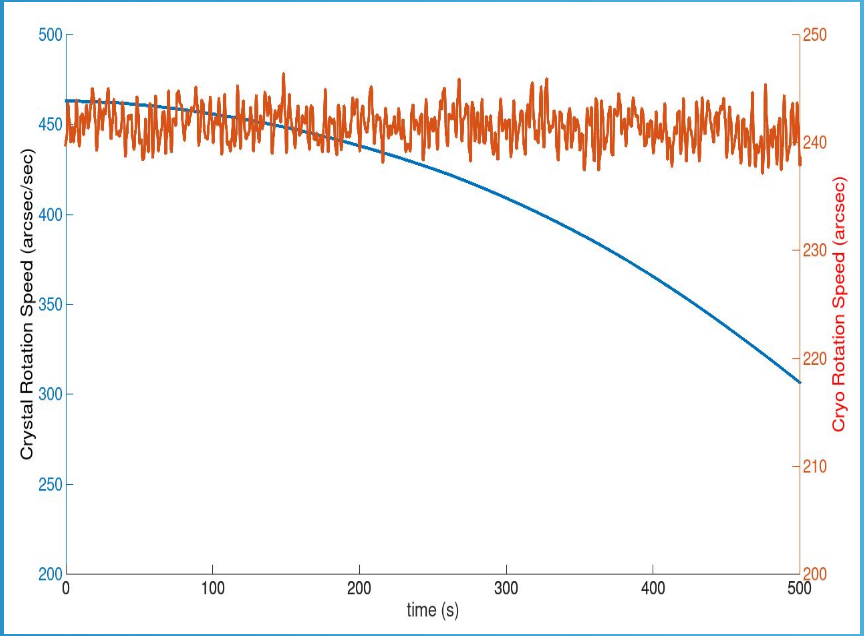


Figure: Crystal rotation velocity and cryo axis velocity

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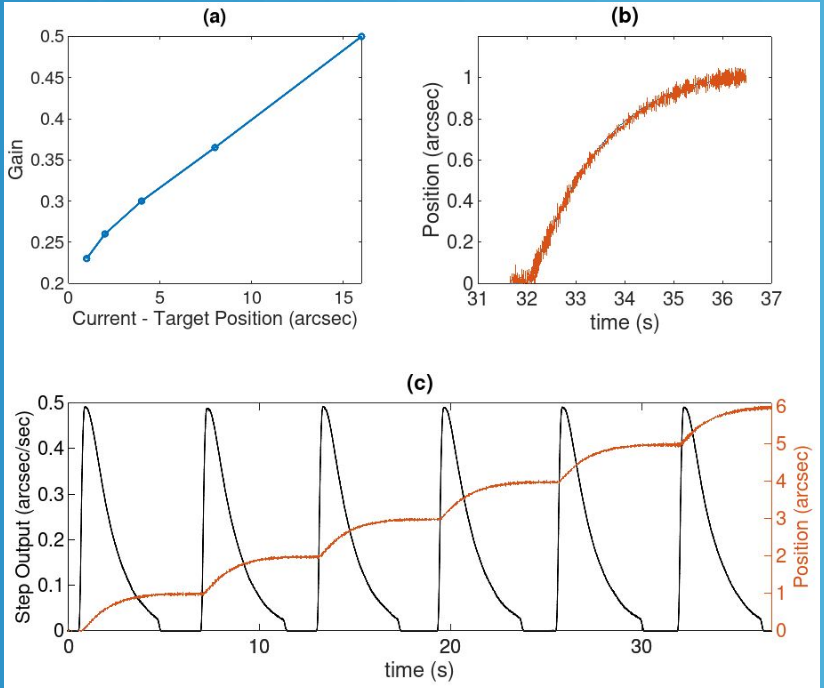
Closed Loop End Positioning

- Generate Spline
- Changing gain close to target
- Smooth approach
- In-position band
  No direction inversion
- No vibrations



TODO

- Predictable path
- Good results for full stop directly to end-position
- Mechanical errors and non-linearities
- Extend algorithm for fast closed-loop deceleration phase

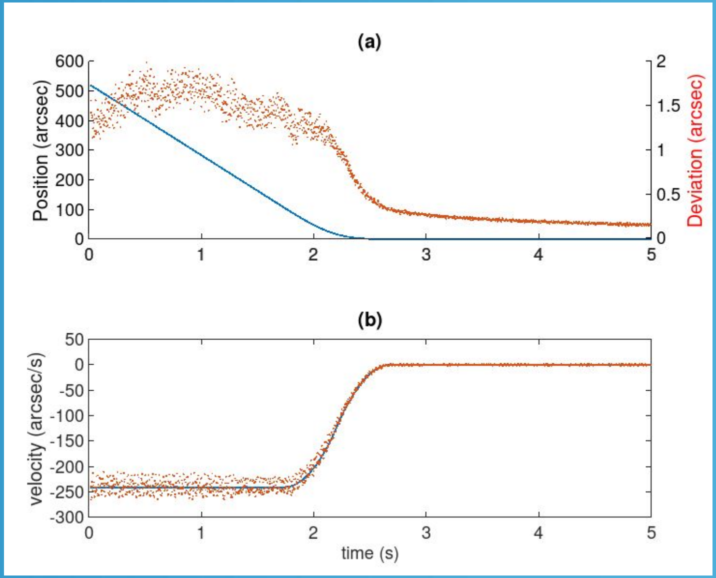
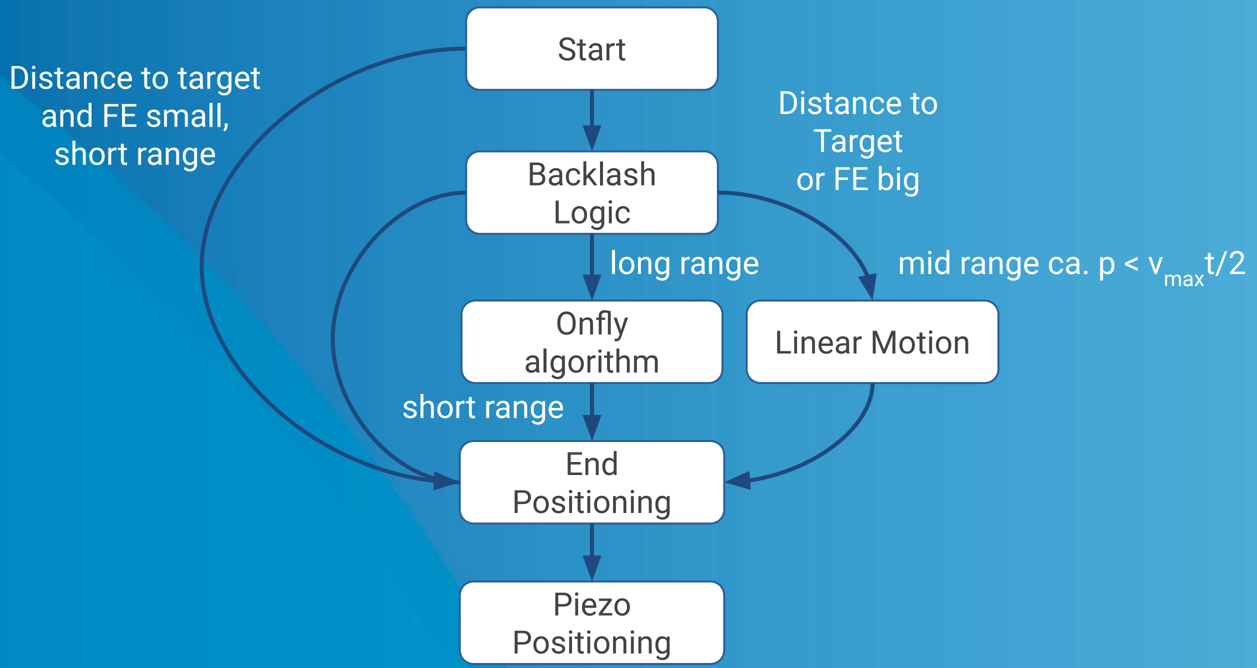


Figure: Deceleration phase

Motion Program Logic (DCM)



Piezo motors for crystal parallelism

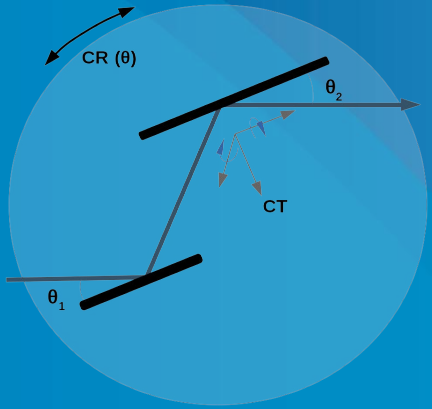


Figure: Ray diagram and degrees of freedom of piezo motor system

Crystal System		
Axis	**Motor**	**Range**
Crystal translation	Stepper motor	70mm
	Piezo motor	90 µm
Crystal Pitch	Piezo motor	90 µm
Crystal roll	Piezo motor	90 µm

Table: Motors and their ranges

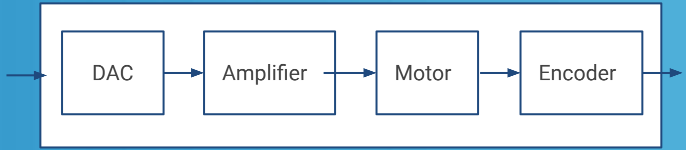


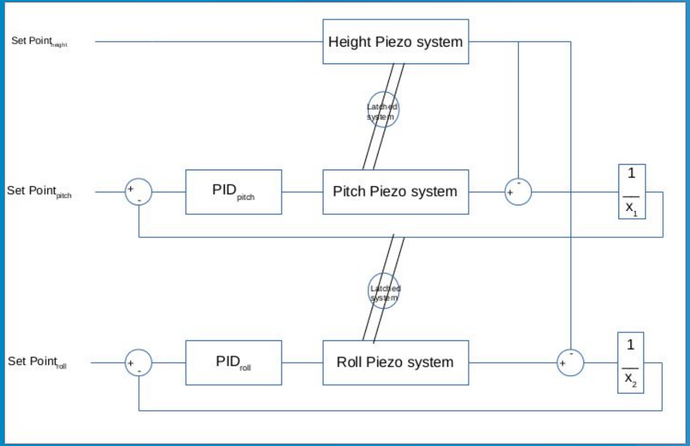
Figure : Open-loop system

Closed loop system

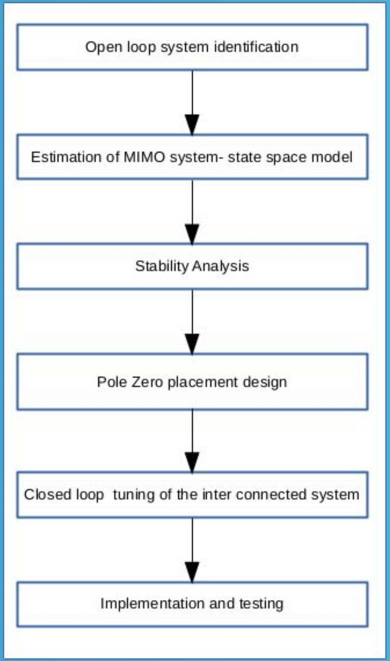
Requirements

1. Setpoints in micro radians
2. Pitch and roll positioning in closed loop
3. Stable and fast closed-loop control

X_1=distance between pitch and height encoders.
X_2=distance between roll and height encoders.



Procedure



Results

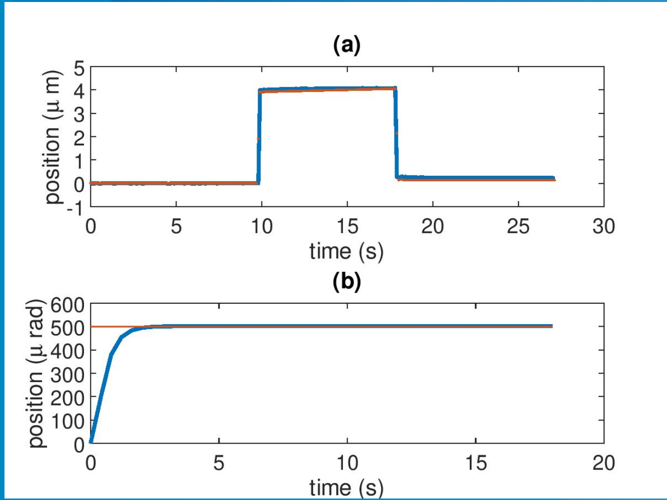


Figure : System estimation and closed loop response

Figure (a)
A pi signal response of the measured system and estimated system

Figure (b)
The closed-loop performance of the roll piezo motor

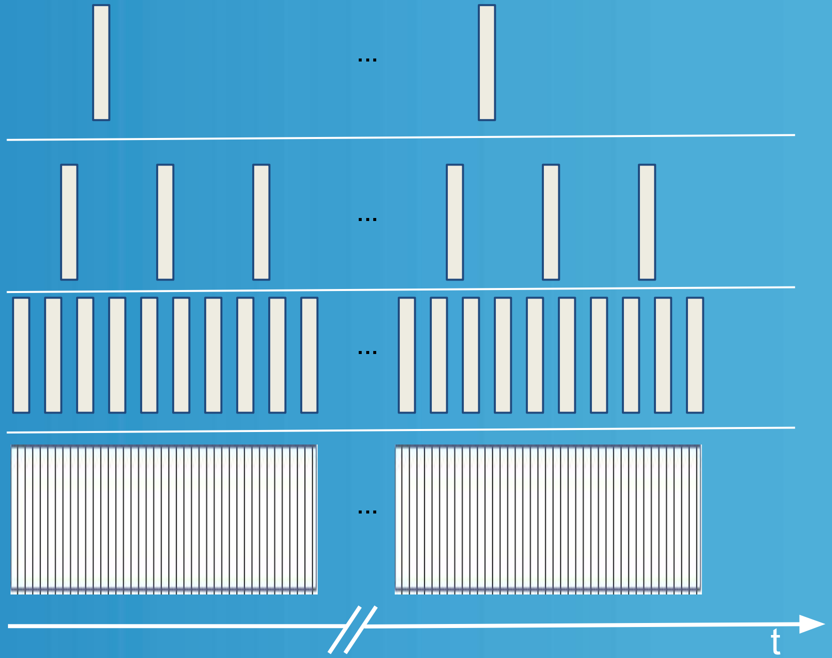
Diagnostic: Continuous Feedback

EPICS wf-records monitored by client software

Feedback module processes data

Poll task checks/reads data package

PLC code calculates and fills data package in user buffer



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