

Hardware solutions for Positioning and Motion Control at the ESRF

José María Clement
Instrumentation Services and Development Division
Detector & Electronics Group / Electronics Unit
11/05/2011

Positioning and Motion Control at the ESRF

1. Positioning at the ESRF
2. Some ESRF developments
3. The icePAP motor control system

Piezoelectric actuators and their control

Used for fine positioning of optical elements

Main actuators used:

- PI (physik Instrumente)
- Queensgate

Controller:

A single controller family from PI: E-500

- High voltage Amplifier
- Servo controller modules



Position is controlled with an analog voltage

A standard cabling is used in all ESRF

“Hotspares” are kept for a fast response in case of module breakdown

Motors and their control

Some numbers at the ESRF:

- More than 4000 motorised axes with stepper motors
- More than 100 axes per beamline
- Between 2 and 3 M€ in motor control electronics
- Heavy involvement of the staff (installation, setup...)

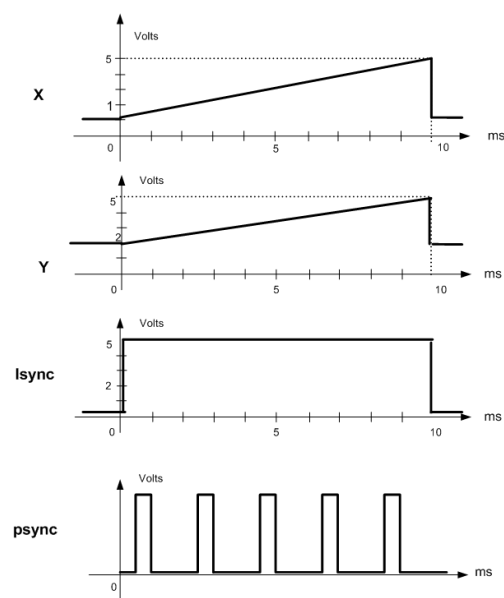
Two standards coexist at the ESRF

- The old standard
 - Covers the basic needs
 - Very reliable (20 years of operation, low breakdown rate)
 - Cost between 750~1500 €/axis
 - BUT: component obsolescence, basic performance
- The icePAP system

Some ESRF developments

VSCANNER:

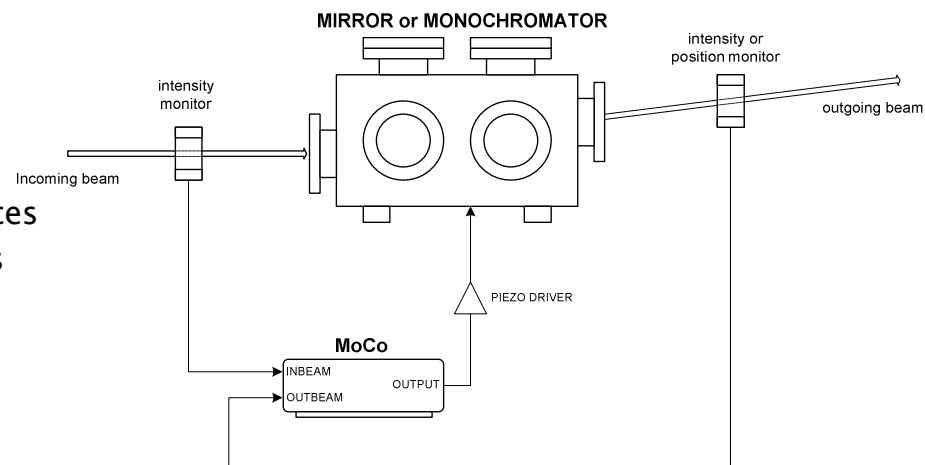
- Generates up to two analog voltages to drive two piezo controllers
 - several synchronisation signals to:
 - trig a detector at given positions (output trig)
 - Start a scan (input trig)
 - Full control by serial line commands
- 



Some ESRF developments

MoCo: Monochromator Controller

- Low-current or voltage inputs with built-in gain control
- Regulation time constant from 1 ms to 1 minute
- Detection of beam presence
- Automatic tuning and autoscaling
- Full control by serial line
- Software INBEAM monitor
- Hardware handshake with other devices
- Gain control of external preamplifiers



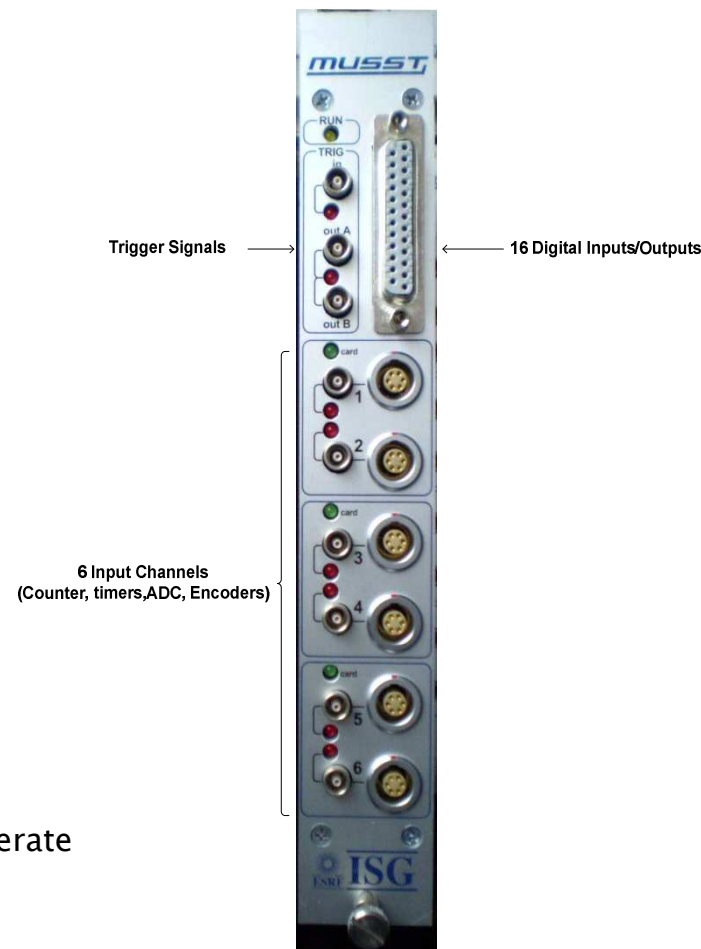
Some ESRF developments

MUSST : Synchronisation / Triggering unit.

Can be operated also as a data acquisition unit.

MUSST hardware resources:

- 6 main input channels (counters, incremental and absolute encoders, analog signals, ...).
- 1 32-bit timer
- 16 general purpose I/O TTL lines
- 4 dedicated trigger signals
- 1 interface for spectroscopy ADCs (MCA)
- 2 MB of internal RAM
- GPIB interface (> 1 MB/sec)
- An internal programmable sequencer (FPGA based)
 - Fast comparators (20 ns resolution)
 - Microcode execution module
 - Internal general purpose data registers
- External or internal events can be combined to generate trigger sequences



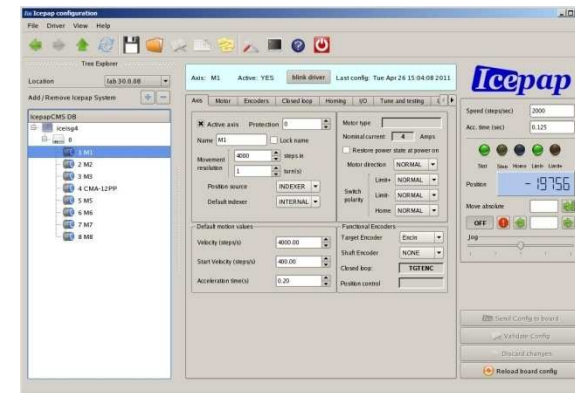
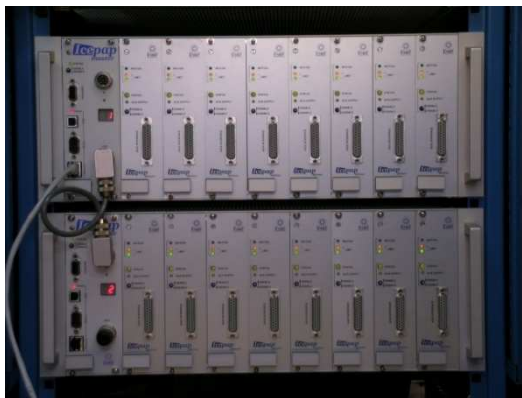
The icePAP motion control system

An ESRF/ALBA development collaboration

The motor control standard for ESRF and ALBA
First installations at ESRF started in 2006

Some numbers:

- 2700 drivers **manufactured** for the ESRF
- 2000 drivers installed and working in the beamlines



The icePAP driver

The driver board

Single-axis controller

Indexer and motor power controlled by a 150 MHz DSP

Able to drive different types of motors (1, 2 or 3-phase motors, stepper, DC, brushless), **only steppers implemented so far.**

Incremental and absolute (SSI) encoder management (2 encoders/board)

Some of the features are:

- Closed-loop operation
- High position resolution
- Fully software configurable
- Reduced vibration and motor heating
- Non-volatile position storage
- Hardware position output signals allow detector synchronisation (“fast scans”)
- Exhaustive diagnostics:
 - Motor failures
 - Driver operation
 - Trajectory
- Indexer or power control can be “bypassed”



A high quality system at low cost

- Low production cost: ~500 € per axis
- High performance
 - high resolution with high speed
 - Generalisation of closed loop with stepper motors
 - Advanced homing functionalities
- Good quality system
 - High quality cabling and shielding design
 - Good mechanical integration
- Reliable:
 - less than 10 driver board failures in 5 years



Well adapted to ESRF needs

With one single equipment, 99% of the motors at ESRF can be driven.

- A rich set of configuration parameters
 - fully software configurable
 - Need of a configuration tool -> icepapcms
- Flexible power supply
 - 1 KW power supply per crate (with PFC)
 - motor power supply voltage variable and configurable per driver

Easy to maintain

- Simple installation and maintenance
- Standard cabling

Multiaxes and synchronisation capabilities

Up to 128 axes in a single system

- Synchronised actions
- Output signal multiplexer for detector synchronisation
 - fast scans with different axes is simplified
 - need of a synchronisation board (MUSST)
- Linked axes
- Parametric, multiaxes trajectories (on-going development)

Further developments

The icePAP is an open platform and development continues on several directions

- Improved power control strategies
 - FOC
 - DC motors control
- Parametric trajectories
- Tracking operating modes

Acknowledgments

ESRF Electronics Unit / Electronics Support Lab

P. Fajardo, J. Clement, R. Hino, H. Gonzalez

icePAP developers:

M. Perez, P. Pinel, H. Gonzalez, F. Thurel, P. Chappelet, E. Paisier, P. Fajardo(ESRF)

J. Lidón, P. Ribas, G. Cuní (Alba)

Thank you all for your attention