

2024 / CASE STUDY

# Collaboration improves ESRF's precision and control capabilities

The European Synchrotron Radiation Facility (ESRF) in Grenoble (France) constantly upgrades its experimental capabilities. The latest project with Prodrive Technologies is to study the use of single- and three-phase linear motors to improve the scanning performances of positioning end-stations.

The ESRF consists of a 844m long circular particle accelerator that generates a powerful X-ray light that is used on over forty beamlines. The particle accelerator effectively forms a huge microscope that allows to fathom the structure of matter down to the minutest detail, at the atomic level. The accelerator was recently upgraded (150M€ budget, 2015-2022) to make ESRF the world's first fourth-generation accelerator. It now produces X-ray light some 10,000 billion times more powerful than medical X-rays. This facility is an exceptionally powerful tool for scientists in a very wide variety of fields: chemistry, archeology and cultural heritage, structural biology and medical applications, environmental sciences, and nanotechnologies.

ESRF is also upgrading its beamline instrumentation, and in particular nano-positioning end-stations which are used to precisely position samples with respect to the X-ray.

In partnership with:



There are around 10,000 axes (mainly stepper motors and piezoelectric actuators) currently in use for positioning purposes at the ESRF, usually combined to form complex multi-axis systems. For most demanding applications, single- and three-phase linear motors are planned to be used. The major challenge has been to find a high-end servo drive flexible enough to work seamlessly in all the highly demanding instrument applications at the ESRF.

The Simulink® integration in Prodrive Technologies' PMP® (Prodrive Motion Platform) real-time software allows ESRF engineers to design any control architecture they need to match their application. It also simulates the application without connecting it to any hardware. This gives a "First Time Right" path to connect all the application's hardware and mechatronics. PMP's Python APIs helped integrate Prodrive's versatile servo drives into their existing control system.

### The design challenges: positioning within 10-15 nm for negligible-jitter scanning

The existing piezoelectric stack actuators can position to within 10 nm but have a stroke limited to around 0.1 mm. The new positioning needs on the beamlines are of similar accuracy but with larger strokes and for continuous vibration-free and low-jitter scans.

To tackle these new positioning needs, single- and three-phase linear motors are being used more and more at the ESRF. As each drive manufacturer usually provides their own drives, the ESRF engineers are facing the issue of having to master each manufacturer's control platform. This is a huge task not helped by the reluctance of many manufacturers to share information on their architecture, providing access to only a few parameters. That's usually not enough because each application is different and needs customization.

The individual motor and drive quantities are relatively low, though, and not enough for suppliers to customize their products. ESRF therefore needs a flexible off-the-shelf solution that can be modified for each implementation. That means standardizing on a common, versatile drive for as many applications as possible.



Arcas motion controller  
& Apogee S3 servo drives

## ESRF needs highly linear drives with ultra-low noise

For accurate scanning applications, ESRF is considering Prodrive's Apogee D1 and Apogee S3 servo drives. These connect to motors from different manufacturers and have excellent linearity, 24-bit current sensing for accurate control, ultra-low noise outputs with very low output current ripple and jitter, and 200kHz PWM output frequency. They work with Prodrive's Arcas motion controller. Arcas can synchronize up to 12 axes @ 10 kHz for semiconductor, medical, and similar applications, and can connect to EtherCAT® devices.



PMP Software developed by Prodrive Technologies

ESRF has established a platform for universal implementation using Prodrive's PMP software.

“ My job is to ensure that the drives can meet as many of our positioning needs as possible for rotating, linear, and voice-coil motors. So we need in-depth data from the drive documentation.”

- Thomas Dehaeze

Motion Control Engineer of the Instrumentation Services and Development Division.



The second requirement was the very low drive current ripple to ensure accuracy. “It was here, too, very important for me that Prodrive measures this and commits to figures – particularly noise levels – in their data sheets. Also, we can interface Prodrive’s drives with many different encoder protocols, especially SSI (Synchronous Serial Interface) and BiSS-C (Bidirectional/Serial/Synchronous-Continuous). That, together with many different I/O types, makes the systems very flexible.”

Simulink compatibility was a bonus for versatile control and maximum compatibility. ESRF already uses it for real-time control of complex positioning applications, along with the digital-to-analog converters connected to Speedgoat. “Prodrive’s drives give us better performance, better accuracy, and very low jitter.”



Servo Drive product portfolio

### Future plans: system integration, testing, and expansion

Now that the Prodrive servo drives and motion controllers have been validated in the ESRF mechatronics laboratory using several test benches, the next step is to study their integration on the beamline. The drives and motion controllers will also be integrated into the Python-based software that orchestrates the complete system. Bridging between PMP and this Python software is much helped by PMP’s Python APIs.

“ Prodrive has drives for single- and three-phase motors with the same software and same control method. Most of our positioning platforms are custom multi-axis systems. So, our first control requirement is the flexibility to work in all these cases. We’ve found both Apogee and Arcas to be very versatile and very high-performance. We’ve also successfully interfaced them with the Speedgoat® simulation and testing system, and with our other control systems //

- Thomas Dehaeze

Motion Control Engineer of the Instrumentation Services and Development Division.

Dehaeze says that he greatly appreciates the support Prodrive has given, with engineer visits helping to set up the system and visioning equipment needed to get started. He found Prodrive very responsive, replying very quickly when requested.

“This is a fascinating and challenging project” concludes Meir Dahan, Prodrive’s Global Sales Manager for Motion Control. “We’ve enjoyed the high-level motion control discussions, they’ve made for some fast collaboration. We’re pleased that ESRF has found our real-time PMP software and Apogee drives so useful, we’re seeing PMP’s increasing adoption throughout the industry.”

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