YAMS: A STEPPER MOTOR CONTROLLER FOR THE FERMI@Elettra FREE ELECTRON LASER*

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Abstract

New projects, like FERMI@Elettra, demand for standardization of the systems in order to cut development and maintenance costs. The various motion control applications foreseen in this project required a specific controller able to flexibly adapt to any need while maintaining a common interface to the control system to minimize software development efforts. These reasons led us to design and build "Yet Another Motor Subrack", (YAMS), a 3U chassis containing a commercial stepper motor controller, up to eight motor drivers and all the necessary auxiliary systems. The motors can be controlled locally by means of an operator panel or remotely through an Ethernet interface and a dedicated Tango device server. The paper describes the details of the project and the deployment issues.

INTRODUCTION

The starting point for this project was the history of the ELETTRA storage ring and particularly of its beamlines and experimental chambers where, although the motion problem was central for experimental people, a number of different solutions were used, ranging from "commercial off the shelf" to "entirely home made". This was the stimulus and the knowledge background from which this stepper controller has been designed.

Project Design Criteria

One of the design goals was to realize a modular and "reasonably" flexible device suitable for the major number of use cases in FERMI@Elettra motion problems. "Reasonably" in the sense that we didn't want to replicate any of the market available controller that claimed to fit with a lot of (all) plants. The reference motor type was fixed as two-phase one.

The initial idea was to assemble the core controller board, a suitable motor power supply and the motor driver boards into a 3U size subrack.

A motor driver board was designed to fit into a DIN41494 Eurocard standard, so a "per motor" modularity could be achieved. It was foreseen to host a small daughter board dedicated to encoder signal conditioning, thus realizing the necessary "encoder flexibility".

The ELETTRA motion control history led us to use the Galil DMC-21x3 as the core of this project [1]. This family of motor controllers may drive from one to eight axis. In order to assure flexibility, the internal connections between the DMC and the drivers have been split in two groups of four axis each.

An obvious effort was done to standardize the connections to motors and encoders: one connector for the "axis", i.e. motor phases, limit/home switches (with supply for optical ones), brake control and "emergency stop" signal; and one connector carrying signals both for "digital" and "analog" encoders.

Another design criteria was to be able to re-use this stepper motor controller also in the ELETTRA beamlines, which will anyway require the design of new 3 and 5 phase driver boards.

Software application programs availability, especially in the Tango control framework, was another key point in the enumeration of the criteria used in the design phase.

Figure 1: YAMS chassis (front view).

HARDWARE DESCRIPTION

A 3U subrack contains the power supply for the motor driver circuitry, the DMC controller, the power supply for the DMC and for the other electronics (encoders, etc.), a simple local control panel and the Ethernet connection. In addition, this subrack may be equipped with up to 8 motor driver boards.

Figure 2: YAMS chassis (rear view).

In Fig. 2 a YAMS subrack equipped with six motor driver boards is shown; blind panels are used to close the unused slots (here not shown).

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YAMS Subrack

Table 1 summarizes the main characteristics of this controller:

Table 1: YAMS Subrack Characteristics

Function	Value
Mains power supply	220V
Motor power supply	24V, 350W max
Electronics power supply	5V, 50W - ±12V, 30W
Core motion controller	DMC family by Galil Inc.
Communication Interface	Ethernet 10BASE-T
Local Interface & Control	Motor, speed (1 out of 2), direction-movement selectors Stop-all-motion pushbutton Power supply leds.
Motor driver boards	up to 8

YAMS Motor Driver Boards

These boards are designed in the DIN41494 Eurocard standard, each carrying the electronics necessary to cope with different motor type and power. From the point of view of the core controller the connecting bus is the same, being its main feature the pulse/direction interface. The power section of the board is realized using the IMxxxH hybrid family produced by IMS (now "Schneider Electric Motion USA") [2].

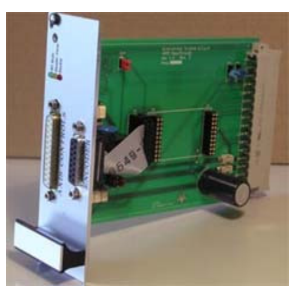

Figure 3: (A, left) Low Power Driver Board IM481H, (B, right) Passthrough Driver Board.

Table 2 shows the main common characteristics of these boards:

Table 2: YAMS Motor Driver Characteristics

Common feature	
Motor power supply	24V
Electronics power supply	5V, ±12V
Motor type	2 phase
Motor run/hold current configuration	via dip switch

As Fig. 3A shows, the board features three connectors. The first (upper in the figure) is dedicated to the axis connections: motor phase, limit/home switches (with power supply for the optical ones), brake and emergency stop signal. The central connector is used for connecting the hybrid power, i.e. the power section of the board, to the internal power supply, or to an external one. In this way multiple high power motors may run at the same time. In the third connector, the sud-D one, there are all the encoder signals, both for digital and analog encoders.

Table 3 summarizes the motor current ranges of the three adopted IMS boards:

Table 3: YAMS Motor Current Ranges

Card Name	IM481H	IM483H	IM805H
IMS hybrid	IM481H	IM483H	IM805H
Motor current (peak)	0.2– 2.1 A	0.5 – 4.2 A	1 – 7.1 A

Besides the driver board that actually may power a stepper motor, a “versatile board” was designed called “Passthrough”, Fig. 3B. This board is equipped with two connectors. One of them carries the motor, switches and brake signals: this is not directly connectable to the phases of a motor, a power stage with the pulse/direction interface must be interposed (for instance motors with power electronic integrated). The other connector is exactly the same sub-D encoder connector of the other boards, and, in fact, this board has the same “encoder conditioning philosophy” and may host the same range of encoder daughter boards.

YAMS Encoder Daughter Boards

The purpose of the encoder boards is to adapt and/or condition the signals coming from the encoder to the inputs accepted by the DMC controller. Up to now we have developed three types of encoder boards, as shown in Fig. 4:

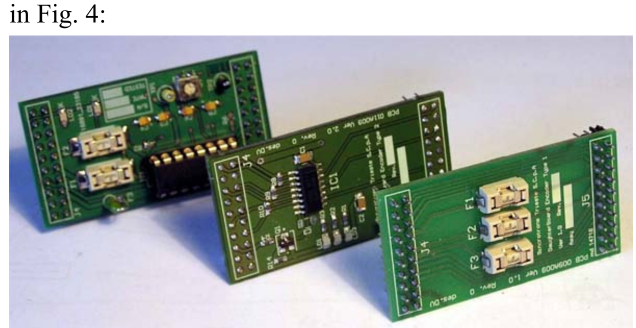

Figure 4: Encoders Boards.

- Type 1 encoder board: it just connects the external encoder connector to the internal signal buses. No conditioning is performed.
- Type 2 encoder board: it converts RS422 level balanced signals from digital sin/cos encoders to unbalanced signals.
- Type 3 encoder board: it accepts a 4-20mA analog signal and converts it to an internal voltage signal.

SOFTWARE DESCRIPTION

The DMC family controllers have their own communication and programming protocol and language, besides a good basic instruction set for motion control. So, if necessary, it is possible to add specific routines into the controller memory to improve the controller functionalities. These routines may be referred as "firmware".

A similar solution for motion control was also adopted by the SOLEIL synchrotron light source, participating with other partners, including Sincrotrone Trieste, to the Tango collaboration. They developed the software architecture and the first releases of the "galilbox-srv" and "galilaxis-srv" Tango device servers (Fig. 5). As a result, the YAMS project has inherited a considerable amount of knowledge and ready to re-use code, thus reducing the overall development time.

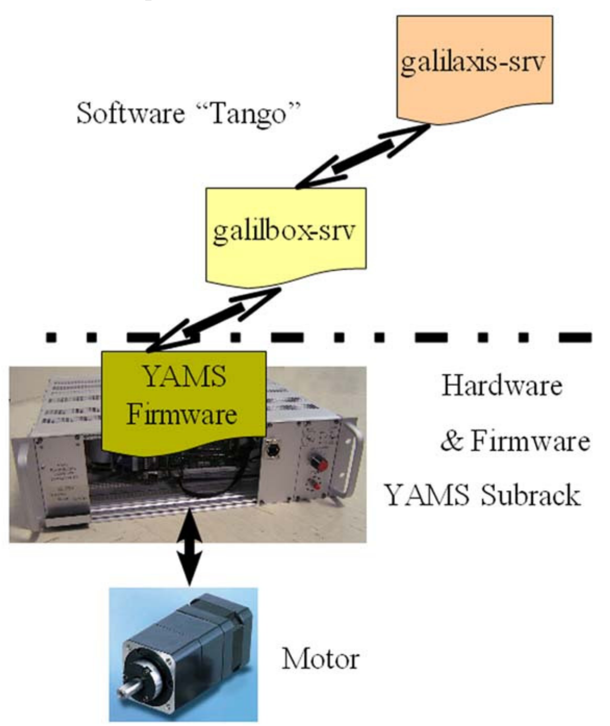

Figure 5: Hardware/Software Architecture.

Differences between SOLEIL and FERMI@Elettra in the modality the stepper controllers are employed, led us to modify both firmware and software from their initial releases. For instance, the FERMI@Elettra version is capable to read a potentiometric encoder, i.e. an analog sensor, and close on it the motion control loop.

FERMI INSTALLATIONS

In the whole facility, more than 400 axes will be eventually controlled by YAMS, using different phase currents, with or without brakes and with different encoder types, RS422 digital, potentiomentric and LVDT. The range of applications span from heavy duty ones (like the "bunch compressor" in Fig. 6), to high precision ones such as the photon spectrometer installed in the photon beam transport area (Fig. 7).

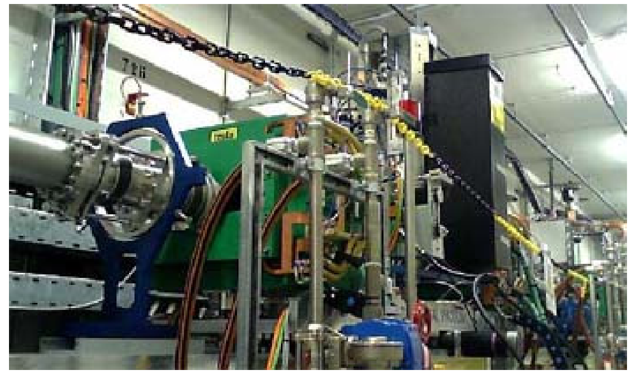

Figure 6: Bunch Compressor, an heavy duty installation.

Figure 7: Photon spectrometer, an high precision installation.

DEVELOPMENT

A new driver board is under development, it will adapt the YAMS bus interface to the old "Berger-Lahr" D450 (5 phase) and D920 (3 phase) stepping motor cards, thus confirming and realizing the "retro-fit" issue for the old installations in ELETTRA.

A piezo motor driver board and a 1Vpp analog encoder daughter board will soon be designed for beamlines and experimental chambers.

CONCLUSIONS

In this project, a significant reduction of the development time has been achieved, meanwhile maintaining costs at a reasonable low level. The "in depth" knowledge of all hardware and software components of this motion system allows to suggest the best solution for each motion request that arose during the design and installation. In the installations carried out up to now, YAMS has proved the good features of modularity and flexibility of this motion approach.

REFERENCES

[1] DMC-21x2/21x3 User Manual Galil Motion Control, Inc. http://www.galilmc.com.
[2] "PCB mounted microstepping drivers", IM481/483/805H IMS http://imshome.com.