

## SOFTWARE CONTROL FOR A MULTILAYER MONOCHROMATOR

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### Abstract

The EMBL is located at the DESY site in Hamburg and operates 5 beamlines at the DORIS III storage ring. Currently the EMBL Hamburg is in charge to build three new beamlines at the new PETRA III high-brilliance synchrotron radiation source which will start user operation in 2009. A new multilayer double-crystal monochromator has been developed in house. This project served as test application for the software and hardware architecture of the new PETRA III beamlines. An embedded-PC control the electronic integrated in the EtherCAT real-time Ethernet bus. Inside this PC, a logic of PLC's directly drives the hardware allowing real time data acquisition. The control of the system is distributed and remotely accessible by a connection to a TINE device server. During the commissioning phase a Labview TINE client application has been used. The client is able to perform on-the-fly scans, control and configure the motors of the instruments. In the following paper the different pieces of the system are presented and an overview of the instrument is given.

### INTRODUCTION

A focusing double multilayer monochromator (MLM) has been designed during 2007 by the EMBL-Hamburg Instrumentation group. The MLM has been installed and commissioned at a wiggler beamline (BW7A) at DORIS light source at DESY. The main advantage offered by the MLM optical system is its ability to reflect X-rays over a much wider energy range than perfect single crystal monochromators. At a 'white' synchrotron radiation source this is translated directly into a proportional gain in intensity. The first test measurements proved that the photon flux has been increased at the sample position by almost two orders of magnitude. The increase in intensity has reduced the exposure time by about one order of magnitude.

The instrument is composed by two substrates with an adjustable offset between 8 and 22 mm. The whole system is motorized with fifteen stepper motors, allowing many degrees of freedom (see Figure 1). Each range of movement is attached to its corresponding encoder system. Beam position monitor and slit system are also integrated.

The high scientific challenge needs an extendable, robust and distributed software/hardware architecture that can be applied also for future developments in particular the future PETRA III [1] beamlines developed by the EMBL-Hamburg.

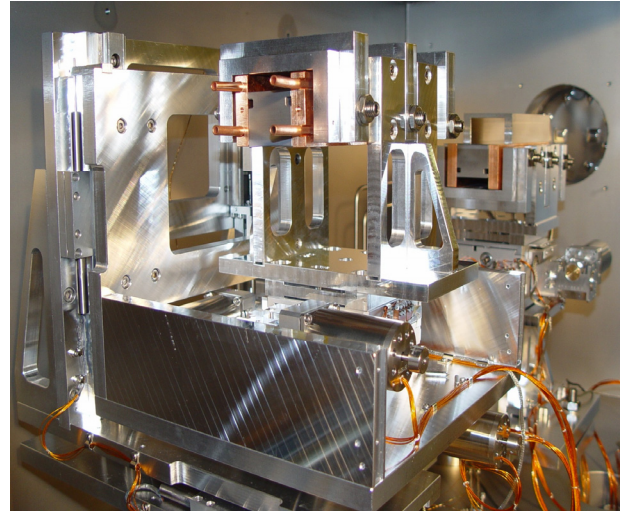


Figure 1: Multilayer monochromator installed in the vacuum vessel.

### SYSTEM DESCRIPTION

In the following section we present an overview of the different pieces needed for the instrument control and automation. This has been intended to be a practical demonstration of the control architecture [2] planned for the new PETRA III beamline. On one hand there is a low level layer that is responsible for the direct control of the hardware and on the other hand there is a higher level layer that distributes the system and connects with the graphical user interface (GUI).

#### Hardware overview

The main hardware components of the MLM are stepper motors, optical encoders, linear variable differential transformers (LVDT), potentiometers and the pin diode which measures the intensity of the beam. Each of these pieces is connected to an electronic driver provided by the company Beckhoff (Beckhoff Automation GmbH). In the case of the stepper motors a controller model KL2541 has been used which supports up to 64-fold microstepping and has a very low resonance thanks to the control current of 25 kHz. The optical encoders are directly connected to a counter (EL5101) and the rest of the signals are read as analogue inputs of 16 bits.

All the control hardware is interconnected through an EtherCAT [3] real-time Ethernet field bus, combined with an Industrial-Ethernet field bus. The field bus is based on a master-slave communication. An embedded PC is the master of the line and the electronic drives are the slaves.

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Each slave processes the received data packages on the fly, adding just a few nanoseconds of delay. Moreover, there are distributed clocks in every slave, synchronized by the master.

The embedded-PC runs a set of programmable logic controllers (PLC) in fast cycling and is the direct responsible for the hardware control. The PC has a CPU of 1,5 kHz, 1 Gbyte of RAM memory and runs a dedicated distribution of the operating system Windows CE 6.0 [4]. The running PLC system allows high frequency synchronization of the motors and the analogue signals. The main MLM PLC is set-up to run every millisecond.

*Software overview*

The next step is the connection of the low level layer with the control system. TINE has been selected as control system. This is a control system developed at DESY and also used for PETRA III [5]. It has also been introduced at some of the EMBL beamlines at DORIS.

A TINE server has been developed in order to command the low level PLC. The server also includes the alarm, archiving and logging functionality.

After developing the server, a GUI application has been created which is the only part of the instrument visible to the external user.

Thanks to the multi-programming language support of TINE, it was possible to choose between different options (C++, Java, VisualBasic, Matlab, and Labview). Labview 8.2 has been selected as the programming language of the GUI. During the commissioning many changes in the software and new functionalities have been added. It was essential to dispose of a flexible environment that allows fast prototyping but also robust final applications. Also, the experience about this programming tool available in-house made a fast development possible. A screen shot of the GUI is shown in the following figure (Figure 2).

The client is able not only to connect to the multilayer TINE server, but also to other existing servers that provide valuable data for the experiments.

The developed application is subdivided in the following tools:

- Motor controller application: responsible for the control of all motors and encoders. It allows making synchronized moves and also energy calculations. It provides monitoring of the parameters required for operating the multilayer.
- Motor configuration application: with this tool it is possible to configure the registers of the installed motors. It allows also saving and loading existing configurations.
- Scan application: this tool makes *step scans* and *on-the-fly* scans of the motors, encoders and intensity monitors. The results are presented in data sheets and in XY plots. It can generate reports of the scanned data and even has extra functions to publish the data as an html web page. The ordinary step scan logic is included in the client side. It performs a sequence of movements in intervals, recording the intensity signal in between and drawing a graph. The *on-the-fly* scan follows another concept with the logic introduced into the PLC layer: Every time a movement is started, the position and intensity information is recorded synchronously with high frequency by the PLC. At the end of the movement this information is transferred through the control system and displayed in the client plot. This is possible thanks to the synchronization between the PLC layer and the TINE client. This kind of scans is fast and has been very helpful during the commissioning of the MLM.

A simpler GUI version has been also developed for user operation. Here the complex functionality is not available. The user can only automatically tune energies and wavelengths, and perform afterwards an energy optimization thanks to an automatic on-the-fly scan.

**CONCLUSIONS**

The MLM has been commissioned and the first scientific results are already available. A major challenge in this project was the introduction of a new instrument control; a new field bus system has been tested and integrated with the TINE control system and with rich-client applications. This has provided valuable experience for the forthcoming developments.

A modular architecture has been implemented in the different software layers, so that it allows the reusability of many pieces of the system in future projects. Thanks to the flexibility of the system, it has been possible to add supplementary devices during the commissioning period. The instrument will be available for the user community in November 2008, running with the lighter version of the GUI.



Figure 2: Multilayer monochromator GUI.

## ACKNOWLEDGMENTS

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