Deutsches Elektronen-Synchrotron
DESY

Summer Student Programme 2010

Digital Monochromator Stabilizer (MOSTAB)

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Hamburg, 2010

1 Abstract

During my training and working at DESY the main my goal was to create the hardware, firmware and software for the digital monochromator stabilizer to replace its old analog version at beamline D3 at DORIS III, HASYLAB, which is using at other beamlines too.

2 Introduction

The monochromator using to filter the "white" synchrotron radiation usually based on Bragg reflection from crystals of Si(111) or Si (333). In low-energy experiments usually is used a double crystal monochromator (DCM), which consists of two mirrors (Fig.1).

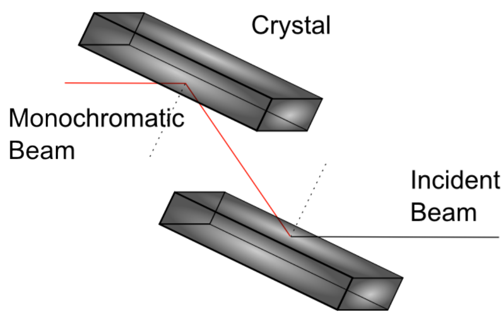

Figure 1: Double Crystal Monochromator (www.desy.de)

Output wavelength is changing by its rotating. This mirrors are moving by stepper motors. They must be always parallel to each other, because the polarization of synchrotron radiation is linear only in the orbit plane. Also not parallel positioning of the mirrors leads to wavelength shifting of the output beam. That is why in DCM additional position controlling by piezo actuators is using. Because of continuously changing of properties of the synchrotron radiation the feedback for this piezo actuators is needed. Usually in beamlines is using the special analog device named Monochromator Stabilizer (MOSTAB).

3 Principle of working

Dependence of output intensity from the incident angle is illustrated on Fig.2. This dependence has the maximum when the two crystals are parallel. MOSTAB always controls the detuning angle using the piezo to maximize the output intensity. However staying in the maximum of intensity is not useful because when this maximum is shifting during an experiment direction of this shifting is unknown and it needs to some additional piezo detuning to detect the direction of detuning and only then to maximize the intensity. More useful is to stabilize the output intensity not in the maximum, but near to it. Usually in the left edge of this maximum (point A), because some additional 2nd harmonic's peak can be available close to the right edge. In this case of the stabilization it is always obvious to detect the direction of a shifting.

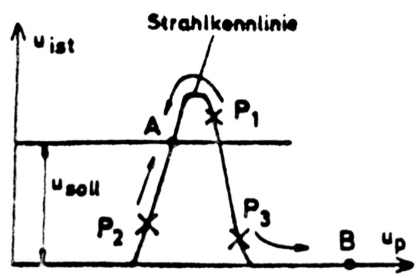

Figure 2: Intensity-detuning graph (MOSTAB documentation)

However intensity of the synchrotron radiation in DORIS III is always changing, therefore the intensity of monochromatic beam must be changing in the same way as incident. On this account not the output intensity should be constant but the ratio of intensities of incident and monochromatic beams.

Figure 3: Foto of analog MOSTAB

4 Digital MOSTAB

The block scheme of the device is illustrated at Fig 4.
Digital version of the MOSTAB is based on 8-bit AVR Microcontroller AT90CAN128. For receiving of intensity values of incident and monochromatic beams external 14-bit ADCs LTC1418 were used. Their maximum sampling frequency is 200ksps. For piezo driving external 14-bit DAC AD7840 was used. Its maximum sampling frequency is approximately the same as ADCs'. Parallel interface was used to communicate between ADCs and DAC. Special communication protocol was developed, which difference from SPI is that all data transceiving take a place in one pocket. Thus receiving of two 14-bit words and sending of one 14-bit word need about 5μs, when SPI needs about 15μs.
The microcontroller send information and receive commands from PC via USB with a help of USB Node controller USBN9604.

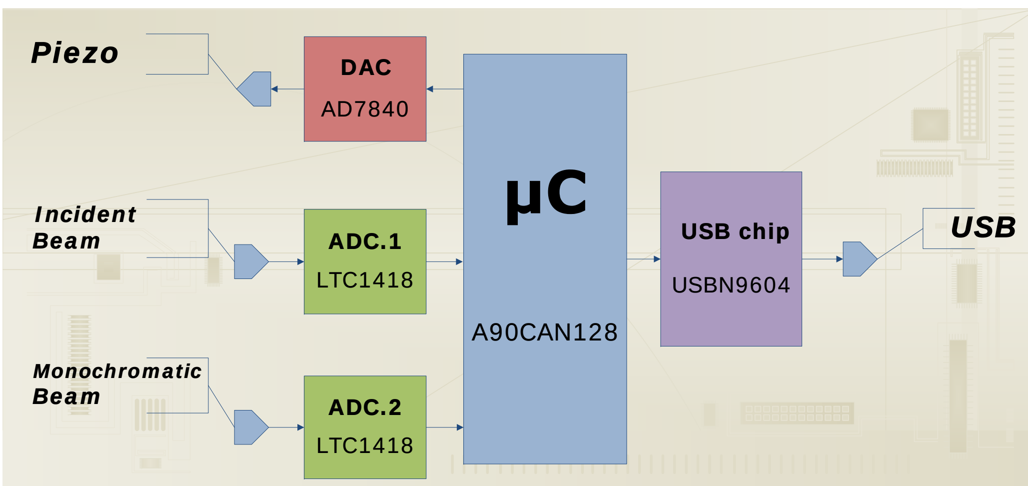

Figure 4: Block scheme of the digital MOSTAB

The firmware is working with fixed time duration cycles. At the beginning of this cycles data exchange with ADC's and DAC's takes a place. Then some calculations for piezo adjustments are making. After that the microcontroller communicates with PC via USB. Commands from PS are writing to the linked list, therefore if there is no time to process all commands in one cycle, the will be processed in the next cycle.

5 Summary

From the list of originally planned goals were realized:

- developing and designing of the MOSTAB's hardware for its using in NIM-module;
- developing of the basic firmware for microcontroller for autonomous real-time data analyzing, using of linked lists and communicating with PC;
- developing of the basic software for Linux OS for command sending and data transcieving via USB.

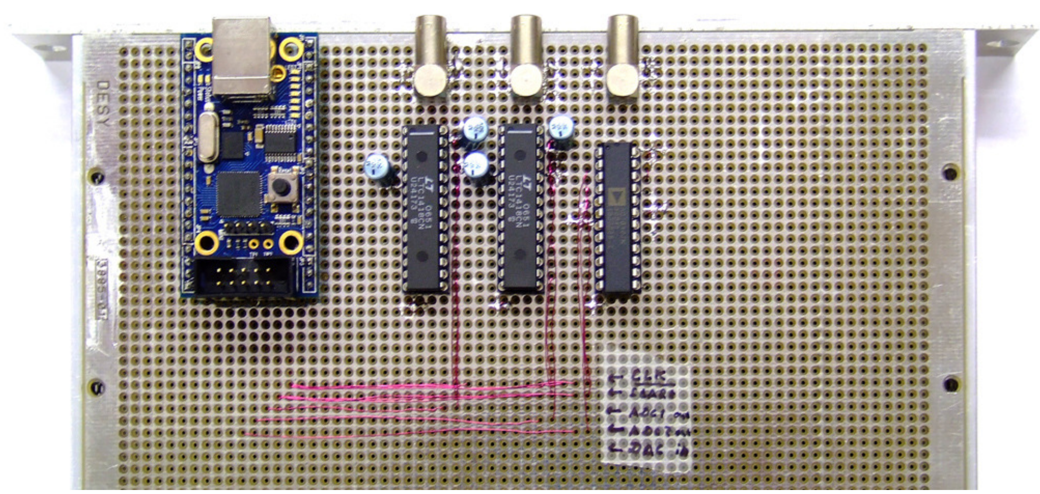

Figure 5: Foto of the digital MOSTAB's board with mounted microcontroller, ADC's, DAC and connectors