

Remote Software of Double Crystal Monochromator for ADXRD Beamline

Priya Tiwari¹, Amit Mittal², S.R. Kane³

^{1,2}Institute of Engineering and Technology, Devi Ahilya Vishwavidyalaya, Indore-452017 (India)

³Indus Synchrotrons Utilization Division, Raja Ramanna Centre for Advanced Technology, Indore-452013.

Email: tiwaripriya013@gmail.com

Abstract: Double crystal Monochromator (DCM) is used for getting monochromatic beam from the synchrotron radiation. In order to get the specified energy out of DCM, various motors are used to move the X-ray mirrors. Movements of these motors are controlled by a dedicated PC along with its software. The provided software along with DCM was controlling its parameters locally. There was no provision to control or modify the motor movement parameters remotely. As the number of users for ADXRD beamline at BL-12 is increasing and the type of experiments they are preferring to perform by using DCM has demanded the DCM software to be controlled remotely. The software has been developed using Windows based Agilent VEE.

Keywords-Double crystal Monochromator, X-ray Synchrotron, ADXRD Beamline, Agilent VEE

I. Introduction

Angle Dispersive X-ray Diffraction Beamline (ADXRD) is a hard X-ray beamline [1] which is located on BL-12 at INDUS-2 synchrotron source at Raja Ramanna Center for Advanced Technology (RRCAT), Indore. Double crystal Monochromator [2] is an element of this beamline which is selecting a monochromatic beam for photon energy from the synchrotron radiation. Monochromator has two parallel crystals (called as C2-T1 and C2-T2 in the software) which are aligned to focus a monochromatic beam on fixed exit point. There are 10 motors for different mirror movements which are controlled by the software. The software is developed using Agilent VEE. Agilent VEE [3] program is graphical and user friendly on windows platform which provides quick analysis of data. The software controls and monitors the parameters of DCM. The newly developed software removes all anomalies of old software. The software can achieve 0.1eV step in motor movement. There is an option to find the energy of DCM whenever software is executed and also provision to control the DCM remotely which were not available in the previous system.

Features:

The newer version of software provides following salient features to beamline users so that they can get energy spectrum easily. Features are:

- i. No need to calculate the number of steps to be moved by the specific motors for the specified energy range span. As

this had to be done in the previously used software by the user.

- ii. Two modes of operation of DCM (1) Local (2) Remote are provided. Mode can be changed by the toggle switch provided in the front panel of the software.
- iii. In Local mode the functionality of the software is similar to the previous version. In the Remote mode the energy can be set from any software over TCP/IP .Whenever there is a change in the set energy value then only the movement of DCM takes place.
- iv. A new feature is added which informs the user about the energy of DCM during the execution of software or any energy movement taking place either locally or remotely.
- v. The DCM control PC is configured as Master and other PC as client. Only one connection at a time is permitted. With these features a beamline user can perform his experiments efficiently.

II. Design and Implementation

Double Crystal Monochromator has two parallel Si111 crystals which produces a monochromatic beam to fixed exit point. The energy range of beam is selectable from 5keV to 25keV at ADXRD beamline-12 at RRCAT synchrotron source. The lowest energy (5keV) of beam passed in monochromator is decided by Beryllium window and the higher energy is decided by critical angle, so 5keV to 25keV is fixed. All the motor parameters such as encoder, lattice, and position of motors are saved as configuration file and crystal parameters such as step factor, offset are saved as another configuration file. These two scan configuration files are used for calculating the status of DCM energy and for moving the DCM to the new position.

A mathematical formula has been coded and implemented by using these parameters in the software as mentioned below in figure-1.

For calculating the DCM energy

$$Energy = \frac{h * c * 6.24 * 10^{18}}{\sin(bragg) * 2 * scancon fig. Lattice} \text{-----(1)}$$

Where h is Planck constant; c is velocity of light and scanconfig.Lattice defines the lattice of motor which is in configuration file.

$$bragg = \frac{motion[0].Pos}{stepfactor} - scanconfig.C1Roffset \quad \text{--- (2)}$$

In above equation (2), motion[0].Pos defines the encoder value of motor 0. Scanconfig.C1Roffset defines the value of offset if any for C1-R motion. Offset is a distance between mirrors.

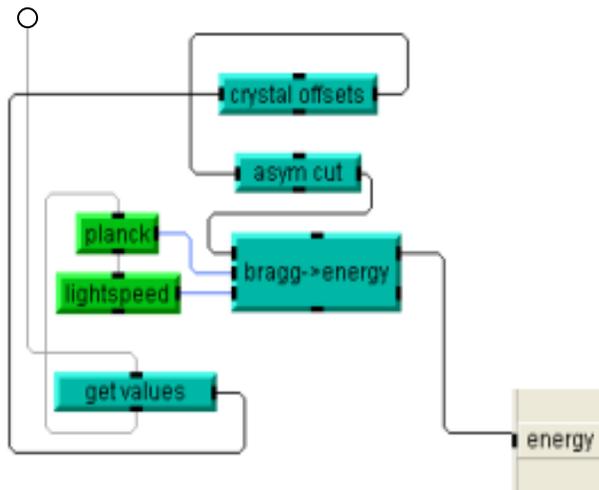


Fig.1: Calculation of actual energy

The value of crystal-offset has been taken from scan configuration file. Asymmetric cut is zero because the DCM is configured for symmetric cut only, at ADXRD beamline. The value of Planck's constant and speed of light are universally defined. In the first stage, software calculates the value of bragg angle by using equation (2) and pass to the next stage for calculating the energy. In the last stage software gets the calculated energy and position of motors (i.e. C1-R, C2-T1 (1st crystal) and C2-T2 (2nd crystal)) to be moved.

Remote communication has been implemented in the software as per the requirement of user, which was not available in the default software along with the DCM. For remote communication, DCM PC is configured as a server which has been developed by using Agilent VEE. The control PC acts as a client, the client side software can be implemented in any language. In our case client software is developed using LabVIEW. Hence both the software perform cross language independent communication. For remote communication TCP/IP protocol has been used as it is a connection oriented protocol and it performs communication among computers over the LAN. There are various characteristics of TCP/IP which includes point to point communication, reliability, platform independency and it performs communication in full duplex mode without occurrence of any congestion that is why TCP/IP is used for remote communication in DCM software. In the

software, the server and the client PC are on the same network for performing connection.

For the remote access with the client PC, the toggle switch has been provided in the front panel of the server side software. By default the switch is in local mode and remote mode is disabled. User has to toggle a switch on the server to activate the remote link. Once the link is established then user can send instructions remotely. The set of instructions "GE" and "SE" are executed to get the present energy of the DCM and to set the DCM for user defined energy respectively. If a client wants to define the energy of DCM remotely then the client sends energy with "SE" to server via TCP/IP. The server first checks the two initial characters of the command string if they are "SE" then fetches the associated energy value and then automatically goes on to the calculation stage and start the motor movements corresponding to desired energy. The different possible test cases are mentioned below which have been occurred at run time.

- i. Defining energy by "SE" command executes the motor movements on the server; till it reaches the desired energy. No new command can be executed from any side.
- ii. If the user sets energy less or more than the DCM prescribed energy level i.e. 5000-25000eV then no action is taken by the software.
- iii. At each consecutive transactions energy value must be different. If same value is sent for consecutive transactions then the server does not perform any movement.
- iv. If a client sends a blank string then the server will read the earlier energy and it transfers the earlier energy on motor continuously.
- v. The length of string (i.e. 11) is fixed on the client side as well as on the server side. If the length of the string exceeds than the specified size then extra characters are dropped on both the sides. If the length of the string is less than the specified size then extra zeros are appended by software itself.
- vi. Synchronization of time is a major concern factor for remote communication. It is achieved by keeping the same timeout on server and client.

III. Graphical User Interface

Graphical user interface (GUI) of software of Server PC and Client PC are showing in following figure2 and figure 3. In the mentioned below figure2, the DCM Control server is showing the status of energy, movement (absolute motion and relative motion) of motors during the execution of software and actual energy after the execution of software. In the GUI, the provided toggle switch has a blue status light which signifies the establishment of a connection with the remote PC.

Server:

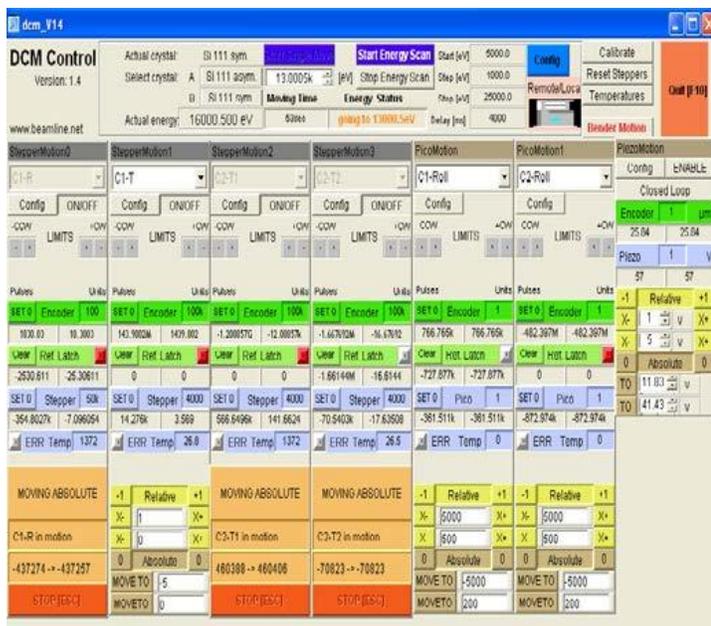


Fig. 2: DCM Control in Remote mode

Client:



Fig.3 DCM Client

The Graphical User Interface of client PC is developed using LabVIEW [4] to monitor and change the value of energy for DCM. In the GUI, the Boolean switch is used to set the energy value of DCM.

IV. Result

The newly developed DCM control system has enhanced features for beamline user. In the old version, the user has to maintain number of data points (i.e. Energy in eV) in excel sheet for performing the movement of motors, which

is a very time consuming process also it was very difficult for the user to maintain an excel sheet for every energy scan. The disadvantage of this process is that the user has to call an excel sheet for a particular range which depends on size of the step (different sheet for 1 eV, 0.1eV or 2eV step size and so on). Another disadvantage of old software was that the user could not get energy which has been executed after performing all movements of DCM System. Cause of those drawbacks user gets less accurate result of a scientific experiment. The newer version of the DCM control system removed all drawbacks of existing systems.

The DCM control system version 8.5 provides facility to move energy even for a small step size of 0.1eV. An encoder provides 0.01 arc resolutions for movements of crystal which has been tested theoretically as well as practically.

The newer software has two modes, i.e. local and remote for performing motor movements either locally or remotely. Now user can control the software from outside the experimental station and get an accurate result of experiment without any delay. In the case of remote mode, users can communicate from any software language over TCP/IP which has been verified by us.

The software also provides calculated energy after performing all operations of DCM so that the user can see status of DCM after the execution of software.

V. Conclusion

DCM control system has reduced time complexity. It has enhanced features as compared to the previous version. The DCM control software uses publish and subscribe technique to communicate between two computers. Due to remote facility, this software may be used for performing energy scan with different sets of instruments in a close loop fashion.

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