DEFLECTOR POWER SUPPLY CONTROL FOR ROOM TEMPERATURE CYCLOTRON

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Abstract

During the modernization of room temperature cyclotron, the control of the high voltage electrostatic deflector, required for beam extraction, has been rejuvenated using Experimental Physics and Industrial Control System (EPICS).The controlling criteria to condition the deflector after air admission and the operation during beam tuning have been described in this paper. The difficulties faced during the development of control for high voltage system and its solutions are also mentioned.

INTRODUCTION

The extraction system of room temperature cyclotron, called deflector, consists of four 'inconel' electrodes, two being ground electrodes and two are high voltage electrodes separated from each other, however, the exit side high voltage electrode is not in use. This deflector is used for extracting the accelerated beam from the final orbit of the cyclotron and guides it to the external beam line. A high voltage power supply with serial interface has been imported and installed for providing the high voltage bias across the electrode and septum as shown in Figure 1. The details of power supply, control logic, development of computer control and its advantages have been described in the subsequent sections.

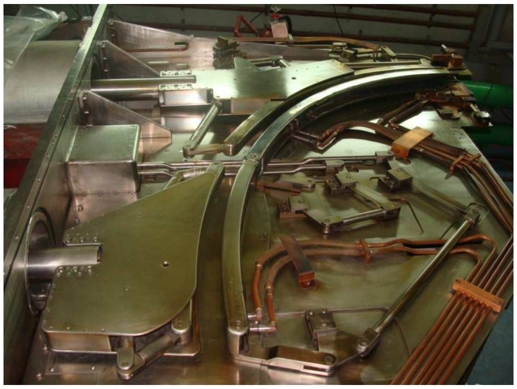

Figure 1: Deflector electrodes.

SYSTEM COMPONENTS

The overall system for deflector conditioning and operation comprises of a high voltage power supply, low voltage instrumentation interface and EPICS based computer control.

Power Supply

A High Voltage Power Supply (HVPS), rated 120kV/600 μA, 0.005% line regulation is installed in the vault, adjacent to the cyclotron for biasing the deflectors. The power supply can operate in both constant current (CC) and constant voltage (CV) modes. The current limit is defined inside the power supply and it operates in CV mode till it reaches that limit. The power supply and the deflector electrodes are protected against damage due to arcing by a high voltage series resistor as per Figure 2. The vacuum, door and water interlocks are connected with the main power of the power supply for safety purpose.

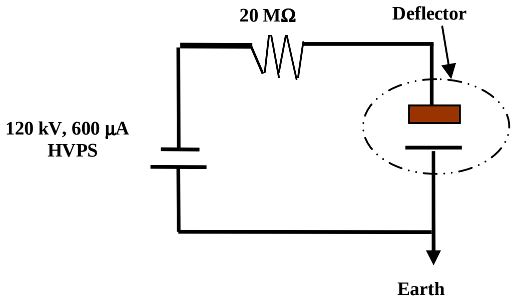

Figure 2: Deflector power supply Connection.

Controlling devices and software

A Pentium-IV PC, operated in Linux environment, is used as EPICS Input output Controller (IOC) and placed in a control rack near the power supply. A Serial to Ethernet Converter in the same rack interfaces the power supply over RS232 link. The converter, connected in the control LAN, communicates with the IOC through device driver. The EPICS IOC consists of the device driver, database and channel access server as shown in Figure 3.

The device driver, consisting of the communication protocol, similar to the ASCII Modbus, is developed using EPICS "asyn" module and all raw data transaction with the power supply is done here.

The conditioning and operation logic has been implemented inside EPICS database.

The Channel Access (CA) server communicates with the graphical user interface developed using MEDM in windows platform, as shown in Figure 4.

The CA server uses client/server and publish/subscribe protocol to communicate with the client located at control console.

The IOC restarts automatically after booting in Linux with the help of a start up script. It facilitates remote restart of the deflector IOC over secure shell connection from the control room.

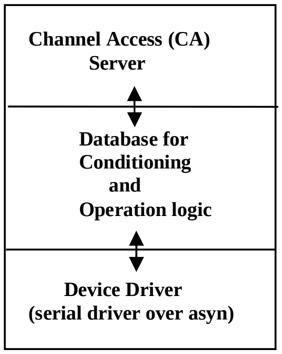

Figure 3: Deflector IOC.

CONTROL LOGIC

Conditioning during maintenance and operation during beam tuning are the two modes of control with the deflector system. The conditioning is required at the initial stage just after the mechanical fabrication and each time after the deflector is exposed to air. The conditioning is done by controlled linear up/down ramping of the high voltage. Whenever the total deflector current crosses the user defined limit, the power supply ramps down till the current drops below the set limit. At that point the ramp up operation starts automatically towards the desired voltage level following the same ramp down logic described earlier. This process is repetitive and continues till it reaches the desired high voltage.

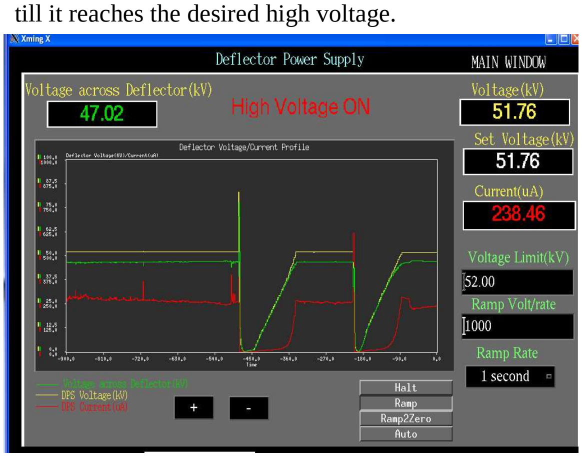

Figure 4: Deflector control Graphical Interface.

Once the conditioning is over, the deflector is ready to withstand and maintain the desired high voltage. In operation mode, exponential ramping is adopted to increase the beam time. Since the deflector is connected with the power supply with a series resistor, the voltage across the electrode will depend upon the total current. As the “beam on” time and beam stability are sacrificed during random variation of the total deflector current, it is not desirable to allow such current variation. It has been observed that the current varies drastically during operation whenever there is a contamination after small spark. This contamination is not removed till the high voltage is withdrawn. As a solution, the deflector is programmed to quickly ramp down to zero when it passes the user defined operating current limit. It stays there for a defined time to let the vacuum system to extract those contaminants and after that the deflector ramps up to regain the target voltage for beam extraction without any human intervention.

DIFFICULTIES

The communication failure due to ground loop formation over RS232 link and damages of the communicating devices due to high voltage surges during deflector sparks are the major problems while working with high voltage devices. The optical isolation can break the ground loop. However, an optical isolator can generally withstand a few kV and will not guarantee to protect the devices from high surges. The most universal approach of the high voltage surge protection is to use the three stage devices with gas discharge tube in the first stage, transorbs and metal oxide varistors in the consecutive stages [1].

ADVANTAGES

The advantages of using computer control are obvious as all the parameters of the operations can be changed online. The graphical representation and multi parameter comparison facility is useful to judge the health of the deflector. One example and important observation of such diagnosis is the findings of the oil contamination from one of the diffusion pumps.

CONCLUSION

As the conditioning and operation logic is incorporated in the EPICS database file, it is difficult to debug the existing logic or include additional logic. It has been decided to use sequencer in future for logic development.

The interlocks are presently connected with the input supply of the deflector power supply, forcing a complete shut down during trips thereby necessitates a re-initialization of the IOC. These will be changed in future and connected with the HV on/off to make the control logic alive all the time.

ACKNOWLEDGMENT

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REFERENCES

[1] High Voltage power Supply reference manual, http://www.spellmanhv.com/