

FIBRE OPTIC CONTROL FOR ELECTRON GUN POWER SUPPLIES AND DATA ACQUISITION OF 3MEV DC ACCELERATOR

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Abstract

A 3 MeV, 10mA DC Industrial Electron Beam Accelerator is being commissioned at Electron Beam Centre, Navi Mumbai. The electron beam is generated by a triode electron gun and injected into the accelerating column at 5 keV. The gun and its power supplies, (5kV anode, 3kV grid and 15V/20A filament), are floating at 3 Million volts, and are situated in a tank which is pressurized with SF₆ at 6kg/cm². These power supplies are required to be controlled remotely. The various accelerator parameters like Beam Energy, Beam Current, RF Electrode Voltage, Power Oscillator Plate Voltage / Current and Vacuum are required to be monitored during beam operation, The software was developed in VB.Net for control and data acquisition. The database is provided in SQL 2005 for storing the data. For this purpose, control system using ADAM modules and Optical fibre has been designed and developed. This paper describes the design features of the control system and experience of use of control software during initial beam trials.

INTRODUCTION

A 3 MeV, 10mA DC Industrial Electron Beam Accelerator [1] is being developed at Electron Beam Centre, Navi Mumbai. During initial beam trial, the tank was pressurised with nitrogen at 6kg/cm² and dome voltage was increased in the steps of 100kV to 1MV. At around 450kV dome voltage Fibre Optic link was activated after which the dome power supplies can be controlled remotely. After reaching 1MV on the dome, Anode voltage of electron gun was excited and slowly filament power was raised in steps to 95W, taking into consideration the vacuum level. If vacuum deteriorates the filament power was kept stable and after improvement in the vacuum, Filament power was further increased. During this process continuous monitoring and data logging of the accelerator parameter was done.

CONTROL SYSTEM PHILOSOPHY

One set of ADAM control modules is situated inside the pressure vessel, at the dome floating at 3 MV. The other set of ADAM modules is placed at ground potential at the bottom of the pressure vessel. The distance between module floating at 3 MV and the module at ground potential is ~3.8 metres. Communication between the two sets of modules is through optical fibre. The module at ground potential converts RS-485 signal to optical signal. These signals are then transmitted to the PC. Other set of hardware using Moxa Ethernet to 4 Port RS-232/RS-485 converter is used to acquire the Accelerator parameter and

Vacuum. For transferring the dome power supplies data from power supply room to control room, socket program feature was introduced. Software was developed in VB.NET 2005 using Serial Port class.

DESIGN ASPECTS

For fiber optic control the design of the system is based on Advantech make ADAM modules. ADAM 4017+ (Analog Input Module) and ADAM 4024(Analog Output Module) [2] are used for data acquisition and control of power supplies in the dome. In addition, thermocouple module ADAM 4018+ is used for monitoring temperature at various locations in the dome. All these modules communicate over RS-485 network to control and acquire the data of power supplies. Signals from the above ADAM modules are fed to ADAM 4541, which then converts RS-485 signals to Fibre Optic signals. The signals are then transmitted via the fibre optic cable to the lower set of modules, where they are converted to RS-485 signals. These signals, taken out of the pressure vessel via suitable ceramic feedthroughs, are transmitted to PC for control and display, via RS485 to RS232 converter. For acquiring the various parameter of the accelerator MOXA make Ethernet to 4-Port RS-232 converter is used. One port of RS – 232 is used for Vacuum Controller to read the vacuum in the accelerating tube and scan horn area. Another port is used for communicating with Two Analog Input (AI) ADAM module are used for acquiring the various accelerator parameters.

Details of Software

VB.Net 2005 (.NET Framework 2.0) [4] is used for developing software for control and GUI of dome power supplies, shown in Fig.1. The SerialPort class is used to access the gain of RS-232 port of the PC for communication with the control modules. To access a COM port, the designed application creates a SerialPort object, sets the communication parameters and opens a connection to the port. Once the port is open, read and write operations to the port can be performed. To access a particular module in the dome the command needs to be sent in appropriate format i.e. starting character, module address, data and the End of String Character. To change the output of any power supply the command is sent to the analog output 4024 module. To read back the output of each power supply and to get the temperature of various locations in the dome, commands are sent to 4017+ and 4018+ modules respectively. Two ADAM 4017+ AI modules are used for acquiring the accelerator parameters. Proper query was sent to AI modules and parameter was acquired. For vacuum data appropriate

query was sent to the vacuum controller and data was received.

Data is refreshed every 1sec. Database is developed in SQL Server 2005 for storing the data. The table was designed to store all the required data of the dome power supplies, accelerator parameter, vacuum along with time and date. To view the data, user selects the date for the data required and the data of that particular date is displayed in the Dataview Control. The option of storing the data at various time intervals has been provided.

Additional feature like Beep audio signal and blinking of the error message during the failure of fibre optic link is provided for immediate attention of the operator.

Details of Socket Programming

Two separate modules Server and Client were developed. In server program, a socket is created which is bound local port by socket.BIND () method. Then this socket is put in listen mode by socket.LISTEN () method for listening to the incoming request from the clients. The client program sends the request command to the server using CONNECT (IP Address, Port Number) method with server IP Address (192.168.0.8) and Port number (8000) mentioned in the method. Server accepts the connection and sends the acknowledgment signal to the client after establishing the connection. Once the connection is established server and client can transfer data using Write () & Read () command. TCP/IP protocol is being used for transferring the data from server to client on Ethernet.

Details of ADAM Modules

ADAM-4017+ is a 16-bit, 8-channel analog input module that provides programmable input ranges on all channels. Its opto-isolated inputs provide 3000 VDC of isolation between the analog input and the module, and protect the module and peripherals from damaging due to high input line voltages. It offers signal conditioning, A/D conversion, ranging and RS-485 digital communication functions [2].

When prompted by the host computer, the module sends the data to the host through a standard RS-485 interface. It has eight differential channels with multiple input ranges starting from $\pm 150\text{mV}$ to maximum of $\pm 10\text{V}$. It has expanded capability to accept 4 - 20 mA input value for various other applications.

ADAM-4018+ is an 8-channel T/C input module. It enables eight differential channels with multiple input types. Various thermocouples like J, K, T, E, R, S and B are accepted by the module. It is used for monitoring temperature at various locations in the dome.

ADAM-4024 is a 4-channel analog output module. It provides multi-range AO support and has four A/O channels working at the same time with different and more output ranges. Output ranges can be configured to current (0-20mA or 4-20mA) or Voltage ($\pm 10\text{V}$) as per the requirement. By varying the output voltage of the ADAM module from 0-10V, output voltage of

corresponding power supply can be changed from minimum to maximum.

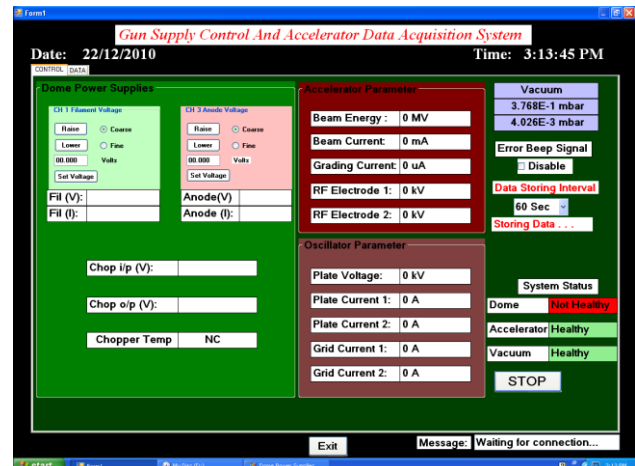


Figure 1: GUI for control of 3 MeV Dome Power supplies

TECHNOLOGICAL CHALLENGES

During initial beam trials at 1MV many sparking occurred due to which many components of the dome power supplies failed. Also the Input Output channels of ADAM modules were damaged. To protect the I/O Channels of ADAM AD202 Isolation Amplifier based protection circuit was designed and developed. It provides 2kV DC isolation between channel to channel. Also proper high voltage surge protection circuit were designed and implemented in the input of the dome power supplies for protection.

TESTS

Each module was tested individually for its performance with simulated inputs. The control system was then integrated with the power supplies and tested with PC control. High voltage tests were conducted on the optical fibre to determine its dielectric strength and hence the length required to withstand 3 MV. For studying the behaviour in high pressure, the modules were placed in a pressurized test chamber at 6kg/cm^2 . The software was extensively used during High voltage conditioning and beam trial. The Maximum power of 7kW of beam power was extracted at 1MV dome voltage.

CONCLUSION

The development of the above described control system is complete and installed in 3 MeV dome. The communication is being successfully implemented. Control of all these power supplies is being done remotely through PC. All the accelerator parameters and vacuum details are stored in database.

REFERENCES

- [1] K.C.Mittal, "Accelerators at Electron Beam Centre, Kharghar," Proc. InPAC 2006, p.98-101.
- [2] ADAM 4000 Series, Data Acquisition Modules, p 3-27 – 3-36.