BASIC DESIGN OF CONTROL SYSTEM FOR IPM LINEAR ACCELERATOR

S. Haghtalab† F. Abbasi Davani, Shahid Beheshti University Radiation Application Depament, Tehran, Iran
F. Ghasemi, Nuclear Science and Technology Research Institute (NSTRI), Tehran, Iran
M. Lamehi Raschti, School of Particles and Accelerators, IPM, Tehran, Iran
M. Jafarzadeh, Iranian Light Source Facility (ILSF), Tehran, Iran

Abstract

A control system has been designed for the commissioning of 10 MeV linear accelerator which is under construction in institute for research in fundamental science (IPM). The IPM e-Linac is a traveling wave accelerator consisting of 62 components in five major sections: control and safety, beam injection, radio frequency production and transmission, acceleration tube and target. The existence of a central control system for controlling and monitoring all parts of the machine is necessary. The aim of the system design is to implement a fast and reliable control system which is easy to operate and extensible for future upgrades and improvements. For this purpose, EPICS has been chosen as the main environment due to high performance and distributed structure. In this system, Siemens PLC is used as EPICS IOC and graphical designs will performed by CSS and WinCC. In this study, first we present a brief description of the IPM electron linear accelerator, and then architecture of the control system will be discussed.

INTRODUCTION TO IPM LINAC

Design and development of an electron linear accelerator is in progress in institute for research and fundamental sciences (IPM). This machine is a traveling wave accelerator consisting of 62 components in five major sections as shown in Figure 1: Control and safety (C & S), Beam injection (I), Radio frequency production and transmission (R), Acceleration tube and target (A). The main parameters of the machine are given in Table 1.[1]

Table 1: e-Linac Parameters

Parameter	Value
Beam Energy	10 MeV
RF operating frequency	2997 MHz
Max. Beam current	10 mA
Pulse Repetition Frequency (PRF)	250 Hz
Injection energy	45 keV
Pulse width	10 µs

The thermionic electron gun of this accelerator is a triode type. The cathode and grid voltage is in -45 kV and the anode voltage is set to zero. Thus, the output electrons have energy of 45 keV. Right after electron gun, there is pre-buncher which consists of a cavity. Accelerating tube lies after the pre-buncher. The accelerating section of this accelerator consists of three components: accelerating tube, buncher and the couplers.[2] An S-band pulsed klystron operating at 2998 MHz produces 2.5 MW RF power. In cooling system, there are one chiller, pumps, and pipes which surrounded the tube and keep that in a constant temperature by flow of water. All the accelerating section operates in pressure of 10-6 mbar from atmospheric pressure. This vacuum will obtain by rotary and diffusion pumps.

CONTROL SYSTEM ARCHITECTURE

Figure 2 shows the intended control system configuration, including the main blocks of IPM-Linac control system.[3] The aim of the system design is to create a fast and reliable control system which is easy to operate and extensible for future upgrades and improvements. For this purpose, Experimental Physics and Industrial Control System (EPICS) has been chosen. It has been used in many accelerator laboratories to design the control system of accelerator under a unified architecture for better reliability, integrity and security of the overall control system of an accelerator.[4]

For controlling the field level instruments, S7-300 PLC supplied by Siemens has been adopted for its wide variety of I/O modules, reliability, compact size and long product lifetime. Since some of the field equipments are connected directly to the PLC's I/O modules, others (like vacuum meters and valve controllers etc.) are connected via serial lines RS-232. S7plc has been used as EPICS driver that implements communication with Siemens PLCs for the EPICS IOCs supporting all PV record types. S7plc periodically receives a data buffer from the PLC to update all the input PVs mapped on this buffer. Similarly, it sends the output buffer to PLC when any of the output PVs change.[5]

Main communication protocols for intended control system are TCP/IP, RS232 and RS485 which backbone will be composed of fast Ethernet switch and TCP/IP to RS232 or TCP/IP to RS485 converters that introduce the connection of serial port devices to main control system.

THE INTERLOCK SYSTEM

The interlock actions for the machine protection will be assured by a mixed system made up of hard-wired devices and Programmable Logic Controllers (PLC). The interlock logic is structured in four hierarchical levels and

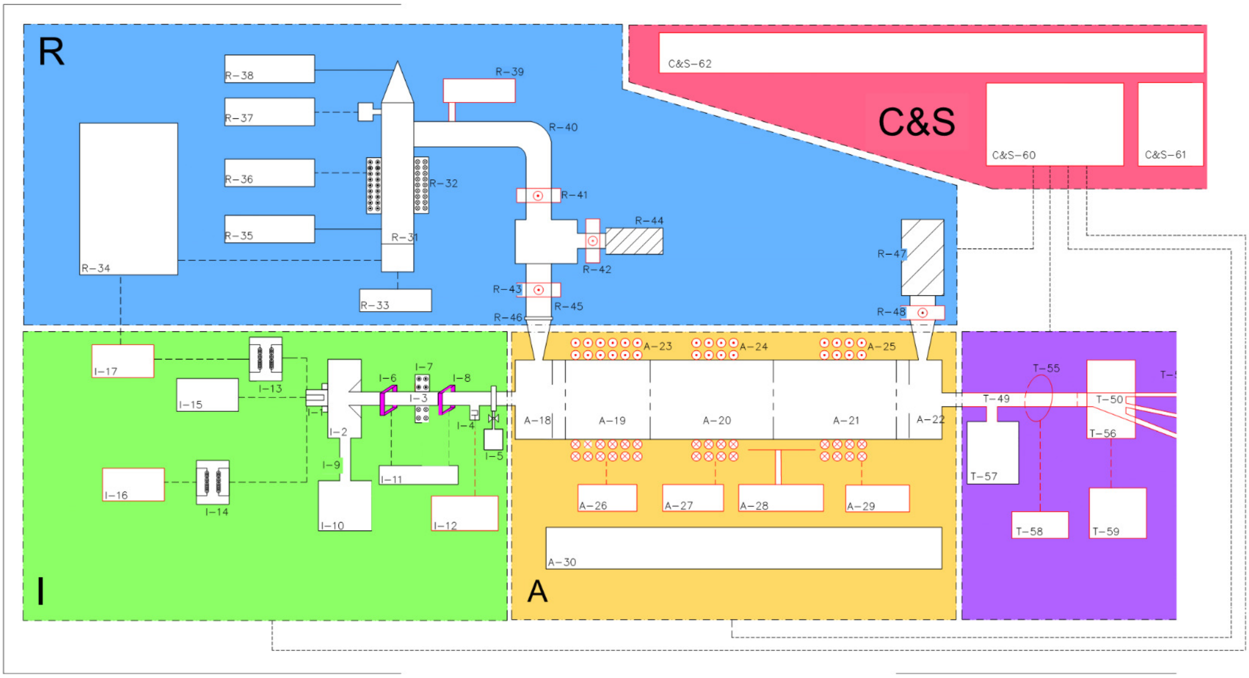

Figure 1: IPM e-Linac configuration.

defines a sequence of enabling signals for the klystron filaments, high voltage, radio frequency, etc. Most of the inputs are digital signals but in some cases analogue signals can generate interlock events whenever a given threshold is exceeded; dedicated comparator boards are foreseen for this purpose.

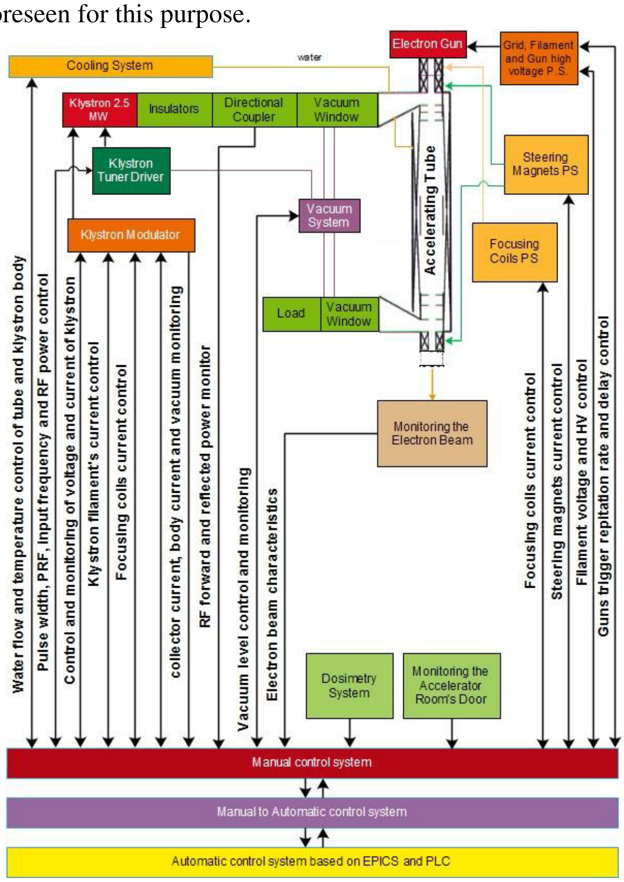

Figure 2: IPM e-Linac control system configuration.

E-GUN TEST STAND CONTROL VIA WINCC

Since EPICS is being used for the first time and due to relatively long development process; in order to not to interrupt rest of the test stand studies, an alternative control system based on WinCC has been created. WinCC has been chosen because of its good integration with S7 PLC's. also, WinCC is being used widely in industrial automation and Supervisory Control And Data Acquisition (SCADA) systems. This system is capable of producing and controlling the electron beam which consists of 4 power supplies for steering magnets, one power supply for filament, a vacuum gauge, a high voltage power supply and an oscilloscope connected to faraday cap. All the devices (except power supplies) are connected to PLC via RS232-TCP/IP converter. Power Supplies for Steering magnets and gun filament are connected to PLC's I/O modules directly. PLC sends the SetPoint voltage and reads the output current with AI and AO modules.

CONCLUSION

Design and development of IPM Linac control system is in progress. Our objective is to develop a reliable, flexible and up to date control system. For these purpose EPICS has been chosen. for controlling the field level instruments, Siemens S7-300 PLC has been adopted as input output controller (IOC) that communicates with EPICS via s7plc module. A temporary E-gun test stand interface has been created by WinCC till the development of the EPICS is being done.

ISBN 978-3-95450-147-2

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to Dr. H. Shaker, Mr. Jahedi, Mr. S.AhmadianNamini, Mr. M. ShirShekan for their valuable suggestions and support for this work.

REFERENCES

[1] S. Zarei, F. AbbasiDavani, S. Ahmadiannamini, F. Ghasemi "Design and simulation of Prebuncher for S-band Traveling Linear Accelerator", WEPPD063, Proceedings of IPAC2012, New Orleans, Louisiana, USA.

[2] F. Ghasemi, F. AbbasiDavani, S. Ahmadiannamini, M.Sh. Shafiee "Construction of Disk-Loaded Buncher for S-Band Low Energy TW Electron Linac", WEPPD063, Proceedings of IPAC2012, New Orleans, Louisiana, USA.

[3] D. Martin, D. Ighigeanu, A. Jianu "ALID-7 Electron Linac Control System", ICALEPCS1999, Trieste, Italy.

[4] http://www.aps.anl.gov/epics/

[5] http://epics.web.psi.ch/style/software/s7plc/s7plc.html