16th Int. Conf. on Accelerator and Large Experimental Control Systems ICALEPCS2017, Barcelona, Spain JACoW Publishing
ISBN: 978-3-95450-193-9 doi:10.18429/JACoW-ICALEPCS2017-TUPHA214

CURRENT STATUS OF IPM LINAC CONTROL SYSTEM

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Abstract

This paper reports the progress of the control system for IPM 10 MeV accelerator. As an electron linac, it consists of beam injection acceleration tube, radio frequency production and transmission, target, diagnostics and control and safety. In support of this source, an EPICS-based integrated control system has been designed and being implemented from scratch to provide access to the critical control points and continues to grow to simplify operation of the system. In addition to a PLC-based machine protection component and IO interface, a CSS-based suite of control GUI monitors systems including Modulator and RF, Vacuum, Magnets, and electron gun. An overview of this system is presented in this article.

INTRODUCTION

The IPM Electron Linac is an 8 MeV (upgradable to 11 MeV) electron linear accelerator under development at the Institute for Research in Fundamental Science (IPM), Tehran, Iran. Design and development of this linac is in its final steps and it will be commissioned within next few months.

This machine is an S-band travelling wave linac with the current of up to maximum 10mA that works in $\pi/2$ phase advance operation mode. The main parameters of the machine are given in Table 1.[1]

Table 1: e-Linac Parameters

Parameter	Value
Beam Energy	8 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

While the accelerator is being built and brought online, a remote control system is being developed in parallel to run it, with features added on demand as the accelerator grew in complexity and as tasks amenable to automation became apparent. For this control system, we had several choices as the basis for the bulk of the control system. We used Siemens Step7-300 PLC which provide basic IO and machine protection functionality. For this reason, on the first steps of designing and implementing of the control system, we also selected WinCC because of its good integration with S7 PLC's. Some GUI screen designed by WinCC to operate the Beam injection subsystem.

In the latter design of the control system, we choose EPICS as the main control system architecture because of its flexibility to communicate with devices with various protocols and also gain the experience of using EPICS due to its wide usage in large accelerator facilities.

OVERALL ARCHITECTURE OF CONTROL SYSTEM

Control system of IPM e-Linac follows a standard "three-layer" model of distributed architecture, which are OPI layer (operator interface), the front-end layer, and the device control layer. One set of PC/Linux are used for EPICS IOC development and Client Apps. The platform of the control system is based on EPICS system, which is widely applied in large accelerator facilities. EPICS provides a structure of three parts: IOC (Input and Output Controller) running on server-end, CA (Channel Access), OPI (Operator Interface) running on client-end [2]. In this control system, EPICS plays an important role in order to connect different devices with different protocols to the control system. As shown in Figure 1, the Soft IOC runs on a Linux client console that communicates with client application such as CSS, Matlab etc. with channel access protocol.

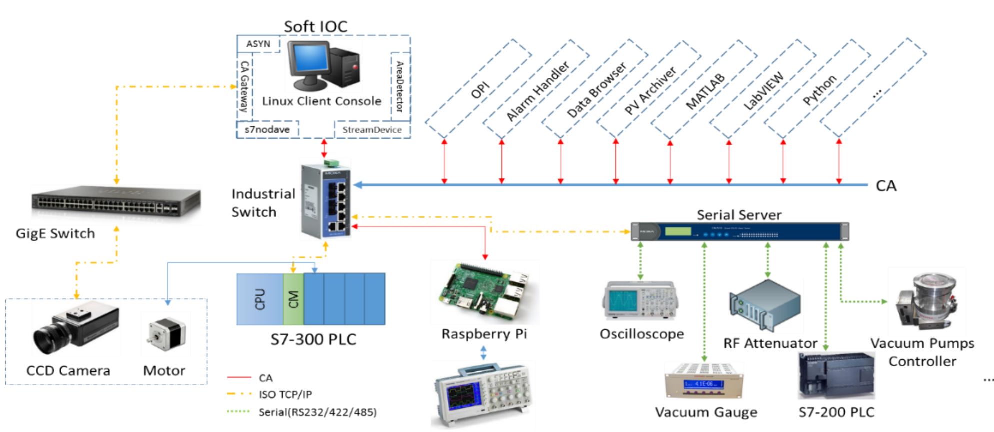

Figure 1: Layout of IPM e-Linac control system network architecture.

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All the devices except CCD camera is connected to the TCP/IP Ethernet via Moxa Industrial switch, which will be used as a physical communication backbone. The network that building by industrial Ethernet switch is required to work steady under the extreme conditions, such as high temperature, electromagnetic interference. Thus the critical control equipment and interlocking protection devices is constituted by the industrial Ethernet switch

The Gigabit Ethernet CCD camera has been connected to the console with the located GigE switch which is used for computer networks. A stepper motor will be used in order to control the position of YAG plane. The S7-PLC will send the pulses to the motor and receive the position using encoder in its AI card. The connection of EPICS and this diagnostic system will be performed using AreaDetector module and MATLAB and MCA in order to analyse the image.

Serial devices, (such as Pfeiffer vacuum gauge, Step7-200 PLC, RF attenuator and oscilloscopes that don't support USBTMC protocol) using either RS-232 or RS-485 standards, are connected to Moxa NPort 5650 Serial server, allowing the different kinds of serial devices to be accessible over a TCP/IP based Ethernet. The COM ports are mapped that makes it easy to send and receive command between the IOC and devices using StreamDevice and ASYN.[3]

In order to connect oscilloscopes with USBTMC port to the control system, we user Raspberry Pi to act as an IOC. This Single Board Computer (SBC) connects to the oscilloscope via USBTMC and send the screens via CA to the control system.

EPICS act as a middle layer between the devices and client applications. PV data collected by controller will be stored in EPICS real-time database. Client apps like Vacuum control program could fetch the PV data from EPICS real-time database by creating channel accesses and calling related functions.

PLC CONTROLS

In addition to a Siemens S7-200 PLC which controls the modulator and klystron, a Siemens S7-300 PLC system provides machine protection functions. This system monitors pressure set points on vacuum gauges throughout the system, quickly sealing off the gate valves if an overpressure condition is detected. It also monitors water flow and temperature through the solenoids and cooling systems to prevent overheating. The PLC provides a permissive signal to the facility relay logic system, preventing operation of the RF system if an error in any of these key parameters is detected. This system controls the vacuum gate valve, the mechanical system that insert YAG diagnostic screens into the beam at various points, and monitors the water temperature via several RTDs. The PLC hardware also serves as a general purpose analog and digital I/O device, that communicate with devices using analog voltage or currents. It also serves up access to EPICS through s7nodave driver. S7nodave for EPICS is a device support based on Asyn and libnodave that communicates with S7 (or compatible) PLCs.

GUI INTERFACES

CSS has been chosen for designing the GUI for the IPM e-Linac control system because of its good functionality and integration. CSS is a collection of tools: Alarm handler, archive engine, as well as several operator interface and control system diagnostic tools. Most of them deal with Process Variables (PV), i.e. named control system data points that have a value, time stamp, alarm state, maybe units and display ranges, but they do this in different ways. One tool displays the value of a PV, one displays details of the PV configuration, while another concentrates on the alarm state of a PV. Each individual tool deserves some attention, and the Experimental Physics and Industrial Control System toolkit, EPICS, indeed offers each functionality as a separate tool. A key point of CSS is the integration of such functionalities [4].

Figure 2 shows the electron gun operator screen. Vacuum and modulator system status are displayed on a separate screen, along with the magnets and cooling system.

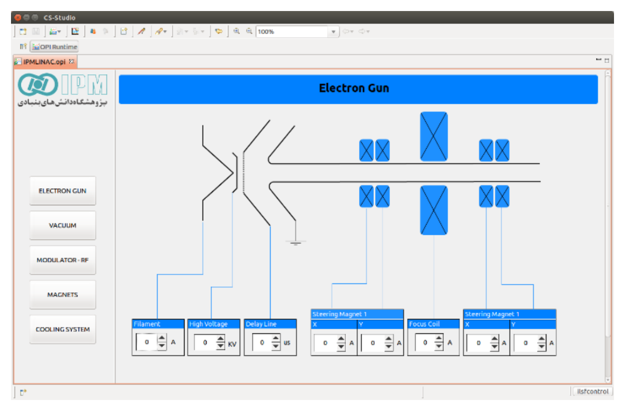

Figure 2: Electron gun operator screen.

Figure 3 shows the vacuum setting screen. Here, user can see the sensor channel status, set the sensor On/Off, set the poll interval as well as setting the general vacuum gauge settings.

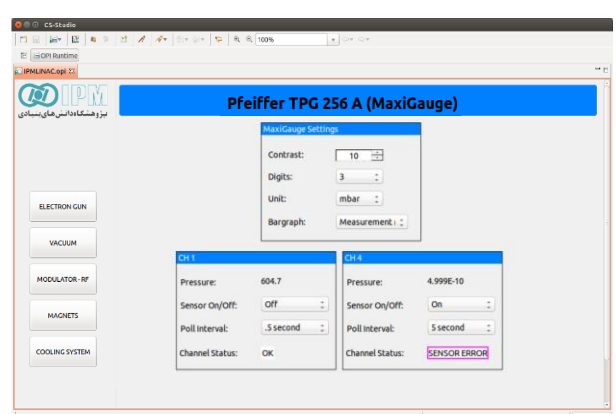

Figure 3: Vacuum setting operator screen.

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CONCLUSION

Design and development of IPM Linac control sys-tem is still in progress. Our objective is to develop a reliable, flexible and up to date control system. Some part of this control has been implemented and other parts will be designed in parallel while the other part of the accelerator being built.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to Dr. H. Shaker for his valuable suggestions and support for this work.

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