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CURRENT STATUS OF TARLA CONTROL SYSTEM*

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Abstract

Turkish Accelerator and Radiation Laboratory in Ankara (TARLA) is a Free Electron Laser (FEL) facility designed to generate Free Electron Laser (FEL) in 3-250 um wavelength range, based on four 9-cell Super Conducting (SC) cavities with 10MeV/m gradient each. TARLA electron gun has been in operation since 2012[1]. Control system studies with EPICS are being run as test stand control and permanent system and each are running as individual projects while test stand control is in stable revision. 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/improvements. Now, the development and implementation of control system is ongoing in a parallel manner with the rest of the accelerator as well as the architectural design, In this study, the permanent and the test stand control systems of TARLA will be discussed.

TARLA CONTROL SYSTEM

TARLA control will be held by an in-house developed EPICS based system running under Linux OS on industrial PC's. The reason EPICS was chosen as main environment is commitment to next generation accelerators as well as the distributed structure and high performance capabilities.[2] Design point is to create an easy to use/maintain, soft IOC style, fast, stable and extendible control system suitable for laser generation and beam diagnostics as well as gathering control and monitor requirements of all auxiliary systems. Control system studies are divided into two parallel aspects; to design a complete system for TARLA from scratch (requirement analysis and architectural design is completed, hardware selection and device support development is ongoing) and to develop a minor system as prototype for e-gun test stand (alpha version is released in March 2014).

Architectural Design

Figure 1 shows the intended conceptual design of TARLA control system where IOC's are soft servers running on Linux machines. In accordance with EPICS philosophy system will be designed in a distributed manner where extension for repetitive tasks are held via macros. Personal Safety System (PSS) which is also EPICS based, will be a stand alone system acting like a supervisor for operator interface to enable/disable operation start-up. Interlock will be developed in a layered structure where lower layer DSP is responsible for machine protection and a higher layer EPICS IOC for interlock status logging and a soft interlock for extensibility.CentOS 6.3 and OpenSuse 13.1 are being used for development machines along with EPICS base 3.12.4, synApps R5_7 and StreamDevice2. For client operations CSS will be used (version bundled for SNS). Beam diagnostics cameras are selected as GigE compliant with PoE option. For EPICS integration AravisGigE module and AreaDetector are being tested. Naming convention and class hierarchy has been established. Main communication protocols for TARLA are RS232, TCP/IP and RS485 where backbone is composed of CISCO 49 series fast ethernet switches and TCP/IP to RS232 or TCP/IP to RS485 converters, therefore Streamdevice and Asyn module combination is highly critical and relied upon throughout the facility. All of the devices are being chosen SCPI compatible where available.

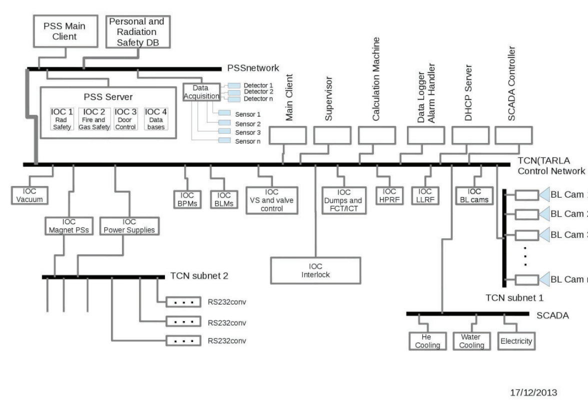

Figure 1: Architectural design of TARLA control system.

In order to meet time constraints we aim to use devices with Linux drivers already written and avoid preparing EPICS device support as much as possible where a remote host/target approach is not suitable. In this manner we are currently porting NI DAQ hardware device support to CentOS 6.3 obtained from ITER project CODAC public tarball. For low priority GPIO, we intend to use RaspberryPi derivatives and for this purpose we have written a general purpose EPICS device support by using WiringPi I/O library which will be released shortly.

E-gun Test Stand Control via EPICS

A control system for TARLA e-gun test stand has been released in alpha version in March 2014. The system is capable of producing and controlling the electron beam in DC/CW or macropulsed mode but has no diagnostic capabilities yet. In terms of control system aware devices e-gun

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test stand consists of 5 power supplies (3 remote controllable), a vacuum gauge, a master oscillator/macro-pulser, a pulse shape controller, a step motor controller, a high voltage power supply and a relay controller for 4 pneumatic view-screens. All of the devices are RS232 controlled and device communication is held via streamdevice and asyn combination.

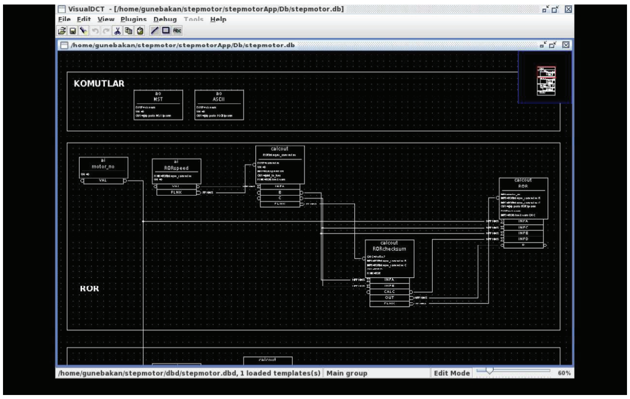

Figure 2: VDCT screen for step motor rotate right feature.

A simple CSS/BOY screen provides operator action interface. System currently has no data logging or image acquisition capability yet. System runs as 5 discerete IOC's running on the same machine with different user ID's. A startup script defines user parameters and devices to be used on system boot. In order to create a more complete prototype, planed improvements for the next few months are NI PXI6259 implementation for ion pump current and ICT readings, GigE camera support by areaDetector for beam image acquisition and a RaspberyPi implementation which can also be used as a back-up machine in emergency cases instead of relay controller. Operator ID dependant device limits, data logger, alarm handler and UAG descriptions are not planed to be introduced to prototype but will be included in first version of TARLA injector control.

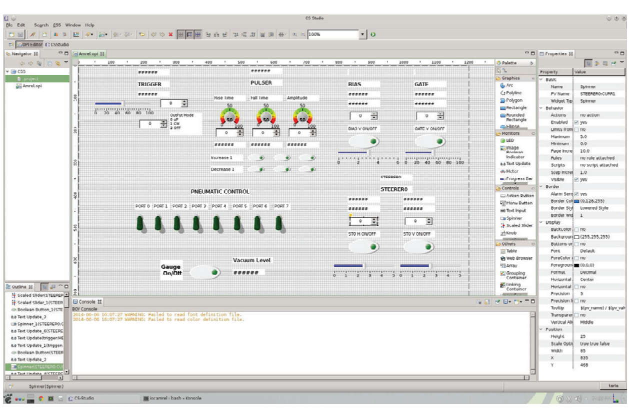

Figure 3: CSS screen for e-gun test stand. As can be seen it is highly primitive and being used for development purposes only.

E-gun Test Stand Control via LABVIEW

Since EPICS is being used for the first time in Turkey and due to relatively long development process; in order to not to interrupt rest of the test stand studies, a discrete control system based on Labview 2010 and running on a Win7 IPC has been created.

For being a high level language and having a wide range of ready to use functions and libraries, Labview vastly reduces the development time. This enables us to focus our assets into mechanical and electronical development. On the other hand having a central architecture and not enabling memory operations hardens the system maintainability and expandability. Additional features Labview based system offers compared to EPICS one are data logging and online or offline monitoring of user selectable data sets, save/load device parameters for easy operation, image acquisition for transverse beam length/transverse emittance measurements and user configurable soft interlock. As of June 2014 latest released version is 2.20.2 and the beam operation lifetime is about 500 hours without no major bugs or problems. For device communication system uses 2 Brainboxes Es271 ethernet to RS232 converter and Brainboxes BoostlanManager driver along with NI VISA. For the next major release it is planed to switch communication method to TCP in order to avoid dependence to BoostlanManager driver. This change will not effect the devices used or device routines. Another feature to be added on same release is EPICS compatibility achieved by Labview EPICS server implementation via DSP module. This feature will enable operator to pass data between two systems and divide the workload as needed. Another major change in next planed release is to convert system architecture into message based consumer/producer loop. Current architecture is stand alone application loops combined in a top level executable within same hierarchy. This approach provides good long term stability and performance but minimum expandability and error handling. By the aid of architectural change and EPICS/Labview integration it is planed that Labview will provide a good complimentary tool for non-vital applications like offline diagnostic, resource monitoring, debugging and low priority I/O.

Emittance Calculations

Beam emittance in e-gun is being measured by pepper-pot technique. 100 um wide holes separated by 1 mm distance in both directions are printed on 35 mm copper mask. 45 ^{0}C YAG:Ce screen is placed approximately 35 cm in distance after the mask. Both the mask and screen can be moved back and forth via a pneumatic actuator by control system. The image is taken by the same camera control system uses. In order to calculate the emittance a stand alone Labview program has been prepared. The calculations are being made according to the technique Zhang M.[3]described. The program is written as two sections. Image management and data calculation are divided as independent but linked software. This approach enabled us to

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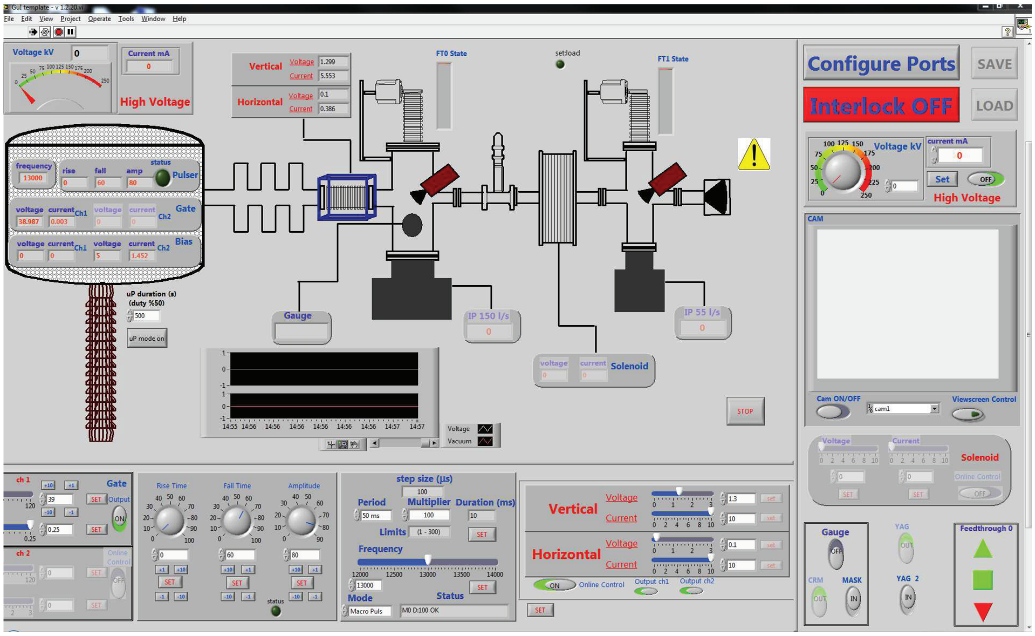

Figure 4: Main operator screen designed in Labview. Main section in up left is monitor screen where user can track all device parameters. It has also hidden shortcuts for two infinite length control sections. Additional screens like port configuration or image acquisition are not shown.

verify the code with data taken form other facilities or use the data for other purposes.

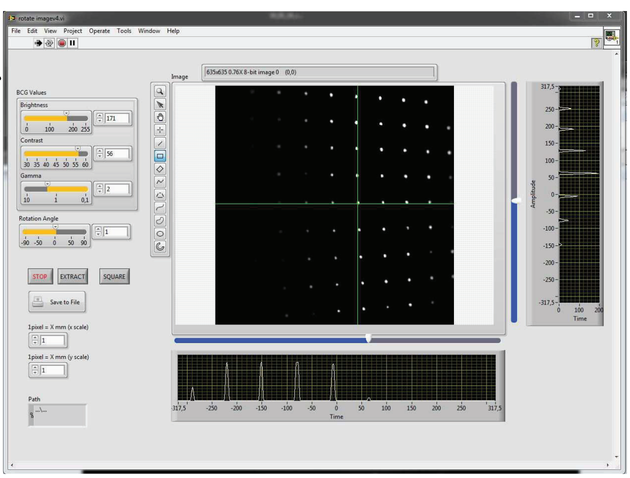

Figure 5: Image management.

Emittance calculation software is verified by external data and ready to use. It is planned to be used in the actual machine and developed to be an integral part of diagnostics system.

CONCLUSIONS

Design and development of TARLA control system has been ongoing in parallel to device itself. The motivation of the team is to create a state-of-art system, fully featured and debugged by the first laser beam generation. To achieve this goal, it is planed to release two versions which includes

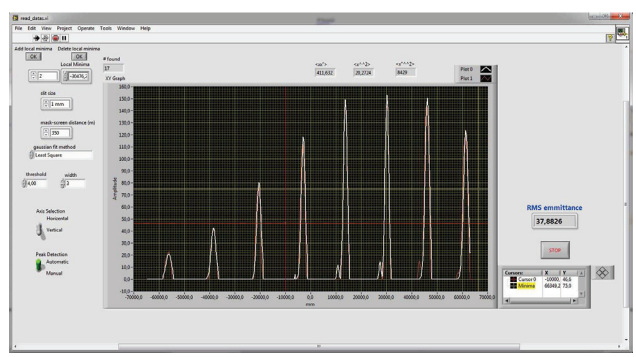

Figure 6: data management and calculation.

newly gathered requirements of machine development process every year from January of 2015.

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

[3] Min Zhang, “Emittance Formula for Slits and Pepper-pot Measurement“, FERMILAB-TM-1988 (1996)