Booster RF Controls Upgrade for SPEAR3

S. Condamoor#, S.Allison, J.Sebek, J.Vasquez, J.Wachter
SLAC National Accelerator Laboratory, Menlo Park, CA 94025 USA

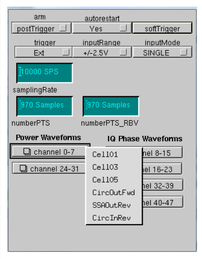
ICALEPCS2017 Barcelona · Spain, October 8-13 · Palau de Congressos de Catalunya

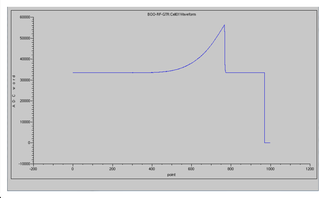
Abstract

SLAC's SPEAR3 Booster RF system was recently upgraded where the existing klystron providing RF power to a 5-cell cavity was replaced with a Solid State Amplifier (SSA). The Low Level RF Controls (LLRF) to drive the SSA was provided by a high performance FPGA based system built on SLAC ATCA modules. RF Cavity Tuner Controls were replaced with EtherCAT-based stepper motor controller. New hardware was designed and built for PLC-based Machine Protection System (MPS). Fast digitizers to sample and acquire LLRF signals were implemented in a LinuxRT Server. All of these required new Controls Software implementation. This poster illustrates the Controls associated with each of the above hardware.

PCIe Digitizer

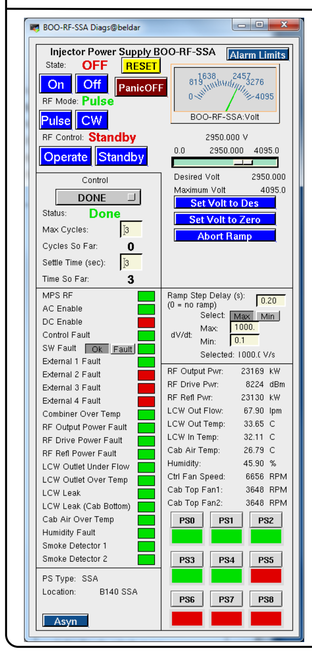
Fast digitizer read back of LLRF waveforms from the Gain Phase Detector chassis. EPICS Soft IOC GS runs on LinuxRT Server.





- 16-bit 64-channel PCIe ADC board installed in the Server.
- digitizes the LLRF signals received from the chassis such as 5-cell RF cavity probe IQ waveforms, SSA and Circulator Forward and Reverse power.
- EPICS Asyn-based GTR module configures the digitizer and acquires fast waveforms.

Solid State Amplifier



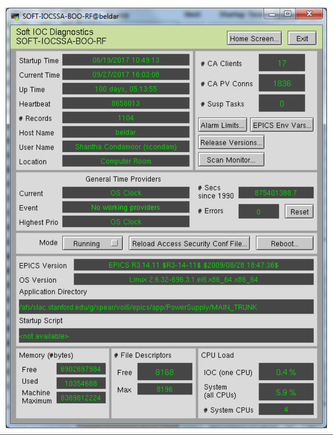
SSA control via the MODBUS-based XPORT device. EPICS Soft IOC SSA runs on Linux Server:

- provides Digital and Analog Status updates via EPICS EDM display panels.
- provides controls for fault reset, power supply on/off, setting operating mode (cw/pulse mode, RF operate or standby), set DC power supply output voltage levels, enable/disable individual power supplies, read error codes, read internal and external faults.

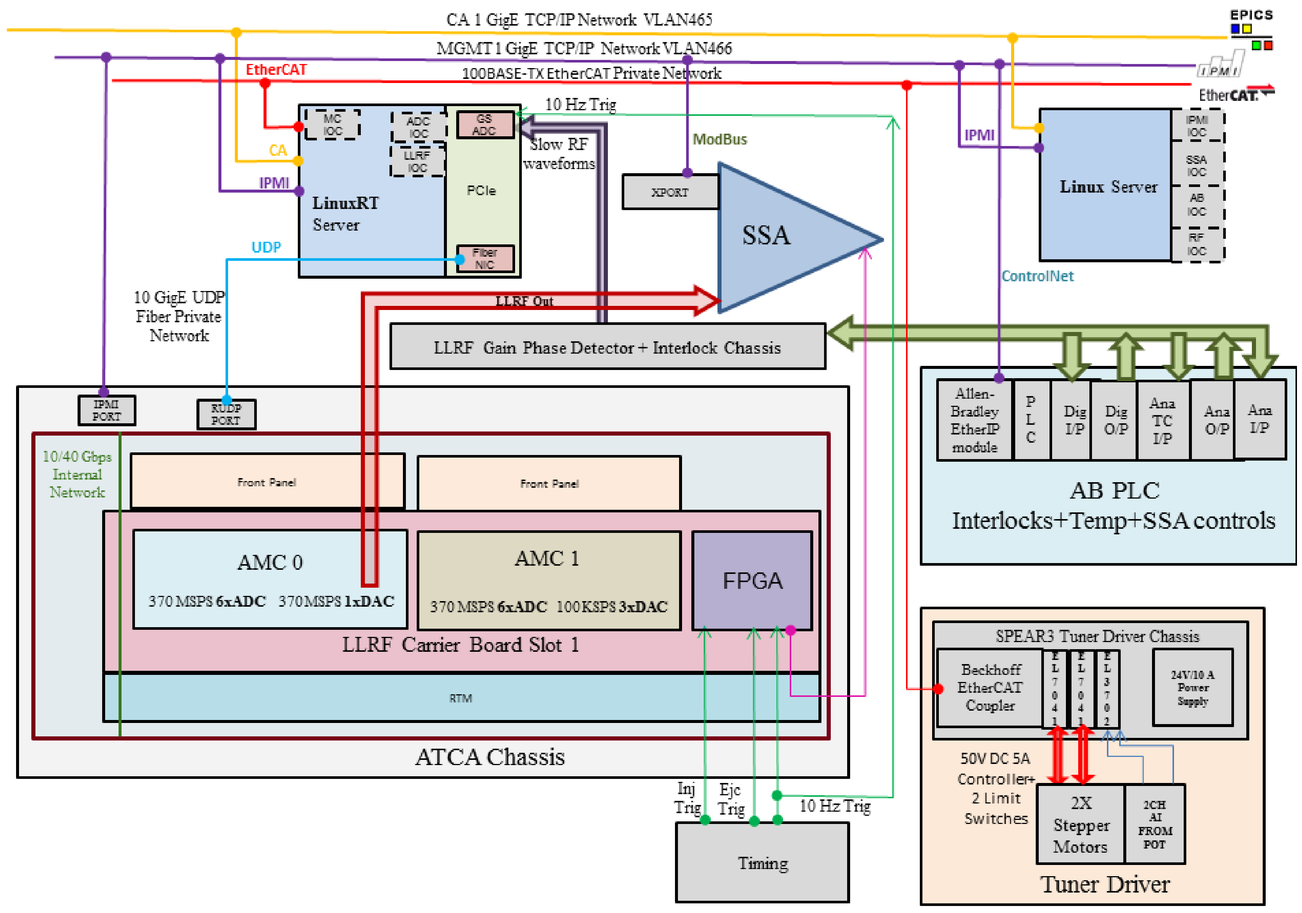
EPICS IOCs

All IOCs:

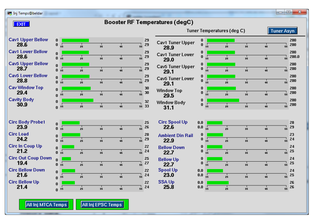
- provide alarm setup capabilities and alarm handling notifications.
- archive new PVs for history data.
- support message logging.
- save/restore non-safety critical values on IOC boot-up.
- are monitored for CPU load, memory usage and heartbeats



Booster RF Upgrade Controls Block diagram



PLC Interlocks



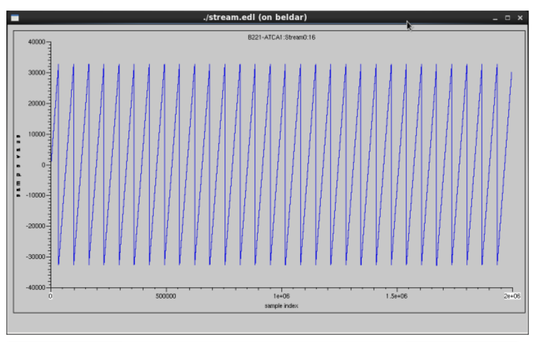
Readback of LLRF Gain Phase Detector chassis scalar analog signals and digital Interlock statuses. EPICS Soft IOC AB runs on Linux Server.

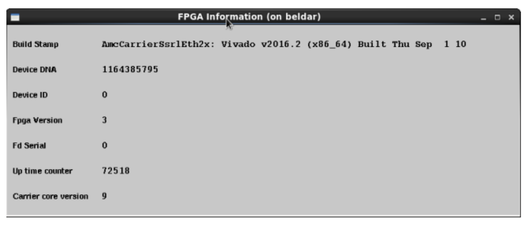
- communicates with the PLC modules module using the EtherIP protocol.
- provides Analog Input readbacks of various Booster RF signals such as temperatures, pressure, voltage, current etc. via EDM panels.
- provides Digital Input readbacks of various interlock statuses.
- provides Digital Output control for fault reset.

ATCA LLRF

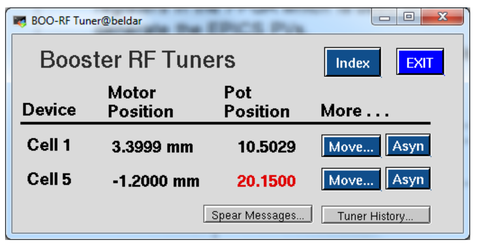
LLRF control via ATCA-chassis based AMC modules on carrier board that has custom FPGA. EPICS Soft IOC LLRF runs on LinuxRT Server:

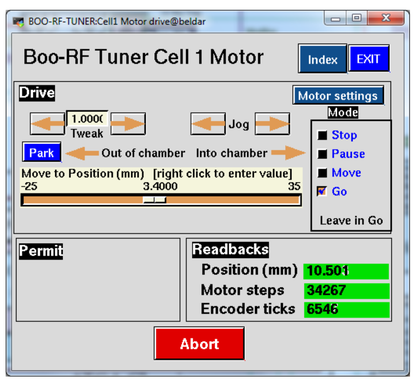
- communicates with the FPGA via Ethernet/UDP using custom protocol CPSW over fiber.
- configures the carrier board FGPA, AMC ADC/DAC modules and the RTM.
- uses AsynPortDriver-based EPICS module that interfaces with the CPSW.
- module supports YAML definitions of the registers in the FPGA which is used to auto-generate the EPICS PVs.
- monitors slowly updating LLRF PVs provided by the FPGA.
- EPICS Soft IOC IPMI provides IPMI-based monitoring and controls of the LinuxRT server and the ATCA chassis.





RF Cavity Tuner





Tuner control via EtherCAT based Beckhoff modules in a driver chassis that controls two stepper motor-controlled tuners in cell1 and 5 of the 5-cell Booster RF cavity. EPICS Soft IOC MC runs on LinuxRT Server:

- communicates with the coupler module using the EtherCAT fieldbus protocol.
- configures the stepper motor driver module and senses the limit switches.
- uses Analog Input module for potentiometer-based motor position read back.
- uses AsynMotor-based EPICS module.
- cavity tuner control for slow feedback control of cavity RF.

Summary

Initial commissioning of the controls for the various hardware was recently completed. Work still in progress to add support for RF slow feedback controls and additional support for the ATCA-based LLRF controls.

SLAC National Accelerator Laboratory, Menlo Park, CA | Operated by Stanford University for the U.S. Dept. of Energy Office of Science. Work supported by U.S. Department of Energy under Contract Numbers DE-AC02-76SF00515. scondam@slac.stanford.edu