LCLS-II Accelerator Vacuum Control System Design, Installation and Checkout

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ABSTRACT

The LCLS-II Project at SLAC National Accelerator Laboratory has constructed a new superconducting accelerator which occupies the first kilometer of SLAC's original 2-mile-long linear accelerator tunnel. The LCLS-II Vacuum System consists of a combination of particle free(PF) and non-particle free vacuum(non-PF) areas and multiple independent and interdependent systems, including the beamline vacuum, RF system vacuum, cryogenic system vacuum and support systems vacuum.

The Vacuum Control System incorporates controls and monitoring of a variety of gauges, pumps, valves and Hiden RGAs. The design uses a Programmable Logic Controller (PLC) to perform valve interlocking functions to isolate bad vacuum areas. In PF areas, a voting scheme has been implemented for slow and fast shutter interlock logic to prevent spurious trips. Additional auxiliary control functions and high-level monitoring of vacuum components is reported to global control system via an Experimental Physics and Industrial Control System (EPICS) input output controller (IOC). This paper will discuss the design as well as the phased approach to installation and successful checkout of LCLS-II Vacuum Control System.

SCOPE

LCLS-II Accelerator Vacuum Control System provides the local and remote (EPICS) monitoring and control for all the mechanical vacuum components.

- Beamline vacuum system
  - Injector through Electron Beam Dump – warm & cold beamline components.

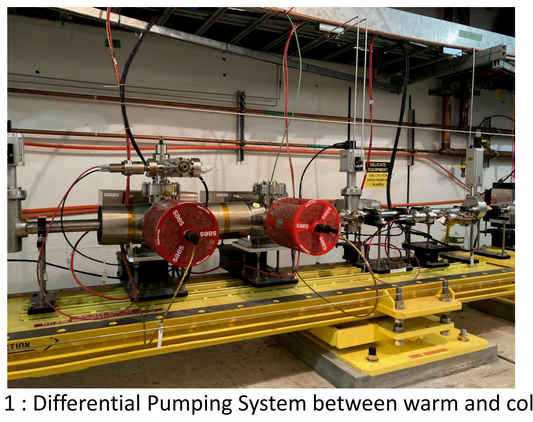

Figure 1 : Differential Pumping System between warm and cold regions

- RF vacuum system
  - RF Couplers, Laser Transport Tubes (UV & IR)
- Cryomodule vacuum system
  - Insulating Vacuum Gauges & Pump Cart
    (Poster : LCLS-II CM Isolation Vacuum Pump Cart)

Figure 2 : CM Coupler

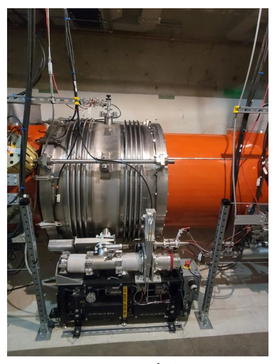

Figure 3 : CM Isolation Vacuum

ARCHITECTURE

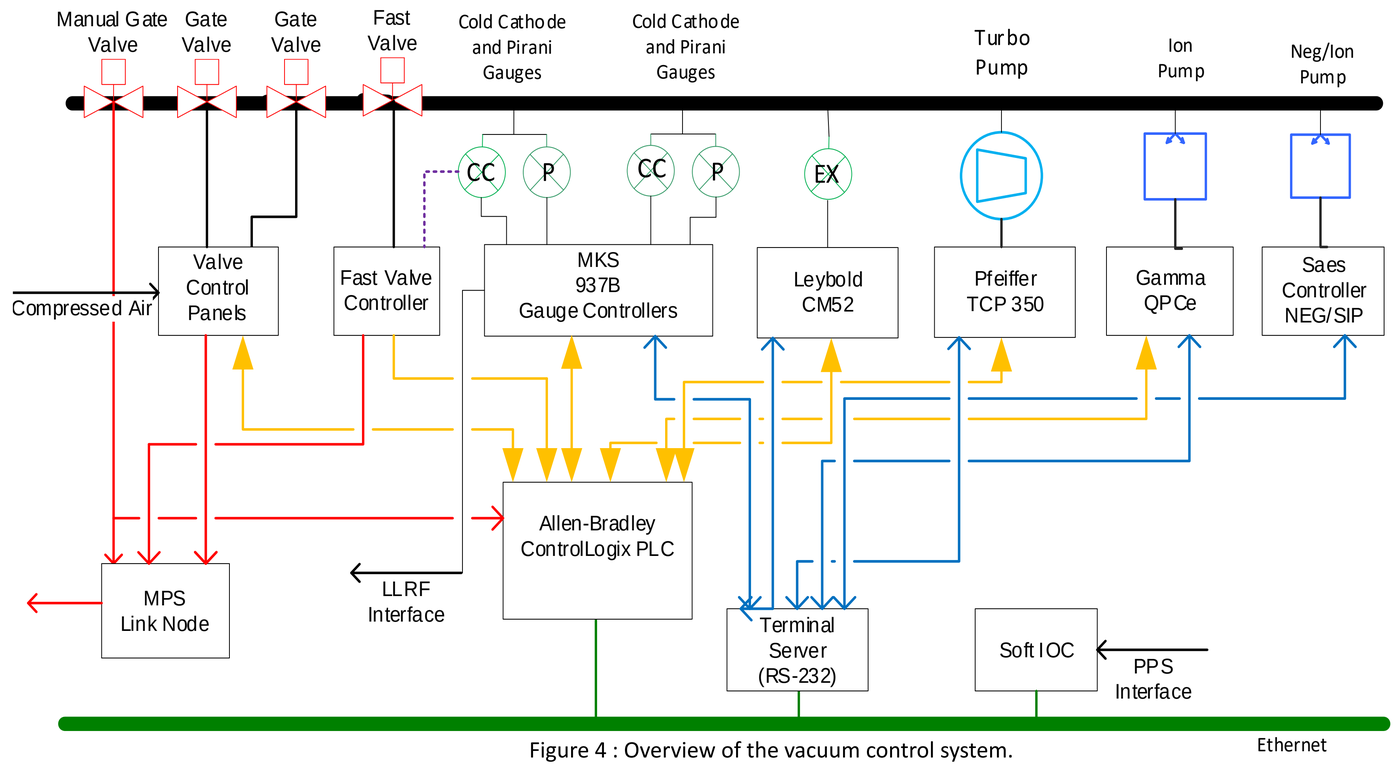

Figure 4 : Overview of the vacuum control system.

- Pump and Gauge Controllers – PLC Interface
  - Digital Input for interlock & device status.
  - Analog Input for pressure readback.
- Pump and Gauge Controllers – EPICS Interface
  - On/Off control and additional diagnostic data via serial communication.
- Allen-Bradley ControlLogix PLC
  - 1756-L83E Controller & Input / Output Modules
  - 15” PanelView touch panel
- Primary-secondary crate configuration communicating over Ethernet/IP.
- PLC Interface to EPICS uses etherip support.

VALVE INTERLOCKS

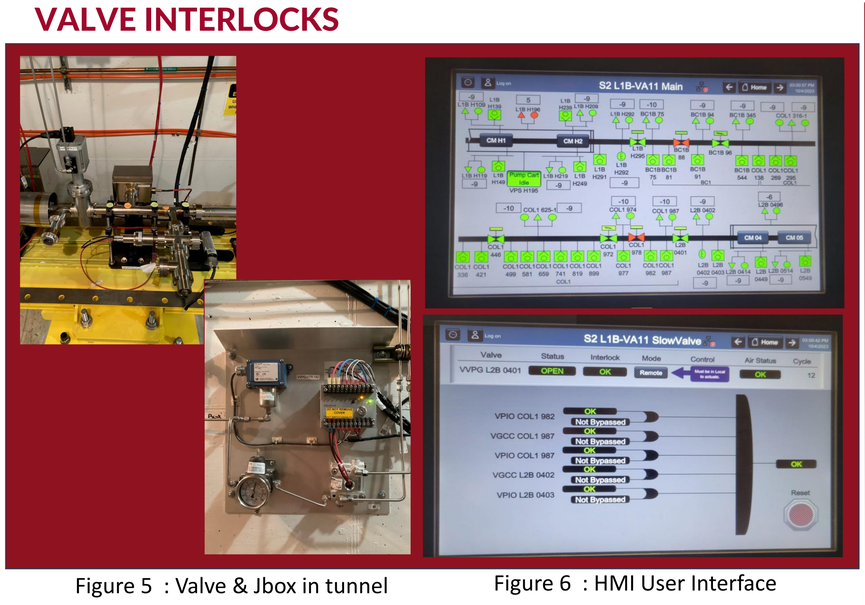

Figure 5 : Valve & Jbox in tunnel

Figure 6 : HMI User Interface

- Password protected Mode Selection
  - Remote : EPICS Control
  - Local : Allen Bradley HMI Control
  - Jbox : Key Switch on SLAC built Panel located in the tunnel
  - Closed : Locked Closed.
- Valve Interlock Logic is implemented in the PLC using ladder logic. Cold Cathode Gauge and Ion Pumps are used as interlock inputs.
- Interlock input fault when configurable vacuum threshold is exceeded. Access security is implemented for interlock bypasses.
- For LCLS-II, the Gun, CM (cold) beamline as well as the adjacent warm areas are specified as particle free. Valve actuations cause particulate generation. To minimize spurious trips, the valve logic is based on a voting scheme so that 2 or more interlock inputs need to be faulted for the valve logic to register an interlock fault causing the valve to CLOSE.

INSTALLATION AND CHECKOUT

Figure 7 : Vacuum Rack & PLC Installation

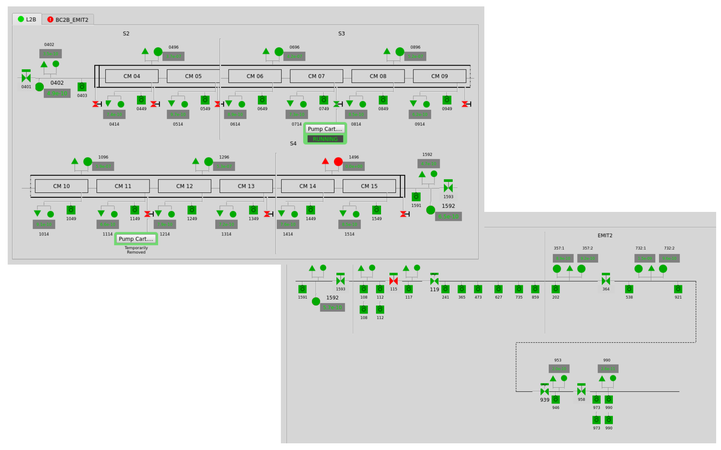

Figure 8 : EPICS Control System Interface (PyDM)

The LCLS-II Accelerator Vacuum Control system successfully deployed over 65 racks and instrumented approximately 364 Pumps, 407 Gauges, 118 Valves & 9 Pump Carts. It utilized 18 PLC primary-secondary installations to monitor the system and to isolate unexpected loss of vacuum. Since protection of the particle free & CM vacuum was critical to the success of the Project, the checkout of this system involved extensive documentation and rigorous WPC ensuring a successful certification of the system.

ACKNOWLEDGEMENTS

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