A GENERAL SOLUTION FOR COMPLEX VACUUM SYSTEM CONTROLS

G. Bischof, A. Barbour, A. Walter, B. Sobhani. (Brookhaven National Laboratory)

BROOKHAVEN NATIONAL LABORATORY

NATIONAL SYNCHROTRON LIGHT SOURCE II

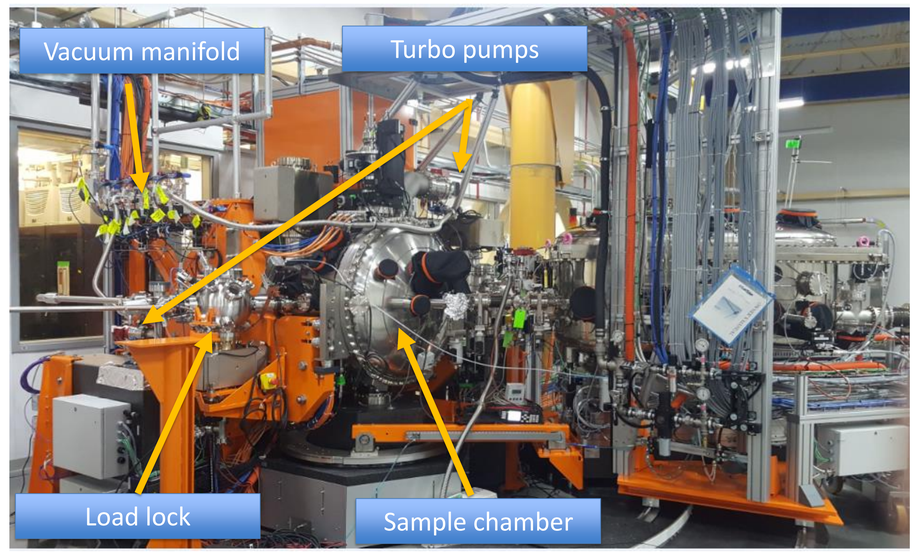
ABSTRACT

At the National Synchrotron Light Source II (NSLS-II) there are many different ultra-high vacuum system configurations on the unique beamline end-stations. The proposed controls solution attempts to capture the requirements of all of these configurations with a single standard logic and graphical user interface. Additional design considerations include: resource management for multiple users, providing a high level of abstraction to simplify operation for users, providing a high level of flexibility to do nonstandard operations, minimizing shock from pressure differentials when opening valves, supporting a variety of pumps, and maximizing pump lifetime. At NSLS-II it was determined that all vacuum configurations can be captured by the composition of three standard objects: a "rough vacuum group", "high vacuum group", and a "smart vacuum manifold" which implements a blocking queue. These objects can be flexibly linked together to meet the needs of the beamline experiments. This solution is platform independent, but implemented and tested here using Pfeiffer vacuum Pumps, Allen Bradley PLC, EPICS, and Control System Studio (CSS).

BACKGROUND

- The end-station vacuum systems often differ from those of the accelerator and beamline in that they frequently need to have sections vented. They also often have unique vacuum requirements for their experiments.
- End-station vacuum systems often incorporate roughing pumps and turbo pumps to meet their pumping speed and throughput requirements. They also incorporate ion pumps and NeG pumps to achieve a very good vacuum.
- Some configurations are quite simple. For example: a single vacuum chamber with a vacuum system consisting of a roughing pump, isolation valve, turbo pump, and a gate valve. Other vacuum system configurations are much more complex.
- The goal of this project is to create a modular standard logic and Graphical User Interface (GUI) that supports all of the different end-station vacuum configurations.

SIX End-station vacuum



Rough group

- A rough vacuum group is responsible for supplying rough vacuum to a chamber, the high vacuum group or manifold. The rough group has only two states, “On” and “Off”. It can be turned “On” by pressing the power symbol on the GUI, or by a request from a master (manifold or high vacuum group).
- **Components**: Roughing pump, water flow meter/switch, vacuum gauge, isolation valve (main valve).

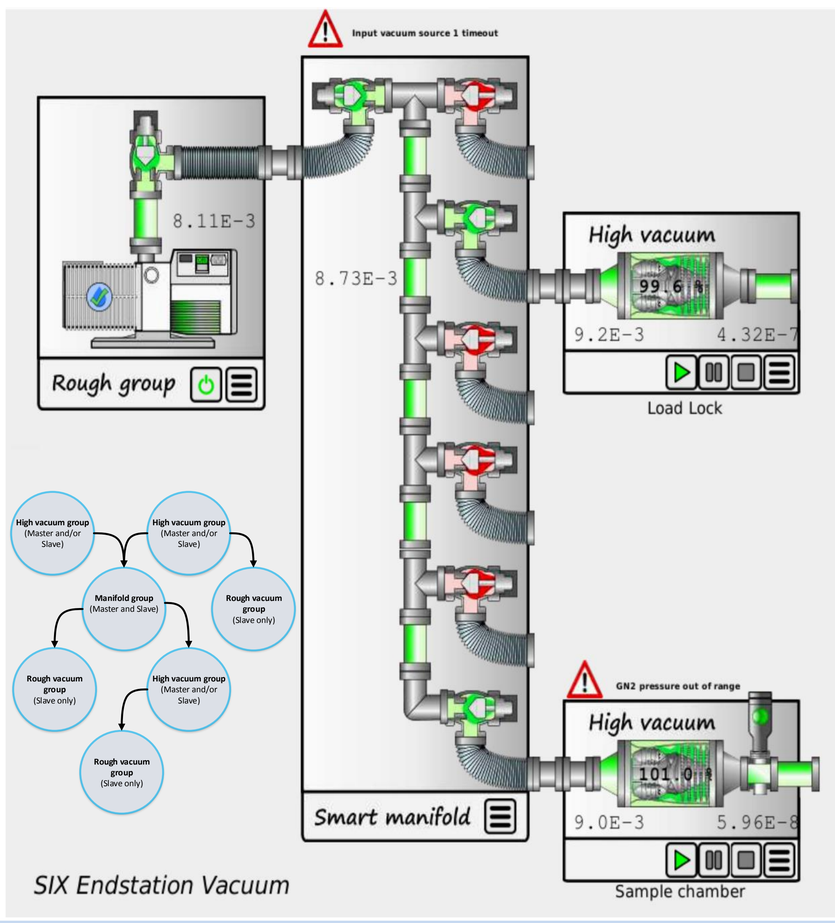
```
If CmdRoughOn and Interlock_RoughOK and not HardStopAlarm then
    Output_RPOnOff := 1;
end_if;

if (Input_MainVlvClosed or Alarm_MainVlvFB)
and (not CmdRoughOn or not Interlock_RoughOK or HardStopAlarm) then
    Output_RPOnOff := 0;
end_if;

if CmdRoughOn and Interlock_RoughOK and not HardStopAlarm
and Input_RPOnSts and (InputLessThanUS or RoughVacGood) then
    Output_MainVlvCmd := 1;
end_if;

if not CmdRoughOn or not Interlock_RoughOK or HardStopAlarm
or not Input_RPOnSts then
    Output_MainVlvCmd := 0;
end_if;
```

GUI



SIX Endstation Vacuum

High vacuum group

- The high vacuum group has several states that can be requested, “Play”, “Pause”, “Stop”, and “Vent”. These automated states should cover the most of the operations required by the users.
- In the “Play” state, the turbo is running, and GV is open.
- In the “Pause” state, the turbo is running and the GV is closed.
- In the “Stop” state, the GV is closed, the turbo is stopped, and the turbo section is vented if the vent option is enabled.
- In the “Vent” state, the GV is open, the turbo is stopped, the chamber and turbo section are vented. The “Vent” state can be requested through the detailed GUI.

Smart manifold

- The smart vacuum manifold is used to share rough vacuum with multiple high vacuum groups or manifolds. The smart manifold consists of an array of input valves, and an array of output valves. The smart manifold acts as both a master and slave. High vacuum groups can make request to manifold for rough vacuum. The manifold can make requests to rough vacuum groups or other high vacuum groups
- Requests to the manifold can be “blocking” requests, or “non-blocking requests”. A blocking request means that all other output valves other than the output that is receiving the request must be closed. If multiple blocking requests are issued at the same time the requests will be added to a FIFO queue in the order that they were received. If there are no blocking requests, then all non-blocking requests can be fulfilled at the same time. This is useful for allowing multiple users to make requests at the same time.

Contact

gbischof@bnl.gov

https://github.com/gwbischof/VacuumGroups.git

CONCLUSIONS

- This solution was deployed and tested at the SIX beamline and is currently being used for their end-station. It currently meets the goals defined in the requirements section.
- Some polishing is still required, and further development and testing to improve the robustness is planned. The CSX, IOS, and ESM beamlines were also considered and have the existing hardware to roll out the new vacuum control system. This new system will provide unprecedented protection and automation of these beamline vacuum end-stations.

U.S. DEPARTMENT OF ENERGY

Office of Science