SNS STANDARD VACUUM CONTROL SYSTEM
CONCEPTUAL DESIGN REVIEW
Tuesday April 18, 8:00 – 4:00

A combination "PLC standardization workshop" and "vacuum control system conceptual design review" was held April 18, 2000 at the SNS Building, 701 Scarboro Rd., Oak Ridge, TN, Room 101A.

Attendees included the following persons:

John Hammonds, ANL (via phone + NetMeeting)
Rich Reidel, ANL
John Smith, BNL
Johnny Tang, BNL
Dave Gurd, LANL
Kay Kasemir, LANL
Bob Dalesio, LANL
Bob Weiss, LANL
Steve Lewis, LBNL (via phone + NetMeeting)
Bill DeVan, ORNL
Mike Hechler, ORNL
John Munro, ORNL
Mike Hechler, ORNL
Paul Wright, ORNL
John Cleaves, ORNL
Bill Stone, ORNL

Vacuum-control-system-relevant highlights from the design review / workshop are presented below.

1. Johnny Tang presented information on (a) PLC development activities at BNL and (b) the control system architecture BNL is advocating for vacuum controls. Excerpts of the slides are attached. Comments on the slides follow:

   <u>PLC Architecture Standards R/D Conducted at BNL:</u> A PLC software development lab has been set up at BNL to help establish PLC hardware and software standards for SNS. These PLC standards will apply to the vacuum control system (as well as other SNS control systems).

   <u>Three Allen-Bradley PLC models have been evaluated:</u> The SNS "Integrated Controls Working Group" (ICWG) is advocating the use of Allen-Bradley ControlLogix PLCs.

   <u>Link IOC and PLC over Ethernet for real-time control:</u> At least two methods of communications between vacuum control system PLCs and IOCs are being advoctated for SNS: (1) ethernet "Control and Information Protocol" (CIP) and (2) ControlNet. Johnny Tang concluded that A-B support for CIP was too limited at this time to pick it as a standard. So BNL is proposing using the ControlNet interface.

Three types of RS485 link modules are under evaluation: Since most vacuum instrumentation has an RS-232/485 interface, these links are vital to supervisory control of vacuum equipment.

The consensus was that PLC-based RS-232/485 interfaces had the problem of introducing yet another development environment. The consensus was that we should use the IOC for RS-232/485 interfaces. The PLC interface should be relegated to discrete and analog I/O.

A vacuum instrumentation interface prototype control system is planned to be implemented. This is perhaps the most important slide of the review, as it shows the most-favored vacuum control system architecture. The consensus of the group was that this should be the model for the SNS standard vacuum control system architecture.

Bob Dalesio emphasized that the IOC driver for the RGA should be written. At LEDA, operations originally said they didn't need to interface with the RGA but ultimately they did have to. The program that they love to see is nothing more than a plot of the different gases that are present.

Plan for ControlNet EPICS support: Development of the ControlNet driver is still in progress. It will have to be completed to support vacuum controls.

2. Mike Hechler presented the latest on vacuum equipment standardization. Of particular interest was equipment that the control system has to interface with. Tables of equipment are attached.

   Bob Dalesio noted that a fast ion gage interlock (<15msec response time) may be required by linac RF controls.

3. Bill DeVan presented a table showing available interfaces to a variety of vacuum equipment that has been proposed for SNS (e.g. in cost estimates). This table is attached. As can be seen, RS-232 / RS-485 interfaces predominate as the field bus connection to this equipment.

CONCLUSIONS:

Adopt Johnny Tang's network architecture as our standard, with the following change: Add discrete I/O connection from PLC to ion pump controller and turbo pump controller.

Assume a ControlNet interface between vacuum control system PLCs and IOCs. We will continue to keep an eye on the ethernet "Control and Information Protocol" and maybe transition to it if it happens soon enough.

PLC Architecture Standards / Vaccum Control System CDR Agenda:

Time	Activity	Presenter
8:00	Coffee & bagels	
8:30	Intro / Purpose of meeting	Gurd
	Inter-PLC Architecture Discussions:	
8:45	BNL PLC lab	Tang
9:00	Target Test Facility (TTF) control system	Battle
9:15	LANL experience / linac hot model	Weiss
9:30	BNL PLC plans (for vac. sys., P.S., R.F., etc.)	Tang / Smith
9:45	LANL PLC plans (for vac. sys., P.S., R.F., etc.)	Weiss?
10:00	ORNL Target PLC plans	Battle
10:15	Break	
10:30	ControlNet demonstration	Tang
11:00	Advantages / disadvantages of ContolNet A-B I/F	Tang
11:15	Advantages / disadvantages of Ethernet A-B I/F	Kasemir
11:30	Ethernet vs. ControlNet discussion & consensus	
	Fieldbus Architecture Discussions:	
12:00	SNS vacuum standardization efforts (and interfaces offered by the preliminary set of standard equipment)	Hechler / DeVan
12:30	Vacuum system control architecture discussion & consensus	Tang / Gurd / etc.
1:15	Lunch (provided on-site) (Delayed because Dalesio and Kasemir have to leave at this time)	
1:45	Role of DeviceNet, FlexIO, Foundation Fieldbus	Battle?
2:30	Wildcard: Options are: - schedule slip - follow-on discussions - other PLC-related information attendees want to make known - SNS conventional facilities plans - SNS PLC standards	
3:30	Summarize	
4:00	Adjourn	

I. SNS PLC Lab - *BNL effort*

PLC Architecture Standards R/D Conducted at BNL

- Evaluated three Allen-Bradley's PLC models
- Studied the possibility of using Ethernet to link IOC and PLC for real-time control
- Implemented a prototype system of using ControlNet to link IOC and PLC or remote I/O modules, such as Flex I/O or A-B 1771 I/O modules
- Tested IP-DeviceNet module
- Compared VME RS485 link vs PLC RS485 link

I. SNS PLC Lab - *BNL effort* - *AB PLCs*

Three Allen-Bradley's PLC models have been evaluated

- We choose A-B PLCs because A-B PLCs are the most popular models that have been used in existing projects at the five SNS collaborating labs
- Although ControlLogix is the most advanced PLC model among the A-B three PLC models and it is even less expensive than PLC-5 model, we experienced difficulties of pushing ControlLogix as a standard model. BNL engineers have the most expertise on PLC-5 models.

I. SNS PLC Lab - *BNL effort* - *Ethernet link*

Link IOC and PLC over Ethernet for real-time control

For IOC to perform a real-time task over Ethernet to communicate with PLC or remote I/O devices, we need two things:

❶ The plant network has to be configured in a “star” topology with Ethernet hubs & switches to avoid collisions and entitle its deterministic label

❷ Ethernet provides only physical and data-link layer protocol. We need obtain the upper layer information to be able to implement an EPICS driver to communicate with PLC - we experienced the difficulty to get A-B PLC Ethernet client protocol from Allen-Bradley

Good News -- A-B is opening its PLC Ethernet application layer protocol --- Control and Information Protocol (CIP)

Real-Time control over Ethernet is innovative, but it will be a future control network while Ethernet will begin to approach the guaranteed delivery and reliability of powered switches or hubs is improving.

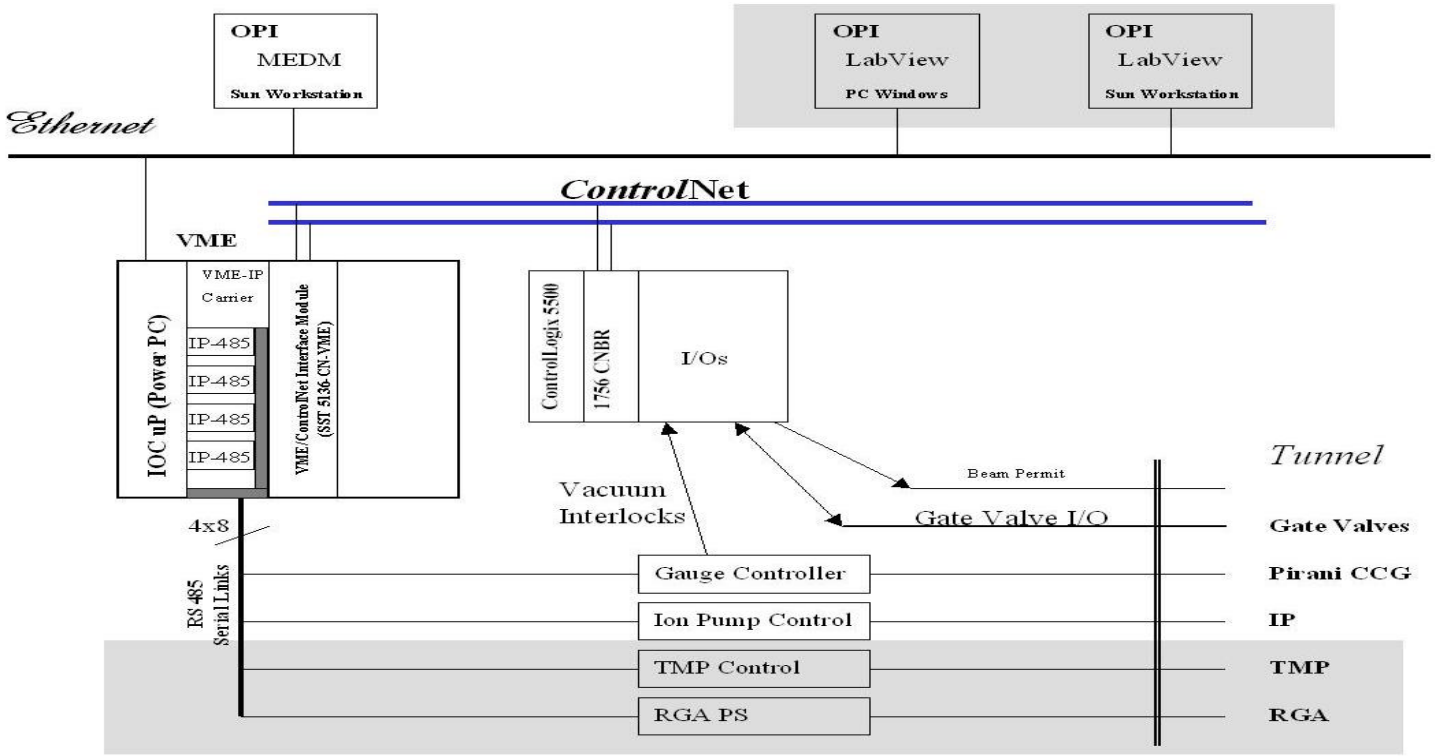
I. SNS PLC Lab - *BNL effort* - *RS485 link*

Three types of RS485 link modules are under evaluation

- GS VME/IP-485 module
- ProSoft MVI94 Flex I/O Module
- 1756-MVI module for ControlLogix (Online Development Inc)

II. BNL PLC Plan - *Vacuum Control*

A Vacuum Instrumentation Interface Prototype Control System is planned to be implemented



II. BNL PLC Plan - *EPICS/CNET Support*

Plan for ControlNet EPICS Support

- Document and release alpha version of ControlNet EPICS Support
- Add mapping feature so that val, rval, alarm limit can be mapped to one record
- Add one layer so that applications with 6008 RIO can be replace to with SST vme-cn module
- Port existing A-B I/O device support to ControlNet
- Implement EPICS ControlNet configuration tools

SNS ACCELERATOR
VACUUM SYSTEM
GAUGE SUMMARY
DRAFT 4-17-00

SYSTEM	VACUUM GAUGES				CONTROLLER	MISC INFO
	TYPE	RANGE TORR	QTY	MAKE/MODEL	MAKE/MODEL	
FRONT END						
LEBT						
	Turbo foreline Convectron	0 -1x10^{-4}	3	Granville-Phillips -TBD	TBD	TBD
	Tank Ion gauge	5x10^{-4} - 2x10^{-10}	1	Granville-Phillips -TBD	TBD	TBD
	Tank Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -TBD	TBD	TBD
	Capacitive Manometer		1	MKS - TBD	MKS - TBD	TBD
RFQ						
	Pump Ion gauge	5x10^{-4} - 2x10^{-10}	5	Granville-Phillips -TBD	TBD	TBD
	RFQ Ion gauge	5x10^{-4} - 2x10^{-10}	2	Granville-Phillips -TBD	TBD	TBD
	Chamber Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -TBD	TBD	TBD
	Residual Gas Analyzer	1x10^{-14}	1	TBD	TBD	TBD
	Turbo foreline convectron	0 -1x10^{-4}	3	Granville-Phillips -TBD	TBD	TBD
MEBT						
	Rebuncher Ion gauge	5x10^{-4} - 2x10^{-10}	5	Granville-Phillips -TBD	TBD	TBD
	Chopper Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -TBD	TBD	TBD
TEST STAND						
	Turbo foreline Convectron	0 -1x10^{-4}	3	Granville-Phillips -TBD	TBD	TBD
	Tank Ion gauge	5x10^{-4} - 2x10^{-10}	1	Granville-Phillips -TBD	TBD	TBD
	Tank Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -TBD	TBD	TBD
LINAC						
DTL						
	Tank Ion gauge	5x10^{-4} - 2x10^{-10}	6	Granville-Phillips -360120	Granville-Phillips -360101	STABIL-ION
	Tank Convectron gauge	0 - 1x10^{-4}	6	Granville-Phillips -275238	Granville-Phillips -360107	CONVECTRON
	Residual Gas Analyzer	1x10^{-14}	6	SRS - RGA100	SRS - TBD	RGA
CCL						
	Chamber Ion gauge	5x10^{-4} - 2x10^{-10}	16	Granville-Phillips -360120	Granville-Phillips -360101	STABIL-ION
	Chamber Convectron gauge	0 - 1x10^{-4}	16	Granville-Phillips -275238	Granville-Phillips -360107	CONVECTRON
	Residual Gas Analyzer	1x10^{-14}	8	SRS - RGA100	SRS - TBD	RGA
SRF						
Diff Pump Stand	Tank Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -275XXX	Granville-Phillips -360XXX	CONVECTRON
Cryomodules (32)	CM Insul Vac Ion gauge	1x10^{-2} - 2x10^{-8}	32	TBD	TBD	CCG
Warm Sections (32)	Tank Convectron gauge	0 - 1x10^{-4}	32	Granville-Phillips -275XXX	Granville-Phillips -360XXX	CONVECTRON
Diff Pump Stand	Tank Convectron gauge	0 - 1x10^{-4}	1	Granville-Phillips -275XXX	Granville-Phillips -360XXX	CONVECTRON
RING						
HEBT						
	Line Ion gauge	1x10^{-2} - 2x10^{-8}	10	TBD	TBD	inverted-magnetron CCG
	Line Convectron gauge	0 - 1x10^{-3}	10	TBD	TBD	convectron type Pirani
	Residual Gas Analyzer	1x10^{-14}	5	TBD	TBD	RGA
RING						
	Line Ion gauge	1x10^{-2} - 2x10^{-8}	12	TBD	TBD	inverted-magnetron CCG
	Line Convectron gauge	0 - 1x10^{-4}	12	TBD	TBD	convectron type Pirani
	Residual Gas Analyzer	1x10^{-14}	8	TBD	TBD	RGA
RTBT						
	Line Ion gauge	1x10^{-2} - 2x10^{-8}	10	TBD	TBD	inverted-magnetron CCG
	Line Convectron gauge	0 - 1x10^{-4}	10	TBD	TBD	convectron type Pirani
	Residual Gas Analyzer	1x10^{-14}	5	TBD	TBD	RGA

TOTALS	
ION GAUGES	100
Convectron GAUGES	98
RGAs	34
MANOMETER	1

M. Hechler 8/11/00

SNS ACCELERATOR
VACUUM SYSTEM
PUMP SUMMARY
DRAFT 4-17-00

SYSTEM	DESIGN	VACUUM PUMPS				CONTROLLER	MISCELLANEOUS
	VAC LEVEL	TYPE	SIZE	QTY	MAKE/MODEL	MAKE/MODEL	
FRONT END							
SOURCE/LEBT	1.0×10^{-7}						
		TURBO PUMP	1000 L/S	3	Pfieffer - Model 1000	TBD	
		ROUGHING PUMP	550 L/S	3	TBD	TBD	TBD
RFQ	5.0×10^{-7}						
		CRYO PUMP	4000 L/S	5	CTI - CT8		
		ROUGHING PUMP	TBD L/S	1	TBD	TBD	TBD
MEBT	5.0×10^{-8}						
		WAVEGUIDE ION PUMP	25 L/S	8	TBD	TBD	TBD
		ROUGHING PUMP CART	500 L/S	2	VARIAN - MSPA8419N		Integral with cart
TEST STAND	1.0×10^{-7}						
		TURBO PUMP	1000 L/S	3	Pfieffer - Model 1000	TBD	
		ROUGHING PUMP	550 L/S	3	TBD	TBD	TBD
LINAC							
DTL	5.0×10^{-8}						
6 Vessels x 3 per		MAIN ION PUMP	500 L/S	18	VARIAN - 9190406	VARIAN - 9295000	
4 Vessels x 2 per, +2		WAVEGUIDE ION PUMP	25 L/S	10	VARIAN - 9115036	VARIAN - 9290191	
		ROUGHING PUMP CART	500 L/S	6	VARIAN - MSPA8419N		Integral with cart
CCL	5.0×10^{-8}						
8 Modules x 3 per		MAIN ION PUMP	500 L/S	24	VARIAN - 9190406	VARIAN - 9295000	
8 Modules x 1 per		WAVEGUIDE ION PUMP	25 L/S	8	VARIAN - 9115036	VARIAN - 9290191	
		ROUGHING PUMP CART	500 L/S	6	VARIAN - MSPA8419N		Integral with cart
SRF	1.0×10^{-9}						
Diff Pump Stand		MAIN ION PUMP	30 L/S	3	Perkin-Elmer -2043000	TBD	
Warm Sections (32)		MAIN ION PUMP	TBD L/S	32	TBD	TBD	TBD
CM Coupler (116)		TURBO PUMP	TBD L/S	116	TBD	TBD	TBD
Diff Pump Stand		MAIN ION PUMP	30 L/S	4	Perkin-Elmer -2043000	TBD	
		ROUGHING PUMP CART	500 L/S	0	VARIAN - MSPA8419N		Integral with cart
RING							
HEBT	5.0×10^{-8}						
		ION PUMP	200 L/S	17	TBD		
		TURBO / ROUGHING		4	TBD		Turbo Pump w/ Dry Mech Pump
		ROUGHING PUMP CART	500 L/S	0	VARIAN - MSPA8419N		Integral with cart
RING	1.0×10^{-8}						
		ION PUMP	200 L/S	36	TBD		
		TURBO / ROUGHING		5	TBD		Turbo Pump w/ Dry Mech Pump
		ROUGHING PUMP CART	500 L/S	0	VARIAN - MSPA8419N		Integral with cart
RTBT	1.0×10^{-7}						
		ION PUMP	200 L/S	16	TBD		
		TURBO / ROUGHING		5	TBD		Turbo Pump w/ Dry Mech Pump
		ROUGHING PUMP CART	500 L/S	0	VARIAN - MSPA8419N		Integral with cart

TOTALS - LINAC	
LARGE ION PUMP	111
SMALL ION PUMP	65
LG TURBO PUMP	3
SM TURBO PUMP	57
CRYOPUMPS	5
ROUGH PUMP STA	18
ROUGH PUMP CAR	14

M. Hechler 8/11/00

SNS ACCELERATOR
VACUUM SYSTEM
VALVE SUMMARY
DRAFT 4-17-00

SYSTEM	VACUUM VALVES				CONTROLLER	MISC INFO
	TYPE	SIZE	QTY	MAKE/MODEL	MAKE/MODEL	
FRONT END						
SOURCE/LEBT						
	LEBT Beam Line	TBD	1	TBD	TBD	TBD
	LEBT Pump Isolation	8 in	3	MDC/ TBD	N/A	Manual
	Backing Pump Foreline	1 1/2 in	3	MDC/ TBD	TBD	TBD
	LEBT Vent Valve	TBD	1	MDC/ TBD		TBD
RFQ						
	RFQ Beam Line	TBD	1	TBD	TBD	Pneumatic
	RFQ Pump Isolation	8 in	5	MDC/ TBD	N/A	Manual
	Backing Pump Foreline	1 1/2 in	5	MDC/ TBD	TBD	TBD
MEBT						
	MEBT Beam Line	TBD	1	TBD	TBD	Pneumatic
	MEBT Pump Cart Isolation	8 in	2	MDC/ TBD	N/A	Manual
TEST STAND						
	LEBT Beam Line	TBD	1	TBD	TBD	Pneumatic
	LEBT Pump Isolation	8 in	3	MDC/ TBD	N/A	Manual
	Backing Pump Foreline	1 1/2 in	3	MDC/ TBD	TBD	TBD
	LEBT Vent Valve	TBD	1	MDC/ TBD	N/A	Manual
LINAC						
DTL						
	DTL Tank Beam Line	1 1/2	1	MDC - GV-2500M-P	TBD	Pneumatic
	DTL Pump Cart Isolation	6 in	5	MDC - GV-6000M	N/A	Manual
CCL						
	CCL Module Beam Line	2 1/2	8	MDC - GV-2500M-P	TBD	Pneumatic
	CCL Pump Cart Isolation	6 in	16	MDC - GV-6000M	N/A	Manual
	CCL Gauge Isolation	1 1/2	16	MDC - MAV-150-V	N/A	Manual
	CCL Gauge Isolation	2-Jan	24	MDC - AV-050M	N/A	Manual
SRF						
Diff Pump Stand	Beam Line Isolation	1 1/2	1	TBD	TBD	Pneumatic
Cryomodules (32)	Beam Line Isolation	4	60	TBD	TBD	Pneumatic
	Beam Line Isolation	4	58	TBD	TBD	Manual
Warm Sections (32)	Rough Pump Isolation	1 1/2	59	TBD	TBD	Manual
Diff Pump Stand	Beam Line Isolation	4	1	TBD	TBD	Pneumatic
RING						
HEBT						
	HEBT Sector Beam Line	TBD	6	TBD	TBD	Pneumatic
	HEBT Fast Closing Beam Line	TBD	1	TBD	TBD	Pneumatic
	Rough Pump Isolation	TBD	5	TBD	TBD	Manual
RING						
	RING Sector Beam Line	TBD	8	TBD	TBD	Pneumatic
	RING Beam Line	TBD	1	TBD	TBD	Pneumatic
	Rough Pump Isolation	TBD	8	TBD	TBD	Manual
RTBT						
	RTBT Sector Beam Line	TBD	5	TBD	TBD	Pneumatic
	RTBT Fast Closing Beam Line	TBD	1	TBD	TBD	Pneumatic
	Rough Pump Isolation	TBD	5	TBD	TBD	Manual

TOTALS		Remote
Beam Line Valve	153	98
Pump/Cart Isolation	111	
Instru Isolation	40	
Foreline Valves	11	

M. Hechler 8/11/00

INTERFACES AVAILABLE FOR SOME EQUIPMENT BEING CONSIDERED FOR THE STANDARD

Equipment Type	Vendor & Model No.	Interfaces Available				Comments
		Discrete & analog I/O	RS-232 RS-422 RS-485	Device Net	IEEE 488	
Ion Pump Controller	Varian MultiVac	X	X			Probably meets RHIC spec
	Varian MidiVac	X	X			Spec'ed in LANL cost estimate
	Varian MiniVac	X	X			Spec'ed in LANL cost estimate
	Physical Electronics (PHI)	X	X			Probably meets RHIC spec
Vacuum Partial Pressure Analyzer	MKS / Pfeiffer / Leybold	?	X			RS-485 (per RHIC spec). Could not find on web
Vacuum Gauge Controller	Varian Multi-Gauge	X	X			Probably meets RHIC spec
	MKS Type 146 Cluster Gauge	X	X			Probably meets RHIC spec
	Pfeiffer MaxiGauge	X	X			Probably meets RHIC spec. Not much info on web
	Granville-Phillips Series 360 Stabil-Ion	X	X		X	Spec'ed in LANL cost estimate
Turbo Pump Controller	Varian	X	X			Probably meets RHIC spec
	Pfeiffer	?	?			RS-485? Not much info on web
	Leybold	?	?			Couldn't find enough info on web