LEDA Vacuum Interlocks

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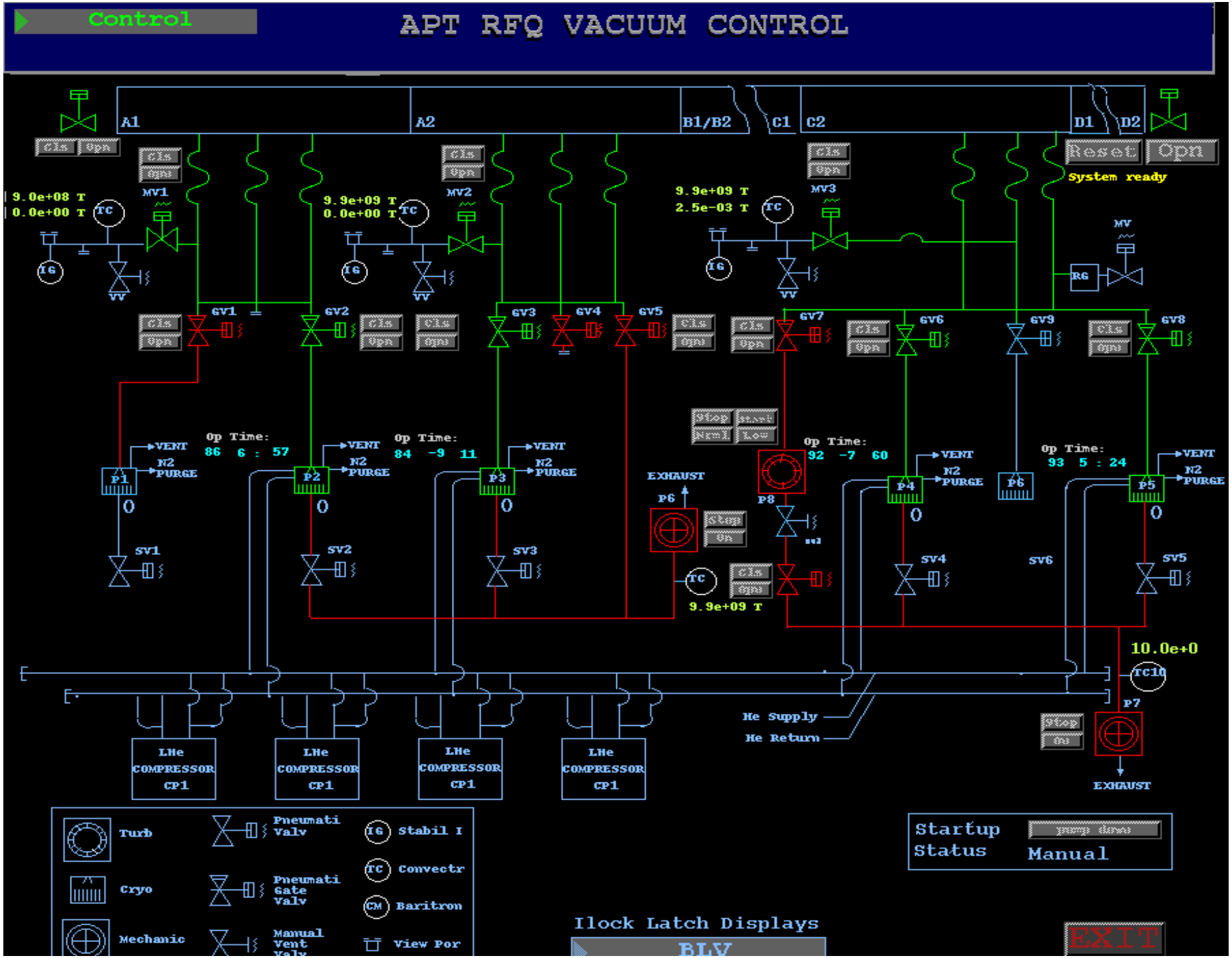
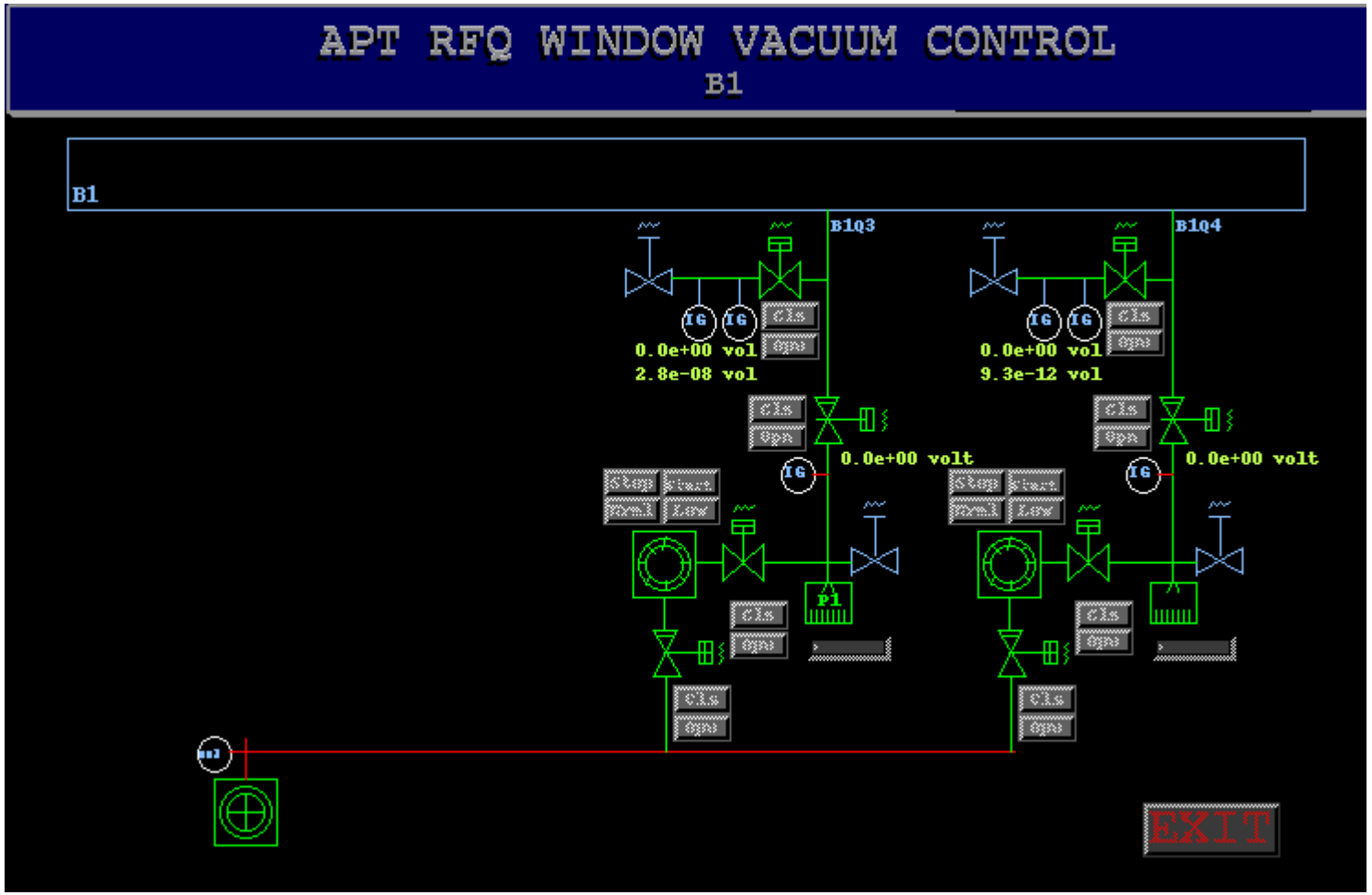
Outline

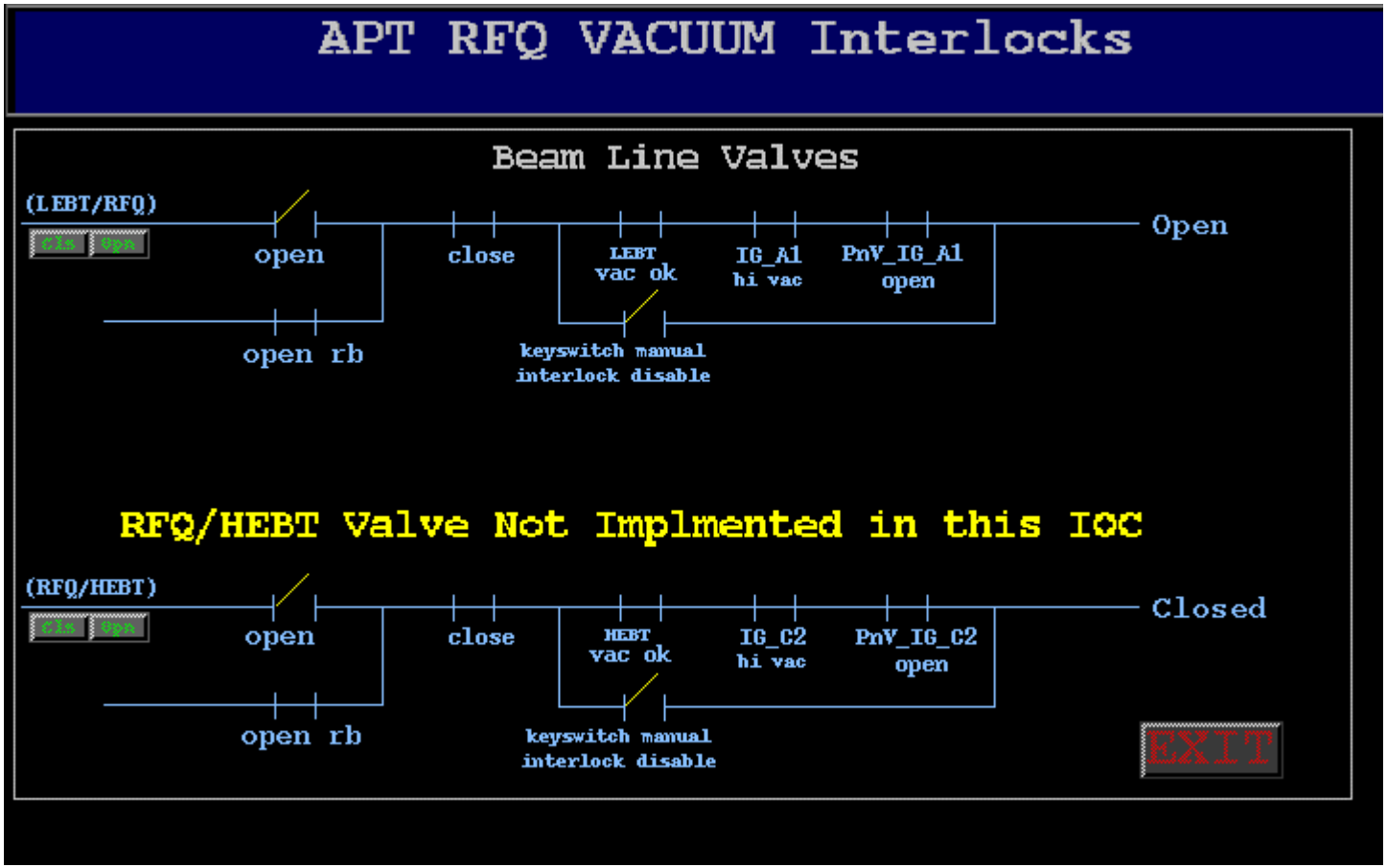
- Leda vacuum system – displays and interfaces
- PLC Interlocks as presented to the operator
- EPICS interlock to fast protect
- EPICS logic for fast protect as drawn in Capfast
- Fast faults as they appear on stiptool
- PLC communications diagnostics
- Conclusions

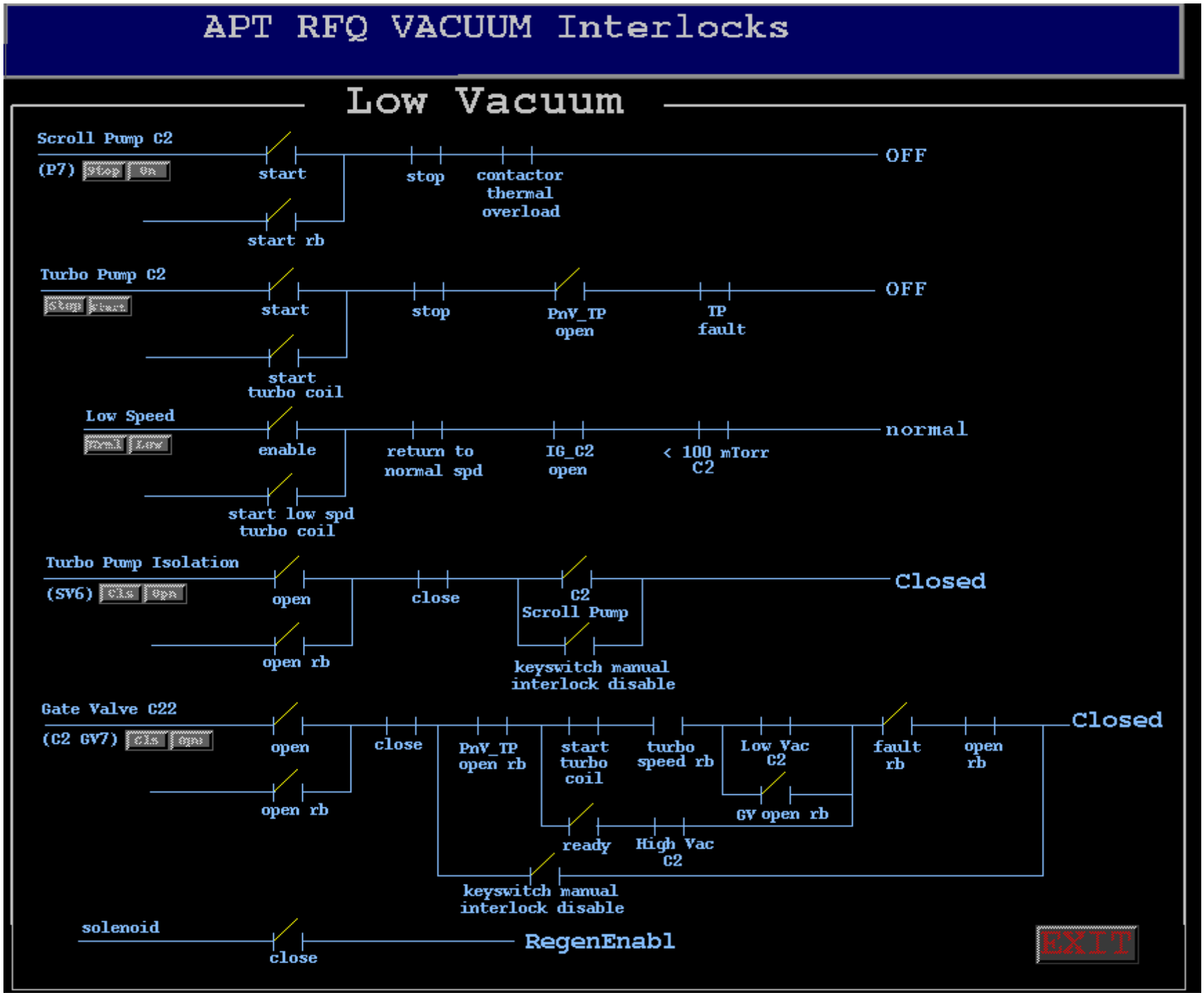

Control
APT RFQ VACUUM CONTROL
A1
A2
B1/B2
C1
C2
D1
D2
Reset
Opn
System ready
9.0e+08 T
0.0e+00 T
9.9e+09 T
0.0e+00 T
9.9e+09 T
2.5e-03 T
MV1
MV2
MV3
MV
RG
IG
TC
VV
GV1
GV2
GV3
GV4
GV5
GV7
GV6
GV9
GV8
Op Time: 86 6 : 57
Op Time: 84 -9 11
Op Time: 92 -7 60
Op Time: 93 5 : 24
VENT
N2 PURGE
P1
P2
P3
P4
P5
P6
P7
P8
EXHAUST
SV1
SV2
SV3
SV4
SV5
SV6
9.9e+09 T
10.0e+0
TC10
He Supply
He Return
LHe COMPRESSOR CP1
LHe COMPRESSOR CP1
LHe COMPRESSOR CP1
LHe COMPRESSOR CP1
Turb
Cryo
Mechanic
Pneumati Valv
Pneumati Gate Valv
Manual Vent Valv
Stabil I
Convectr
Baritron
View Por
Startup Status
Manual
Ilock Latch Displays
BLV
EXIT


APT RFQ WINDOW VACUUM CONTROL
B1
B1
B1Q3
B1Q4
IG
IG
Cls
Opn
0.0e+00 vol
2.8e-08 vol
0.0e+00 vol
9.3e-12 vol
0.0e+00 volt
0.0e+00 volt
Stop
Start
Manl
Low
P1
EXIT

PLC Interlocks

- These are used for equipment protection.
- Displays of the interlock chains are available from the control screens.
- The HEBT Valve is special - the rfq vacuum only warns that the valve is open but not armed for shutdown.

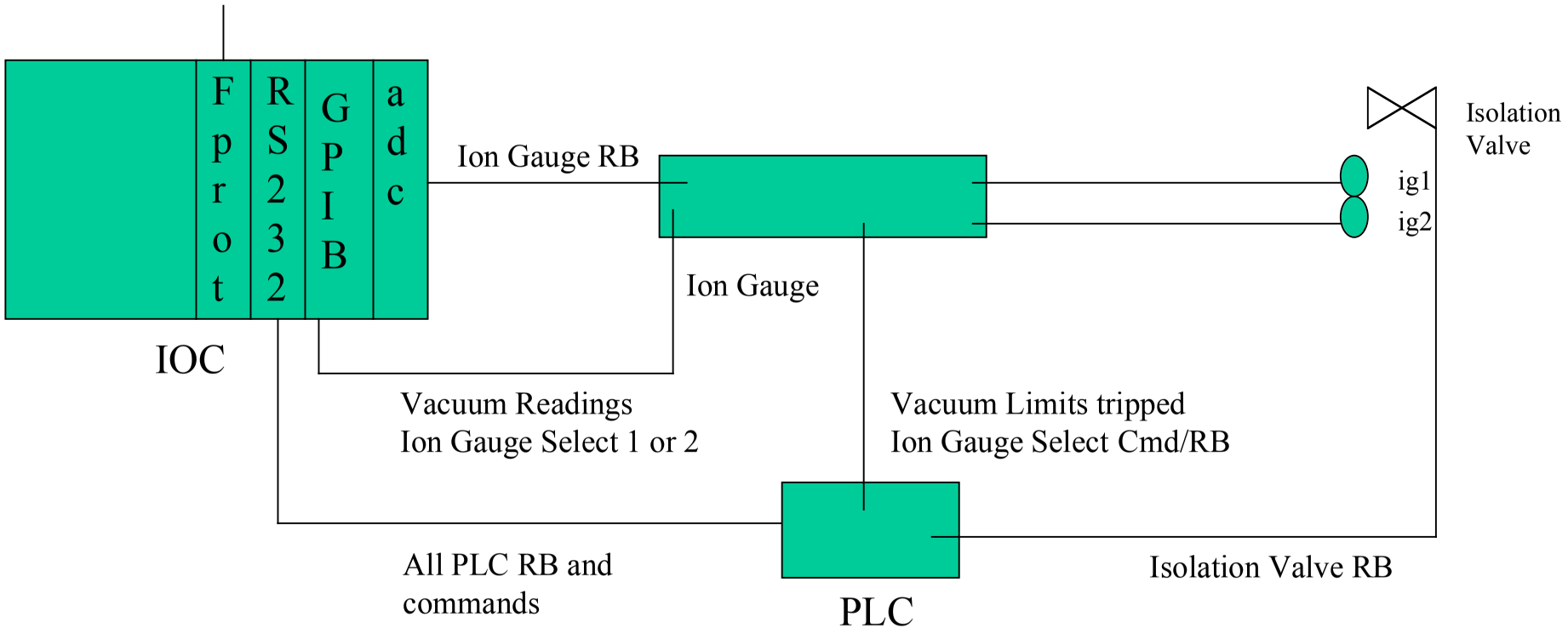

APT RFQ VACUUM Interlocks
Beam Line Valves
(LEBT/RFQ)
Cls
Opn
open
close
LEBT
vac ok
IG_A1
hi vac
PnV_IG_A1
open
Open
open rb
keyswitch manual
interlock disable
RFQ/HEBT Valve Not Implmented in this IOC
(RFQ/HEBT)
Cls
Opn
open
close
HEBT
vac ok
IG_C2
hi vac
PnV_IG_C2
open
Closed
open rb
keyswitch manual
interlock disable
EXIT


APT RFQ VACUUM Interlocks
Low Vacuum
Scroll Pump C2
(P7)
start
stop
contactor thermal overload
OFF
start rb
Turbo Pump C2
start
stop
PnV_TP open
TP fault
OFF
start turbo coil
Low Speed
enable
return to normal spd
IG_C2 open
< 100 mTorr C2
normal
start low spd turbo coil
Turbo Pump Isolation
(SV6)
open
close
C2 Scroll Pump
Closed
open rb
keyswitch manual interlock disable
Gate Valve C22
(C2 GV7)
open
close
PnV_TP open rb
start turbo coil
turbo speed rb
Low Vac C2
fault rb
open rb
Closed
open rb
GV open rb
ready
High Vac C2
keyswitch manual interlock disable
solenoid
close
RegenEnabl
EXIT

Interface to fast protect

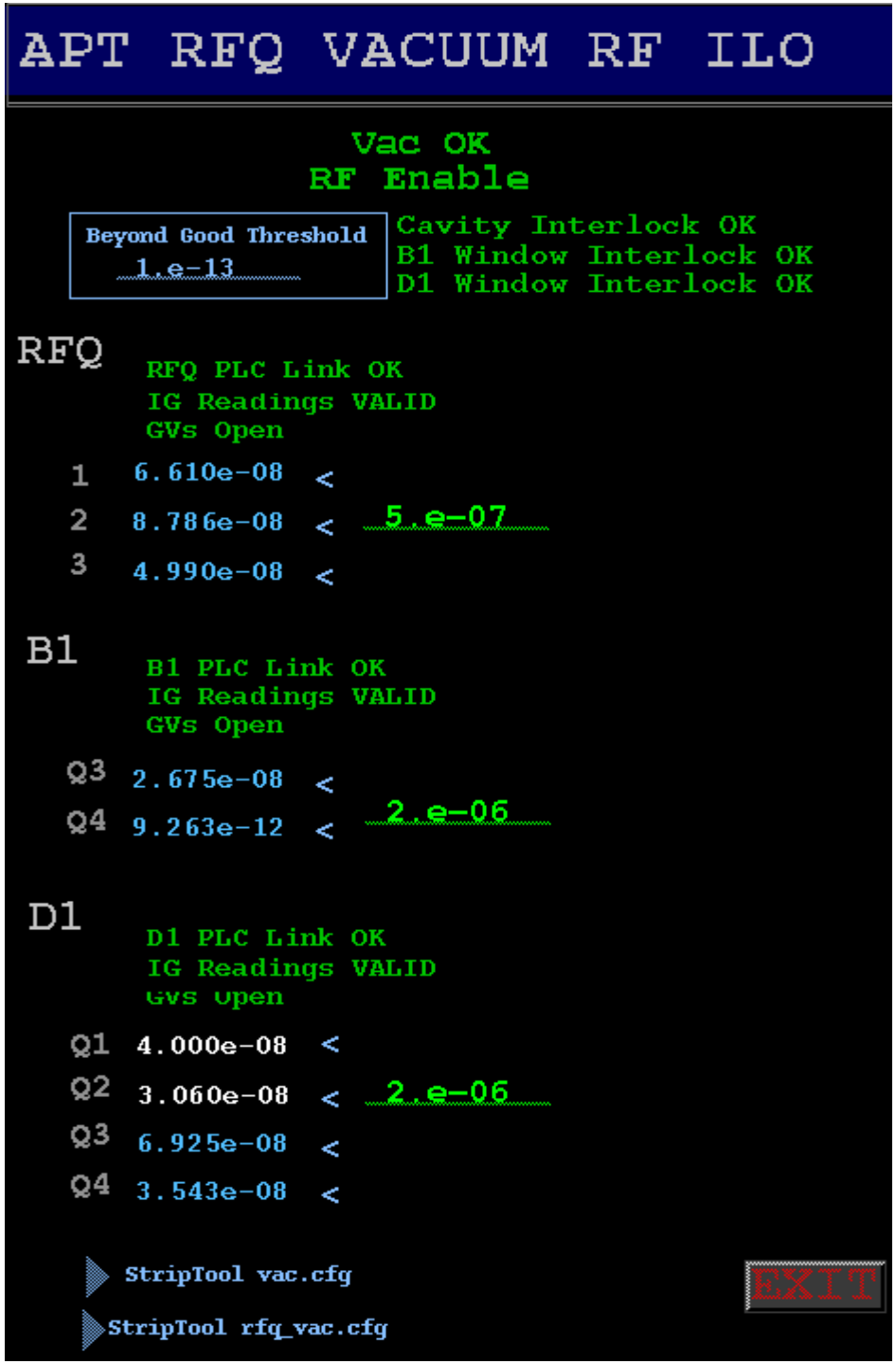
- Normal operation
  - Loss of vacuum trips beam. Vacuum drops below 10e-6 or 10e-5.
- Interlocks that are disabled and the causes
  - bad readings from the ION Gauges
  - disconnected cables will not trip - but vacuum goes to 10e-10. Best vacuum reading is 10e-8.

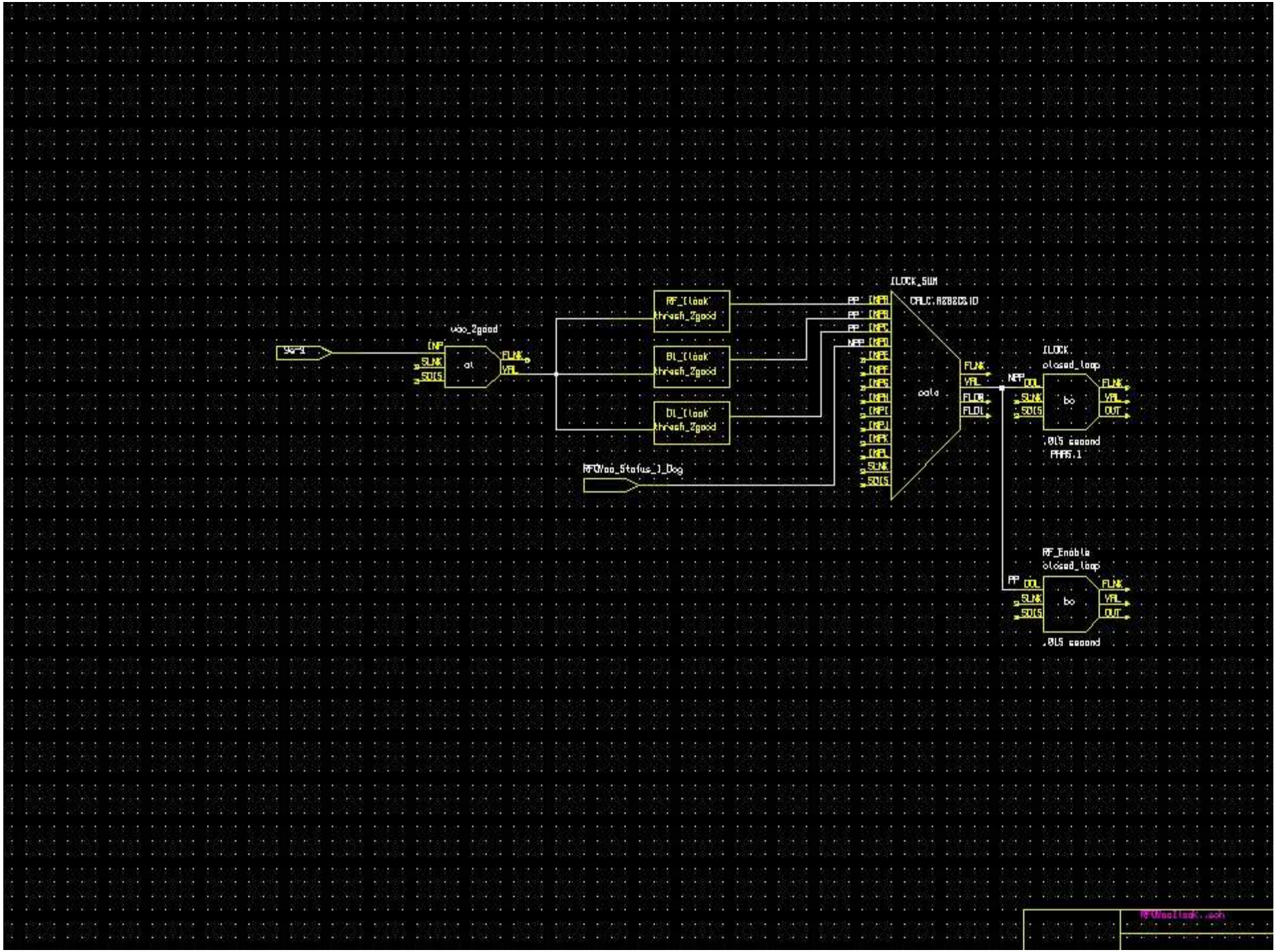
Vacuum System Hardware



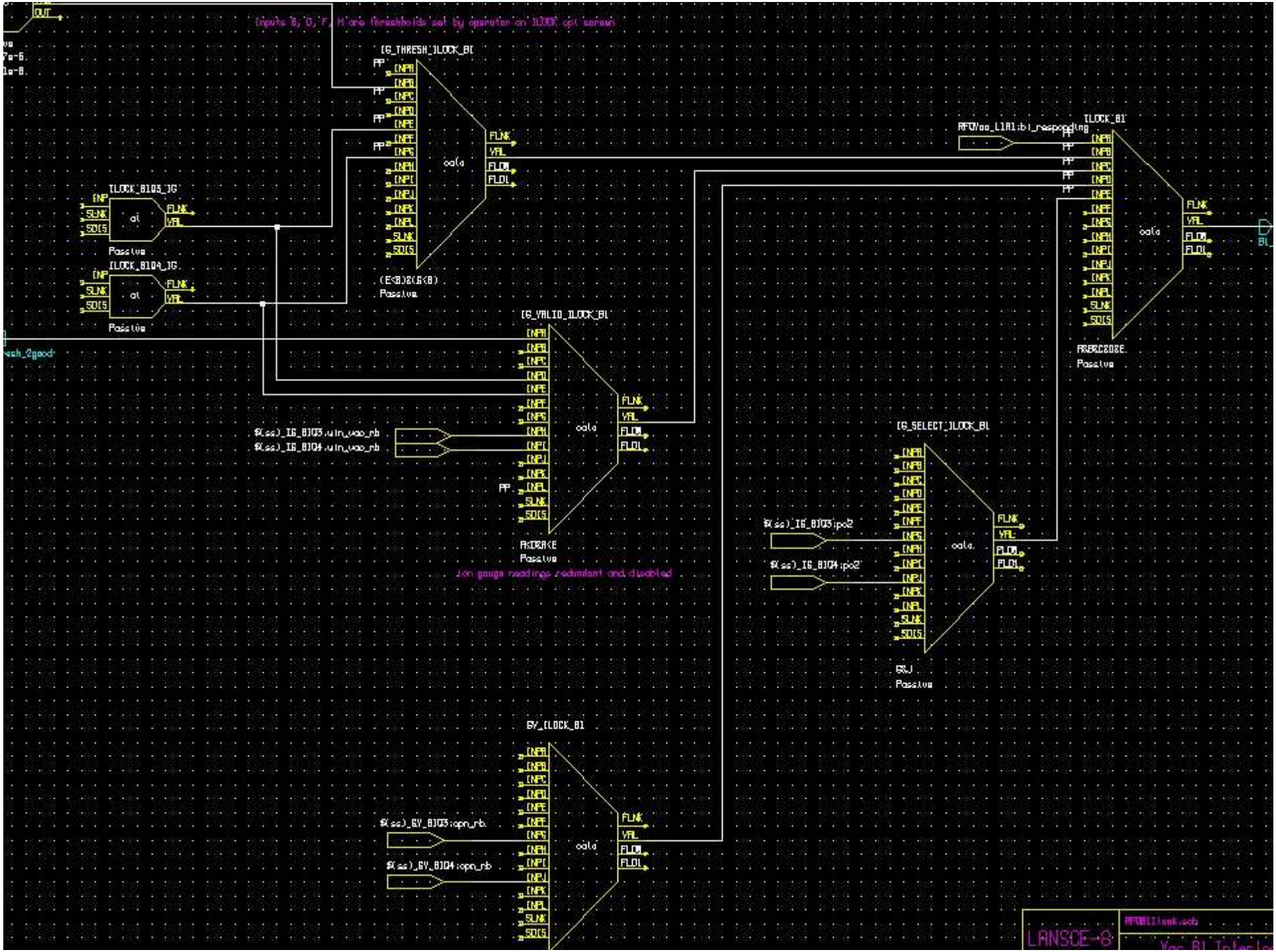
Hardware Interfaces

- 1 Systran adc into IP - 60 Hz scan of ion gauge readings used for fast protect. Lights are on solid
- MV133 4 port Serial interface to modicon PLCs - most of the vacuum readings and controls are through here.
- 4 IP - GPIB readings of the vacuum gauges
- 1 IP - fast protect interface for vacuum

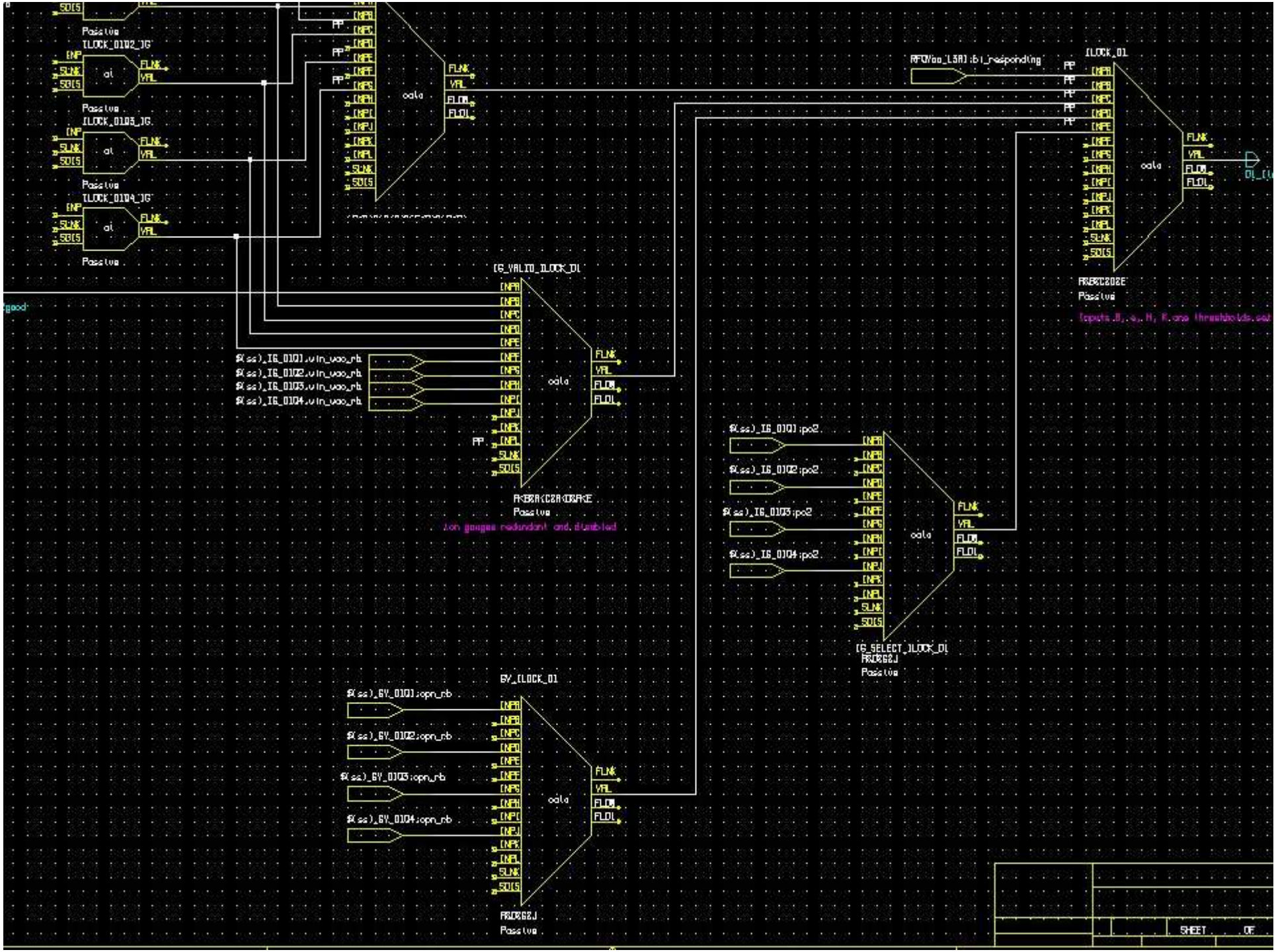

APT RFQ VACUUM RF ILO
Vac OK
RF Enable
Beyond Good Threshold
1.e-13
Cavity Interlock OK
B1 Window Interlock OK
D1 Window Interlock OK
RFQ
RFQ PLC Link OK
IG Readings VALID
GVs Open
1 6.610e-08 <
2 8.786e-08 < 5.e-07
3 4.990e-08 <
B1
B1 PLC Link OK
IG Readings VALID
GVs Open
Q3 2.675e-08 <
Q4 9.263e-12 < 2.e-06
D1
D1 PLC Link OK
IG Readings VALID
GVs Open
Q1 4.000e-08 <
Q2 3.060e-08 < 2.e-06
Q3 6.925e-08 <
Q4 3.543e-08 <
StripTool vac.cfg
StripTool rfq_vac.cfg
EXIT



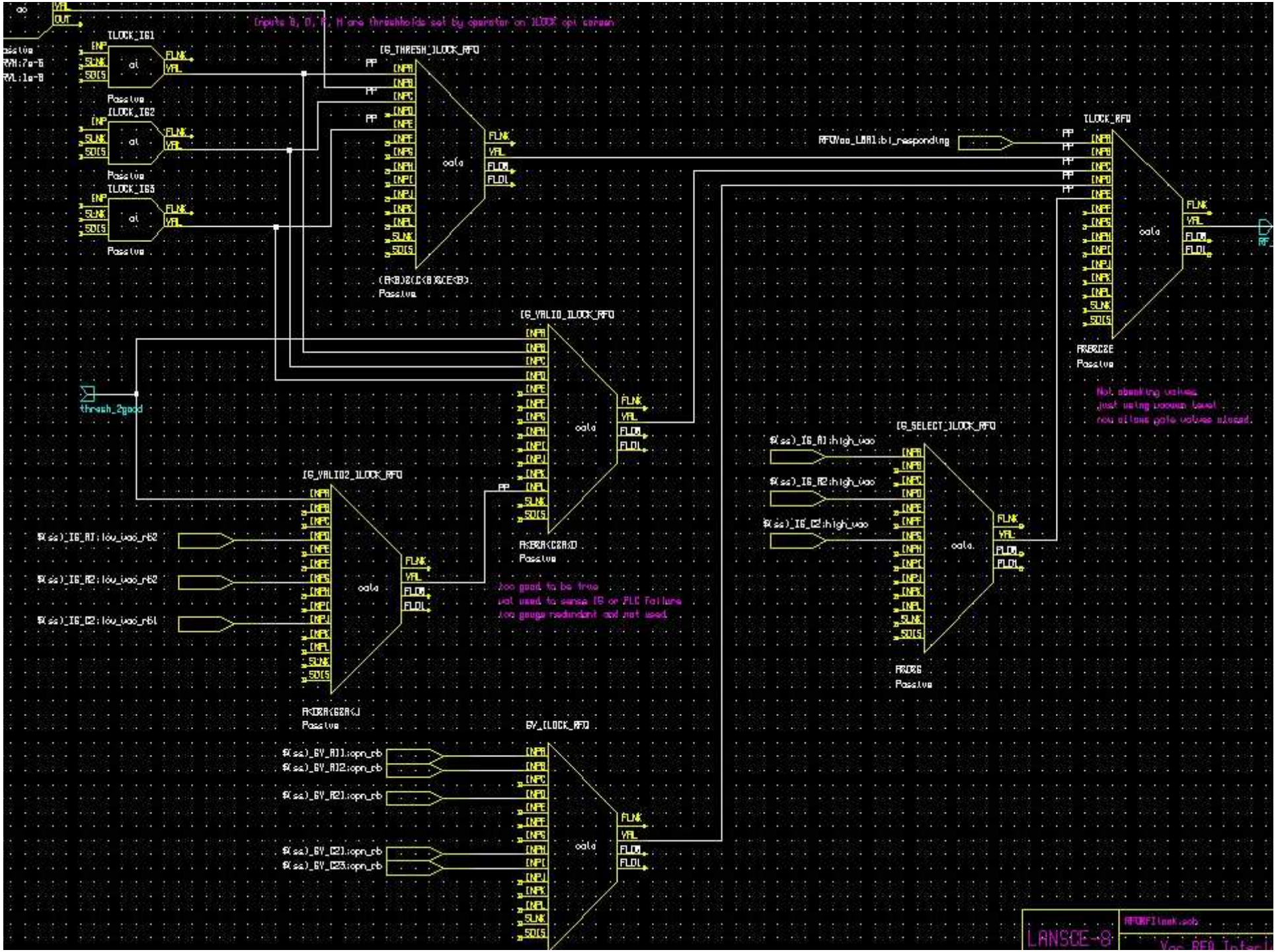
ILOCK_SUM
CALC:A2B2C3ID
vac_2good
INP
SLNK
SDIS
ai
FLNK
VAL
RF_Ilock
thresh_2good
BL_Ilock
thresh_2good
DL_Ilock
thresh_2good
RFQVac_Status_1_Dog
PP
NPP
calc
FLNK
VAL
FLDL
ILOCK
closed_loop
DOL
bo
OUT
.015 second
PHAS.1
RF_Enable
closed_loop

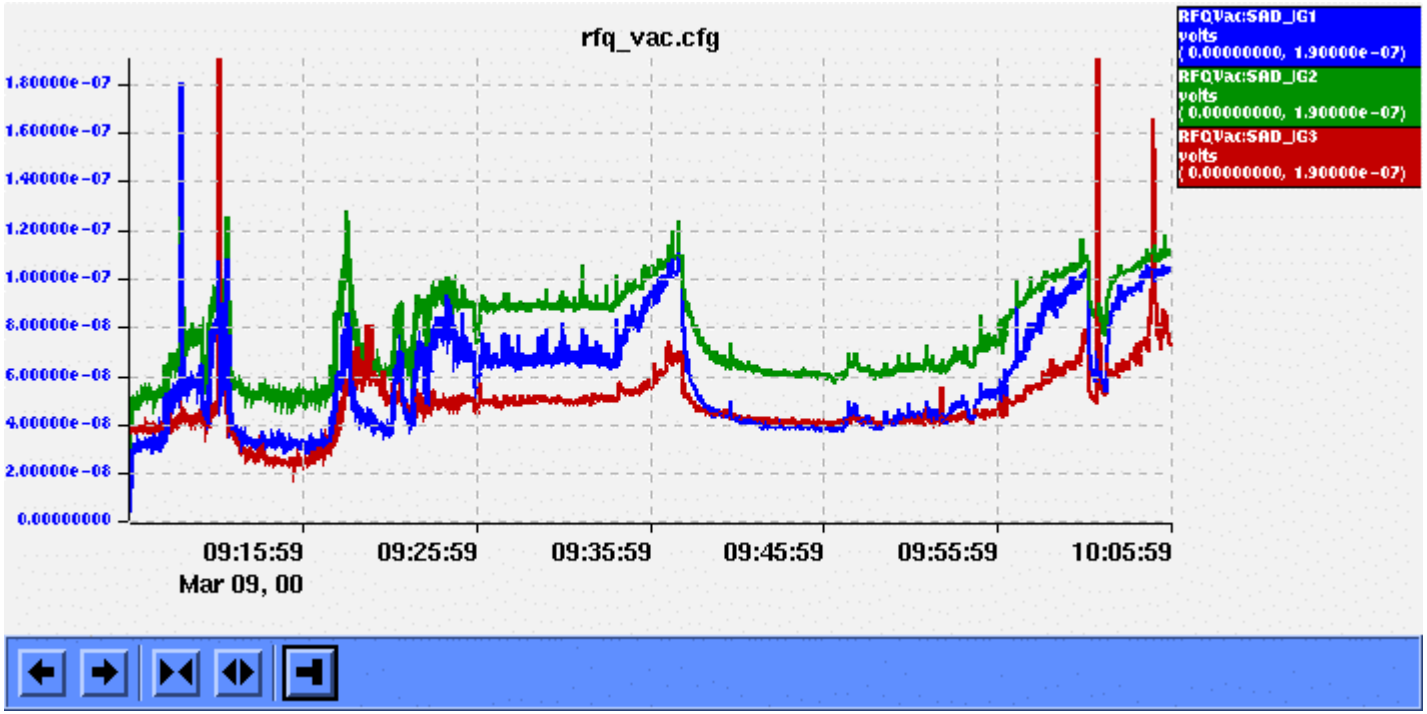


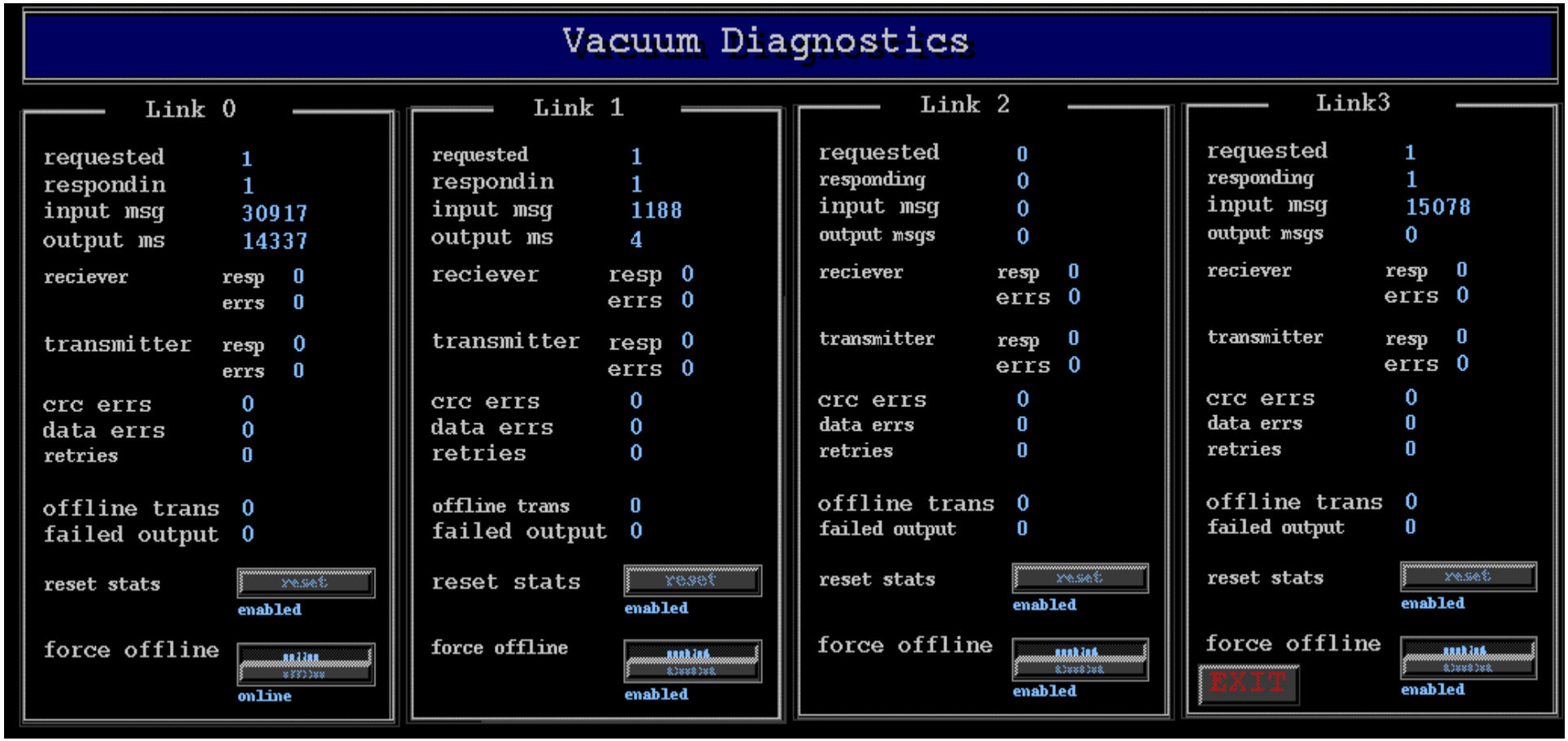
Inputs B, D, F, H are threshholds set by operator on ILOCK opi screen
[G_THRESH_]LOCK_BI
[LOCK_B1O3_]G
[LOCK_B1O4_]G
Passive
(E<B)&(G<B)
Passive
[G_VALID_]LOCK_BI
$(ss)_IG_B1O3:uin_vac_rb
$(ss)_IG_B1O4:uin_vac_rb
Ion gauge readings redundant and disabled
[G_SELECT_]LOCK_BI
$(ss)_IG_B1O3:po2
$(ss)_IG_B1O4:po2
GSJ
Passive
GV_[LOCK_B1
$(ss)_GV_B1O3:opn_rb
$(ss)_GV_B1O4:opn_rb
RFQVac_L1A1:bi_responding
[LOCK_B1
Passive
LANSCE-8



Passive
ILOCK_0102_IG
ILOCK_0103_IG
ILOCK_0104_IG
ILOCK_01
IG_VALID_ILOCK_01
$(ss)_IG_0101.vin_vac_rb
$(ss)_IG_0102.vin_vac_rb
$(ss)_IG_0103.vin_vac_rb
$(ss)_IG_0104.vin_vac_rb
$(ss)_IG_0101:po2
$(ss)_IG_0102:po2
$(ss)_IG_0103:po2
$(ss)_IG_0104:po2
IG_SELECT_ILOCK_01
GV_ILOCK_01
$(ss)_GV_0101:opn_rb
$(ss)_GV_0102:opn_rb
$(ss)_GV_0103:opn_rb
$(ss)_GV_0104:opn_rb
SHEET
OF


Inputs B, D, F, H are thresholds set by operator on ILOCK opi screen
ILOCK_IG1
ILOCK_IG2
ILOCK_IG5
Passive
[G_THRESH]ILOCK_RFQ
(A<B)&(C<B)&(E<B)
[G_VALID]ILOCK_RFQ
thresh_2good
[G_VALID2]ILOCK_RFQ
A<B&A<C&A<D
Not checking valves
just using pressure level
now allows gate valves closed.
[G_SELECT]ILOCK_RFQ
A&B&C
BV_ILOCK_RFQ
ILOCK_RFQ
A&B&C&E
LANSCE-8


rfq_vac.cfg
RFQVac:SAD_JG1
volts
(0.00000000, 1.90000e-07)
RFQVac:SAD_JG2
volts
(0.00000000, 1.90000e-07)
RFQVac:SAD_JG3
volts
(0.00000000, 1.90000e-07)
1.80000e-07
1.60000e-07
1.40000e-07
1.20000e-07
1.00000e-07
8.00000e-08
6.00000e-08
4.00000e-08
2.00000e-08
0.00000000
09:15:59
Mar 09, 00
09:25:59
09:35:59
09:45:59
09:55:59
10:05:59


Vacuum Diagnostics
Link 0
requested 1
respondin 1
input msg 30917
output ms 14337
reciever resp 0
errs 0
transmitter resp 0
errs 0
crc errs 0
data errs 0
retries 0
offline trans 0
failed output 0
reset stats
enabled
force offline
online
Link 1
requested 1
respondin 1
input msg 1188
output ms 4
reciever resp 0
errs 0
transmitter resp 0
errs 0
crc errs 0
data errs 0
retries 0
offline trans 0
failed output 0
reset stats
enabled
force offline
enabled
Link 2
requested 0
responding 0
input msg 0
output msgs 0
reciever resp 0
errs 0
transmitter resp 0
errs 0
crc errs 0
data errs 0
retries 0
offline trans 0
failed output 0
reset stats
enabled
force offline
enabled
Link3
requested 1
responding 1
input msg 15078
output msgs 0
reciever resp 0
errs 0
transmitter resp 0
errs 0
crc errs 0
data errs 0
retries 0
offline trans 0
failed output 0
reset stats
enabled
force offline
EXIT
enabled

Conclusions

- Making up an interlock in the IOC requires consideration of all software and hardware failures possible.

- Interlocks made up in a PLC should be easily understood at the operator workstations. At LEDA this was done with DM screens that mimic ladder logic.