

Interlock Controller for the Cryogenic Distillation Column (ICC) (Technical description)

1. Introduction

The Cryogenic Distillation Column at the PAB includes two 600 watt cryocoolers and three 600 watt heaters. The cryocoolers and heaters are used to maintain desired low temperature in the column. The cryocoolers always run at full power and the resistive heaters are controlled by the closed control loop consisting of one or two Agilent power supplies operated by the LakeShore Model 336 Temperature controller. The Temperature controllers are interfaced with the National Instrument cRIO-9073 PLC via GPIB interface. The purpose of the Interlock Controller for the Cryogenic Column (ICC) is to prevent various undesirable conditions when either cryocoolers or heaters are not operating normally.

2. ICC main features

The ICC is implemented as a 19" rack chassis (Figure 1). All necessary connectors to cryocoolers, power supplies and controllers and a DC Power socket are located on the rear panel of the chassis.



Figure 1: The Interlock Controller

The front panel has a LCD display to indicate the status of the Interlock and the following controls and indicators (Figure 2):

- a. SELECT button
- b. COMPRESSOR 1 START button
- c. COMPRESSOR 1 STOP button
- d. COMPRESSOR 2 START button

- e. COMPRESSOR 2 STOP button
- f. EMERGENCY STOP button
- g. ACTIVATE INTERLOCK button
- h. DISABLE INTERLOCK button
- i. POWER ON LED (Green)
- j. COMPRESSOR 1 ON LED (Green)
- k. COMPRESSOR 2 ON LED (Green)
- l. SYSTEM ERROR LED (Red)
- m. INTERLOCK ACTIVE LED (Green)
- n. INTERLOCK DISABLED LED (Yellow)



Figure 2: Front panel of the ICC

There are nine connectors on the rear panel (Figure 3). The STATUS/CONTROL DB25 connector provides status information to the external device and accepts emergency stop input signal. Two TEMP CTRL DB9 connectors are dedicated for LakeShore Model 336 Temperature controller's signals. The other three PS DB9 connectors provide control and status information to/from Agilent power supplies. The last two COMP DB15 connectors provide remote control and status for the cryocoolers. The rightmost connector +5V POWER on the panel provides power supply connection for the Interlock.



Figure 3: Rear panel of the ICC

3. Operation of the ICC

At the power up the ICC starts in the monitoring mode. In this mode it only monitors various status signals from the external devices and displays it on the LCD screen (Figure 4). This mode can be used for debugging the system. Note that during powering up, the ICC may issue shutdown signals to the connected equipment and shut it down. Therefore, the ICC must be turned on first with all the equipment connected to it turned off. After the ICC is powered up, the Agilent power supplies and cryocooler's compressors can be operated as usual. The SYSTEM ERROR LED will indicate if any status errors occurred. The LCD display will provide additional information about the error (see below).

If the interlock function is activated (ACTIVATE INTERLOCK button pushed), the ICC will shut down the system if any status of the compressor, power supply or temperature controller has failed. The INTERLOCK ACTIVE LED will flash every other second indicating that the system was shut down. The LCD display will provide additional information about the ICC status (Figure 4). Pushing INTERLOCK DISABLE button will return the ICC to the power up status.



Figure 4: LCD display

The following error codes are used to display system errors on the LCD:

- a) Compressor error: "E1" or "E2"
- b) Compressor temperature error: "T1" or "T2"
- c) Compressor pressure error: "P1" or "P2"
- d) Power supply error: "S1" or "S2" or "S3"
- e) Temperature high controller error: "H1" or "H2"
- f) Temperature low controller error: "L1" or "L2"

The system will stop immediately if the EMERGENCY STOP button is pushed. The SYSTEM ERROR LED will flash every other second to indicate the emergency stop. The ICC will return to power up status after INTERLOCK DISABLE button is pushed. Similar reaction will occur

if an external emergency stop signal is received. The LCD display will indicate which of the two emergency stops occurred.

4. Specifications

- Power supply voltage: 5V
- Power consumption: 0.5A
- Control outputs switching capacity: 1A, 30V max
- Status inputs signal level: TTL/CMOS
- Status outputs signal level: LVTTTL

Appendix A External connections and signals

Pinouts for AL600_CP1014 System I/O DB15 connector (female)

#	DB15	16-pin header	Signal	Comment
1	1	1	Compressor running CC	Contacts Closed
2	9	2	Input Reference	Local GND
3	2	3	Compressor running CC	Contacts Closed
4	10	4	+24V Return	0V
5	3	5	He Pressure Error CC	Contacts Closed
6	11	6	Isolated +24V	+24V
7	4	7	He Pressure Error CC	Contacts Closed
8	12	8	Local/Remote Toggle	True = Remote
9	5	9	He Temperature Error CC	Contacts Closed
10	13	10	Interlock	True = Inhibit
11	6	11	He Temperature Error CC	Contacts Closed
12	14	12	Local Mode Stop	True = Stop
13	7	13	No Errors CC	Contacts Closed
14	15	14	Local Mode Start	True = Start
15	8	15	No Errors CC	Contacts Closed
16	NC	16	NC	N/A

Notes:

- a. DB15 Inputs 12, 13, 14 and 15 accept -12V referenced to pin 9 as a True signal
- b. DB15 Inputs 14 and 15 are edge sensitive (minimum signal width is 200 ms)
- c. DB15 Input 13 is level sensitive

Pinouts for Agilent N5700 Programming J1 Analog Programming DB25 connector (female)

#	DB25	DB9	10-pin header	Signal	Comment
1	1	1	1	Enable +	Contacts Closed
2	14	6	2	Enable -	Contacts Closed
3	2	2	3	Chassis Common	Local GND
4	15	7	4	Shut Off	High-to-Low
5	3	3	5	Chassis Common	Local GND
6	16	8	6	Power Supply OK	TTL
7	11	4	7	Output Voltage Monitor	Analog 0 – 5V
8	12	9	8	Common	Analog GND
9	24	5	9	Output Current Monitor	Analog 0 – 5V
10	N/A	NC	10	N/A	N/A

Notes:

- a. DB25 Inputs 1 and 14 must be shorted to enable power supply output
- b. DB25 Input 15 is edge sensitive (signal level 2.5v to 15V)
- c. DB25 Input 13 is level sensitive

Pinouts for Model 336 Controller terminal block

#	DB9	10-pin header	Signal	Comment
1	1	1	Relay 1 N.C.	Contact Closed
2	6	2	Relay 1 COM	Common
3	2	3	Relay 1 N.O.	Contact Open
4	7	4	N/A	N/A
5	3	5	Relay 2 N.C.	Contact Closed
6	8	6	Relay 2 COM	Common
7	4	7	Relay 2 N.O.	Contact Open
8	9	8	N/A	N/A
9	5	9	N/A	N/A
10	NC	10	N/A	N/A

Notes:

- a. Normally Closed (N.C.) contacts used by the ICC
- b. Each Relay must be assigned to one of the Alarms (A or B) in the Off mode

Pinouts for ICC status/control DB25 connector (female)

#	DB25	26-pin header	NI 9401 Signal	ICC Signal	Comment
1	1	1	COM		Local GND
2	14	2	DIO0	ILOCK ACTIVE	TTL OUT
3	2	3	NC		N/A
4	15	4	NC		N/A
5	3	5	COM		Local GND
6	16	6	DIO1	SYSTEM ERR.	TTL OUT
7	4	7	COM		Local GND
8	17	8	DIO2	COMP. #1 ON	TTL OUT
9	5	9	NC		N/A
10	18	10	NC		N/A
11	6	11	COM		Local GND
12	19	12	DIO3	COMP. #2 ON	TTL OUT
13	7	13	COM		Local GND
14	20	14	DIO4	PS #1 OK	TTL OUT
15	8	15	NC		N/A
16	21	16	NC		N/A
17	9	17	COM		Local GND
18	22	18	DIO5	PS #2 OK	TTL OUT
19	10	19	COM		Local GND
20	23	20	DIO6	PS #3 OK	TTL OUT
21	11	21	NC		N/A
22	24	22	NC		N/A
23	12	23	COM		Local GND
24	25	24	DIO7	SHUT DOWN	TTL IN
25	13	25	COM		Local GND
26	NC	26	NC		N/A

Notes:

- a. DB25 Inputs/Outputs correspond to NI 9401 Digital I/O module

Appendix B

System wiring diagram

