Sumitomo
(SHI) CRYOGENICS OF AMERICA, INC.

Marathon Cryopump Controller Programmer's Reference Guide

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1 Introduction

1.1 Introduction

The Marathon Cryopump Controller used to provide automated control of cryopump operations through an RS-232 port. This allows the controller to communicate with the cryopump to provide automated regeneration operation and intelligent feedback during operation. This guide should be used in conjunction with the Marathon Cryopump Controller Regeneration Reference Guide to program a device to communicate with a single or multiple Marathon Cryopump Controllers.

NOTE: Personnel should read and understand the contents of the cryopump operator's manual for all safety concerns before developing software which uses a cryopump or cryopumps.

1.2 General Specifications

Weight: 10 lbs. (4.54 kg)
Electrical Input: 200-240 VAC single phase.
Ambient Temperature: 50-120 F (10-48.9 C)
Communication Port (Rightmost DB9F): RS-232 Null Modem 9-Pin - 2.4K Baud with maximum cable length of 40 feet (12.2 meters)

A Null-Modem type RS-232 cable is required for communication with a standard PC RS-232 port configuration. Sumitomo Cryogenics Of America has part number 266965B, which is a 25 foot (7.6 meters) female to male null modem cable, as an option. The communication port should be configured as 1 start bit, 7 data bits, even parity with 1 stop bit. No hardware or software flow control is required.

1.3 Command Format

Commands are sent and received in 7-bit ASCII format.

- Synchronization character ($)
- Command with appropriate parameters
- Checksum character

- Termination (return = 0x0D hexadecimal see note below)

Note: For terminal use or serial traffic logs it is helpful to add a line feed character, '0x0A' hexadecimal, to the end of sent commands and responses. It would be acceptable to send a line feed character to the cryopump controller because it would be outside of the starting '$' and ending '0x0D' characters and thus ignored.

1.4 Checksum Creation

To create the checksum character for the command body, calculate the 8-bit sum of all the characters in the command excluding the pre ($) and post (carriage return) character. Exclusive OR (XOR) the sum result's seventh bit with the first bit with the first bit becoming the result of the logic. Repeat the same Exclusive OR procedure with the sixth bit and zero bit. Next, AND this result with 0x3F hexadecimal to reduce the result to 6 bits and finally increase this value by 0x30 hex (character '0') to produce result in a 7-bit protocol's range. An example C Plus Plus code snippet is given below to demonstrate how the checksum is calculated.

Example C++ Code

```
char CheckSum(AnsiString FCommandString)
{
//calculate the mod 256 of the character sum
unsigned __int8 CharSum=0;
for(int countChars=1;countChars<=FCommandString.Length();countChars++)
  {
   //add up each character value adding it to the total
   CharSum+=FCommandString[countChars];
  }//end of for
 //now that the characters are added XOR bits
 bool D0, D1, D6, D7;
 //get the bit values of the sum
 D0=CharSum&0x01; //and the sum with the zero bit
 D1=CharSum&0x02; //and the sum with the first bit
 D6=CharSum&0x40; //and the sum with the sixth bit
 D7=CharSum&0x80; //and the sum with the seventh bit
 //calculate XORs to strip bits 6&7
 D1=D1^D7; //D1 XOR D7
 D0=D0^D6; //D0 XOR D6
 //strip out old bits D0-D1, D6-D7
 CharSum&=0x3C; //and the sum with 0x3C
 //replace bits D0-D1 with the results
 CharSum|=D0; //OR in the resultant zero bit
 CharSum|=D1*0x02; //OR in the resultant one bit
```

```
 //now add the '0' character to the result
 //so the final outcome is a character from '0' to '??'
 CharSum+='0';
 //return the end result
 return CharSum;
}
```

1.5 Minimum Command Requirements

The minimum command requirements are the commands which must be used by a host controller in order to properly operate the system, debug system software and diagnose hardware conditions for the cryopump and the system.

- Module Version 11
- First Stage Temperature 9
- First Stage Temperature Control 10
- Second Stage Temperature 20
- Second Stage Temperature Control 21
- Thermocouple Pressure 22
- Duty Cycle 8
- Pump On/Off/Query 13
- Purge On/Off/Query 14
- Rough On/Off/Query 19
- TC On/Off/Query 22
- Regeneration 14
- Regeneration Error 15
- Regeneration Parameters 16
- Regeneration Sequence 17
- Rough Valve Interlock 20

2 Pump Commands

2.1 What's New

Sept 2007 - Firmware Version 2.17

Repurge Count Limit Of Two Hundred

The repurge cycle limit count (see regeneration parameters 16) had a previous maximum of fifty counts. During cases of large water volume (>250cc) more frequent shorter duration repurge cycles work most efficiently to remove water content. In this case, a large amount of repurge cycles are necessary.

ROR Count Limit Of Two Hundred

In extremely rare cases forty rate of rise cycles (see regeneration parameters 16) are not enough during one regeneration cycle. The rate of rise cycle count has been increased to accept a maximum value of two hundred to prevent this issue.

Thermocouple Range Expansion

The thermocouple 22 range has been expanded to read over 1 Torr to approximately 2.5 Torr. Although the sensor is not accurate above 1 Torr it can be used as a general idea of the vacuum condition during the regeneration cycle. The update rate of the sensor value has also been increased.

April 2007 - Firmware Version 2.13

Optional stand-by mode after regeneration cycle is completed.

During the cool down cycle of regeneration or after a power failure, when power failure recovery 11 is used, the pump will stand-by and hold T2 at 20K when standby mode is set to active condition with the regeneration parameters 16 command. This saves power when multiple pumps are attached on a single compressor and allows active pumps the ability to achieve higher performance by conserving energy.

When a cryopump is in stand-by mode the regeneration sequence 17 will state 'z' indicating the stand-by mode. When ready to take a cryopump off-line for a regeneration, place a stand-by pump into active mode by sending the controller the N3 command explained in the regeneration 14 section of the guide. Then, place the other pump into a regeneration cycle.

Speed limit control uses number of cryopumps per compressor

Controller will now accept the number of cryopumps on a single compressor with the 'PC' command. This is used to prevent the use of more Helium gas than is available from the compressor. See the regeneration parameters 16 section.

Cryopump Warm Up Cycle

When the controller is given the 'N4' regeneration 14 command, the cryopump will stop and warm up to room temperature. After the cryopump has been fully warmed up the regeneration sequence 17 character will report 's' for the stopped condition.

2.2 Overview

The Marathon Cryopump Controller responds to commands given by the controlling RS-232 device and executes an action or returns data based on the command's function. Commands that are received with an incorrect checksum character will be ignored. All other incorrect commands result in an error response. For a list of the possible responses to commands see the command response 7

section. Only one command may be sent at a time until a response is given by the controller.

Commands with required parameters are given in parenthesis and optional parameters are shown in brackets. Each command is shown with a full example of both a set or query operation to make understanding and programming and simple as possible.

Most commands respond with a signed or unsigned integer or floating point number. Although examples are given, it should never be assumed that results will always respond with either a certain sign or certain amount of decimal places. A response parser should be designed to accept numeric formats such as integer, double and scientific values for future software compatibility. The controller features C-style command parsing which accepts many numerical formats of an input so proper sign and decimal placement is not important to the Marathon Cryopump Controller.

Additionally, the controlling RS-232 device needs to incorporate standard error control logic and communication timeout features should the Marathon Cryopump Controller not respond to a command. The recommended time out interval for communication is 500 milli-seconds. If a response is not received within this time period, it should be assumed that a communication error occurred and the command should be resent to the Marathon Controller. The controller's electronics have been designed to *vastly exceed CE specifications* to be extremely reliable in electrically noisy environments. It does not mean, however, that standard error control measures should not be used.

Commands have the ultimate in ability to control the cryopump module. Commands such as open the purge valve and open the roughing valve have the ability to function even when a regeneration process is active. These commands should be used carefully as it can become possible to create unfavorable conditions. Interlocks should be incorporated into the system to prevent such occurrences and should have an override for diagnostic purposes. Some interlocks have been provided in the control mechanism itself to provide safety measures. For diagnostic purposes the thermocouple gauge might need to be enabled during initial cryopump installation without the desire to run an entire regeneration cycle. It is best to ensure it is possible to enable or disable all of the major inputs and outputs of the cryopump without operating in a controlled environment such as within a regeneration cycle.

2.3 Command Response

Responses start with the synchronization character '$' followed by a status indicator character. The character 'A' indicates the command was accepted and action was taken. Commands responding with the character 'E' indicate an error condition where the command was either not understood or an improper parameter or range was given. If a power failure has occured the response character will be 'B' if the command was accepted or 'F' if an error occured. It is the same as ASCII 'A' or 'E' + 1 decimal ('B' and 'F'). The remainder of the command is the result of a query function or nothing if the command was an action followed by the checksum character.

2.4 Duty Cycle

Description:

This command gets the running speed in duty cycle of the cryopump motor. The result is an integer between the minimum (3) and maximum speed limitation (default 23). To get the duty cycle in percent divide the result of this command into 23 and multiply the result by 100.

Command: XOI

Parameters (??)

Response: Result is an integer value.

Example: '$XOI??_[CR]' - Get duty cycle status.
Response: '$A23T[CR]' - 23 = 23/23*100 = 100% duty cycle.

2.5 Elapsed Time

Description:

This command gets the operating time of the cryopump running off the controller. The result is the operating time in hours up to 65 thousand. After 65 thousand hours the counter will wrap around back to zero. The elapsed time meter is running when a cryopump is on and is useful in tracking recommended cryopump maintenance intervals. The time meter does not increase when the cryopump is not running.

Command: Y

Parameters (?)

Response: Result is an integer value.

Example: '$Y?J[CR]' - Get time status.
Response: '$A+001150A[CR]' - 1150 hours run time.

2.6 Failed Rate Of Rise Cycles

Description:

Retrieve the number of failed rate of rise cycles. The counter tracks the number of failed rate of rise cycles during a regeneration cycle. This count can be up to the maximum rate of rise cycles

set in the regeneration parameters 16.

Command: m

Parameters: None

Response: The current failed repurge cycle count as an integer.

Example: '$m\[CR]' - Get count.
Response: '$A+1O[CR]' - 1 failed ROR cycle.

2.7 Failed Repurge Cycles

Description:

Retrieves the counter for the number of failed repurge cycles.

Command: l

Parameters: None

Response: The current failed repurge cycle count.

Example: '$l][CR]' - Get count.
Response: '$A+1O[CR]' - 1 failed repurge cycle.

2.8 First Stage Temp

Description:

This command gets the temperature of the first stage / radiation shield.

Command: J

Parameters: None

Example: '$J;[CR]' - Get T1
Response: '$A+0064.0F[CR]' - T1 is 64K.

2.9 First Stage Temp Control

Description:

This command sets or gets the control temperature of the first stage / radiation shield. The settings for first and/or second stage temperatures are predetermined by the factory based on the cryopump's process.

The first and second stage temperature control commands should be included in user software. When the temperature control value or method is changed the change will take affect on either the next regeneration cycle or by turning off and on the pump with the Pump On/Off 13 command

Command: H

Parameters: (0-320,?)[,0-3] [Temperature range and optional control method]

Control Temperature:

With the control temperature set to zero the temperature control function will be turned off. This command accepts a range of 0-320 as a setting.

Control Methods:

0: *External heater control.* This is the default if the control method is not supplied with the command's second parameter. The external heater will attempt to raise and control the first stage at this temperature. Note: It may not always be possible to reach the desired control temperature with the external heater.

1: *First stage with speed control.* The cryopump's operational speed will be controlled in order to achieve the selected temperature of the first stage. In this mode, the second stage control temperature 21 value is ignored.

2: *Second stage with speed control.* The operation speed will control the second stage temperature at the desired value which can be set with the 'I' command 21. When using this mode, the first stage control temperature value is ignored.

3: *Dual stage temperature control.* The cryopump controller will try to maintain the desired first stage given temperature value but will default to second stage control if over the second stage set point. If the second stage temperature meets the set point control is given back to the first stage control point.

Response:

If queried, an integer value is returned. Divide the integer result by 400 to retrieve the control method and the remainder is the first stage control temperature.

Example: '$H65,1@[CR]' - Set first stage temperature control at 65K with first stage speed control.

Response: '$A0[CR]' - Okay.

Example: '$H?5[CR]' - Get heater control point / method.
Response: '$A000465I[CR]' - The heater control method is first stage (465/400=1) and the temperature is 65K.

2.10 Last Rate Of Rise Value

Description:

Retrieve the last rate of rise value in microns per minute. This command is useful to the diagnosis of a failed regeneration cycle and should always be included in system software.

Command: n

Parameters: None

Response: The previous ROR value as an integer.

Example: '$n_[CR]' - Get value.
Response: '$A+8V[CR]' - 8 microns per minute.

2.11 Module Version

Description:

Retrieves the module type and software version for the controller. This is an important part of servicing information and should be included in a system's software.

Command: @

Parameters: None

Response: The software module and version.

Example: '$@1[CR]' - Get module and version.
Response: '$AMC02.08:[CR]' - Marathon controller version 2.08.

2.12 Power Failure Recovery

Description:

Set or retrieve the power failure recovery mode of the cryopump. If a power failure occurs enabling power failure recovery will try to re-cool T2 to 20K after the power resumes. When the power failure recovery mode is enabled in modes one or two, the controller will attempt to re-cool the cryopump if the second stage temperature is below the restart temperature limit set with the regeneration parameters 16 command. If not below the temperature limit, a full regeneration cycle will start if the power failure recovery mode is set for mode one. If the recovery mode is set at two and the temperature is above the limit setting, the cryopump will remain idle with its motor in the off state.

Command: i

Parameters: (0-2 or ?)

Parameter:

0: Power failure recovery disabled.

1: Power failure recovery enabled.

2: Power failure recovery enabled only when T2 is less than the limit set point.

?: Returns power failure recovery mode.

Response: The character returned indicates acknowledgement or the power failure recovery mode if requested.

Example: '$i1H[CR]' - Set power failure recovery to on.
Response: '$A0[CR]' - Okay.

Example: '$i?H[CR]' - Get power failure recovery mode.
Response: '$A1c[CR]' - Power failure recovery enabled.

2.13 Power Failure Recovery Status

Description:

Get the power failure recovery status mode of the cryopump. The response indicates the current status of the power failure recovery cycle which occurs after power is resumed.

Command: t

Parameters: (?)

Response: A character value of the following:

0: No power failure recovery in progress.

1: Cool down in progress.

2: Regeneration in progress.

3: Attempting to cool pump to 17K.

4: Recovered pump to less than 17K.

5: Pump second stage temperature (T2) not recovering well.

Example: '$t?a[CR]' - Get power failure recovery status.
Response: '$A0`[CR]' - No power failure detected.

2.14 Pump On/Off/Query

Description:

This command turns the cryopump on and off and can return the cryopump's current operating mode. Supplying a second query character will return an extra bit which indicates the pump readiness status.

Command: A

Parameters: (0-1 or ?[?]) - Off, On, Query; If provided a second query questionmark will return the pump readiness status.

Response:

Character 1
Bit 0: Cryopump Motor On if active

Character 2
Bit 1: Cryopump ready for vacuum pumping operations if active

Example: '$A1c[CR]' - Turn on pump.
Response: '$A0[CR]' - Okay, pump turned on.

Example: '$A?2[CR]' - Get pump condition
Response: '$A0`[CR]' - Okay, pump is currently off.

Example: '$A??m[CR]' - Get pump motor operation plus status character bit.
Response: '$A11Q[CR]' - Pump motor is on plus pump is ready.

Response: '$A10P[CR]' - Pump motor is on but pump is not ready.

2.15 Purge On/Off/Query

Description:

This command opens or closes the cryopump's purge valve or will return the position of the valve.

Command: E

Parameters: (0-1 or ?) - Closed, Open, Query

Example: '$E0d[CR]' - Close purge valve.
Response: '$A0[CR]' - Okay, purge closed.

Example: '$E?6[CR]' - Get purge valve position.
Response: '$A1c[CR]' - Okay, purge is open.

2.16 Regeneration

Description:

Start a fast or full regeneration by using this command or abort a current regeneration cycle. For more details on the full and fast regeneration cycles see the Marathon Cryopump Controller Regeneration Reference Guide. If the temperature is too high for a fast regeneration cycle a full regeneration cycle will be completed instead.

Command: N

Parameters: (0-4)

Parameter:

0: Abort current regeneration cycle.
1: Start full regeneration cycle.
2: Start fast regeneration cycle.
3: Activate stand-by pump module for normal pumping operation. See

Regeneration Parameters 16.
4: Warm up cryopump and stop.

Example: '$N1n[CR]' - Start full regeneration.
Response: '$A0[CR]' - Okay.

2.17 Regeneration Cycles

Description:

Retrieve the total number of regeneration cycles performed by the controller.

Command: Z

Parameters (?)

Response: The integer result is the number of cycles not including aborted cycles.

Example: '$Z?K[CR]' - Get total cycles.
Response: '$A+11=[CR]' - 11 total cycles.

2.18 Regeneration Error

Description:

Retrieve the regeneration error code from the last aborted regeneration cycle. This command is critical in failure diagnosis and should always be included in the system's software.

Command: e

Parameters: None

Response: The character returned indicates the error code.

@: No Error
B: Warm up Timeout - Did not reach room temperature within 60 minutes. Normally an indication of lack or purge flow and/or external heater.
C: Cool down Timeout - Did not cool down within 5 hours.
D: Roughing error - Repurge cycle limit exceeded. Check cryopump vessel for leakage to chamber or atmosphere.
E: Rate of rise limit exceeded - Rate of rise cycle limit was exceeded. Check cryopump vessel for leakage to chamber or atmosphere.
F: Manual Abort - Regeneration was intentionally aborted.
G: Rough valve timeout - Rough valve was open longer than 60 minutes.

H: Illegal system state - Redundant software checks prevent unexpected software operation. Contact service center.

Example: '$eT[CR]' - Get error.
Response: '$A@1[CR]' - No error.

2.19 Regeneration Parameters

Description:

This command sets or gets a regeneration cycle parameter.

Command: P

Parameters: (0-6,A,C,G,S,z)(variable or ?)

Parameters:

0: Pump restart delay (0-59994) minutes: When the rate of rise cycles complete and the pump is ready to cool down this delay period is used prior to the cool down. This can be used to create a delay between the restart of the pump after a completed regeneration cycle.

1: Extended Purge Time (0-9990) minutes: This is the amount of time the purge gas is left on after the pump has warmed up during a regeneration cycle. It is particularly useful for speeding water removal if the cryopump is used on a load lock or transfer chamber which tends to be exposed to water content.

2: Repurge Cycles (0-200): This counter controls the maximum amount of repurge cycles the controller may do. A repurge is initiated after the controller determines it's not making good progress through the regeneration cycle. Normally this is due to water content in the pump enclosure or charcoal on the second stage array. This counter is used in conjunction with the repurge cycle time see below.

3: Rough To Pressure (25-200): The regeneration cycle will ensure this pressure is met at maximum before beginning the cool down cycle.

4: Rate Of Rise (1-100) microns per minute: The rate of rise test looks for outgassing or the pressure rising in the cryopump vessel prior to cool down. This ensures a leak tight system and clean cryopump array.

5: Rate Of Rise Cycles (0-200): This is the amount of rate of rise cycles that will be attempted before aborting a regeneration cycle should this counter be exceeded. If this count is exceeded it is normally due an atmospheric leak in a system component.

6: Restart Temperature (0-80): The maximum second stage temperature the cryopump may start to restart after a power failure has occurred. See power failure section 11 for more details.

A: Roughing Interlock (0-1): When set to one the roughing interlock prevents the cryopump from opening its roughing valve. During a regeneration cycle the cryopump will wait in the 'J' step [see regeneration sequence 17] until clearance is received from the controlling RS-232 device. The controlling device should then issue the roughing permission to this cryopump with the Q command 20, which helps to automate the process.

C: Pumps Per Compressor (1-3): This value needs to be set to the total number of cryopumps physically running on the same compressor for maximum performance. Each controller attached to a cryopump sharing the same compressor should have the same value. I.E. - If two cryopumps are sharing a compressor the value for each cryopump controller should be given 2. If three cryopumps are sharing a compressor but only two are in operation each operating controller should be given the value 2.

G: Repurge Time (0-9999): This parameter sets the delay time that the controller goes through in a repurge cycle.

z: Standby Mode (0-1): This parameter allows (1) or disallows (0) standby mode from occurring after a regeneration cycle or after a power failure recovery is completed. See also regeneration 14 command for exiting standby mode and going into active mode.

Example: '$P220W[CR]' Set repurge cycles to 20.
Response: '$A0[CR]' Okay.

Example: '$PG?E[CR]' - Get repurge time.
Response: '$A+20=[CR]' - Twenty minutes.

2.20 Regeneration Sequence

Description:

This command returns a character which represents the current step of the regeneration process.

Command: O

Parameters: None

Response:

Z: Start delay (See regeneration start delay 18)
A: 20 second cancellation delay. Warm up and purging will not start for 20 seconds. During

this period abort regeneration 14 command may be given and the pump may be manually set to Pump On 13. Once the regeneration step is beyond step B the pump will become unrecoverable. It will no longer provide high vacuum.

B-E: Cryopump Warm up
H: Extended Purge / Repurge Cycle
J: Waiting for roughing clearance (See roughing interlock 20 section)
L: Rate Of Rise
M: Cool down
P: Regeneration Completed
T: Roughing
W: Restart Delay (See regeneration parameters 16)
V: Regeneration Aborted (See regeneration error conditions 15 section)
z: Pump is ready for operation but in stand-by mode. See regeneration command 14 for activating pump for normal operation.
s: Cryopump is stopped after warm up cycle is completed.

Example: '$O>[CR]' - Get regeneration step.
Response: '$AH[CR];' - Okay, pump is in repurge step.

2.21 Regeneration Start Delay

Description:

This command sets or gets the regeneration start delay time. When a full regeneration cycle is started this delay counts down in minutes prior to the warm-up step.

Command: j

Parameters: (0-59994 or ?) - Time in minutes. Use zero for no delay.

Response: If queried the response will be the time in minutes of the regeneration delay.

Example: '$j?[[CR]' - What is regeneration start delay?
Response: '$A+0N[CR]' - There is no delay time.

2.22 Regeneration Step Timer

Description:

Retrieve the time left in the current regeneration step in minutes. If the time remaining is less than one minute, one minute is returned.

Command: k

Parameters: None

Response: The time remaining as an integer.

Example: '$kZ[CR]' - Get time remaining in regeneration step.
Response: '$A+1535[CR]' - 153 minutes remain.

2.23 Regeneration Time

Description:

Gets the amount of hours since the last full regeneration cycle.

Command: a

Parameters: None

Response: The amount of hours since the last full regeneration.

Example: '$aP[CR]' - Get time.
Response: '$A+1265[CR]' - One hundred twenty six hours since last full regeneration.

2.24 Rough On/Off/Query

Description:

This command opens or closes the cryopump's roughing valve or can return the position of the valve.

Command: D

Parameters: (0-1 or ?) - Closed, Open, Query

Example: '$D1d[CR]' - Open roughing valve.
Response: '$A0[CR]' - Okay, rough opened.

Example: '$D?3[CR]' - Get rough valve position.
Response: '$A0`[CR]' - Okay, rough is closed.

2.25 Rough Valve Interlock

Description:

This command sets or gets the roughing manifold clearance. See the roughing interlock 16 regeneration parameter setting.

Command: Q

Parameters: (None or ?)

Parameters:

None: If no parameter is given the pump is given permission to use the roughing valve and thus the roughing manifold the cryopump is connected to. Once the pump is done with the roughing sequence the permission to use the manifold is lost until the clearance to use the manifold is received again.

?: The return result is the character '0' through '7'. Subtract '0' (0x30 hex) from the result to get the binary result.

Bit 0: The cryopump currently has roughing permission.
Bit 1: Indicates the cryopump needs the roughing manifold.
Bit 2: Is on when the cryopump is running.

Example: '$Q@[CR]' - Give cryopump roughing permission.
Response: '$A0[CR]' - Okay.

Example: '$Q?B[CR]' - Is cryopump still using roughing manifold?
Response: '$A0`[CR]' - No, and it no longer has permission to use it.

Response: '$A1c[CR]' - The cryopump has roughing permission.

Response: '$A2b[CR]' - The cryopump needs the roughing manifold.

2.26 Second Stage Temp

Description:

This command retrieves the temperature of the second stage / condensing array.

Command: K

Parameters: None

Example: '$K:[CR]' - Get T2.
Response: '$A+0013.0<[CR]' - T2 is 13K.

2.27 Second Stage Temp Control

Description:

This command sets or gets the control temperature of the second stage / condensing array. Command 'H' 10 must be set to control from second stage.

Command: I

- **Parameters: (0-320,?)** Set temperature control point or get temperature control point.

Control Temperature:

With the control temperature set to zero the temperature control function will be turned off. This command accepts a range of 0-320 as a setting.

Response:

An integer value is returned. The integer is the second stage control temperature.

Example: '$I13_[CR]' - Set second stage temperature control at 13K.
Response: '$A0[CR]' - Okay.

Example: '$I?:[CR]' - Get temperature.
Response: '$A+00012N[CR]' - The temperature setting is 12K.

2.28 Status

Description:

This command gets general status indicators from the cryopump.

Command: S1

Response: Subtract 0x20 hex from the character to get the binary values.

Bit 0: Pump On
Bit 1: Rough Open
Bit 2: Purge Open

Bit 3: Thermocouple Gauge On
Bit 5: Power Failure Occurred

Note - The power failure bit is cleared after the query occurs.

Example: '$S16[CR]' - Get cryopump status.

Response: '$A`S[CR]' - Nothing is on or open and no power failure occurred since the last query.

Response: '$A@3[CR]' - Nothing is on and a power failure occured since the last query. See also Command Response 7 section.

Response: '$AaP[CR]' - Pump is on.

2.29 TC On/Off/Query

Description:

This command turns the cryopump's thermocouple gauge on and off and can return the thermocouple gauge's current operating mode.

Command: B

Parameters: (0-1, or ?) - Off, On, Query

Example: '$B1b[CR]' - Turn on TC.
Response: '$A0[CR]' - Okay, TC turned on.

Example: '$B?3[CR]' - Get TC condition
Response: '$A1c[CR]' - Okay, TC is currently on.

2.30 Thermocouple Pressure

Description:

This command retrieves the pressure of the cryopump vessel. It can also be used to determine if the thermocouple gauge is active. If the thermocouple gauge is active the command will respond with the milli-Torr pressure the gauge is reading. If the pressure exceeds the maximum pressure range of the gauge, the response will read '+2999.0'. If the gauge is off, the response will read '+3999.0'.

Command: L

Parameters: None

Response:

Double result indicates the cryopump vessel pressure or status of the thermocouple gauge.

Example: 'L=[CR]' - Get cryopump vessel pressure level.
Response: '$A+0030.0?[CR]' - Pressure is 30 milli-Torr.

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