ATA Cooled, Antonio Feed
Control Commands Manual
Matt Fleming, Minex Engineering, Ver 07c

Other related files may be stored in folder "Testing".

Version	Date	Comment	Initials
Version 5a	2018-11-05	Released. (still preliminary)	MCF
Version 06	2019-03-17	Slightly improved.	MCF
Version 07c	2020-06-15	Feed Firmware 5.4	JSK

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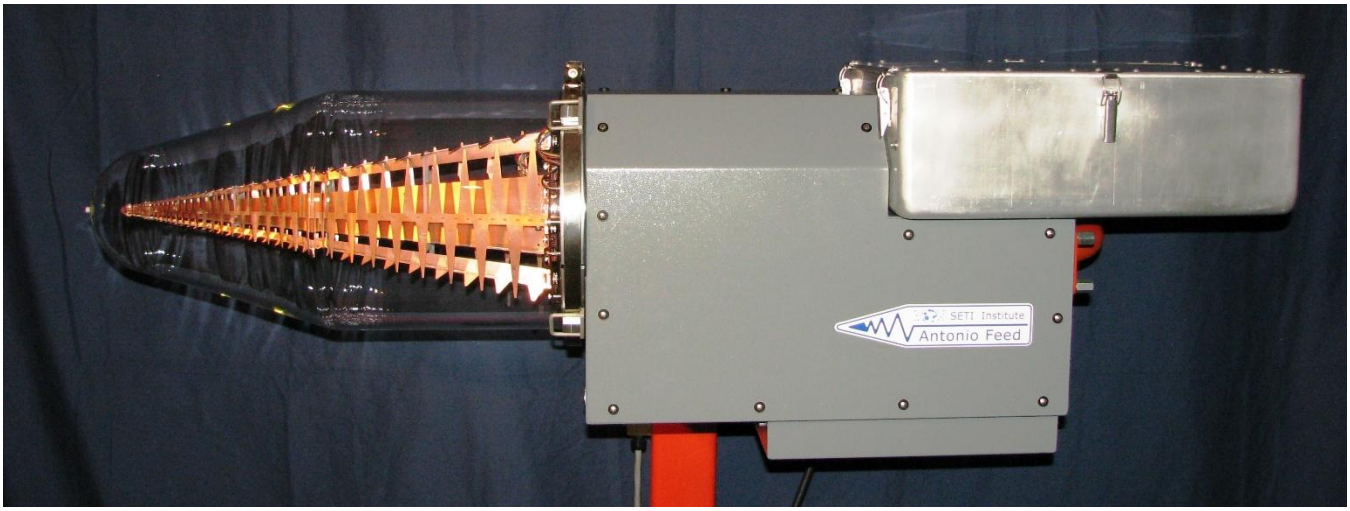

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Introduction:

These instructions should be read along with the following documents:
ATA Cooled Feed Manual Operation and Installation.
ATA Cooled Feed Development History.

There are 3 discrete control boards in the Feed Housing. They are: Feed Control, Vacuum Control & Cooler Control. There is also 1 control board in the Pax Box, but that is unrelated to this discussion. The Feed Control Board, designed by Rob Ackermann, coordinates all functions in the feed housing. It communicates with the Rim Box via RS-232, 19200 N 8 1. The Feed Control Board has a set of commands for monitor and control of devices in the feed, such as fan speed, temperature monitoring, etc. The board also passes several commands through to the Sunpower Cooler Control and the Pfeiffer Vacuum Control. Several tables of commands are shown in the pages that follow, one for each board.

The following notes apply.

- All commands are delivered to the Feed Control Board, but some are passed through to other controllers.
- No commands are identical among controllers. (Ackermann, Pfeiffer, Sunpower)
- All commands to the Cooler Control Board are in upper case. (Sunpower)
- All commands to the Vacuum Control Board begin with lowercase p. (Pfeiffer)
- On a functional terminal screen, after command entry, the response will appear on the next line(s) below.
- We are now using the Feed Control Board relay to act as a thermostat input to the Cooler Control, 2019-02.
- More cooler commands are listed in the separate Sunpower controller manual. (version 06)
- More vacuum commands are listed in the separate Pfeiffer controller manual. (version etc ?)
- On some commands a 0 before the decimal may be needed. (not sure if this is still true)
- Colors used in this document have meaning and are intended to indicate the type of attention needed.

Examples of typical commands used on the 3 control boards			
Item	Command	Response	Description (direct to Feed Control Board)(always lower case)
1	setfanpwm 30	ok	Ackermann commands take any form except those of pass thru.
2	p316	22	Pfeifer commands begin with a lower case p and are passed thru.
3	TC	TC\r\n65	Sunpower commands are upper case and are passed thru. command is echoed and next line(s) contain answer

Rob Ackermann has written a Data Logging Program in python (feed_test.py). It is used on a laptop at the command prompt. It opens a terminal program communicating with the feed via RS-232. One can also open a terminal program and type in commands
directly.
The logs generated from feed_test may be plotted with plot_logs.py. Several log files may be combined together (and optionally save it to pickle file) e.g. ./plot_logs.py -d --save plot_pickles/now.pkl logs/*log. Pickle files may be compared (currently temperature only) with compare_plots.py program.
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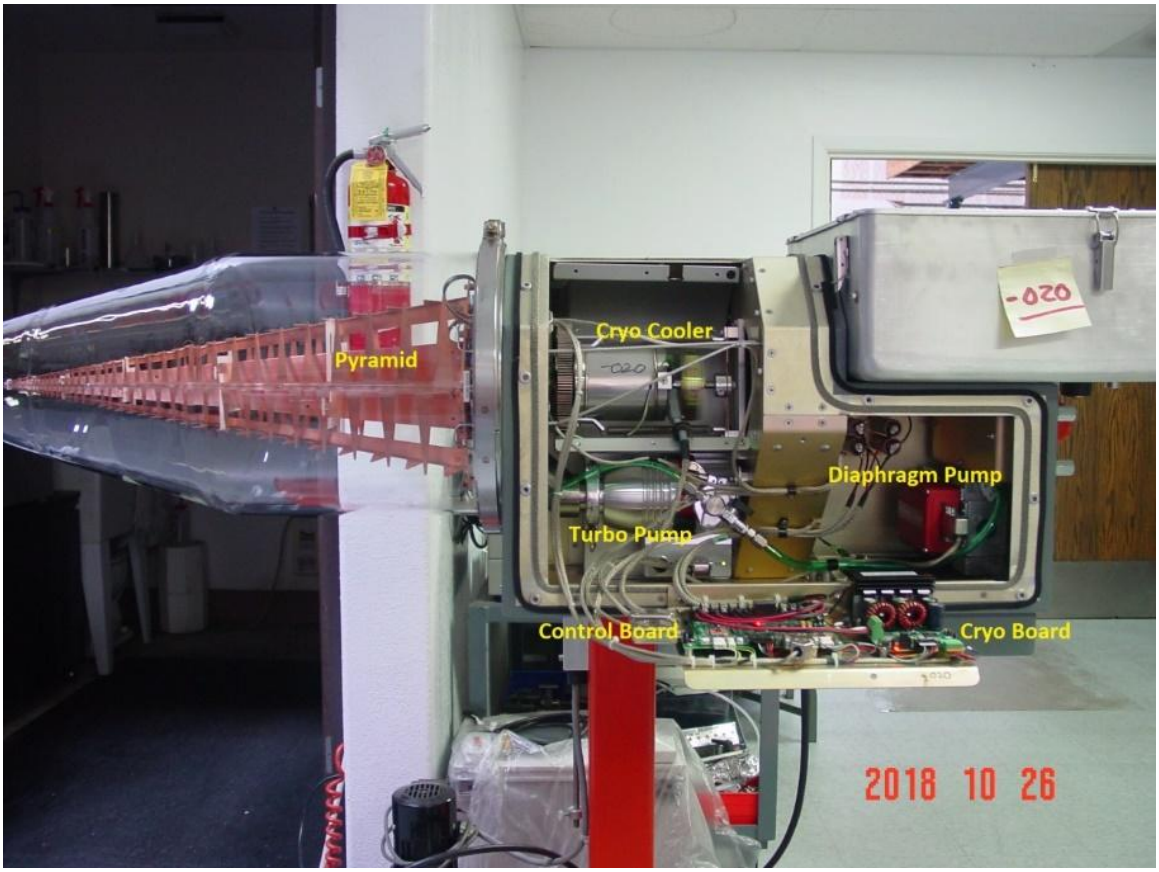
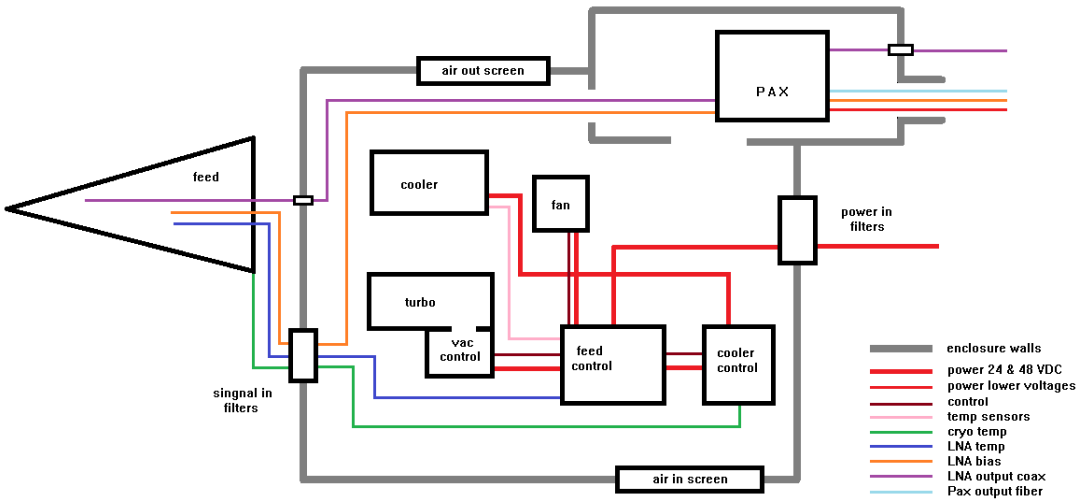
ATA Cooled Feed Image and Diagram:





Feed Control Board Commands:

Feed Control Board Commands (Ackermann, direct) (via RS-232 19,200 N 8 1)			
Item	Command	Response	Description (direct to Feed Control Board)(always lower case)
1	help	big list	Display a list of supported commands. (feed control only)
2	help commands		Display a list of all commands.
3	help gt	specific	Example: how to get help with the "gt" command.
4	man	specific	alias for help
5	getfanpwm	25	Display fan power. (% on time) (pulse width modulation)
6	setfanpwm 30	OK	Set new fan power. (% on time) (or “setfanpwm auto” for temp reg)
7	getfanspeed	2420	Display current fan speed. (rpm) (3000 rpm max speed)
8	getcryoattemp	regulating	Display Cooler State, at setpoint temp. (yes, no) (cooler pin 4)(5V=yes)
9	gettemp a0	28.1	Display temperature, on control board. (°C) (near ambient)
10	gettemp a1	27.8	Display temperature, Outside air. (°C) (lower vent from amb)
11	gettemp a2	27.8	Display temperature, PAX air. (°C) (PAX case exit air)
12	gettemp a3	27.1	Display temperature, Exhaust air. (°C) (to amb) (a4 not used)
13	gettemp a5	26.5	Display temperature, Cooler rejection. (°C) (near to fins)
14	gettemp a6	25.5	Display temperature, Cooler housing. (°C) (back of housing)(70 C max)
15	gt a6 -f		Options use "gt" abbreviation or " -f" gives value in (°F)
16	getdiode or gd	68.0	Display LNA temperature. (Kelvin) (uses equation to calculate) (T = -67792 X3 + 1661 X2 - 1794.7 X + 899.38 from excel)(Lakeshore 41 or 67 ?)
17	gd -v	0.527	Display LNA diode voltage. (_-v gives)(volts x.xxx)
18	getvac or gv	1.2 E-05	Display vacuum gauge. (mbar)(equation)(if gauge is present) (p = 10^(1.667xU-d) (U volts) (d = 11.33 for mbar) Similar to p340 when using Pfeifer DCU. (1 atm = 1.013 E+3 mbar) also message "under range" "over range" "sensor error"
19	gv -v		Display vacuum gauge voltage. (5 volts = 1.0E-3)
20	getaccel	table	Display accelerometer data in a 3 x 4 matrix. since last call. (g) 3 rows, X, Y, Z, and 4 columns, min, mean, stddev, max. 1 sec running avg.
21	getaccel -d x 100	string	Dump samples, x axis, 100 count. (1 to 400) (400 / second)
22	getrelay	0	Display relay state
23	setrelay 1		Set Relay, 1 = closed, 0 = Open. (future use)(maybe gauge)
24	getfeedstartmode	string	Displays manual or auto.
25	setfeedstartmode	OK	manual or auto. (if auto selected, use reset to start auto program)
26	getcryoattemp	Y –or- N	Display Y for regulating or N for not regulating.
27	get24v	23.9	Display 24 VDC actual measured.
28	get48v	47.9	Display 48 VDC actual measured. (not connected)
29	getversion	5.3	Display current firmware version.
30	reset	string	Resets the program. (this will take 1 minute, then 1 minute to fix all com)
31	restart	string	Resets the program (much faster, by setting a reset bit)
32	osc	integer	Don’t know this one. Seems to control external oscillator and changing that value will invalidate many constaints in the code
33	bootloader		Don’t know this one. (seems to reload firmware to bootloader state, where external memory may be flashed)
34	stty –or- rimbox		Changes line separator to ‘|’ instead of ‘\r\n’ for virtual tcpip

35	ls –or- dir	list	Display the contents of a directory. (example: “dir”)
36	cat –or- type	text	Display the contents of a file. (example: “type log.txt”)
37	minex –or- ht –or- hyperterminal		From the command prompt in the correct directory of a laptop.
38	aa ON --or-- accelonesec ON	table*	Starts calling getaccel every second.
39	aa OFF --or-- accelonesec OFF	table*	invalidates aa ON
40	rs	string	apparently test command to see if rs232 is working properly
41	state --OR-- getstate	0x00	returns the auto start state machine state (and auto start error numbers), 8 LSB are autostart states, rest are error numbers. see help state to get information about every bit meaning
42	getswitchtemp	130.0	returns autostart diode switch temp (from power to temperature control mode)
43	setswitchtemp	OK	update and save to file the new switch temperature. If “OK” is not returned, it means that the temperature was not updated
44	autostart	OK	sets autostart flag to true. In most cases (e.g. not in error 004) it should start the startup routine. Also, shortens current timeout to at max 3 s. (e.g. turbopump cycle if called during that state)
45	shutdown	OK	sets the shutdown flag. In most cases (e.g. not in error 004) it should start the shutdown routine (heat up)
46	getbackingtime	20	display backing pump runtime in autostart routine
47	setbackingtime	OK	update and save to file the new backing pump runtime [minutes]. If “OK” is not returned, it means that the time was not updated
48	getstandbytime	20	display standby turbo runtime in autostart routine
49	setstandbytime	OK	update and save to file the new standby turbo runtime [minutes]. If “OK” is not returned, it means that the time was not updated
50	getturbotime	10	display full turbo throttle runtime in autostart routine
51	setturbotime	OK	update and save to file the new full turbo throttle runtime [minutes]. If “OK” is not returned, it means that the time was not updated
52	clrerr -or- clearerror	OK	clear autostart status errors

Do not allow cooler temperatures "a6" to exceed 70 to 75 C.
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Vacuum Control Commands:

Vacuum Control TC-110 Commands (Pfeiffer, passed through Feed Control Board) (prefix p) (RS-485 9,600 N 8 1)
-------- **Initial programmed Settings are Shown in Column 2** ------- **Other Options Shown in Column Last** ----------

Item	Command	Response	Description (always lower case ?)
1	p009=1	111111	**Set acknowledge error.** 1 = acknowledge, (data type 0 for true false) note: Allows station start if p010=1 but stopped due to fault, maybe p010=0 first.
2	p010=0	000000	**Set pumping station.** turbo & diaphragm. (takes 8 to 10 min to wind down) 0 = off. (setting is preserved at power down and applied at next power up) 1 = on. (clears error)(starts Diaphragm, starts Turbo if p023=1)
3	p002=000000	000000	**Set turbo standby on / off.** for turbo motor, In standby mode turbo will spin with lower RPM (controlled by p717) and lower power. Prefered way instead of switching it off completely
4	p023=1	111111	**Set turbo on / off.** for turbo motor only. (not the same as Station On) 0 = off. (technically 000000) & 1 = on. (technically 111111)(but 0 & 1 work)
5	p024=000	000	**Set D pump speed high / low.** Set Cfg D01, Output, , 0 = Rot speed switch point. (see p701, turbo at 90%) 9 = always 0, MVP-006 pin 8 = open, high speed, 3000 rpm. 10 = always 1, MVP-006 pin 8 = 24 VDC, low speed 1000 rpm. (seasoned) 13 = follow backing mode. (see p025)(MVP-006 DIP Sw 2 set to off) note for 13, Control is equal to p010 and p025. (111111 and 001)
6	p025=001	001	**Set D pump intermittent.** backing pump. 0 = continuous. (uses p024=9 or p024=10) 1 = intermittent. (assumes p024=13) (uses settings p710 & p711) 2 = delayed switch-on. (not used for our process)
7	p035=003	003	**Set D pump on / off / backing.** Set Cfg Acc A1, Accessory , , 3 = backing pump. 6 = always 0, MVP pin 3/10 = open, diaphragm pump off. 7 = always 1, MVP pin 3/10 = 24 VDC, diaphragm pump on.
8	p027=001	001	Set gas load. 1 = light gas.
9	p700=000120	000120	Set value run-up time. (min) (1 to 120)(maybe need shorter)
10	p701=000090	000090	Rotation speed switchpoint 1. (% turbo full speed,) (used by p024)
11	p707=010000	010000	Set value in rotation speed setting mode. (% full speed 100.00 = 90,000 rpm)
12	p708=070	070	Set value power consumption. (% full power, 100% = 110w unit, 90w at p316)
13	p710=000014	000014	Set point diaphragm intermittent on. (motor off) (watts)(based on p316)
14	p711=000024	000024	Set point diaphragm intermittent off. (motor on) (watts)(based on p316)

Vacuum Control TC-110 Commands related to DCU 002 (only relevant for Pfeiffer hand held unit attached)

	p794=001	7	001	Set extended parameter set. (0 = basic, 1 = extended set, like p710 etc)
	p738=PKR2xx	4		Set type of gauge. (PKR251 Combined Pirani & Cold Cathode)(DCU page 8)
	p340	7	1.2 E-4	Display pressure from gauge. (mbar)(only Pfeiffer DCU) (p738 gauge type)

Data Type. ("T" in the table above)		
Type 0	for true false,	000000 or 111111.
Type 1	positive 6 place integer	000000 to 999999

Note: ECU indicator LED lights mean the following:	
Green flashing	= power on.
Green Solid	= station on.

Type 2	positive 6 place integer,	001571 is 15.71 , decimal 2nd & 3rd place.
Type 4	symbol chain 6 places	TC_400
Type 7	positive 3 place integer.	000 to 999

Yellow Solid	= Warning. (usually wrn117)
Red solid	= Malfunction. (usually err117)
Note: To extend life, delay p023=1 until 1.2 E+1 mbar.	

Vacuum Control TC-110 Values to Monitor, Thresholds, Warnings & Errors. (See page 46 Pfeiffer Manual)

Item	Monitor	Returns	
10	p303	wrn117	Display error messages, (also use p360 to p369 for history)
11	p304	0	Display Excess Temp Electronics. (0 = no, 1 = yes)
12	p305	0	Display Excess Temp Turbo. (0 = no, 1 = yes)
13	p310	000183	Display Turbo current consumption. (amps) (000183 = 1.83) (data T2)
14	p311	85	Display Station operation (hours)(0 to 65535)
15	p315	001500	Display Turbo speed, nominal. (Hz) (1500 Hz = 90,000 rpm)(x6)
16	p316	000022	Display Turbo power consumption. (watts)(77 max)(14 good)
17	p326	000034	Display Electronics control board temperature. (°C xx.x) (tenths ?)
18	p330	000035	Display Turbo bottom temperature. (°C) (most sensitive to fan)
19	p342	000039	Display Turbo bearing temperature. (°C) (no tenths from Pfeiffer)
20	p346	000042	Display Turbo motor temperature. (°C) (error 117) (100 is hot)
21	P360	Err006	Display Error History, position 1. (p361 gives position 2, p362 gives position 3, etc)
22	p398	90016	Display Turbo speed, actual. (rpm)(90,000 nom)(90,600 bad, reset p023)

Item	Monitor	Warning	Value	Error	Value	Description see page 57 manual.
	p701			Err006		Run-up time error. (Err also called malfunction)
	p326	Wrn044	80	Err044	85	Excess Temp Electronics general, (°C)(better cooling)
	p346	Wrn045	115	Err045	120	Excess Temp Motor. (°C)
	p330	Wrn117	55	Err117	60	Excess Temp Pump bottom. (°C) (most common sensitive)
		Wrn118		Err118		Excess Temp Electronics Power Stage. (°C)
	p342	Wrn119	55	Err119	60	Excess Temp Bearing. (°C)
						Warning value will issue a warning, yellow LED.
						Error value will change operation or shutdown sys, red LED.

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Cryo Cooler Control Commands:

Cooler Control Board Commands (Sunpower, passed thru Feed Control Board) (via RS-232 4,800 N 8 1)			
Item	Command	Response	Description (always upper case ?)
1	SET TSTATM=1	001.00	How to use thermostat, 0 = disable , 1 = use IO input 3. (via relay)
2	TSTAT		Display status of thermostat, If M=1
3	SET SSTOPM=1 *	0 change?	Set Soft Stop Mode. (0 = stop via SSTOP , 1 = stop via pin 5. Pin 5 is unused)
4	SET SSTOP=1 *	1	Set Soft Stop. (0 = restart motor, 1 = stop motor)
5	SET MAX=210 *	210	Set Max user defined power. (watts) Not PWOUT. Factory < 240.
6	SET MIN=100 *	80	Set Min user defined power. (watts) Not PWOUT. Factory > 70.
7	SET PID=2 *	002.00	Set control to temperature mode. (0 = power, 2 = temp)
8	SET TTARGET=65 *	065.00	Set cold-head temp target to number. (Kelvin) (risk if below 60)
9	SET PWOUT=200 *	200.00	Set power target to number. (watts) (while in PID mode 0)
10	TC	65 (065.00)	Display Temperature Coldhead. (Kelvin) (risk if below 60)
11	P	210	Display current power. (watts)
12	E	240 70 120	Max allowable power. (watts) (varies with cold, usually 240) Min allowable power. (watts) (never less than 70) Current power. (watts) (usually < 240 during regulation)
13	SHOW MX	80 210	Display Min & Max. (watts)
14	STATE	list	Display status list of 14 commanded states. (see manual)
15	RESET=F	RESETTING	Resets all parameters to factory default.
16	ERROR Over Current Jumper error Serial Error Memory Error Watchdog Error Temp Sensor Error	 000 001 000 010 000 100 001 000 010 000 100 000 100 001	Display error messages. (both LEDs are flashing repeatedly) Red & Grn LED Flash 1 time, then pause then repeat. Red & Grn LED Flash 2 times, then pause then repeat. Red & Grn LED Flash 3 times. (Baud 4800, None, Data 8, Stop 1) Red & Grn LED Flash 4 times. (Non-volatile Memory) Red & Grn LED Flash 5 times. Red & Grn LED Flash 6 times, (coldhead, test sensor at connector) Multiple Errors, Over Current & Cold Temp Sensor.
17	SET PWOUT=70	70	Set cryo power. only valid when PID=0

*1 To display current value for most commands, type the command without " =number".
Example: SET TTARGET displays 065.00 (note space between SET and TTARGET)
*2 PID means proportional, integral, differential, a control method.

Cryo Cooler Notes		
	Operation	Cooler should start within 11 seconds of power on for SSTOP=0.
	Conditions	Needs 48 VDC +/- ? Needs 6 watts minimum thermal load. Needs 100 cu-ft/min air. Cools best with vacuum better than 1.0E-4 mbar.
	Red LED on	Unit in cool down mode, above Set Point Temp.
	Grn LED on	Unit regulating within 0.5 Kelvin of Set Point Temp. (pin 4 high)
	Inhibit motor on/off	see feed control board relay. (maybe)(pin 3 or 10 at 5 VDC to pin 5 soft stop)
	Do not operate without at least 100 cfm airflow. That means 24 VDC must be present.	
	Do not allow cooler temperatures to exceed 70 to 75C. The motor winding bobbin will degrade or melt.	

	Do not allow TC below 65 Kelvin. The unit may backdrive when power is removed. This action may damage the unit. It is an audible knocking sound. Repower the unit and set temperature higher before removing power. Feed -004 seems to do this easily, so it has TTARGET set to 70 Kelvin.

Favorite Control Commands & Setups:

Feed Control Initial Setup:

Item	Command	Response	Description (always lower case ?)
1	p010=0	000000	Set pumping station, 0 = off. (also clears errors ?)
2	p023=0	000000	Set turbo on / off, 0 = off.
3	p024=000	000	Set D pump speed high / low, 000 high to low at Rot speed switch point.
4	p025=000	000	Set D pump intermittent, 000 cont, 001 int. (1 no longer used, see p710 p711)
5	p035=003	003	Set D pump 007 on, 006 off, 003 backing pump mode.
6	p027=001	001	Set gas load. 1 = light gas.
7	p700=000020	000020	Set value run-up time. (min) (1 to 120)(maybe need shorter)
8	p701=000090	000090	Rotation speed switchpoint 1. (% turbo full speed,)(90%)(used by p024)
9	p707=010000	010000	Set value in rotation speed setting mode. (% full speed 100.00 = 90,000 rpm)
10	p708=070	070	Set value power level. (% full power, 100% = 110w unit, 90w at motor p316)
11	p710=000014	000014	Set point diaphragm intermittent on. (motor off) (watts)(based on p316)
12	p711=000024	000024	Set point diaphragm intermittent off. (motor on) (watts)(based on p316)
21	SET SSTOPM=0	0	Set Soft Stop Mode, 0 for software SSTOP. (1 = stop via pin 5 for future use)
22	SET SSTOP=1	1	Set Soft Stop, 1 for stop motor.
23	SET PID=2	002.00	Set control, 2 for temperature mode.
24	SET TTARGET=65	065.00	Set cold-head temp target, 65 Kelvin.
31	getfeedstartmode	auto	

Vacuum Control TC-110 The preferred Start Up Routine:

Time (min)	Cmd	Value	Vacuum (mbar)	Description
assume	p010= p023= p025= p035=	0 001 001 003		Set pumping station, off. (maybe p009=1 clear errors) Set T pump for start with station on. (T = Turbo) Set D pump intermittent on. (no longer used)(was set at 90 min mark) Set D pump power. (backing pump) (usually does not change)
setup	p023= p024= p025=	001 009 000	1.0 atm	Set T pump off. Set D pump speed high. (runs for 60 to 80 minutes) Set D pump Intermittent off (Continuous) (or set 001 now not later)
00	p010=	1	1.0 atm	Set pumping station on. (D pump high speed if p024=000 & p035=003)
08			7.0 E+2	Gauge begins to read a value between 9.0 & 4.0 E+2. (if available)
40			1.2 E+1	Typical vacuum at this time. (might be able to start turbo here)
60	p023=	1	3.0 E+0	Set T pump on. (begin run up time ?) (only works if p010=1)
64			1.0 E -5	Turbo run up complete. (usually 4 to 6 minutes) (12 watts at 75 min)
80	p024=	000		Set D pump speed low. (using turbo rotation speed switch)
90	p025=	001	?.0E -5	Set D pump intermittent on. (optional depending on conditions)

Vacuum Control TC-110 Some Popular Manual Modes:

Item	Cmd	Manual D Fast	Manual D Slow	Normal D Int	Description
	P009=	1	1	1	Set acknowledge current errors (1 clear errors if present)
	P700=	120	120	120	Set run time as desired in minutes, 120 max.
	P708=	070			50% 54 watts, 70% = 76 w, 100% =107 w, might get hot.
	p024=	009	010	000	Set Diaphragm Pump speed, (009 independent of p010)
	p025=	000	000	001	Set operation mode backing pump.
	p035=	007	007	003	Set Cfg Acc A1, Diaphragm pump, 007 on, 006 off, 003 backing.
	p010=	1		1	Set pumping station, turbo & diaphragm. (1 start station)
	p023=	1		1	Set turbo on/off, turbo motor only. (1 start independently)
	P346	watch			Display motor temp.
	P398	watch			Display motor speed.

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Feed Control Program and Auto start:

The "Feed Control Program" resides on the Feed Control Board inside the Feed Housing. In general when power is applied to the feed, 3 control boards become energized: Feed Control, Vacuum Control, Cooler Control. Each of these probably has some initialization process and then attempts to establish communication. The Feed Control Program will initially set certain parameters on other controllers and will use whatever commands were last set. As always it will pass through all entered commands to the appropriate controller at any time.

At startup or after a power cycle or after a reset command. The" Feed Control Program" will take about 2 minutes to initialize. It is best not to enter commands during this period. When the Control Program becomes active it first checks the stored "getfeedstartmode" value. If set to "auto" it will execute a sub program called the "Auto Start Program". We have to assume that the feed operation was terminated without warning by a loss of the 24 and or the 48 VDC for some unknown period of time.

The Auto Start Program will have to address 2 questions: What is the vacuum condition and what is the cold condition? Based on various sensor readings the Auto Start Program will execute the necessary commands to bring the feed to proper operation. The Auto Start Program may operate for several hours before ending in a successful condition or a failed condition. In either case the Feed Control Program will still be active and ready to process any entered commands. If commands are entered during the execution of the Start Program, the commands will be passed to respective controllers but Start Program is unaware of the changes. The Start Program should still detect failure states/unexpected behaviour. If you enter "setautostartmode manual", nothing will change with current execution, but next time the board is power cycled or reset it will not execute the Auto Start Program again.

If "setautostartmode auto" has been entered, the Auto Start Program will not execute until the power is cycled or the "reset" command is entered. If the "reset" command is used please wait 2 minutes before entering any commands.

The Control Program should always be left with “setfeedstartmode auto”. In the future the Control Program should use SET SSTOPM=1 allowing the Feed control board to enable the Cooler Control via pin 5. This will provide protection if 24 VDC & fan fails.

In order to shut down the Cooler when 24 VDC has failed, the Cooler Control, IO input 3, for thermostat has been routed through the relay on the main Feed Control Board.

Fan speed can be manually set “setfanpwm 90” or allow computer to temperature regulate via “setfanpwm auto”.

“autostart” and “shutdown” are two new commands that when typed, change the behaviour of the Auto Start Program

How to run the auto start program :

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At a terminal accessing the feed control board type the following:

setfeedstartmode auto      ( restart may be required to lock in this mode )
OK
reset
reset in one minute...                          ( response )
Antonio Feed Monitor and Control Firmware 3.12 ( response )(this line will be copied over )

Note: When the reset process is complete the fan will cycle to high speed then back down.
Then wait one additional minute for the program to establish full communication with other
boards before requesting actions.

setfeedstartmode manual    ( restart required to begin this mode )( see page X )

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Description of Start Program for Various Conditions:

Operation for (vacuum poor and feed is warm > 200 K)

Power has just been applied or the program is reset and the timer set to zero.
The Diaphragm Pump will start and run at high speed.
After 30 min, the Turbo Pump will start on standby mode.
When Turbo pump on standby reaches low power, standby mode is switched off
After 10 minutes, the RPM and power is being tested
If turbo did not achieve low power (indicating good vacuum) the turbo will go back to standby mode. Such cycle can occur up to 5 times. If after 5th cycle the turbo tests fails, error mode is activated
The Cooler will start, assuming it passed the above test. Cooler will be in constant power mode (70W) untill diode reaches switch point (default 130 K)
cryo temperature (A5/A6) and vacuum pump rotation speed (p302) is being tested periodically from the start of the cooling. If tests fails, error mode will be initialized
The cooler will work in temperature control mode, slowly raising the maximum allowable power (between 70W and 240W within 6h. the target temperature most likely will be achieved faster)
Start up program is complete.

Operation for (vacuum good and feed is warm > 200 K)
With a lack of pressure sensor, the procedure is the same as with low vacuum. However. in this case all vacuum steps should succeed in the first try, making the time to start vacuum probably around 55 min. The time can be changed by calling microprocessor commands.

Operation for (feed is cold < 200 K and cryo was on)

Power has just been applied or the program is reset and the timer set to zero.
The diode will be checked if the temperature is below 200K
Program will ensure that turbo and diaphragm are on and not on standby
Cryo Status will be checked. This paragraph assumes that Cryo was on
The turbo status will be checked (low power and high rpm. If the restart happened during normal operation, the turbo and cryo controller weren't most likely affected)
The cooler will be set first in 70W mode and then the temperature will be checked
if the temperature is below switch point (135K), the power ramp-up will begin. otherwise, the cooler will remain in 70W mode until reaching 135K.
Start up program is complete.

Operation for (feed is cold < 200 K and cryo was off)

Power has just been applied or the program is reset and the timer set to zero.
The diode will be checked if the temperature is below 200K
Program will ensure that turbo and diaphragm are on and not on standby
Cryo Status will be checked. This paragraph assumes that Cryo was off
The diode temperature is controlled untill it reaches 285K
The vacuum system is being shut down

Operation for shutdown when cryo was already started

Program was running and shutdown was called after cryo was running
Cryo is being switched off
the diode temperature is controlled untill it reaches 285K
the vacuum system is being shut down

~

Proposed Startup Program Routine: (actual routine may differ)

The most up-to-date flow diagram is avaliable on github:
https://github.com/SETIatHCRO/antonio-feed-controller-board/tree/v5/flows
The actual program may differ slightly from the diagram (e.g. on various errors, the turbo pump station is not being switched off to try to ensure slower heat-up). Below are parts of the flow diagram

The PDF copy is also available.

==========

Other commands you may wish to send after feed is well established.
p025=001 Set D Pump Intermittent On. (we may want to do this after some number of hours / days)
p700=000008 Set Turbo runup time to 8 minutes. (needed? would force shut down if wake with no control)

==========

Notes on fan speeds:

Power (pwm)	Speed (rpm)	theoretical 3000 rpm max
20	1168	
30	1586	half speed
40	1945	
50	2235	
55	2339	
60	2428	
65	2526	
70	2652	
75	2817	
80	2945	full speed
100	2950	

cryo-reject 48C and housing A6 60C
Fan speed can be manually set “setfanpwm 90” or allow computer to temperature regulate via “setfanpwm auto”.

~

Control Items to Monitor:

The following list of commands are very useful for establishing the current state of the feed hardware. Each command will return data, so some pause between each request may be necessary.

	Suggested Sensors to Monitor			
	Item	Command	Response	Description (always upper case ?)
	1	TC	65.0	Display Temperature Coldhead. (Kelvin) (risk if below 60)
	2	gd	72.9	Display LNA temperature. (Kelvin)
	3	P	213.8	Display current power. (watts) (SHOW MX to display max & min)
	4	p398	90016	Display Turbo speed, actual. (rpm)(90,600 bad, reset p023)
	5	p316	000019	Display Turbo power consumption. (watts)(77 max)(14 good)
	6	p326	000040	Display Electronics control board temperature. (°C)
	7	p330	000033	Display Turbo bottom temperature. (°C) (most sensitive to fan)
	8	p342	000035	Display Turbo bearing temperature. (°C) (no tenths from Pfeiffer)
	9	p346	000042	Display Turbo motor temperature. (°C) (55 gives error 117)
	10	gt a0	24.0	Display temperature, on control board. (°C) (near ambient)
	11	gt a1	22.1	Display temperature, Outside air. (°C) (lower vent from amb)
	12	gt a2	21.8	Display temperature, PAX air. (°C) (PAX case exit air)
	13	gt a3	26.7	Display temperature, Exhaust air. (°C) (to amb) (a4 not used)
	14	gt a5	41.1	Display temperature, Cooler rejection. (°C) (near to fins)
	15	gt a6	47.8	Display temperature, Cooler housing. (°C)(back side)(70 C max)
	16	getfanspeed	2256	Display fan speed. (rpm)
	17	get24v	23.9	Display 24 VDC actual measured.
	18	get48v	47.9	Display 48 VDC actual measured. (not all feeds connected)
	19	P360	Err006	Display Error History, position 1. (p361 gives position 2, etc.)

		Suggested Settings to Monitor (list not complete)		
		getversion	3.12	Display current firmware version.
		getfeedstartmode	auto	Displays manual or auto.
		p035	003	Display D pump, 007 on, 006 off, 003 backing pump mode.
		SET SSTOPM	0	Set Soft Stop Mode. (0 = stop via SSTOP , 1 = stop via pin 5)
		SET SSTOP	1	Set Soft Stop. (0 = restart motor, 1 = stop motor)
		SET PID	002.00	Set control to temperature mode. (0 = power, 2 = temp)
		SET TTARGET	065.00	Set cold-head temp target to number. (Kelvin) (risk if below 60)
		SET PWOUT	200.00	Set power target to number. (watts) (while in PID mode 0)
		SHOW MX	70 240	Display Min & Max. (watts)
		STATE	list	Display status list of 14 commanded states. (see manual)
		ERROR Over Current Jumper error Serial Error Memory Error Watchdog Error Temp Sensor Error	 000 001 000 010 000 100 001 000 010 000 100 000 100 001	Display error messages. (both LEDs are flashing repeatedly) Red & Grn LED Flash 1 time, then pause then repeat. Red & Grn LED Flash 2 times, then pause then repeat. Red & Grn LED Flash 3 times. (Baud 4800, None, Data 8, Stop 1) Red & Grn LED Flash 4 times. (Non-volatile Memory) Red & Grn LED Flash 5 times. Red & Grn LED Flash 6 times, (coldhead, test sensor at connector) Multiple Errors, Over Current & Cold Temp Sensor.

~

Data Logging Program used at Minex:

The output of the desired Data Logging Program would look similar to the table shown below. The program is designed for use in the assembly and testing lab. It is written in python and is used on a laptop and a terminal program communicating with the feed via RS-232. The data filename is generated using the date & time from the computer. For example a filename would appear as follows. 2015-05-07-15-07-26-antonio-feed-status-log.txt. The file is a space delimited TXT file and will contain 2 lines of header information followed by lines of data as shown in the table below. The file will record the header only once but the display will re print the header every 10 rows of data. When the program starts it will display the headings shown and a first line of data. It will display a line of data every 1 minute. After 10 lines are displayed a line of headings will be displayed. **KEEP IN MIND THAT IF CONNECTED VIA COM PORT, ONLY ONE PROGRAM SHOULD BE USING THAT COM PORT. CALLING 2 PROGRAMS FOR THE SAME PORT WILL RESULT IN ERROR MESSAGES OR ONE PROGRAM FAILING**.

The program starts with a data line every 1 minutes.
The " ? " character will give a data line right away.

	Vac	----Vac Drv----			---Temp TC7x---				------Cryo-----				Diode	---Fan--	
Time	Guage	p316	p398	p346	A0	A1	A2	A3	TC	Max	Min	Cur	(V)	PWM	RPM
18:44	-------	15	90014	43	25	24	24	23	164	0	0	0	0.838	---	2259
18:45	-------	15	90017	43	25	24	24	23	164	0	0	0	0.837	---	2259
18:46	-------	15	90013	43	25	24	24	22	164	0	0	0	0.836	---	2259

Time - HH:MM based on computer clock. Date not avaliable
Gauge - I have no idea
p316 - vac turbo power [W]
p398 - vac turbo RPM
p346 - turbo motor temperature [C]
A0 - control board temp [C]
A1 - Outside air temp [C]
A2 - PAX air temp [C]
A3 - Exhaust air temp [C]
TC - coold head temp [K]
MAX - max allowable cryo power [W]
MIN - min allowable cryo power [W]
Cur - current cryo power [W]
V - diode voltage [V], (convertible to [K])
PWM - fan pwm [no idea]
RPM - fan rpm

~

State bits (from getstate command):

Last 2 bytes are cleared on stable states and rest is OR-ed. That means e.g. if shutdown happened after heating up, but before stable state, state bytes may look like: 0x00003d.
Lack of vac pumping bit means that "autostart" started from cold state T<200. Only 0x10 and 0x80 clean remaining bits.
Error bits are only being cleared on reset/restart

0x000000 - not initialized (or manual autostart)
0x000001 - started initialization
0x000002 - started vacuum pumping
0x000004 - init cooling
0x000008 - cooling down - power
0x000010 - cooling down - temp/stable low temp
0x000020 - heating up
0x000040 - switching off
0x000080 - stable high temp (shutdown) state
0x000100 - e000 occurred (auto start init error)
0x000200 - e001 occurred (vac creation)
0x000400 - e002 occurred (vac rot speed error)
0x000800 - e003 occurred (vac power error)
0x001000 - e004 occurred (serious cryo/vac comm error)
0x002000 - e005 occurred (vac rot speed error with cryo running)
0x004000 - e006 occurred (cryo init comm error)
0x008000 - e007 occurred (rot speed on heat-up error)
0x010000 - e008 occurred (cold init error)
0x020000 - e009 occurred (vac cold start error)
0x040000 - e010 occurred (vac rpm oscillation)
0x080000 - e011 occurred (cryo motor temp issue)
0x100000 - temp readout problem (A5/A6)
0x200000 - e012 occurred (cryo down while low temp)
0x400000 - cryo comm problem (timeout)
0x800000 - vac comm problem (timeout)

Because only 2 states clears the full state bits, several other readouts may occur that describe a "partial history" of the feed state. The most valuable information is still stored in the LOG.txt file. So, state - 0x03 means that both initialization and vacuum pumping state started in the past. 0x0f means that feed is being cooled with constant power, 0x1f means the feed is cooling with increasing max power, while 0x10 (all other bits cleared) means that it reached steady state. 0x3f means it started to heat up before reaching the steady state, 0x30 means that it started heating up after reaching steady state, whereas 0x2f means it started heating while in constant power mode.

Feed Control Board Help Command Examples:

```
help

SYNOPSIS
        help [topic]
```

```
DESCRIPTION
shows help information for Antonio feed control board internal commands.  Cryo and vacuum
controller commands, which pass through the control board, are documented elsewhere.

Commands beginning with a lowercase p and three numbers (e.g., "p316") are routed to the
vacuum controller.
Uppercase commands (e.g., "TC") are routed to the cryo controller.

EXAMPLES
       list all available internal commands: help commands
       show help information for getvacuum command: help getvacuum

help commands

setfanpwm                                 getcryoattemp
getfanpwm                                 getfeedstartmode
getfanrpm -or- getfanspeed                setfeedstartmode
gettemp -or- gt
getvacuum -or- gv
getdiode -or- gd
setcryostartmode
getaccel                                  getrelay
setrelay                                  bootloader
minex -or- hyperterminal -or- ht          reset
ls -or- dir                               stty -or- rimbox
cat -or- type                             getversion
get24v                                    get48v


help getvacuum
SYNOPSIS
    getvac [options] gv [options]

DESCRIPTION
    get Pfeiffer vacuum gauge reading in millibar units.  May also return
    "underrange," "overrange," or "sensor error" (see manual).

    -v  return measured voltage (don't convert to millibar)

EXAMPLES
    get vacuum gauge reading converted to millibar units: getvac
    get measured vacuum gauge voltage: getvac –v
```

How to Connect to Feed Control via the Rim Box:

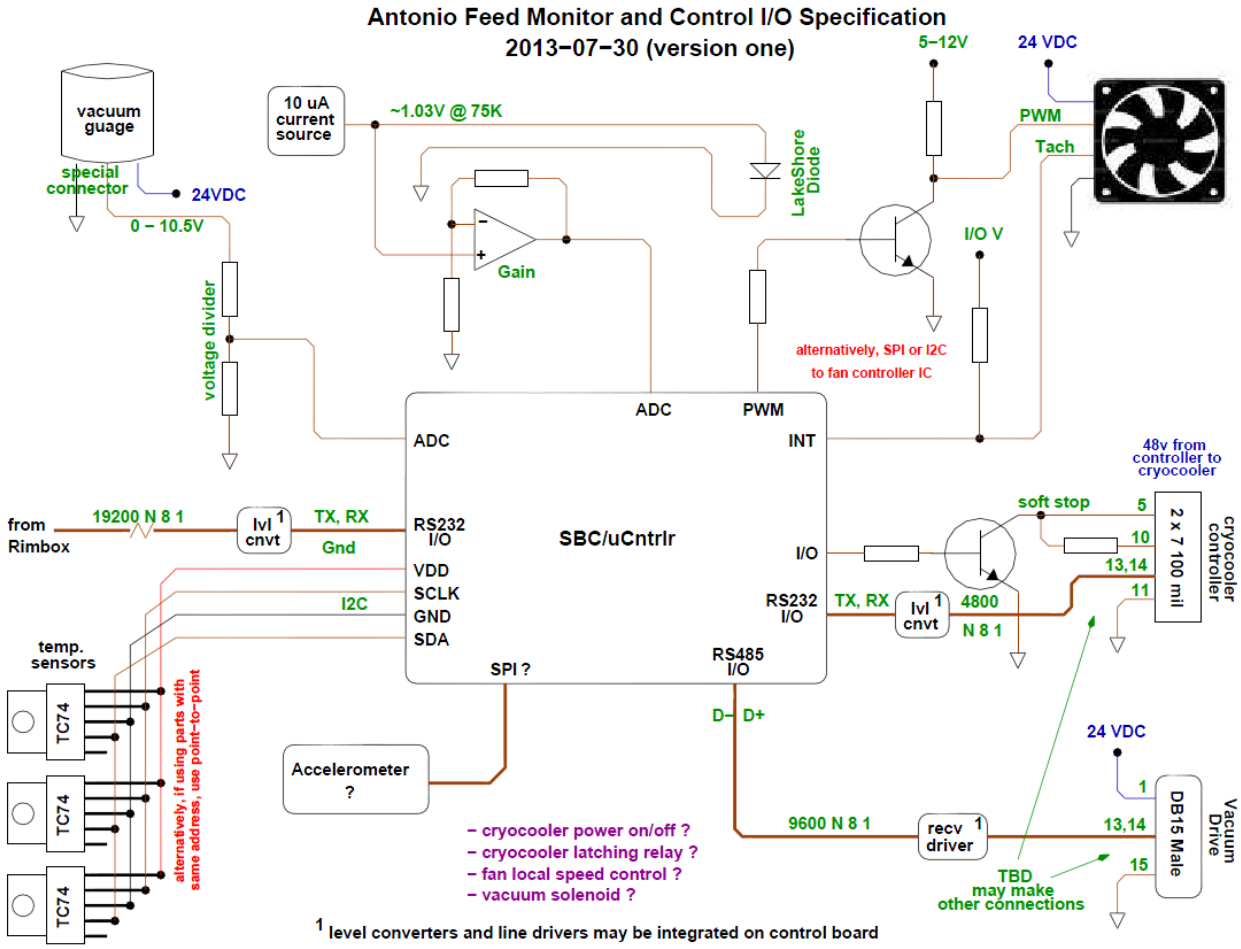
From ant2e linux command line:

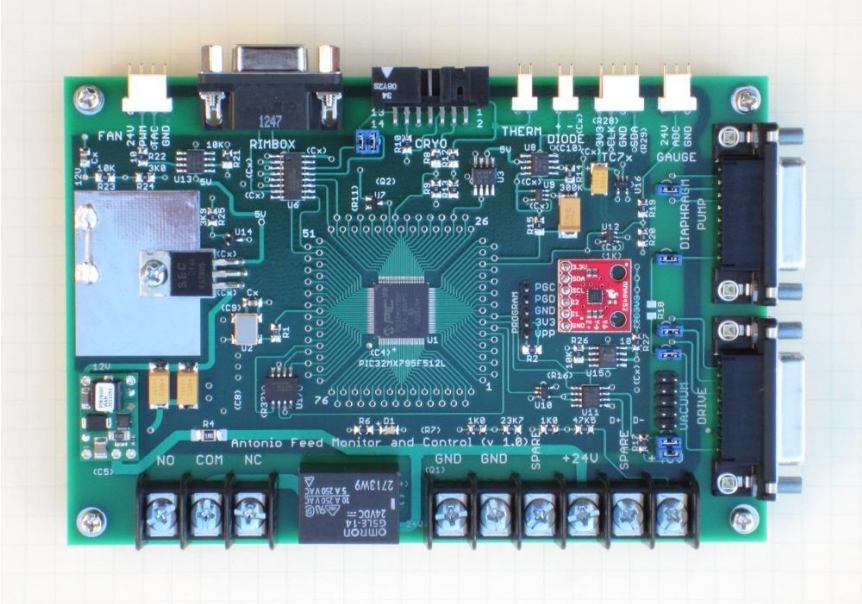
```
telnet rimbox 1518
```

The above, will open a connection to the rimbox RS-232 port over which you can talk to the feed controller board. Just like telnet'ing to other boards, you can hit "control-C e " to close the connection.

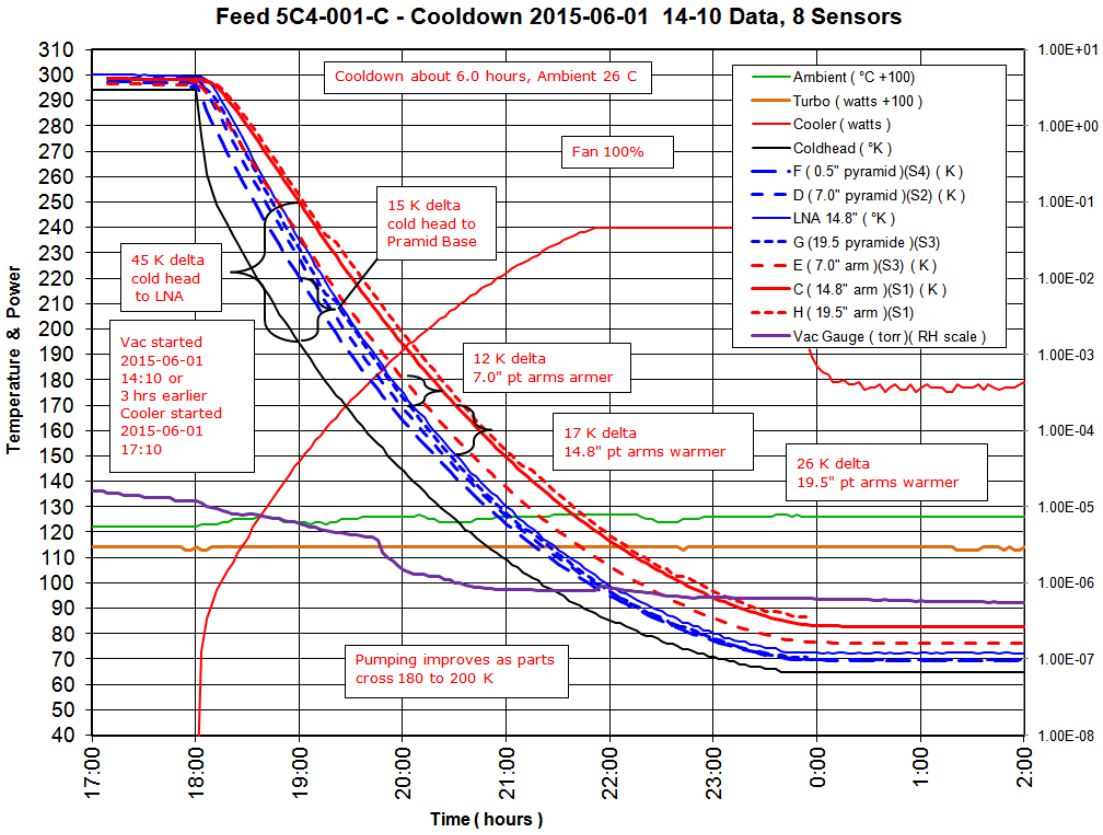
~

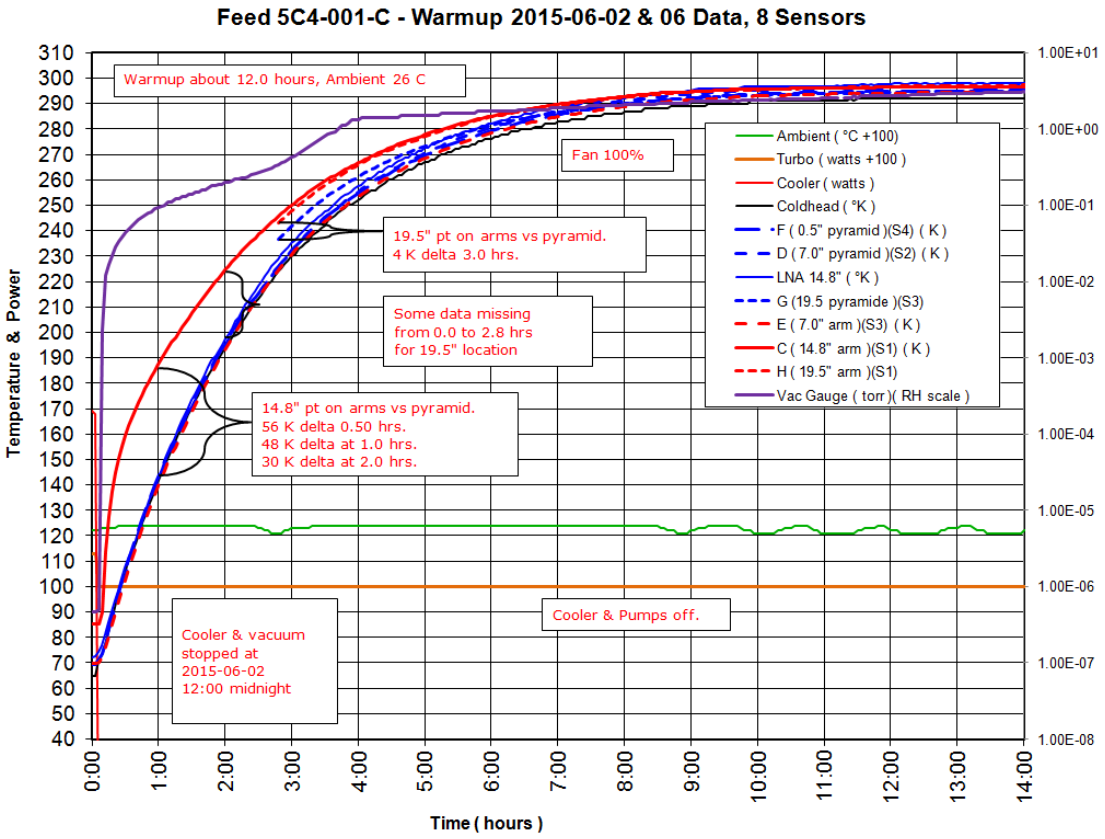
Feed Control Board Diagram and Photo:



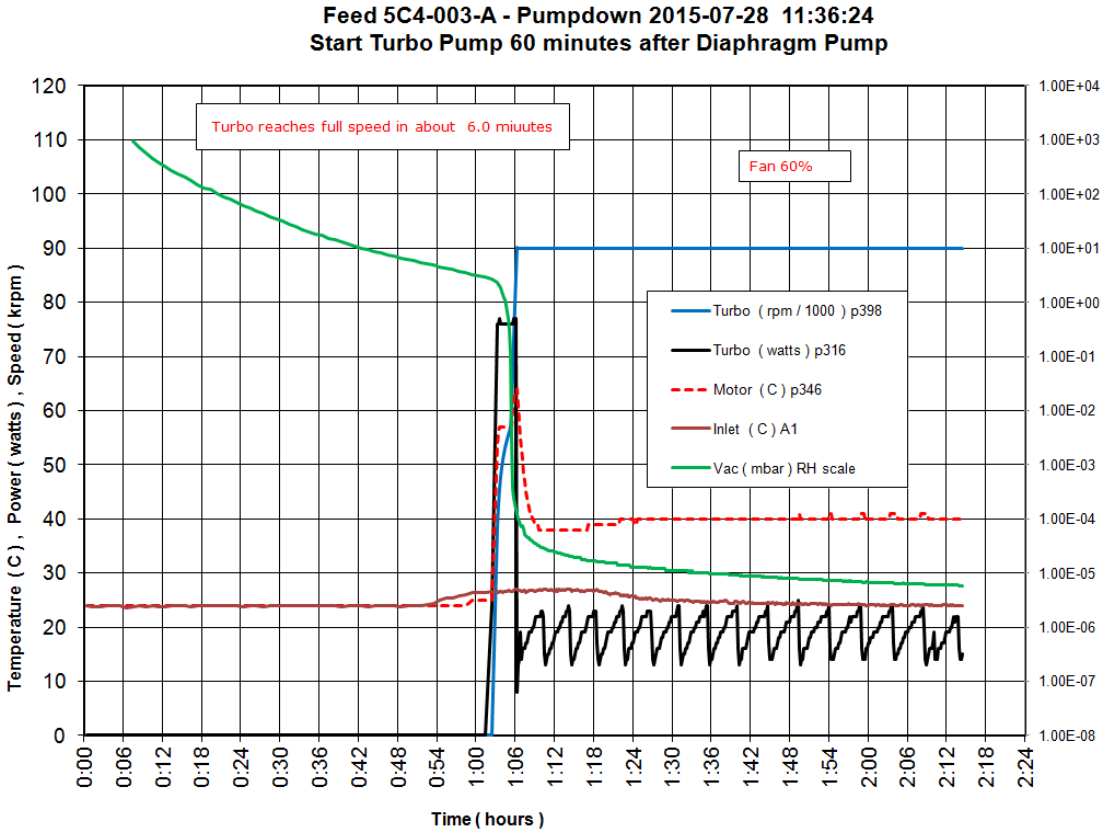


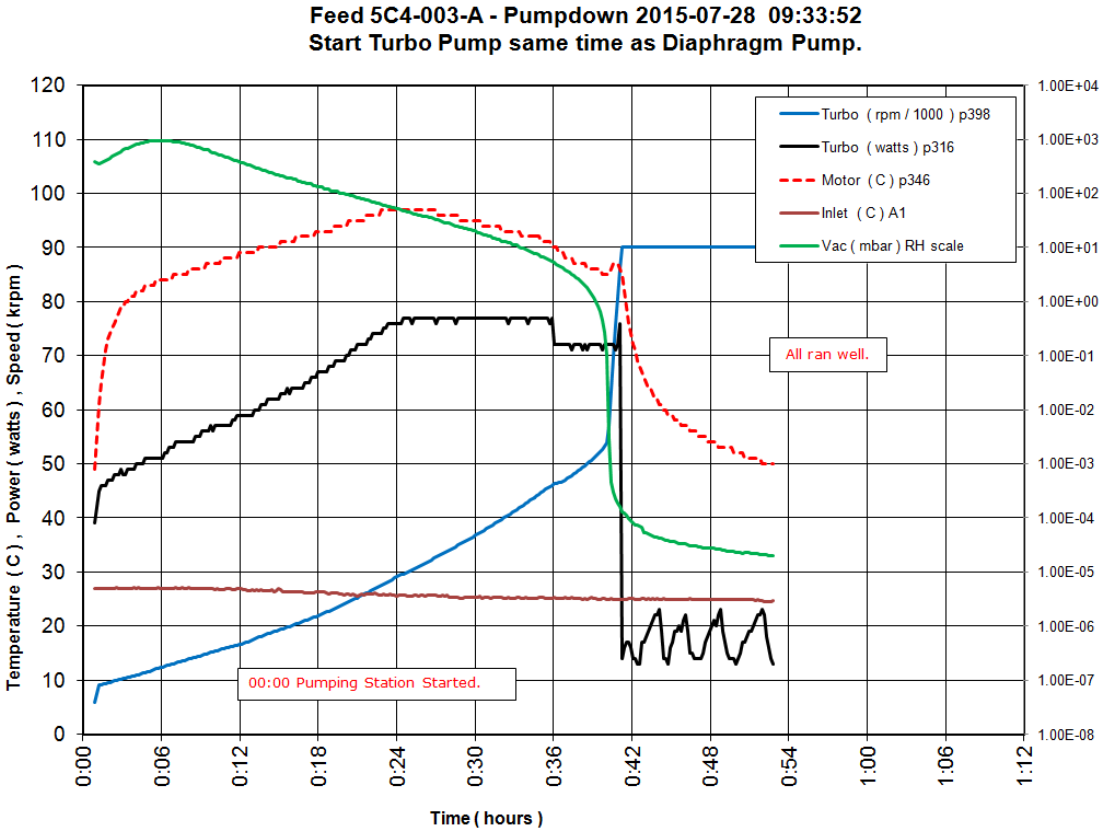
Appendix A Typical Performance Charts (page 1)





Appendix A (page 2)


Feed 5C4-003-A - Pumpdown 2015-07-28 11:36:24
Start Turbo Pump 60 minutes after Diaphragm Pump
Turbo reaches full speed in about 6.0 miuutes
Fan 60%
Turbo (rpm / 1000) p398
Turbo (watts) p316
Motor (C) p346
Inlet (C) A1
Vac (mbar) RH scale
Temperature (C) , Power (watts) , Speed (krpm)
Time (hours)


Feed 5C4-003-A - Pumpdown 2015-07-28 09:33:52
Start Turbo Pump same time as Diaphragm Pump.
Turbo (rpm / 1000) p398
Turbo (watts) p316
Motor (C) p346
Inlet (C) A1
Vac (mbar) RH scale
All ran well.
00:00 Pumping Station Started.
Temperature (C) , Power (watts) , Speed (krpm)
Time (hours)

Appendix B Improvements Needed (page 1)

This Appendix stores some ideas about maintenance routines. (not implemented)

Possible Thermal Control Routine:
Determine current programmed fan speed lower limit Y. (Y for user input of user defined value)
If cooler rejection temp is > X and $T_2/T_1 > 1$, increased fan speed by X%.
If cooler case temp > X and $T_2/T_1 > 1$, increased fan speed by X%.
If pump electronics temp > X and $T_2/T_1 > 1$, increased fan speed by X%.
If none of the above is true, reduce fan speed by X %, until low speed limit Y is reached.
(evaluate every 10 sec ??)

If cooler rejection temp exceeds X, turn off cooler and wait X minutes.
If cooler case temp exceeds X, turn off cooler and wait X minutes.
If the above is executed 3 times, stop attempts and send error message.

Other Maintenance Monitoring:
If acceleration exceeds X, send error.
If gauge has been on for more than X hours, turn off. (relay)

Record data log for period Y in local memory. (this would give some data to laptop without use of main lab data)
Update most recent maximums or extremes. (when did it occur ?)
Update fraction of time over period Y that data value exceeded Y.

LNA Temperature Troubleshooting:
Cold Head Temperature strange while LNA Temperature is consistent:
If TC = 400K, the RTD sensor most likely has a broken wire or open circuit.
If TC = 35K then the RTD sensor most likely has a short to ground.
If TC = variable numbers over a short time scale, the RTD may have an cracked wire vibrating at 60Hz.
If TC = Incorrect value the RTD may have a vibrating rub spot where insulation is worn through and grounding.
If TC = variable numbers over a longer time scale, the sensor maybe loose or cooler malfunctioning, check P or E.

~

Appendix B (page 2)

Other Important Ideas to Implement:

Disable cooler under the following conditions: (avoid icing and major vibration, hammering, from vacuum loss)

If 24 VDC is not present. Idea: use SET SSTOPM =1, allow pin 5 control, run = pin 5 open or low, stop = pin 5 high to 5V from onboard isolated pin 10 or 12, use relay or IO on Feed Control Board, wiring Feed Board to Cooler Board in existing?

If vacuum is not present. Idea: turbo control status

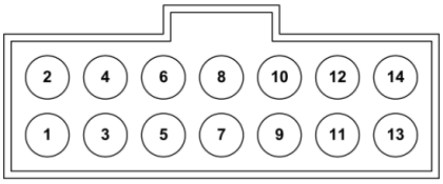
If air flow is not present. Idea: use temp sensor on cooler, use rpm sensor on fan, hard wire switch to Cooler Control.

Physically move the clamp on Cooler End Pin so it will not hit the cross bar at zero vacuum.

==========

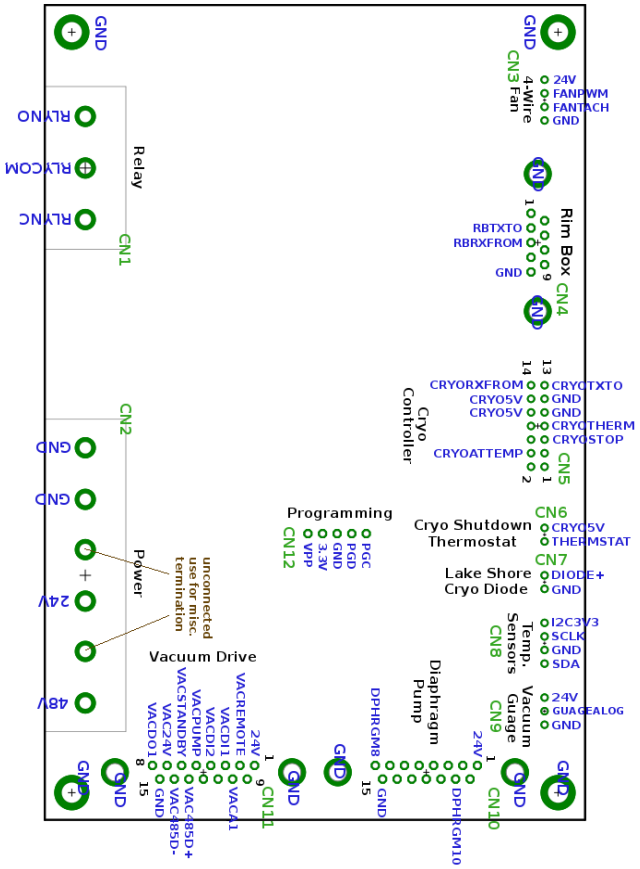
Controller Connector Wiring Information

Pin Numbering for I/O connector and RS-232 connections on CryoTel® Controller



Pin Number	Function
1	Digital Out 1
2	Digital Out 2
3	Digital Out 3
4	Digital Out 4 (AT Temperature)
5	Digital Input 1 (Soft Stop)
6	Digital Input 2
7	Digital Input 3 (Thermostat)
8	Digital Input 4
9	Isolated I/O GND
10	Onboard Isolated 5V
11	Isolated I/O GND
12	Onboard Isolated 5V
13	RS-232 RX (Input)
14	RS-232 TX (Output)

Figure 16: I/O connector



SET SSTOPM =1 001.00

d) When in Soft Stop Mode 1, setting Digital Input 1 high will shut down the cryocooler. Setting it low or leaving it disconnected will allow the cryocooler to run. The Onboard Isolated 5V (I/O connector pin 10 or pin 12) can be used to set Digital Input 1 high.

e) The soft stop function will slowly ramp down the cooler before shut down to minimize shutdown vibration.