DAYSTAR FILTERS

Quantum &
Solar System Filter Wheel
RS232 Protocol

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Changes

Ver	Date	Description
v1.0	10/12/2009	Initial release.
v1.1	10/22/2009	Minor corrections and cosmetic changes.
v1.2	5/11/2012	Add documentation of Filter Wheel and Turbo Tilt commands.

Overview

The Quantum filter and Solar System Filter Wheel features an RS-232 serial port for interfacing to a customer's computer, for remote control and status monitoring. This document describes the protocol used for monitoring and control via that serial port. The intended audience is programmers implementing their own control software, for situations when the DayStar-provided Windows QuantumControl or QuantumCommand software is unsuitable.

This port features full signaling voltages with ESD protection. Settings are 9600 baud, 8 bits, no parity, 1 stop bit, with no handshaking. Only pins 2, 3, and 5 of the DB9 jack are connected internally. To prevent a ground loop, it is recommended that the Quantum be powered separately from the computer. The ground pin of the Quantum serial port is electrically separated from the ground of the power supply by a rectifier, in order to allow full operation with reversed polarity.

The communication protocol consists of plain ASCII commands and responses. All commands must be terminated with a linefeed and/or carriage return. Numeric values sent to the Quantum must be in decimal ASCII format. Numeric values returned from the Quantum will typically be in hexadecimal (0-9, A-F) ASCII, except that very early Quantums (firmware versions v1.2 and earlier) use decimal. A program intended to work with all Quantums on the market must support both decimal and hexadecimal. If the application will only be used with Quantums manufactured or serviced after December 2007, then only support for hexadecimal need be included. Free firmware upgrades for v1.2 and earlier users are available from DayStar.

Throughout the remainder of this document, examples in quotes are literal but do not show linefeeds nor carriage returns for readability reasons. The "quotes" simply surround such examples and are not to be transmitted to the Quantum.

Due to the limited processing power of the microcontroller used in the Quantum, activity on the serial port is ignored for a brief window of time during certain complex mathematical calculations. This manifests itself as a roughly 1% chance of a command being dropped, in which case no response from the Quantum will be forthcoming. As such, it is **mandatory** to read back the status of any changes written (for example, to follow all SE commands with a GE), and to provide for resends of information requests should they be dropped.

For the differential heat Quantum (see GA, body style 3), there are two independent heaters inside the body, each with their own temperature setpoint, temperature readout, and PWM readout. All other Quantum body styles have only one heater control inside.

Examples

An example byte-by-byte example communication session is as follows. First, we send a command to query the on-band status of the Quantum:

Computer sends "GF\n" or 0x47 0x46 0x13.

Quantum responds with "01\r\n" or 0x30 0x31 0x0D 0x0A.

Next, we put the filter to sleep:

Computer sends "SH1\n" or 0x53 0x48 0x31 0x13.

Quantum responds with "H OK\r\n" or 0x48 0x20 0x4F 0x4B 0x0D 0x0A.

A typical communication session is as follows:

1) Issue the GI command to obtain the firmware version, to determine whether the subsequent responses will be in decimal or hexadecimal.
2) Issue GA to obtain the body style, and to determine whether there are one or two heaters inside. Alternatively, the presence of two heaters can be inferred by counting the number of fields returned by the GI command in the previous step.
3) Issue GY, GB, GJ, GN, GS, and GX to gather the basic identity data of the filter.
4) Optionally, issue GD, GH, GL, and GU to obtain the status of user-modifiable settings.
5) Initiate a polling of the filter, issuing the GI command at periodic intervals (once per second or minute, etc).

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Set Commands

These commands modify settings on the filter.

SD Set offset vs absolute readout

Purpose: Changes the wavelength readout mode for the LCD display on the Quantum body. This change is nonvolatile.

Argument: ASCII '1' for offset mode, '0' for absolute mode.

Return value: "D OK" on success or "D FAIL" if the argument is out of range.

Examples:

"SD0" Set absolute wavelength readout mode on LCD (6562.4 Å).

"SD1" Set offset mode wavelength readout on LCD (-0.4 Å).

SE Set wavelength shift (wing shift)

Purpose: Changes the wavelength wing shift setting by adjusting the filter temperature. This change is nonvolatile.

Argument: The desired wing shift in Angstroms, multiplied by 10, in decimal ASCII.

Return value: "E OK". If the argument is out of range, it is clipped to the allowable range and no warning is issued. Note that in some instances the maximum positive wing shift is less than 1.0 Å to limit the set point temperature to within the rated temperature range of the internal components (160-180°F depending on body style).

Examples:

"SE0" Set wing shift to zero, i.e. 6562.8 Å.

"SE-10" Set wing shift to -1.0 Å, i.e. 6561.8 Å.

"SE4" Set wing shift to +0.4 Å, i.e. 6563.2 Å.

SH Set sleep mode on/off

Purpose: Sets sleep mode on or off. Use this to reduce power consumption when the filter is plugged in but will not be in use for an extended period. This change is volatile, the filter always starts up in normal mode upon powerup.

Argument: ASCII '1' for sleep mode, '0' for normal mode.

Return value: "H OK" on success or "H FAIL" if the argument is out of range.

Examples:

"SH1" Turn filter heaters off and display "SLEEP" on the LCD.

"SH0" Turn filter heaters on and display the current wavelength on the LCD.

SL Set button lockout on/off

Purpose: Enables or disables use of the Red/Blue buttons on the Quantum for manual wing shifting. This change is nonvolatile. The button lockout can also be toggled by manually depressing both the red and blue buttons together for several seconds while applying power to the Quantum.

Argument: ASCII '1' to disable the buttons, '0' to enable them.

Return value: "L OK" on success or "L FAIL" if the argument is out of range.

Examples:

"SL0" Enable buttons.

"SL1" Lock out buttons.

SP Set filter wheel cavity (filter wheel only)

Purpose: Move the filter wheel to a different cavity using the internal stepper motor.

Argument: ASCII '1' through '4', up to the number of installed cavities.

Return value: "P OK" on success or "P FAIL" if the argument is out of range.

Examples:

"SP1" Move to cavity 1.

"SP2" Move to cavity 2.

SU Set nanometers vs Angstroms readout

Purpose: Changes the wavelength readout mode for the LCD display on the Quantum body. The sole impact of this setting is the position of the decimal point on the LCD display. This change is nonvolatile.

Argument: ASCII '1' for nanometers, '0' for Angstroms.

Return value: "U OK" on success or "U FAIL" if the argument is out of range.

Examples:

"SU0" Set display to Angstroms (i.e. 6562.8).

"SU1" Set display to nanometers (i.e. 656.28).

S# Set Turbo Tilt wavelength shift (high speed wing shift)

Purpose: Changes the wavelength wing shift setting by tilting the unit using the Turbo Tilt motor, if the filter is so equipped. This change is nonvolatile.

Argument: The desired wing shift in Angstroms, multiplied by 10, in decimal ASCII.

Return value: "E OK". If the argument is out of range, it is clipped to the allowable range and no warning is issued. Note that the thermal wing shift (SE) is additive to the tilt wing shift. Since the Turbo Tilt change can only be negative, to accomplish fast tuning over +/- 1Å we recommend setting the temperature wing shift to +1.0Å ("SE10") and then Turbo Tilting from +0.0 to -2.0 for an effective +/-1.0Å range.

Examples:

"S#0" Set turbo tilt wing shift to zero, i.e. 6562.8 Å.
"S#-10" Set turbo tilt wing shift to -1.0 Å, i.e. 6561.8 Å.

S^ Reboot filter

Purpose: reboots the microcontroller inside the Quantum, reinitializing the filter. To detect if the reboot was successful, it is necessary to check the reboot count (GY) before and after issuing this command. Allow approximately 3 seconds for the reboot to complete before attempting to communicate with the Quantum.

Argument: None.

Example: "S^".

Get Commands: Status

These commands provide information about the current state of the filter.

GI Get status information

Response: GI is intended as the primary command to poll the status of the filter regularly. As such, it includes a number of popular items. Length of the returned string can be up to 76 bytes. The fields of data are as follows, each separated by an ASCII space.

1. Firmware version as an ASCII text string up to 5 characters long. Example: "v1.6".
2. Error code. See GZ.
3. On band indication. See GF.
4. Current center wavelength. See GW.
5. Current wing shift setting. See GE in next section.
6. Current first heater raw PWM setting (0x0000 – 0x03FF) as 16bit hex. Multiply by 100 and divide by PWM limit (below) to obtain the power setting in percent. If the power setting is 0% or 100% for a prolonged period (more than 15 minutes), that indicates that the ambient temperature is too hot or cold, respectively, for proper operation of the filter. Note that values slightly greater than 100% are possible if the supply voltage is rapidly rising, due to the difference in time between when the PWM setting and PWM limit are calculated.
   Example: "03FF" corresponds to the heater being at full power.
7. Current PWM limit. Normally 1023 (0x03FF), but drops lower at high voltages to limit the current consumption of the Quantum.
8. Current temperature of the first heater, as 32bit hex. See GT.
9. Current voltage, as 32bit hex. See GV.
10. Current calibration pot position, as 32bit 2's complement hex. See GC.
11. Differentially heated body only: current temperature of the second heater, as 32bit hex. See GT.
12. Differentially heated body only: current second heater raw PWM setting, as 16 bit hex value.

GC Get calibration pot position (included in GI)

Response: Returns the current position of the calibration potentiometer as a 16bit hex signed 2's complement value. Divide by 10000.0 to obtain the offset in angstroms. Values are rounded to 0.01 Å precision. Range is +/-1.75 Å. The calibration pot should be set to 0.00 for proper operation of the filter.

Example: "BBA4" corresponds to the maximum negative correction of -1.75 Å.

GF Get on-band status (included in GI)

Response: Returns 8 bit hex (or decimal ASCII for firmware < 1.25):

"00" Filter is warming or cooling and LED is orange.

"01" Filter has settled to the setpoint and LED is green.

GG0 Get status of all cavities part 1 (filter wheel only)

Response: for each installed cavity, returns a space delimited list of heater 1 temperature, heater 2 temperature, heater 1 PWM setting, heater 2 PWM setting, and the PWM value corresponding to 100% power, all in hex.

GG1 Get status of all cavities part 2 (filter wheel only)

Response: for each installed cavity, returns a space delimited list of on-band status (1= on band, 0=settling), error code (0-255), wing shift setting (See GE), and the current passed center wavelength times 10, all in hex.

GP Get filter wheel current cavity (filter wheel only)

Reponse: Returns an 8 bit hex number corresponding to the currently selected filter wheel cavity. Examples:

"01" Cavity 1 is currently in view.

"02" Cavity 2 is currently in view.

GT Get current temperature (included in GI)

Response: one (or for differentially heated body, two space separated) 16bit hex values. Divide by 100.0 to obtain the temperature in Fahrenheit.

Example: "3039 223D" corresponds to temperatures of 123.45°F and 87.65°F.

GV Get voltage (included in GI)

Response: 16bit hex value representing the supply voltage of the filter. Divide by 100.0 to obtain the value in volts. Note: As a full-wave bridge rectifier is included in the Quantum, this voltage will read approximately two diode drops lower than the actual external supply voltage. Also, the voltage setting will appear to fluctuate over time, due to changes in current consumption (associated with changes in heater setting), causing a change in voltage drop across the diodes.

Example: "04D2" corresponds to 12.34v.

GW Get current wavelength (included in GI)

Response: Returns 32bit hex (or decimal ASCII for firmware < 1.25) value indicating the filter's current center wavelength. Divide by 10.0 to obtain the value in Angstroms.

Example: "0001005C" corresponds to 6562.8Å.

GY Get age and turn-on count

Response: Returns the number of times the Quantum has been turned on as a 32bit hex value, followed by a space, followed by the amount of time the filter has been powered on as a 32bit hex value in minutes. Note that the internal clock is not a precision timing device and the time elapsed can be in error by several percent.

Example: "00000003 00000057" means the filter has been booted three times, and has been powered on a total of 1 hour 27 minutes.

GZ Get error status (included in GI)

Response: Error code, as 8 bit hex (or decimal for firmware versions < 1.25):

"01" Dead battery (supply voltage below 8v).
"02" Ambient temp. too cold, cannot reach setpoint (firmware v1.1 only).
"03" Low battery (supply voltage below 10v).
"04" High voltage (supply voltage above 30v).
"05" Ambient temp. too hot, cannot reach setpoint (firmware v1.1 only).
"0A" Thermistor connection open (broken wire). Return to DayStar for service.
"0B" Thermistor connection shorted. Return to DayStar for service.

Get Commands: Settings

These commands read back settings available to the end user.

GD Get offset vs absolute LCD readout setting

Response: Returns 8 bit hex (or decimal ASCII for firmware < 1.25).
See SD to modify the setting.
"00" Normal, absolute wavelength readout on LCD (i.e. 6562.4 Å).
"01" Offset wavelength readout on LCD (i.e. -0.4 Å)

GE Get current wavelength shift setting (included in GI)

Response: Returns 8 bit signed 2's complement hex (or decimal ASCII for firmware < 1.25) readout of the current wing shift setting. Divide by 10.0 to obtain the value in Angstroms. See SE to modify the wing shift.

Example: "FF" corresponds to a wing shift of -0.1 Å: if the filter nominal wavelength is 6562.8 Å, it will slew to 6562.7 Å.

GH Get sleep mode status

Response: Returns 8 bit hex (or decimal ASCII for firmware < 1.25).
See SH to modify the setting.
"00" Normal condition, heaters are operating.
"01" Sleep mode, heaters are disabled and the LCD display reads "SLEEP".

GL Get button lockout setting

Response: Returns 8 bit hex (or decimal ASCII for firmware < 1.25).
See SL to modify the setting.
"00" Normal, red/blue buttons are enabled for manual adjustment.
"01" Lockout mode, red/blue buttons are disabled.

GR Get filter wheel cavity count & names (filter wheel only)

Response: Returns an 8 bit hex number corresponding to the number of installed filter wheel cavities, followed by the tab (0x09) character, followed by tab-delimited names of the cavities. An underscore ("_") should be interpreted as a decimal point. Example:

"04 Ha 0_4Ha 0_7Na 0_4 CaH 5"

GU Get nanometers vs Angstroms readout setting

Response: Returns 8 bit hex (or decimal ASCII for firmware < 1.25).
See SU to modify the setting.
"00" Wavelength readout on LCD is in Angstroms.
"01" Wavelength readout on LCD is in nanometers.

G# Get Turbo Tilt (turbo tilt equipped filters only)

Response: Returns 8 bit signed 2's complement hex (or decimal ASCII for firmware < 1.25) readout of the current Turbo Tilt wing shift setting. Divide by 10.0 to obtain the value in Angstroms. See S# to modify the tilt wing shift.

Example: "FF" corresponds to a wing shift of -0.1 Å: if the filter nominal wavelength is 6562.8 Å, it will tilt to a passband of 6562.7 Å.

Get Commands: Fixed Metadata

These commands read back data permanently set at the factory. They need only be read once per session or when a new filter is connected.

GA Get body style

Response: Single character denoting body style.

"0" 38mm non-tilt, standard Quantum housing.
"1" 38mm TS-2/Q-2 tilt Quantum housing.
"2" 50mm non-tilt, standard Quantum housing.
"3" 38mm non-tilt, differentially heated Quantum housing.
"4" 38mm filter wheel, up to four positions.
… Other styles will be defined in the future.

GB Get bandwidth string

Response: Returns decimal ASCII text string of the filter FWHM in Angstroms, up to 8 characters.

Example: "0.42".

GJ Get design temperature(s)

Response: One (or two for body style 3) temperatures, in 16 bit hex (or decimal ASCII for firmware < 1.25), separated by a space. Divide by 100.0 to obtain the temperature in Fahrenheit.

Example: "3039 223D" corresponds to set points of 123.45°F and 87.65°F.

GN Get model string

Response: Returns ASCII text string of the filter's model name, up to 32 characters.

Example: "Quantum".

GO1 – GO4 Get fixed settings on filter wheel cavity 1-4 (filter wheel only)

Response: For the current cavity, returns a tab delimited list of the design wavelength times 10 (for example, 6562.8), the filter FWHM, the etalon quality (SE or PE), the design temperatures of the primary and secondary heaters, and the maximum temperature wing shift, all in hex.

GS Get body serial number

Response: Returns ASCII text string of the filter's serial number as printed on the external label, up to 16 characters.

Example: "QPE-1234".

GX Get design wavelength

Response: Returns 32bit hex (or decimal ASCII for firmware < 1.25) value indicating the filter's nominal (design) center wavelength. Divide by 10.0 to obtain the value in angstroms.

Example: "0001005C" corresponds to 6562.8Å.