



Monochromator Communication Protocol

www.optics-focus.com

sales@optics-focus.com

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1. Introduction

All the location parameters sent in this communication protocol are the **running step number** relative to the mechanical zero. The calculation method between the running step number and the actual wavelength is:

When the wavelength is converted to step number:

If the wavelength is `dblWaveLen`, the corresponding step number `n1`, `n2`, `n3` and `n4` is respectively:

```
dbldata=dblWaveLen/dblStep
n1 = Int(dbldata / (2 ^ 24))
dbldata = Int(dbldata Mod (2 ^ 24))
n2 = Int(dbldata / (2 ^ 16))
dbldata = Int(dbldata Mod (2 ^ 16))
n3 = Int(dbldata / (2 ^ 8))
dbldata = Int(dbldata Mod (2 ^ 8))
n4 = dbldata
```

Thereinto:

The `dblStep` is the minimum step distance of monochromator controller running, which is relevant with the monochromator focal length and scribed line number. For example, the 7IMS30 series monochromator uses the 1200-line grating, then `dblStep=0.00625`; when it uses the 600-line grating, then `dblStep=0.00625*2.....`For the minimum step distance, please refer to the instrument manual.

The `dbldata` is the intermediate variable for converting the decimal number to 4-byte hexadecimal number.

`A Mod(i)` represents remainder of `A` to `i`.

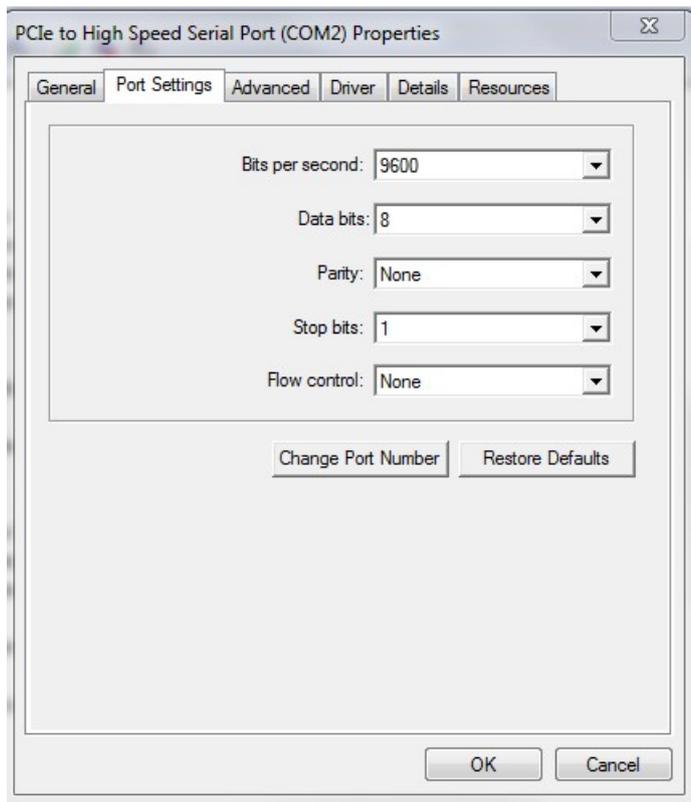
`Int (i)` represents rounding to `i`, i.e. rounding down the decimal places.

When the step number is converted to wavelength:

If the monochromator return wavelength number is: `n1`, `n2`, `n3`, `n4`, then the corresponding wavelength value `dblWaveLen` is:

```
dblWaveLen= (n1 * (2 ^ 24) + n2 * (2 ^ 16) + n3 * (2 ^ 8) + n4 - zero offset) * dblStep
```

Please set the serial port parameters as below:



2. Parameter Setting Commands

2.1 Monochromator setting commands

2.1.1 Boot positioning wavelength: "M"&n1&n2&n3&n4

M is the setting command of boot positioning wavelength, including the n1, n2, n3 and n4 are the step number, each of which is the single-byte hexadecimal number respectively. The n1 and n2 are high-order digit, the n3 and n4 are low-order digit, and the minimum unit is step. After sending, no matter what the current location is, the location will be stored in the flash memory as the default wavelength for the next boot application.

After receiving this command, the monochromator controller returns CHR(13)&"OK", which indicates that the setting is successful.

Example:

Dim bCmd(4) As Byte

Dim IData As Long

bCmd(0) = Asc("M")

bCmd(1) = Int(IData / (2 ^ 24))

$I\text{Data} = \text{Int}(I\text{Data} \bmod (2^{24}))$
 $b\text{Cmd}(2) = \text{Int}(I\text{Data} / (2^{16}))$
 $I\text{Data} = \text{Int}(I\text{Data} \bmod (2^{16}))$
 $b\text{Cmd}(3) = \text{Int}(I\text{Data} / (2^8))$
 $b\text{Cmd}(4) = \text{Int}(I\text{Data} \bmod (2^8))$

2.1.2 Monochromator running speed: "V"&n

V is the setting command of monochromator running speed, n is the code of running speed, the value range is 0-250, which should be converted to the single-byte hexadecimal code.

After receiving this command, the monochromator controller returns CHR(13)&"OK", which indicates that the setting is successful.

2.2 Filter wheel parameters setting commands

2.2.1 Set the commands of filter parameters:

"F" data1&CHR(13), data2&CHR(13), data3&CHR(13), number_1&CHR(13), number_2&CHR(13),number_x&CHR(13)

F is the command of establishing the filter parameter set.

The parameter data1 represents the filter number. The numerical value is input by the commissioning personnel according to the equipment parameters, and the maximum should not exceed, which should be converted to the single-byte hexadecimal code.

Two conditions for the data1 use	
data1+128	Modify the filter number, data2 (positioning location i.e. zero location), data3 (filter wheel total step number), and beginning wavelength of various filters; At this time, write the correct positioning location and filter wheel total step number.
data1	Only modify the filter number, and beginning wavelength of various filters; At this time, fill the positioning location and filter wheel total step number by 0x00.

The data2 represents the positioning location, and is the hexadecimal code of 1# filter mechanical zero location (subject to calibration), which covers 2 bytes.

The data3 represents the hexadecimal code of filter wheel total step number, which covers 2 bytes. It should be set by the commissioning personnel according to the equipment parameters (not exceeding 65535).

From number_1 to number_x (x is filter total number) is the hexadecimal code of beginning wavelength of various filters. Each parameter covers 2 bytes. The numerical value should be arranged from small to big.

In the middle and at the end of each data of this group of data, the monochromator returns the

“OK”&CHR(13) mark, and the next command or data can be input only after receiving this mark in the control program.

2.2.2 Close and start the filter switching functions

The command format is “S0”&CHR(13)or“S1”&CHR(13).

The S0 represents closing the filter switching function, and the S1 represents starting the filter switching function. If the filter is not set, the monochromator returns “E07”&CHR(13), which indicates that the equipment selection is wrong, otherwise returns “OK”&CHR(13).

3. Parameter Query Commands

3.1 Monochromator query commands

3.1.1 Instrument type query: “t”

The t is the instrument type query command.

After receiving this command, the monochromator controller returns “t”&n1.

The n1 is the instrument type No., with range of 0-20. The actual type corresponding to the instrument type No. is shown in the Table 1 Monochromator Type and No. Comparison Table.

No.	Instrument type	No.	Instrument type	No.	Instrument type
0	7IMS102	7	7IMS3011	14	7IMS3022
1	7IMS102A	8	7IMS3011A	15	7IMS102B
2	7IMS1021	9	7IMS3012	16	7IMS1021B
3	7IMS1021A	10	7IMS302	17	7IMS301B
4	7IMS1022	11	7IMS302A	18	7IMS3011B
5	7IMS301	12	7IMS3021	19	7IMS302B
6	7IMS301A	13	7IMS3021A	20	7IMS3021B

Table 1 Monochromator Type and No. Comparison Table

3.1.2 Instrument No. Query: “n”

The n is the instrument No. query command.

After receiving this command, the monochromator controller returns “n”&n1&n2.

The n1 and n2 are the last 5-digit No. of the instrument mark, each of which is the single-byte hexadecimal number.

3.1.3 Grating No.: “g”

The g is the grating No. query command.

After receiving this command, the monochromator controller returns "g"&n.

The n is the grating No.. The specific grating parameters corresponding to grating No. value are shown in the Table 2 Monochromator Grating No., Scribed Line Number and Feedback No. Comparison Table.

No.	Grating scribed line
1	1 (1200g/mm) 30
2	2 (600g/mm) 30
3	3 (300g/mm) 30
4	4 (150g/mm) 30
5	5 (1800g/mm) 30
17	1 (1200g/mm) 10
18	2 (600g/mm) 10
19	3 (300g/mm) 10
20	4 (150g/mm) 10

Table 2 Monochromator Grating No., Scribed Line Number and Feedback No. Comparison Table

When the No. is 1~4, the minimum step distance is $0.00625 * (2 ^ (n - 1))$;

When the No. is 5, the minimum step distance is $0.00625 * 2/3$;

When the No. is 17~20, the minimum step distance is $0.0625 * (2 ^ (n - 17))$.

3.1.4 Grating flash wavelength: "p"

The p is the grating flash wavelength query command.

After receiving this command, the monochromator controller returns "p"&n1&n2.

The n1 and n2 are the single-byte hexadecimal code of the grating flash wavelength respectively.

3.1.5 Zero offset: "z"

The z is the zero offset query command.

After receiving this command, the monochromator controller returns "z"&n1&n2.

The n1 and n2 are the single-byte hexadecimal number respectively. The n1 is high-order digit, the n2 is low-order digit, and the minimum unit is step.

3.1.6 Manufacture year: "y"

The y is the manufacture year query command.

After receiving this command, the monochromator controller returns "y"&n1.

The n1 is the single-byte hexadecimal code for the actual manufacture year of monochromator.

3.1.7 Boot positioning wavelength: "m"

The m is the boot positioning wavelength query command.

After receiving this command, the monochromator controller returns "m"&n1,n2,n3&n4.

Thereinto, the n1 and n2 are high-order digit, and the n3 and n4 are low-order digit. The n1, n2, n3 and n4 are the default wavelength stored in the controller, each of which is the single-byte hexadecimal number respectively.

3.1.8 Monochromator running speed: "v"

The v is the monochromator running speed query command.

After receiving this command, the monochromator controller returns "v"&n1&n2.

Thereinto, the n1 is the status number, and the n2 is the speed number. The n1.7=1 represents that the controller is adjusting the status. The n1.6=1 represents that the grating No., optical zero or default wavelength exceeds the allowed value.

3.1.9 Monochromator current location query: "w"

The w is the monochromator current location query command.

After receiving this command, the monochromator controller returns "w"&n1&n2&n3&n4.

Thereinto, the n1 and n2 are high-order digit, and the n3 and n4 are low-order digit. The n1, n2, n3 and n4 are the controller current location, **which includes the zero offset**. Each of n1, n2, n3 and n4 is the single-byte hexadecimal number respectively.

3.1.10 Monochromator hardware version No. query: "a"

The a is the monochromator hardware version No. query command.

After receiving this command, the monochromator controller returns "a"&n1&n2&n3&n4&n5&"OK".

Thereinto, the n1, n2, n3, n4 and n5 are the hardware version No., each of which is the single-byte hexadecimal number respectively.

3.2 Query filter wheel parameter: "f"

After receiving this command, the monochromator returns Number&CHR(13).

If Number=2, it represents that the filter parameters have not been set. The monochromator returns 27 pieces of CHR(13) and ends query.

If Number=0, it represents that the filter parameters have been set but not been used yet. If

Number=1, it represents that the filter is being used. The monochromator returns:

dataNumber&CHR(13), data_p&CHR(13), data_f&CHR(13), data_1&CHR(13),

data_2&CHR(13).....data_x&CHR(13) (x is the total number of filter), "OK"&CHR(13).

In this data group, the dataNumber is the number of filter wheel. The data_p is the hexadecimal code of filter positioning benchmark (zero), which covers 2 bytes. The data_f is the hexadecimal code of filter wheel disk total step number, which covers 2 bytes. From data_1 to data_x is the beginning wavelength value of various filters.

4. Running Commands

4.1 Fast forward, fast backward and zeroing command: "K"&n

Thereinto, the n is a single-byte (each digit like D7, D6, D5, D4, D3, D2, D1, D0). If D0=1, which is equivalent to key [wavelength fast increase]; D1=1, which is equivalent to key [wavelength fast decrease]; D2=1, set the key as constant; D3=1, which is equivalent to key [home], zeroing operation. When sending commands, the non-characteristic digits must be ensured 0, and multiple characteristic digits should not be set 1 simultaneously, otherwise the lower machine will only returns CHR(13) but does not act.

The "K"&1 is fast forward, the "K"&2 is fast backward, and the "K"&8 is zeroing.

After receiving the fast forward (fast backward) command, the controller returns 5 pieces CHR(13) to personal computer. At this time, the stop command "k" should be sent. After receiving this command, the controller returns "OK"&CHR(13). If the stop command is not sent, the controller runs to the upper limit location (optical zero) and then stops. At this time, the query command "w" needs to be sent again. The controller returns "OK"&CHR(13) and completes operation. In case of zeroing operation, the controller receives this command and returns 5 pieces of CHR(13). After executing this command, the controller returns personal computer "OK"&CHR(13).

4.2 Increment increase running command: "U"&n1&n2&n3&n4

Thereinto, the n1, n2, n3 and n4 are the step number, each of which is the single-byte hexadecimal number respectively. The n1 and n2 are high-order digit, the n3 and n4 are low-order digit, and the minimum unit is step. After sending, no matter what is the current wavelength, the controller advances the sent step number again. After receiving this command, the controller returns the target value (**including zero offset**) n11, n12, n13, n14 and a piece of CHR(13) to personal computer. The n11 and n12 are high-order digit, and the n13 and n14 are low-order digit. In or after the end of running, the personal computer can send the query command "w", and the controller returns "current location"&CHR(13).

4.3 Increment decrease running command: "D"&n1&n2&n3&n4

Thereinto, the n1, n2, n3 and n4 are the step number, each of which is the single-byte hexadecimal number respectively. The n1 and n2 are high-order digit, the n3 and n4 are low-order digit, and the minimum unit is step. After sending, no matter what is the current wavelength, the controller

recedes the sent step number again. After receiving this command, the controller returns the target value (**including zero offset**) n11, n12, n13, n14 and a piece of CHR(13) to personal computer. The n11 and n12 are high-order digit, and the n13 and n14 are low-order digit. In or after the end of running, the personal computer can send the query command "w", and the controller returns "current location"&CHR(13).

4.4 Target running command:"W"&n1&n2&n3&n4

Thereinto, the n1, n2, n3 and n4 are the step number, each of which is the single-byte hexadecimal number respectively. The n1 and n2 are high-order digit, the n3 and n4 are low-order digit, and the minimum unit is step. After sending, the controller runs to the locations specified by the n1, n2, n3 and n4 parameters, **which do not include the zero offset**. After receiving this command, the controller returns the target value (**including zero offset**) n11, n12, n13, n14 and a piece of CHR(13) to personal computer. The n11 and n12 are high-order digit, and the n13 and n14 are low-order digit. In or after the end of running, the personal computer can send the query command "w", and the controller returns "current location"&CHR(13).

4.5 Stop command:"k"

After receiving this command, the controller stops running, and returns "OK"&CHR(13).

5. Error Information

E01&CHR(13): communication error, sending illegal control commands, or communication timeout.

E07&CHR(13): the filter wheel is not connected.

E08&CHR(13): the filter wheel parameters are set wrongly.