

# Maya2000Pro Data Sheet for Versions 3.00.1 and Above

## Description

The Ocean Optics Maya2000Pro and Maya2000Pro-NIR include the linear CCD-array optical bench, plus all the circuits necessary for spectrometer operation. The result is a compact, flexible system, with no moving parts, that's easily integrated as an OEM component.



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### Note

This data sheet is for Maya2000Pro FPGA and FX2 firmware version 3.00.1 and above. For Maya2000Pro Spectrometers with firmware below this version, and for the Maya2000 Spectrometer, please see the [Maya2000 and Maya2000Pro Data Sheet](#).

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The Maya2000Pro and Maya2000Pro-NIR Spectrometers are a unique combination of technologies providing users with high sensitivity for low light-level, UV-sensitive and other scientific applications. The electronics have been designed for considerable flexibility in connecting to various modules as well as external interfaces. The Maya2000Pro series spectrometers interface to PCs, PLCs and other embedded controllers through USB 2.0 or RS-232 communications.

The detector used in the Maya2000Pro series spectrometers are a scientific-grade, back-thinned, CCD array from Hamamatsu (product number S10420 for Maya2000Pro and S11510 for Maya2000Pro-NIR). For complete details on these detectors, visit [www.Hamamatsu.com](http://www.Hamamatsu.com).

The Maya operates from power provided through the USB, or from a separate + 5VDC power supply. The Maya is a microcontroller-controlled spectrometer, thus all operating parameters are implemented through software interfacing to the unit.

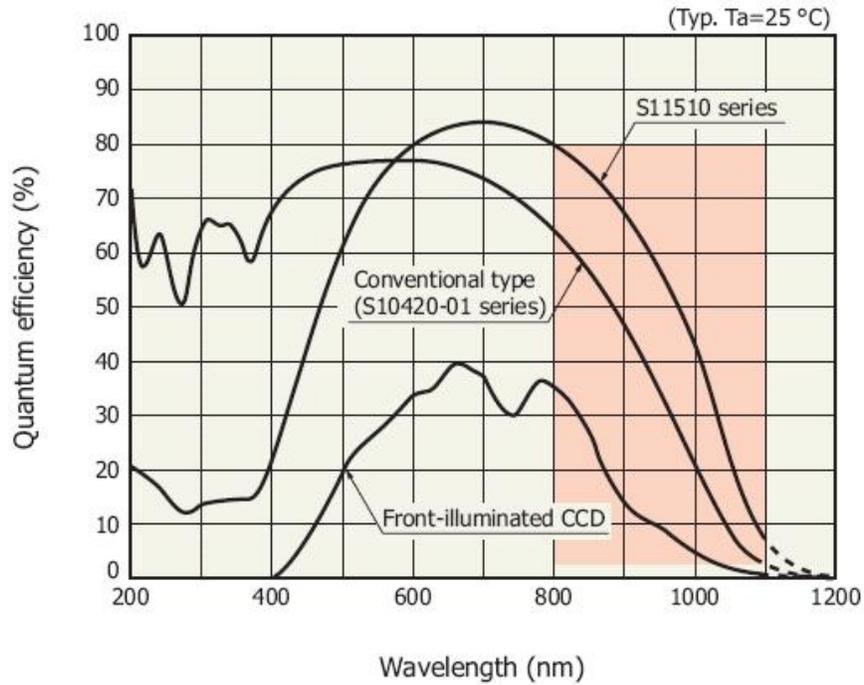
# Features

- ❑ Back-thinned Hamamatsu detectors
  - S10420 – high UV Sensitivity in Maya2000Pro
  - S11510 – high NIR Sensitivity in Maya2000Pro-NIR
- ❑ Spectrometer Design:
  - Symmetrical Crossed Czerny Turner
  - 101.6 mm focal length
  - 15 gratings including the HC-1 composite grating
  - 6 slit widths
- ❑ Electrical Performance:
  - 16 bit, 500kHz A/D Converter
  - Integration time: 7.2ms – 5s
- ❑ Embedded microcontroller allows programmatic control of all operating parameters and standalone operation:
  - USB 2.0 480Mbps (high-speed) and 12Mbps (full speed)
  - RS232 115Kbaud
  - Communication Standards for digital accessories (I2C)
- ❑ Onboard Pulse Generator:
  - 2 programmable strobe signals for triggering other devices
  - Software control of nearly all pulse parameters
- ❑ Onboard GPIO:
  - 10 user-programmable digital I/O
- ❑ EEPROM storage for:
  - Wavelength Calibration Coefficients
  - Linearity Correction Coefficients
  - Absolute Irradiance Calibration (optional)
- ❑ Plug-n-Play Interface for PC applications
- ❑ 30-pin connector for interfacing to external products

# Specifications

Specifications	Criteria
Physical Specifications: Physical Dimensions (LxWxH) Spectrometer Weight Power Supply Weight	149 mm (5.86 in.) x 109.3 mm (4.30 in.) x 50.4 mm (1.98 in.) 0.96 kg (2.1 lbs.) 0.45 kg (1 lb.)
Power: Power requirement Supply voltage Power-up time	500 mA at +5 VDC 4.5 – 5.5 V ~2s depending on code size
Absolute Maximum Ratings: V <sub>CC</sub> Voltage on any pin	+ 5.5 VDC +4VDC
Spectrometer: Design Focal length (input) Input Fiber Connector Gratings Entrance Slit  Detectors Pixels (active) Pixel size Spectral range Quantum efficiency -- Maya2000Pro Quantum efficiency -- Maya2000Pro-NIR Well Depth Sensitivity Filters	Symmetric crossed Czerny-Turner F/4 101.6 mm SMA 905 to single-strand optical fiber (0.22 NA) 14 different gratings 5, 10, 25, 50, 100, or 200 μm slits. (Slits are optional. In the absence of a slit, the fiber acts as the entrance slit.) S10420 (Maya2000Pro) or S11510 (Maya2000Pro -NIR) 2048 x 64 196μm <sup>2</sup> 200 – 1100nm 75% peak@600 nm 85% peak @700 nm 200 Ke- ~0.32 counts/e- OFLV-MAYAPRO-200 available with HC-1 grating
Spectroscopic: Integration Time Dynamic Range (Typical) Dynamic Range (Guaranteed) Signal-to-Noise Dark Noise (single dark spectrum) Nonlinearity (uncorrected) Linearity (corrected)	7.2ms – 5s 15000:1+ 10000:1 450:1 6 RMS counts (Guaranteed) ~10% >99.7%
Environmental Conditions: Temperature Humidity	–30° to +70° C Storage & –0° to +50° C Operation 0% – 90% noncondensing
Interfaces: USB RS-232	USB 2.0, 480 Mbps 3-wire RS-232

**Spectral response (without window)\*1**



KMPDB0324EC

\*1: Spectral response with quartz glass is decreased according to the spectral transmittance characteristic of window material.

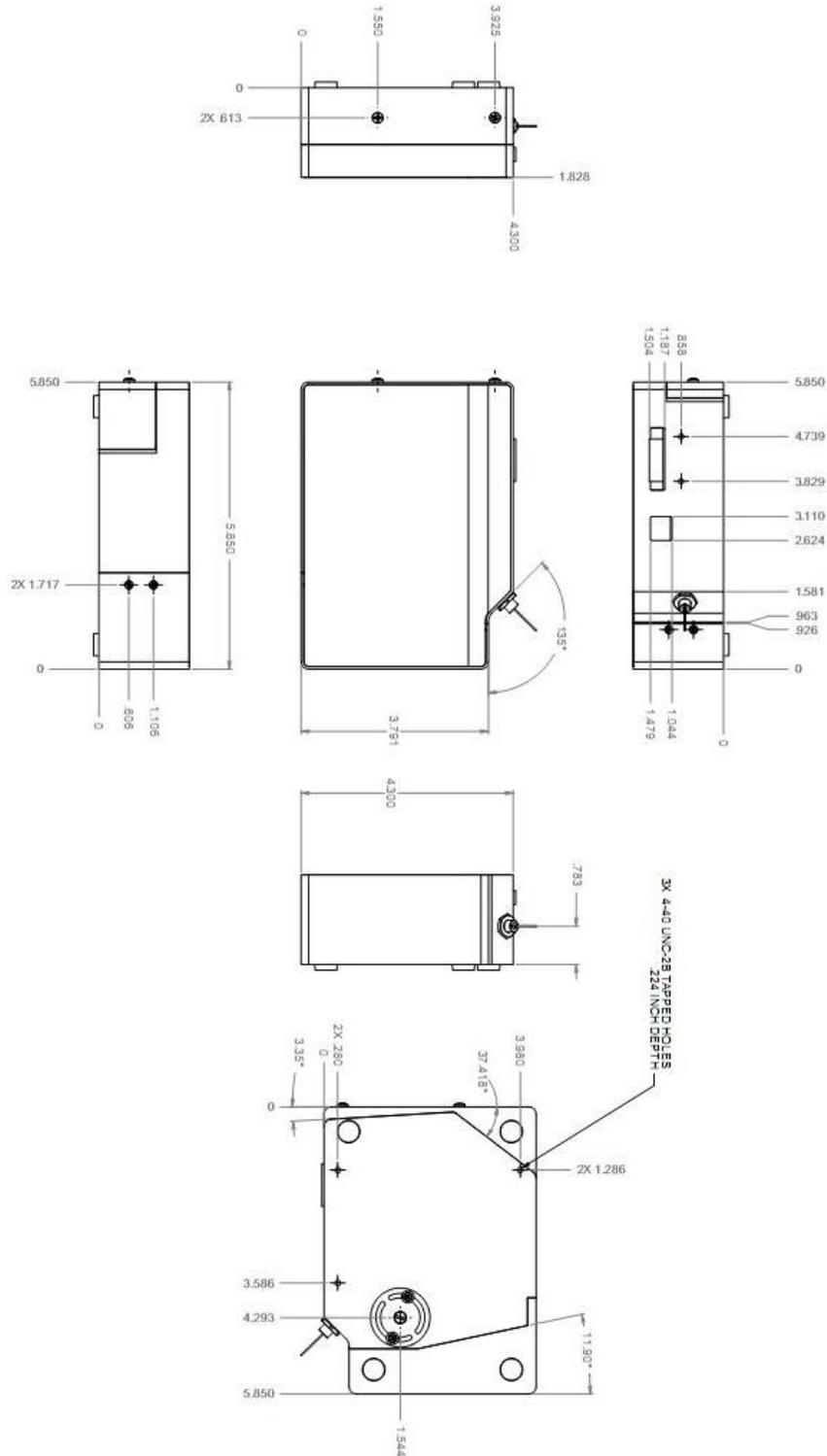
**Quantum Efficiency of S10420 Detector and S11510 Detector**

## Optical Performance

The following table shows the Maya resolution for various slit sizes.

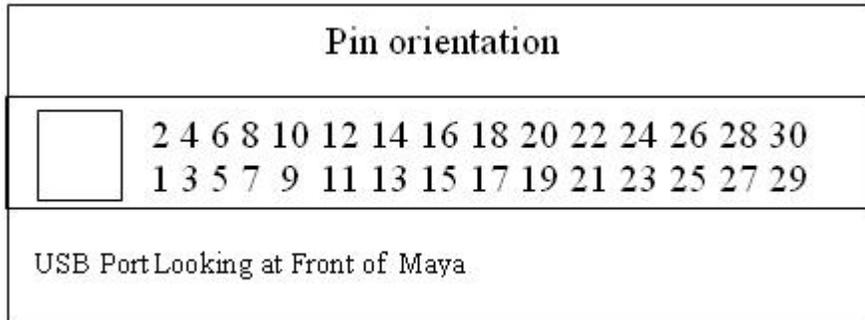
5 micron Slit	10 micron Slit	25 micron Slit	50 micron Slit	100 micron Slit	100 micron Slit
~1.5 pixels	~2.0 pixels	~2.5 pixels	~4.2 pixels	~8.0 pixels	~15.3 pixels

# Mechanical Diagrams



# Electrical Pinout

Listed below is the pin description for the Maya Accessory Connector (J3) located on the front vertical wall of the unit. The connector is a Pak50TM model from 3M Corp. Headed Connector Part# P50-030P1-RR1-TG. Mates with part# P50-030S-TGF (requires two: 1.27mm (50 mil) flat ribbon cable: Recommended 3M 3365 Series)



Pin #	Function	Input/Output	Description
1	RS232 Rx	Input	RS232 receive signal – Communicates with a PC over DB9 Pin 3
2	RS232 Tx	Output	RS232 transmit signal – Communicates with a PC over DB9 Pin 2
3	GPIO (2)	Input/Output	Reserved
4	N/A	N/A	Reserved
5	Ground	Input/Output	Ground
6	I2C SCL	Input/Output	I2C clock signal for communication to other I2C peripherals
7	GPIO (0)	Input/Output	Base clock
8	I2C SDA	Input/Output	I2C data signal for communication to other I2C peripherals
9	GPIO (1)	Input/Output	Master clock
10	Ext. Trigger In	Input	TTL input trigger signal
11	GPIO (3)	Input/Output	Integration clock
12	VCC or 5VIN	Input or Output	Input power pin for Maya – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications
13	N/A	N/A	Reserved
14	VCC or 5VIN	Input or Output	Input power pin for Maya – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications
15	SPI Data In	Input	SPI Master In Slave Out (MISO) signal for communication to other SPI peripherals
16	GPIO (4)	Input/Output	Reserved

Pin #	Function	Input/Output	Description
17	Single Strobe	Output	TTL output pulse used as a strobe signal – Has a programmable delay relative to the beginning of the spectrometer integration period
18	GPIO (5)	Input/Output	Acquire spectra (read enable)
19	N/A	N/A	Reserved
20	Continuous Strobe	Output	TTL output signal used to pulse a strobe – Divided down from the master clock signal
21	N/A	Output	Reserved
22	GPIO (6)	Input/Output	Reserved
23	N/A	N/A	Reserved
24	N/A	N/A	Reserved
25	Lamp Enable	Output	TTL signal driven Active HIGH when the Lamp Enable command is sent to the spectrometer
26	GPIO (7)	Input/Output	Reserved
27	Ground	Input/Output	Ground
28	GPIO (8)	Input/Output	A/D trigger
29	Ground	Input/Output	Ground
30	GPIO (9)	Input/Output	EPFLAG

## Maya2000Pro Spectrometer Detector

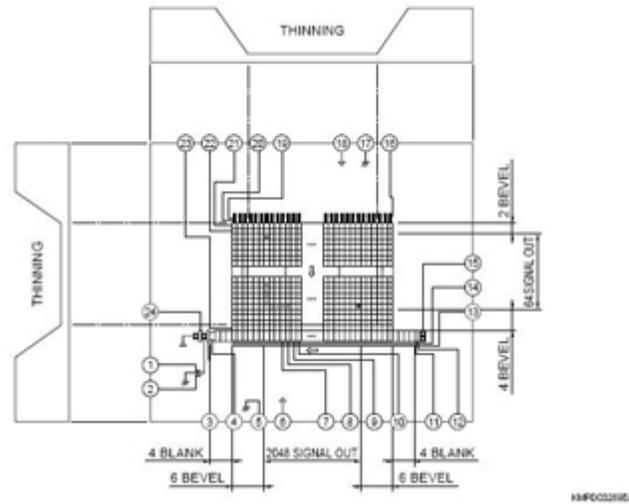
The Maya2000Pro contains a Hamamatsu S10420 CCD and the Maya2000Pro-NIR contains a Hamamatsu S11510 CCD. Both are two-dimensional CCDs. The Maya electronics only support reading out the device as a 1-D array (e.g. all rows are summed together on chip). The structure of the Maya2000Pro series spectrometers Hamamatsu CCDs is shown below. The device has 2048 x 64 active pixels and a total of 2068 x 70 pixels.

### Pixel Definition

The following is a description of all of the pixels:

#### Maya2000-Pro Pixels

Pixel	Description
0	Unusable
1–3	Dark
4–9	Bevels/unusable
10–2057	Spectrum
2058–2063	Bevels/unusable
2064–2067	Dark

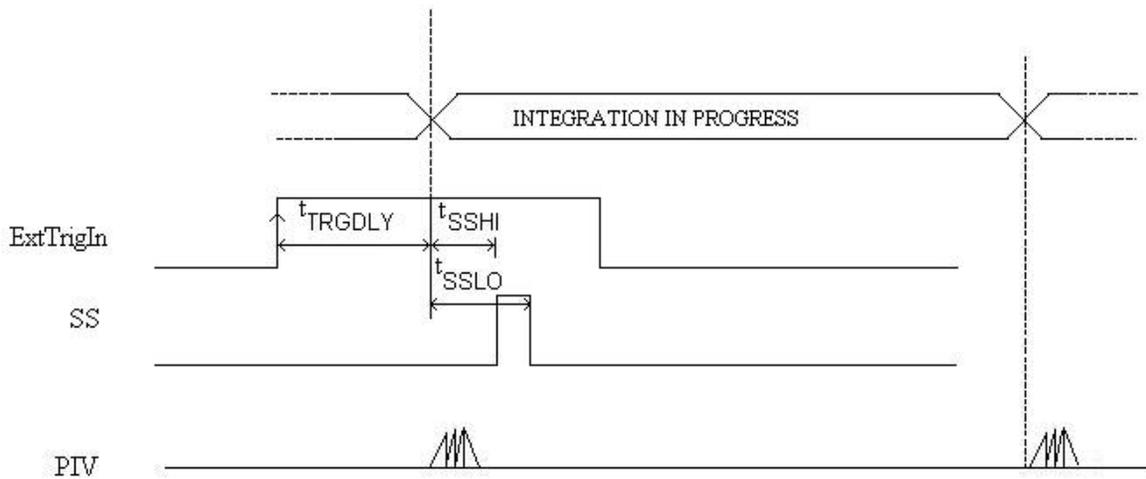


Maya2000Pro CCD Device structure (64 active vertical pixels and 2048 active horizontal pixels)

## Timing Signals (Strobe Signals)

### Single Strobe

The Single Strobe (SS) signal is a programmable TTL pulse that occurs at a user-determined time during each integration period. This pulse has a user-defined delay and pulse width. The pulse is only active if the Lamp Enable command is active. This pulse allows for synchronization of external devices to the spectrometers integration period. The Strobe delay can range from 0 to 30ms. Timing of the Single Strobe is based on the start of the integration period (the time between the starts of PIV vertical clock bursts). Timing for the Single Strobe in External Hardware Trigger mode is shown below:



#### Single Strobe (External Hardware Trigger Mode)

TRGDLY is the start of integration after external trigger, adjustable in 500 ns increments (0 – 30 ms).

The width and delay of the Single Strobe can be adjusted in 500ns increments. The 'SSHI is a programmable delay from trigger to the start of a single strobe. 'SSLO defines the width by setting the delay to clear the single strobe pulse from the trigger.

Similar to the Single Strobe signal in External Hardware Trigger mode, the width and delay of the Single Strobe in Normal or External Synchronization mode can be adjusted in 500ns increments. In Normal mode, the start of integration replaces the function of the external trigger signal.

## Continuous Strobe

The Continuous Strobe signal is a programmable frequency pulse-train with a 50% duty cycle. It is programmed by specifying the desired period whose range is 2us to 60s. This signal is continuous once enabled, but is not synchronized to the Start of Integration or External Trigger Input. The Continuous Strobe is only active if the Lamp Enable command is active.

## Synchronizing Strobe Events

If the application requires more than one pulse per integration period, the user needs to insure the continuous strobe and integration period are synchronized. The integration time must be set so that an equal number of strobe events occurs during any given integration period.

# Maya Trigger/Acquisition Modes

The Maya2000Pro supports 4 triggering modes, including the Normal (free-run) mode, which are set with the Trigger Mode command. These modes are described below. For detailed information on these trigger modes, refer to the External Triggering Options document for Spectrometer Firmware versions 3.0 and above located on our website at <http://www.oceanoptics.com/technical/External-Triggering2.pdf>. The following paragraphs describe these modes.

For Maya2000Pro firmware versions below 3.0 and for Maya2000, see <http://www.oceanoptics.com/technical/External-Triggering.pdf>.

- **Normal (free-run) Mode:** In this mode, the spectrometer will acquire a spectrum based on the integration period specified through the software interface. This data is made available for reading as soon as all the data is stored. The spectrometer will then immediately acquire another spectrum even if one has not been requested. If a new spectrum request has come from the user, then this spectrum will be available to the user. If a new spectrum has not been requested by the user, then this spectrum will be deleted and the Maya2000Pro will go into idle mode waiting for a new spectrum request. If you using strobe enable, the order of operation is strobe enable then integrate. If the second spectrum is not collected by the user, the Maya200Pro will send another pulse to the strobe enable pin but will not collect another spectrum and go into idle mode. While the spectrometer is in the idle mode, new spectra will not be acquired. When a new spectrum request comes from the user, a new data acquisition cycle will begin.
- **Software Trigger Mode:** This mode is not supported by the Maya2000Pro.
- **External Synchronous Mode:** In this mode, two external triggers are required to complete a data acquisition. The first rising edge starts the integration period and the second rising edge stops the integration and starts the next. Thus, the integration time is the period between the two external trigger pulses. As in Normal mode, no further spectra are acquired until the original spectrum is read by the user.

- **External Hardware Level Trigger Mode:** In this mode, a rising edge detected by the spectrometer from the External Trigger input starts the integration period specified through the software interface. After the integration period, the spectrum is stored in the FIFO buffer and is ready to be read by the user. As long as the trigger level remains active, in a logic one state, back-to-back acquisitions will occur, as in the Normal mode. The spectrometer will continue to behave like Normal mode until the trigger transitions to an inactive level.
- **External Hardware Edge Trigger Mode:** In this mode, a spectrum request has to be sent first, then the spectrometer waits for a rising edge detected on the External Trigger input to start the integration period specified through the software interface. After the integration period, the spectrum is retrieved and is ready to be read by the user. Only one acquisition will be performed for each External Trigger pulse, no matter what the pulse's duration is, and the spectrometer will return to the idle state.

## Maya USB Port Interface Communications and Control Information

The Maya is a microcontroller-based Miniature Fiber Optic Spectrometer that can communicate via the Universal Serial Bus. This section contains the necessary command information for controlling the Maya via the USB interface. This information is only pertinent to users who wish to not utilize Ocean Optics 32 bit driver to interface to the Maya. Only experienced USB programmers should attempt to interface to the Maya via these methods.

### Hardware Description

The Maya utilizes a Cypress CY7C68013A microcontroller that has a high speed 8051 combined with an USB2.0 ASIC. Program code and data coefficients are stored in external E<sup>2</sup>PROM that are loaded at boot-up via the I<sup>2</sup>C bus. The microcontroller has 8K of internal RAM and 64K of external SRAM. Maximum throughput for spectral data is achieved when data flows directly from the external FIFO's directly across the USB bus. In this mode the 8051 does not have access to the data and thus no manipulation of the data is possible.

### USB Info

Ocean Optics Vendor ID number is 0x2457 and the Product ID is 0x102A.

## Instruction Set

### Command Syntax

The list of the commands is shown in the following table followed by a detailed description of each command. The length of the data depends on the command. All commands are sent to the Maya

through End Point 1 Out (EP1). All spectra data is acquired through End Point 2 In and all other queries are retrieved through End Point 1 In (EP1). The endpoints enabled and their order is:

Pipe #	Description	Type	Hi Speed Size (Bytes)	Full Speed Size (Bytes)	Endpoint Address
0	End Point 1 Out	Bulk	64	64	0x01
1	End Point 2 In	Bulk	512	64	0x82
2	End Point 6 In	Unused	Unused	Unused	Unused
3	End Point 1 In	Bulk	64	64	0x81

## USB Command Summary

EP1 Command Byte Value	Description	Version
0x01	Initialize Maya	1.01.0
0x02	Set Integration Time	1.01.0
0x03	Set Strobe Enable Status	1.01.0
0x05	Query Information	1.01.0
0x06	Write Information	1.01.0
0x09	Request Spectra	1.01.0
0x0A	Set Trigger Mode	1.01.0
0x0B	Query number of Plug-in Accessories Present	1.01.0
0x0C	Query Plug-in Identifiers	1.01.0
0x0D	Detect Plug-ins	1.01.0
0x60	General I <sup>2</sup> C Read	1.01.0
0x61	General I <sup>2</sup> C Write	1.01.0
0x6A	Write Register Information	1.01.0
0x6B	Read Register Information	1.01.0
0x6D	Read Irradiance Calibration Factors	1.01.0
0x6E	Write Irradiance Calibration Factors	1.01.0
0xFE	Query Information	1.01.0

# USB Command Descriptions

A detailed description of all Maya commands follows. While all commands are sent to EP1 over the USB port, the byte sequence is command dependent. The general format is the first byte is the command value and the additional bytes are command specific values.

Byte 0	Byte 1	Byte 2	...	Byte n-1
Command Byte	Command Specific	Command Specific	...	Command Specific

## Initialize Maya

Initializes certain parameters on the Maya and sets internal variables based on the USB communication speed the device is operating at. This command should be called at the start of every session however if the user does not call it, it will be executed on the first Request Scan command. The default values are set as follows

Parameter	Default Value
Trigger Mode	0 – Normal Trigger

### Byte Format

Byte 0
0x01

## Set Integration Time

Sets the Maya integration time in microseconds. The value is a 32-bit value whose acceptable range is 7200 – 65,000,000  $\mu$ s (65 seconds). If the value is outside this range the value is unchanged.

### Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0x02	LSW-LSB	LSW-MSB	MSW-LSB	MSW-LSB

MSW & LSW: Most/Least Significant Word

MSB & LSB: Most/Least Significant Byte

## Set Strobe Enable Status

Sets the Maya Lamp Enable line (J2 pin 25) as follows. The Single Strobe and Continuous Strobe signals are enabled/disabled by this Lamp Enable Signal.

Data Byte = 0 → Lamp Enable Low/Off
Data Byte = 1 → Lamp Enable HIGH/On

### Byte Format

Byte 0	Byte 1	Byte 2
0x03	Data byte LSB	Data Byte MSB

## Query Information

Queries any of the 20 stored spectrometer configuration variables. . The Query command is sent to End Point 1 Out and the data is retrieved through End Point 1 In. When using Query Information to read EEPROM slots, data is returned as ASCII text. However, everything after the first byte that is equal to numerical zero will be returned as garbage and should be ignored.

The Query command is sent to End Point 1 Out and the data is retrieved through End Point 1 In. The 20 configuration variables are indexed as follows:

Configuration Index - Description
0 – Serial Number
1 – 0 <sup>th</sup> order Wavelength Calibration Coefficient
2 – 1 <sup>st</sup> order Wavelength Calibration Coefficient
3 – 2 <sup>nd</sup> order Wavelength Calibration Coefficient
4 – 3 <sup>rd</sup> order Wavelength Calibration Coefficient
5 – Stray light constant
6 – 0 <sup>th</sup> order non-linearity correction coefficient
7 – 1 <sup>st</sup> order non-linearity correction coefficient
8 – 2 <sup>nd</sup> order non-linearity correction coefficient
9 – 3 <sup>rd</sup> order non-linearity correction coefficient
10 – 4 <sup>th</sup> order non-linearity correction coefficient
11 – 5 <sup>th</sup> order non-linearity correction coefficient
12 – 6 <sup>th</sup> order non-linearity correction coefficient
13 – 7 <sup>th</sup> order non-linearity correction coefficient
14 – Polynomial order of non-linearity calibration
15 – Optical bench configuration info #1: gg fff sss gg – Grating #, fff – filter wavelength, sss – slit size
16 – Maya configuration info #2: Detector Serial Number
17 – Reserved
18 – Power up Baud Rate Value
19 – User Defined

### Byte Format

Byte 0	Byte 1
0x05	Configuration Index

### Return Format (EP1)

The data is returned in ASCII format and read in by the host through End Point 1.

Byte 0	Byte 1	Byte 2	Byte 3	...	Byte 17
0x05	Configuration Index	ASCII byte 0	ASCII byte 1	...	ASCII byte 15

## Write Information

Writes any of the 19 stored spectrometer configuration variables to EEPROM. The 19 configuration variables are indexed as described in the Query Information. The information to be written is transferred as ASCII information.

### Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	...	Byte 17
0x06	Configuration Index	ASCII byte 0	ASCII byte 1	...	ASCII byte 15

## Request Spectra

Initiates spectra acquisition. The Maya will acquire a complete spectra (2068 data values). The data is returned in bulk transfer mode through EP2. The table below provides the pixel order for the two different speeds. The pixel values are decoded as described below.

### Byte Format

Byte 0
0x09

### Return Format

The format for the returned spectral data is dependant upon the USB communication speed. The format for both High Speed (480 Mbps) and Full Speed (12Mbps) is shown below. All pixel values are 16 bit values which are organized in LSB | MSB order. There is an additional packet containing one value that is used as a flag to insure proper synchronization between the PC and Maya.

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### Note

Maya2000-Pro has 2068 pixels. It reads out 4609 bytes, some of which are filler: bytes 0-4135 correspond to pixels 0-2067, bytes 4136-4607 are filler, and byte 4608 is a sync byte.

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### USB High Speed (480Mbps) Packet Format

In this mode, all data is read from EP2In. The packet format is described below.

Packet #	End Point	# Bytes	Pixels
0	EP2In	512	0-255
1	EP2In	512	256-511
2	EP2In	512	512-767
3	EP2In	512	768-1023
4	EP2In	512	1024-1279
5	EP2In	512	1280- 1535
6	EP2In	512	1536-1791
7	EP2in	512	1792-2047
8	EP2In	512	2048-2303
9	EP2In	1	Sync Packet

The format for the first packet is as follows (all other packets except the synch packet has a similar format except the pixel numbers are incremented by 256 pixels for each packet).

#### Packet 0

Byte 0	Byte 1	Byte 2	Byte 3
Pixel 0 LSB	Pixel 0 MSB	Pixel 1 LSB	Pixel 2 MSB
...			
		Byte 510	Byte 511
		Pixel 255 LSB	Pixel 255 MSB

#### Packet 18 – Synchronization Packet (1 byte)

Byte 0
0x69

#### USB Full Speed (12Mbps) Packet Format

In this mode all data is read from EP2In. The pixel and packet format is shown below.

Packet #	End Point	# Bytes	Pixels
0	EP2In	64	0-31
1	EP2In	64	32-63
2	EP2In	64	64-95
...	EP2In	64	
65	EP2In	64	2080-2111
66	EP2In	1	Sync Packet

**Packet 0**

Byte 0	Byte 1	Byte 2	Byte 3
Pixel 0 LSB	Pixel 0 MSB	Pixel 1 LSB	Pixel 2 MSB
...			
		Byte 62	Byte 63
		Pixel 31 LSB	Pixel 31 MSB

**Packet 123** – Synchronization Packet (1 byte)

Byte 0
0x69

## Set Trigger Mode

Sets the Maya Trigger mode to one of the following states. If an unacceptable value is passed then the trigger state is unchanged (refer to the [External Triggering Options for Firmware 3.0 and Above](#) for a description of the trigger modes).

Data Value = 0 → Normal (Free running) Mode
Data Value = 1 → External Hardware Level Trigger Mode
Data Value = 2 → External Synchronous Trigger Mode
Data Value = 3 → External Hardware Edge Trigger Mode

**Byte Format**

Byte 0	Byte 1	Byte 2
0x0A	Data Value LSB	Data Value MSB

## General I<sup>2</sup>C Read

Performs a general purpose read on the I<sup>2</sup>C pins for interfacing to attached peripherals. The time to complete the command is determined by the amount of data transferred and the response time of the peripheral. The I<sup>2</sup>C bus runs at 400KHz. The maximum number of bytes that can be read is 61.

**Command Byte Format**

Byte 0	Byte 1	Byte 2
0x60	I <sup>2</sup> C Address	Bytes to Read

**Return Byte Format**

Byte 0	Byte 1	Byte 2	Byte 3	...	Byte N+3
I <sup>2</sup> C Results	I <sup>2</sup> C Address	Bytes to Read	Data Byte 0	...	Data byte N

I <sup>2</sup> C Result Value	Description
0	I <sup>2</sup> C bus Idle
1	I <sup>2</sup> C bus Sending Data
2	I <sup>2</sup> C bus Receiving Data
3	I <sup>2</sup> C bus Receiving first byte of string
5	I <sup>2</sup> C bus in waiting for STOP condition
6	I <sup>2</sup> C experienced Bit Error
7	I <sup>2</sup> C experience a Not Acknowledge (NAK) Condition
8	I <sup>2</sup> C experienced successful transfer
9	I <sup>2</sup> C bus timed out

## General I<sup>2</sup>C Write

Performs a general purpose write on the I<sup>2</sup>C pins for interfacing to attached peripherals. The time to complete the command is determined by the amount of data transferred and the response time of the peripheral. The I<sup>2</sup>C bus runs at 400KHz. The results codes are described above.

### Command Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	...	Byte N+3
0x61	I <sup>2</sup> C Address	Bytes to Write	Data Byte 0	...	Data byte N

### Return Byte Format

Byte 0
I <sup>2</sup> C Results

## Write Register Information

Most all of the controllable parameters for the Maya are accessible through this command (e.g., GPIO, strobe parameters, etc). A complete list of these parameters with the associate register information is shown in the table below. Commands are written to End Point 1 Out typically with 4 bytes (some commands may require more data bytes). All data values are 16 bit values transferred in MSB | LSB order. This command requires 100us to complete; the calling program needs to delay for this length of time before issuing another command. In some instances, other commands will also write to these registers (i.e., integration time), in these cases the user has the options of setting the parameters through 2 different methods.

### Byte Format

Byte 0	Byte 1	Byte 2	Byte 3
0x6A	Register Value	Data Byte LSB	Data Byte MSB

Register Address	Description	Default Value	Min Value	Max Value	Time Base
0x00*	Master Clock Counter Divisor	6	1	0xFFFF	48MHz
0x04	FPGA Firmware Version (Read Only)				
0x08	Continuous Strobe Timer Interval Divisor	48000	0	0xFFFF	Continuous Strobe Base Clock (see Register 0x0C)
0x0C	Continuous Strobe Base Clock Divisor	4800	0	0xFFFF	48MHz
0x10*	Integration Period LSB Divisor	1000	0	0xFFFF	1MHz
0x14	Set base_clk or base_clkx2 0: base_clk 1: base_clkx2	1	0	1	N/A
0x18*	Integration Period MSB Divisor	10	0	0xFFFF	Integration Period Base Clock (see Register 0x10)
0x20*	Reserved				
0x28	Reserved				
0x2C&*	Reserved				
0x30	Reserved				
0x38	Single Strobe High Clock Transition Delay Count	0	0	0xFFFF	2MHz
0x3C	Single Strobe Low Clock Transition Delay Count	3000 0xBB8	0	0xFFFF	2MHz
0x40	Lamp Enable	0	0	1	N/A
0x48	GPIO Mux Register 0: pin is GPIO pin 1: pin is alternate function	0	0	0x03FF	N/A
0x50	GPIO Output Enable 1: pin is output 0: pin is input	0	0	0x03FF	N/A

Register Address	Description	Default Value	Min Value	Max Value	Time Base
0x54	GPIO Data Register For Output: Write value of signal For Input: Read current GPIO state	0	0	0x03FF	N/A
0x58	Reserved				
0x60	Bit*(0) => Reserved	1	0	1	N/A
	Bit*(1) => Reserved DO NOT MODIFY	0	0	1	N/A
	Bit*(2) => Reserved DO NOT MODIFY	1	0	1	N/A
	Bit*(3) => Reserved DO NOT MODIFY	0	0	1	N/A
	Bit*(4) => Reserved DO NOT MODIFY	0	0	1	N/A
0x2C	Trigger Mode 0: Normal (free running) 1: External HW 2: External Synchronous 3: External HW Edge	0	0	3	N/A

Notes: \* - User should not change these values because spectrometer performance can be effected. This information is included just for completeness  
& - These values are controlled by other command interfaces to the Maya (i.e Set integration time command).

## Read Register Information

Reads the values from any of the registers above. This command is sent to End Point 1 Out and the data is retrieved through End Point 1 In.

### Byte Format

Byte 0	Byte 1
0x6B	Register Value

### Return Format (EPIIn)

Byte 0	Byte 1	Byte 2
Register Value	Value MSB	Value LSB

## Read Irradiance Factors

Reads 60 bytes of data, which is utilized for Irradiance Calibration information from the desired EEPROM memory address.

### Byte Format

Byte 0	Byte 1	Byte 2
0x6D	EEPROM Address LSB	EEPROM Address MSB

### Return Byte Format

Byte 0	Byte 1	...	Byte 59
Byte 0	Byte 1	...	Byte 59

## Write Irradiance Factors

Write 60 bytes of data, which is utilized for Irradiance Calibration information to the desired EEPROM memory address.

### Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	...	Byte 62
0x6E	EEPROM Address LSB	EEPROM Address MSB	Byte 0	...	Byte 59

## Query Status

Returns a packet of information, which contains the current operating information. The structure of the status packet is given below.

### Byte Format

Byte 0
0xFE

### Return Format

The data is returned in Binary format and read in by the host through End Point 1 In. The structure for the return information is as follows

Byte	Description	Comments
0-1	Number of Spectral Data Values – WORD(s)	LSB   MSB order
2-5	Integration Time - WORD	Integration time in $\mu$ s – LSW   MSW. Within each word order is LSB   MSB
6	Lamp Enable	0 – Signal LOW 1 – Signal HIGH

Byte	Description	Comments
7	Trigger Mode Value	
8	Spectral Acquisition Status	For internal use
9	Packets In Spectra	Returns the number of Packets in a Request Spectra Command.
10	Power Down Flag	0 – Circuit is powered down 1 – Circuit is powered up
11	Packet Count	Number of packets that have been loaded into End Point Memory
12	Reserved	
13	Reserved	
14	USB Communications Speed	0 – Full Speed (12Mbps) 0x80 – High Speed (480 Mbps)
15	Reserved	

## Appendix A:

# Maya2000Pro Serial Port Interface Communications and Control Information

## Overview

The Maya2000Pro is a microcontroller-based miniature fiber optic spectrometer, which can communicate via the Universal Serial Bus or RS-232. This document contains the necessary command information for controlling the MAYA2000PRO via the RS-232 interface.

## Hardware Description

The Maya2000Pro utilizes a Cypress FX2 microcontroller, which has a high speed 8051, combined with an USB ASIC. Program code and data coefficients are stored in external EEPROM, which are loaded at boot-up via the I<sup>2</sup>C bus.

## Instruction Set

### Command Syntax

The list of the commands is shown in the following table along with the microcode version number they were introduced with. All commands consist of an ASCII character passed over the serial port, followed by some data. The length of the data depends on the command. The format for the data is either ASCII or binary (default). The ASCII mode is set with the “a” command and the binary mode with the “b” command. To insure accurate communications, all commands respond with an ACK (ASCII 6) for an acceptable command or a NAK (ASCII 21) for an unacceptable command (i.e. data value specified out of range).

In the ASCII data value mode, the Maya2000Pro “echoes” the command back out the RS-232 port. In ASCII data mode the device transmits a prompt “>” to show that is waiting for a command. In binary mode all data, except where noted, passes as 16-bit unsigned integers (WORDS) with the MSB followed by the LSB. By issuing the “v command” (Version number query), the data mode can be determined by viewing the response (ASCII or binary).

In a typical data acquisition session, the user sends commands to implement the desired spectral acquisition parameters (integration time, etc.). Then the user sends commands to acquire spectra (S command) with the previously set parameters. If necessary, the baud rate can be changed at the beginning of this sequence to speed up the data transmission process.

## Command Summary

Letter	Description	Version
A	Adds scans	3.00.1
B	Set Pixel Boxcar	3.00.1
C		
D		
E		
F		
G	Set Data Compression	3.00.1
H		
I	Sets integration time(16-bit resolution)	3.00.1
J	Sets Lamp Enable Line	3.00.1
K	Changes baud rate	3.00.1
L	Clear Memory	
M		
N		
O		
P	Partial Pixel Mode	3.00.1
Q	Initialize Spectrometer	
R		
S	Starts spectral acquisition with previously set parameters	3.00.1
T	Sets trigger mode	3.00.1
U		
V		
W	Write to FPGA Register	3.00.1
X		
Y		
Z		
a	Set ASCII mode for data values	3.00.1
b	Set binary mode for data values	3.00.1
i	Set integration time(32-bit resolution)	3.00.1
k	Sets Checksum mode	3.00.1
v	Provides microcode version #	3.00.1

Letter	Description	Version
x	Sets calibration coefficients	3.00.1
?	Queries parameter values	3.00.1

## Command Descriptions

A detailed description of all Maya2000Pro commands follows. The { } indicates a data value which is interpreted as either ASCII or binary (default). The default value indicates the value of the parameter upon power up.

### Add Scans

Description: Sets the number of discrete spectra to be summed together.

Command Syntax:	A{DATA WORD}
Response:	ACK or NAK
Range:	1-65000
Default value:	1
Response:	ACK or NAK

### Pixel Boxcar Width

Description: Sets the number of pixels to be averaged together. A value of  $n$  specifies the averaging of  $n$  pixels to the right and  $n$  pixels to the left. This routine uses 32-bit integers so that intermediate overflow will not occur; however, the result is truncated to a 16-bit integer prior to transmission of the data. This math is performed just prior to each pixel value being transmitted out. Values greater than  $\sim 3$  will exceed the idle time between values and slow down the overall transfer process.

Command Syntax:	B{DATA WORD}
Response:	ACK or NAK
Range:	0-15
Default value:	0
Response:	ACK or NAK

## Set Data Compression

Description: Specifies whether the data transmitted from the Maya2000Pro should be compressed to speed data transfer rates. For more information on Maya2000Pro Data Compression, see Technical Note 1.

Command Syntax:	G{DATA WORD}
Response:	ACK or NAK
Range:	0 – Compression off !0 – Compression on
Default value:	0
Response:	ACK or NAK

## Integration Time (16-Bit)

Description: Sets the Maya2000Pro's integration time, in milliseconds, to the value specified. This command is limited to a 16 bit value. If a larger integration time is required, utilize the 32 bit version (lower case I command)

Command Syntax:	I{16 bit DATA WORD}
Response:	ACK or NAK
Range:	8 – 65,000
Default value:	20

## Integration Time(32-Bit)

Same as above command(I) but uses 32-bit values and is in microseconds.

Command Syntax:	i{DATA DWORD}
Value:	7200 - 65,000,000
Response:	ACK or NAK
Default value:	20,000

## Lamp Enable

Description: Sets the Maya2000Pro's Lamp Enable line to the value specified

Command Syntax:	J{DATA WORD}
Value:	0 = Light source/strobe off—Lamp Enable low 1 = Light source/strobe on—Lamp Enable high
Response:	ACK or NAK
Default value:	0

## Baud Rate

Description: Sets the Maya2000Pro's baud rate.

Command Syntax:	K{DATA WORD}
Value:	0=2400 1=4800 2=9600 3=19200 4=38400 5=Not Supported 6=115,200 7=230,400
Response:	See below
Default value:	2

When changing baud rates, the following sequence must be followed:

1. Controlling program sends K with desired baud rate, communicating at the old baud rate
2. A/D responds with ACK at old baud rate, otherwise it responds with NAK and the process is aborted
3. Controlling program waits longer than 50 milliseconds
4. Controlling program sends K with desired baud rate, communicating at the new baud rate
5. A/D responds with ACK at new baud rate, otherwise it responds with NAK and old baud rate is used

---

### Notes

If a deviation occurs at any step, the previous baud rate is used.

The power-up Baud rate can be set by setting the EEPROM Memory slot to the desired value (i.e., 6 for a value of 115,200 Baud)

---

## Pixel Mode

Description: Specifies which pixels are transmitted. While all pixels are acquired on every scan, this parameter determines which pixels will be transmitted out the serial port.

Command Syntax:	P{DATA WORD}	
Value:	Description 0 = all 1024 pixels 1 = every $n^{\text{th}}$ pixel with no averaging 2 = N/A 3 = pixel x through y every n pixels 4 = up to 10 randomly selected pixels between 0 and 1023 (denoted p1, p2, ... p10)	Example P 0 (spaces for clarity only) P 1<Enter> N<Enter> P 2<Enter> N<Enter > P3<Enter> x<Enter> y<Enter> n<Enter> P 4<Enter> n<Enter> p1<Enter> p2<Enter> p3<Enter> ... p10<Enter>
Response:	ACK or NAK	
Default value:	0	

---

### Note

Since most applications only require a subset of the spectrum, this mode can greatly reduce the amount of time required to transmit a spectrum while still providing all of the desired data. This mode is helpful when interfacing to PLCs or other processing equipment.

---

## Spectral Acquisition

Description: Acquires spectra with the current set of operating parameters. When executed, this command determines the amount of memory required. If sufficient memory does not exist, an ETX (ASCII 3) is immediately returned and no spectra are acquired. An STX (ASCII 2) is sent once the data is acquired and stored. If the Data Storage Mode value is 0, then the data is transmitted immediately.

Command Syntax:	S
Response:	If successful, STX followed by data If unsuccessful, ETX

The format of returned spectra includes a header to indicate scan number, channel number, pixel mode, etc. The format is as follows:

- WORD 0xFFFF – start of spectrum
- WORD 16Bit or 32Bit Flag. If 1 then DWORDS transmitted for spectral data values
- WORD Add Scans
- DWORD integration time in Milliseconds
- WORD pixel mode
- WORDS if pixel mode not 0, indicates parameters passed to the Pixel Mode command (P)
- WORDS/DWORDS spectral data
- WORD 0xFFFD – end of spectrum

## Trigger Mode

Description: Sets the Maya2000Pro's external trigger mode to the value specified.

Command Syntax:	T{DATA WORD}
Value:	0 = Normal – Continuously scanning 1 = External Hardware Level Trigger Mode 2 = External Synchronous Trigger Mode 3 = External Hardware Edge Trigger Mode
Response:	ACK or NAK
Default value:	0

## Write FPGA Register

Description: Writes a value to an FPGA Register. The register map is defined in the USB command set section.

Command Syntax:	W{Register Address: WORD}{Register Value: WORD}
Value:	
Response:	ACK or NAK
Default value	N/A

---

### Note

To query a register value, issue ?W{Register Address}.

---

## ASCII Data Mode

Description: Sets the mode in which data values are interpreted to be ASCII. Only unsigned integer values (0 – 65535) are allowed in this mode and the data values are terminated with a carriage return (ASCII 13) or linefeed (ASCII 10). In this mode the Maya2000Pro “echoes” the command and data values back out the RS-232 port.

Command Syntax:	aA
Response:	ACK or NAK
Default value	N/A

---

### Notes

The command requires that the string “aA” be sent without any CR or LF. This is an attempt to insure that this mode is not entered inadvertently.

A legible response to the Version number query (v command) indicates the Maya2000Pro is in the ASCII data mode.

---

## Binary Data Mode

Description: Sets the mode in which data values are interpreted to be binary. Only 16 bit unsigned integer values (0 – 65535) are allowed in this mode with the MSB followed by the LSB

Command Syntax:	bB
Response:	ACK or NAK
Default value	Default at power up – not changed by Q command

---

**Note**

The command requires that the string “bB” be sent without any CR or LF. This is an attempt to insure that this mode is not entered inadvertently.

---

### Checksum Mode

Description: Specifies whether the Maya2000Pro will generate and transmit a 16-bit checksum of the spectral data. This checksum can be used to test the validity of the spectral data, and its use is recommended when reliable data scans are required. See Technical Note 2 for more information on checksum calculation.

Command Syntax:	k{DATA WORD}
Value:	0 = Do not transmit checksum value !0 = transmit checksum value at end of scan
Response:	ACK or NAK
Default value:	0

### Version Number Query

Description: Returns the version number of the code running on the microcontroller. A returned value of 1000 is interpreted as 1.00.0

Command Syntax:	v
Response:	ACK followed by {DATA WORD}
Default value	N/A

## Calibration Constants

Description: Writes one of the 16 possible calibration constant to EEPROM. The calibration constant is specified by the first DATA WORD which follows the x. The calibration constant is stored as an ASCII string with a max length of 15 characters. The string is not check to see if it makes sense.

Command Syntax:	x{DATA WORD}{ASCII STRING}
Value:	DATA WORD Index description 0 – Serial Number 1 – 0 <sup>th</sup> order Wavelength Calibration Coefficient 2 – 1 <sup>st</sup> order Wavelength Calibration Coefficient 3 – 2 <sup>nd</sup> order Wavelength Calibration Coefficient 4 – 3 <sup>rd</sup> order Wavelength Calibration Coefficient 5 – Stray light constant 6 – 0 <sup>th</sup> order non-linearity correction coefficient 7 – 1 <sup>st</sup> order non-linearity correction coefficient 8 – 2 <sup>nd</sup> order non-linearity correction coefficient 9 – 3 <sup>rd</sup> order non-linearity correction coefficient 10 – 4 <sup>th</sup> order non-linearity correction coefficient 11 – 5 <sup>th</sup> order non-linearity correction coefficient 12 – 6 <sup>th</sup> order non-linearity correction coefficient 13 – 7 <sup>th</sup> order non-linearity correction coefficient 14 – Polynomial order of non-linearity calibration 15 – Optical bench configuration: gg fff sss gg – Grating #, fff – filter wavelength, sss – slit size 16 – Maya2000Pro configuration: AWL V A – Array coating Mfg, W – Array wavelength (VIS, UV, OFLV), L – L2 lens installed, V – CPLD Version 17 – Reserved 18 – Startup Baud Rate value 19 – Reserved
Response:	ACK or NAK
Default value:	N/A

### Note

To query the constants, use the ?x{DATA WORD} format to specify the desired constant. To query all coefficients issue ?x-1 command.

## Query Variable

Description: Returns the current value of the parameter specified. The syntax of this command requires two ASCII characters. The second ASCII character corresponds to the command character which sets the parameter of interest (acceptable values are B, A, I, K, T, J, y). A special case of this command is ?x (lower case) which requires an additional data word be passed to indicate which calibration constant is to be queried.

Command Syntax:	?{ASCII character}
Response:	ACK followed by {DATA WORD}
Default value:	N/A

## Examples

Below are examples on how to use some of the commands. Commands are in **BOLD** and descriptions are in parenthesis. For clarity, the commands are shown in the ASCII mode (a command) instead of the default binary mode.

The desired operating conditions are: acquire every 4<sup>th</sup> pixel from the spectrometer with a 200ms integration time, set number of scan to add to 5 and operate at 115,200 Baud.

```

aA          (Set ASCII Data Mode)
> K6<CR>    (Start baud rate change to 115,200)
                Wait for ACK, change to 115200, wait for 20ms
K6<CR>    (Verify command, communicate at 115200)
A2<CR>    (Add 5 spectra)
I200<CR>  (Set integration time to 200ms)
P1<CR>    (Pixel Mode 1...
4<CR>    every 4 pixels)
> S      (Acquire spectra)
...      Repeat as necessary
    
```

## Application Tips

- During the software development phase of a project, the operating parameters of the Maya2000Pro may become out-of-synch with the controlling program. It is good practice to cycle power on the Maya2000Pro when errors occur.
- If you question the state of the Maya2000Pro, you can transmit a space (or another non-command) using a terminal emulator. If you receive a NAK, the Maya2000Pro is awaiting a command; otherwise, it is still completing the previous command.
- For Windows users, use HyperTerminal as a terminal emulator after selecting the following:
  1. Select **File | Properties**.
  2. Under Connect using, select Direct to Com x.
  3. Click Configure and match the following Port Settings:
    - Bits per second (Baud rate): Set to desired rate
    - Data bits: 8
    - Parity: None
    - Stop bits: 1
    - Flow control: NoneClick **OK** in **Port Settings** and in **Properties** dialog boxes.

