Maya2000 and Maya2000Pro
Data Sheet

Description

The Ocean Optics Maya2000 Series Spectrometers (Maya2000 and Maya2000Pro) includes 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.

The Maya 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 Maya interfaces to PCs, PLCs and other embedded controllers through a USB 2.0 connection. The information included in this data sheet provides detailed instructions on the connection and operation of both of the Maya spectrometers.

The detector used in the Maya spectrometer is a scientific-grade, back-thinned, CCD array from Hamamatsu (product number S9840 for Maya2000 and S10420 for Maya2000Pro). 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

- Hamamatsu high UV-sensitivity detector
  - S9840 Detector for Maya2000 with Peak QE: >90%
  - S10420 Detector for Maya2000Pro with Peak QE: 75%
  - Back-thinned for good UV sensitivity
  - MPP operation for low noise operation, low dark current, wide dynamic range

- 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: 6ms – 10s (Maya2000)
  - 6ms – 5s (Maya2000Pro)

- Embedded microcontroller allows programmatic control of all operating parameters and standalone operation:
  - USB 2.0 480Mbps (high-speed) and 12Mbps (full speed)
  - 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)

- Software and Quasi Real-time triggering
- Plug-n-Play Interface for PC applications
- 30-pin connector for interfacing to external products
## Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Specifications:</strong></td>
<td></td>
</tr>
<tr>
<td>Physical Dimensions (LxWxH)</td>
<td>149 mm (5.86 in.) x 109.3 mm (4.30 in.) x 50.4 mm (1.98 in.)</td>
</tr>
<tr>
<td>Spectrometer Weight</td>
<td>0.96 kg (2.1 lbs.)</td>
</tr>
<tr>
<td>Power Supply Weight</td>
<td>0.45 kg (1 lb.)</td>
</tr>
<tr>
<td><strong>Power:</strong></td>
<td></td>
</tr>
<tr>
<td>Power requirement</td>
<td>500 mA at +5 VDC</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>4.5 – 5.5 V</td>
</tr>
<tr>
<td>Power-up time</td>
<td>~2s depending on code size</td>
</tr>
<tr>
<td><strong>Absolute Maximum Ratings:</strong></td>
<td></td>
</tr>
<tr>
<td>Vcc</td>
<td>+ 5.5 VDC</td>
</tr>
<tr>
<td>Voltage on any pin</td>
<td>Vcc</td>
</tr>
<tr>
<td><strong>Spectrometer:</strong></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>Symmetric crossed Czerny-Turner</td>
</tr>
<tr>
<td>Focal length (input)</td>
<td>F/4 101.6 mm</td>
</tr>
<tr>
<td>Input Fiber Connector</td>
<td>SMA 905 to single-strand optical fiber (0.22 NA)</td>
</tr>
<tr>
<td>Gratings</td>
<td>14 different gratings</td>
</tr>
<tr>
<td>Entrance Slit</td>
<td>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.)</td>
</tr>
<tr>
<td>Detector</td>
<td>Maya2000: Hamamatsu S9840; Maya2000Pro: S10420</td>
</tr>
<tr>
<td>Pixels (active)</td>
<td>Maya2000: 2048 x 14; Maya2000Pro: 2048 x 64</td>
</tr>
<tr>
<td>Pixel size</td>
<td>14μm²</td>
</tr>
<tr>
<td>Spectral range</td>
<td>165 – 1100nm</td>
</tr>
<tr>
<td>Quantum efficiency</td>
<td>Maya2000: &gt;90% peak; Maya2000Pro: 75% peak</td>
</tr>
<tr>
<td>Well Depth</td>
<td>Maya2000: 130 Ke-</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>~0.45 counts/e-; Maya2000Pro: ~0.32 counts/e-</td>
</tr>
<tr>
<td>Dark Current</td>
<td>4000 e/pixel/sec (typ) @ 25°C; 200 e/pixel/sec (typ) @ 0°C</td>
</tr>
<tr>
<td>Filters</td>
<td>OFLV-MAYA-200 an OFLV-MAYAPRO-200 available with HC-1 grating</td>
</tr>
<tr>
<td><strong>Spectroscopic:</strong></td>
<td></td>
</tr>
<tr>
<td>Integration Time</td>
<td>Maya2000: 6 ms – 10s</td>
</tr>
<tr>
<td>Dynamic Range (Typical)</td>
<td>Maya2000Pro: 6ms – 5s</td>
</tr>
<tr>
<td>Dynamic Range (Guaranteed)</td>
<td>Maya2000: 8000:1+; Maya2000Pro: 12000:1+</td>
</tr>
<tr>
<td>Signal-to-Noise</td>
<td>Maya2000: 5000:1; Maya2000Pro: 8000:1</td>
</tr>
<tr>
<td>Dark Noise (single dark spectrum)</td>
<td>Maya2000: 350:1; Maya2000Pro: 450:1</td>
</tr>
<tr>
<td>Nonlinearity (uncorrected)</td>
<td>Maya2000: 13 RMS counts; Maya2000Pro: 8.2 RMS counts (Guaranteed)</td>
</tr>
<tr>
<td>Linearity (corrected)</td>
<td>Maya2000: ~4%; Maya2000Pro: ~10%</td>
</tr>
<tr>
<td></td>
<td>&gt;99.7%</td>
</tr>
</tbody>
</table>
Specifications | Criteria
--- | ---
Environmental Conditions: | 
Temperature | –30° to +70°C Storage & –0° to +50°C Operation
Humidity | 0% – 90% noncondensing
Interfaces: | USB 2.0, 480 Mbps

### Environmental Conditions:
- **Temperature:**
  - Storage: –30°C to +70°C
  - Operation: –0°C to +50°C
- **Humidity:** 0% – 90% noncondensing

### Interfaces:
- **USB:** USB 2.0, 480 Mbps

### Optical Performance

#### Quantum Efficiency of Maya2000 S9840 Detector
#### Quantum Efficiency of Maya2000Pro S10420 Detector

#### Optical Performance

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

<table>
<thead>
<tr>
<th>Slit Size (micron)</th>
<th>Resolution (pixels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 micron</td>
<td>~1.5 pixels</td>
</tr>
<tr>
<td>10 micron</td>
<td>~2.0 pixels</td>
</tr>
<tr>
<td>25 micron</td>
<td>~2.5 pixels</td>
</tr>
<tr>
<td>50 micron</td>
<td>~4.2 pixels</td>
</tr>
<tr>
<td>100 micron</td>
<td>~8.0 pixels</td>
</tr>
<tr>
<td>100 micron</td>
<td>~15.3 pixels</td>
</tr>
</tbody>
</table>
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)

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

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

### Maya2000 Spectrometer Detector

The Maya2000 contains a Hamamatsu S9840 CCD which is a two dimensional CCD. 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 S9840 CCD is shown below. The device has 2048 x 14 active pixels and a total of 2080 x 20 pixels.
Maya2000 CCD Device structure. The device has 14 active vertical pixels and 2048 active horizontal pixels.

**Maya2000Pro Spectrometer Detector**

The Maya2000Pro contains a Hamamatsu S10420 CCD which is a two dimensional CCD. 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 S10420 CCD 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:

<table>
<thead>
<tr>
<th>Maya 2000 Pixels</th>
<th>Maya2000-Pro Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pixel</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>0–7</td>
<td>Optical Black pixels</td>
</tr>
<tr>
<td>8–15</td>
<td>Unusable</td>
</tr>
<tr>
<td>16–2063</td>
<td>Optical active pixels</td>
</tr>
<tr>
<td>2064–2071</td>
<td>Unusable</td>
</tr>
<tr>
<td>2072–2079</td>
<td>Optical Black pixels</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maya2000Pro CCD Device structure. The device has 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 30 ms. In External Hardware Trigger mode, the timing of the Single Strobe is based on the External Trigger signal. In Normal (free running) and External Synchronization Trigger modes, the timing of the Single Strobe is based on the beginning of the integration period (the falling edge of SH that occurs during ICG). The timing diagram for the Single Strobe in External Hardware Trigger mode is shown below:

```
ExTrigIn

SS

↑

↑

ΣU-SS-HT
```

**Single Strobe (External Hardware Trigger Mode)**
The width and delay of the Single Strobe can be adjusted in 500ns increments. If the delay is set to 0, there is still a setup time between when ExtTrigIn goes HIGH, and when SS goes HIGH. This setup time is defined as $0 < t_{SU \_SS \_HT} < 0.6 \mu s$. If the delay is set to something larger than 0 (which can be controlled by the user through the software interface), then the actual delay is the set delay plus $0 – 0.6 \mu s$. So, for example, if the delay is set to $50 \mu s$, the SS will begin between $50 \mu s$ and $50.6 \mu s$ after ExtTrigIn goes high.

The timing diagram for the Single Strobe in Normal or External Synchronization Trigger mode is shown below:

![Single Strobe (Normal or External Synchronization Trigger Mode)](image)

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. If the delay is set to 0, there is still a setup time between when SH goes LOW, and when SS goes HIGH. This setup time is negative, and is defined as $-7.5 \mu s < t_{SU \_SS} < -9.5 \mu s$. If the delay is set to something larger than 0, then the actual delay is the set delay minus $t_{SU \_SS}$. So, for example, if the delay is set to $50 \mu s$, the SS will begin between $40.5 \mu s$ and $42.5 \mu s$ after SH goes LOW.

![Continuous Strobe](image)

The Continuous Strobe signal is a 976Hz pulse-train (50% duty cycle). The pulse 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 ensure 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. This synchronization only occurs when the integration period is a multiple of a power of 2.

Maya Trigger/Acquisition Modes

The Maya supports 3 Trigger/Acquisition modes including the standard free running mode. Unfortunately the CCD does not have any means to instantly reset all of the pixels in microseconds, so the typical external hardware and external synchronization modes are not supported. The various modes are described below.

- **Free Running Acquisition Mode**: In this mode, the CCD is constantly being driven at the user specified integration time. When a spectra is requested via software, the Maya electronics wait for the current integration period to expire. Then at the start of the next integration period, they readout the CCD which contains the data for photons which were collected by the CCD in the previous integration period.

- **Software Trigger Mode**: This mode is basically the same as the Free Running Mode, except that the on-board microcontroller waits for the External Trigger line to be HIGH before starting the acquisition process.

- **Quasi-Real Time Acquisition Mode**: In this mode, the CCD is running at the integration period of 6ms. When spectra are requested, it waits for the current period to expire before sampling at the desired integration time. When that period completes it switches back to 6ms and reads out the CCD. The resulting lag between the trigger event and the image capture is a maximum 6ms delay.

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 E²PROM that are loaded at boot-up via the I²C 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:

<table>
<thead>
<tr>
<th>Pipe #</th>
<th>Description</th>
<th>Type</th>
<th>Hi Speed Size (Bytes)</th>
<th>Full Speed Size (Bytes)</th>
<th>Endpoint Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>End Point 1 Out</td>
<td>Bulk</td>
<td>64</td>
<td>64</td>
<td>0x01</td>
</tr>
<tr>
<td>1</td>
<td>End Point 2 In</td>
<td>Bulk</td>
<td>512</td>
<td>64</td>
<td>0x82</td>
</tr>
<tr>
<td>2</td>
<td>End Point 6 In</td>
<td>Unused</td>
<td>Unused</td>
<td>Unused</td>
<td>Unused</td>
</tr>
<tr>
<td>3</td>
<td>End Point 1 In</td>
<td>Bulk</td>
<td>64</td>
<td>64</td>
<td>0x81</td>
</tr>
</tbody>
</table>

USB Command Summary

<table>
<thead>
<tr>
<th>EP2 Command Byte Value</th>
<th>Description</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>Initialize Maya</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x02</td>
<td>Set Integration Time</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x03</td>
<td>Set Strobe Enable Status</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x05</td>
<td>Query Information</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x06</td>
<td>Write Information</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x09</td>
<td>Request Spectra</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x0A</td>
<td>Set Trigger Mode</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x0B</td>
<td>Query number of Plug-in Accessories Present</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x0C</td>
<td>Query Plug-in Identifiers</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x0D</td>
<td>Detect Plug-ins</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x60</td>
<td>General I2C Read</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x61</td>
<td>General I2C Write</td>
<td>1.01.0</td>
</tr>
<tr>
<td>EP2 Command Byte Value</td>
<td>Description</td>
<td>Version</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>0x6A</td>
<td>Write Register Information</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x6B</td>
<td>Read Register Information</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x6D</td>
<td>Read Irradiance Calibration Factors</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0x6E</td>
<td>Write Irradiance Calibration Factors</td>
<td>1.01.0</td>
</tr>
<tr>
<td>0xFE</td>
<td>Query Information</td>
<td>1.01.0</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>...</th>
<th>Byte n-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command Byte</td>
<td>Command Specific</td>
<td>Command Specific</td>
<td>...</td>
<td>Command Specific</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger Mode</td>
<td>0 – Normal Trigger</td>
</tr>
</tbody>
</table>

**Byte Format**

| Byte 0 | 0x01 |

**Set Integration Time**

Sets the Maya integration time in milliseconds. The value is a 32-bit value whose acceptable range is 8 – 16,000,000ms (1600s or 26.67min). If the value is outside this range the value is unchanged. For integration times less than 655,000ms, the integration counter has a resolution of 1ms. For integration times greater than this the integration counter has a resolution of 25ms.
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.

<table>
<thead>
<tr>
<th>Data Byte</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Lamp Enable Low/Off</td>
</tr>
<tr>
<td>1</td>
<td>Lamp Enable HIGH/On</td>
</tr>
</tbody>
</table>

Byte Format

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>LSW-LSB</td>
<td>LSW-MSB</td>
<td>MSW-LSB</td>
<td>MSW-LSB</td>
</tr>
</tbody>
</table>

MSW & LSW: Most/Least Significant Word
MSB & LSB: Most/Least Significant Byte

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:

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x03</td>
<td>Data byte LSB</td>
<td>Data Byte MSB</td>
</tr>
</tbody>
</table>
### Data Byte - Description

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

### Byte Format

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x05</td>
<td>Data byte</td>
</tr>
</tbody>
</table>

### Return Format (EP7)

The data is returned in ASCII format and read in by the host through End Point 7.

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>...</th>
<th>Byte 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x05</td>
<td>Config Index</td>
<td>ASCII byte 0</td>
<td>ASCII byte 1</td>
<td>...</td>
<td>ASCII byte 15</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>...</th>
<th>Byte 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x06</td>
<td>Config Index</td>
<td>ASCII byte 0</td>
<td>ASCII byte 1</td>
<td>...</td>
<td>ASCII byte 15</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Byte 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x09</td>
</tr>
</tbody>
</table>

**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.

---

**Note**

Maya2000 has 2080 pixels and Maya2000-Pro has 2068. Both read out 4609 bytes, some of which are filler:

- For Maya2000, bytes 0-4159 correspond to pixels 0-2079, bytes 4160—4607 are filler, and byte 4608 is a sync byte
- For Maya200-Pro, bytes 0-4135 correspond to pixels 0-2067, bytes 4136-4607 are filler, and byte 4608 is a sync byte

---

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

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

<table>
<thead>
<tr>
<th>Packet #</th>
<th>End Point</th>
<th># Bytes</th>
<th>Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EP2In</td>
<td>512</td>
<td>0-255</td>
</tr>
<tr>
<td>1</td>
<td>EP2In</td>
<td>512</td>
<td>256-511</td>
</tr>
<tr>
<td>2</td>
<td>EP2In</td>
<td>512</td>
<td>512-767</td>
</tr>
<tr>
<td>3</td>
<td>EP2In</td>
<td>512</td>
<td>768-1023</td>
</tr>
<tr>
<td>4</td>
<td>EP2In</td>
<td>512</td>
<td>1024-1279</td>
</tr>
<tr>
<td>5</td>
<td>EP2In</td>
<td>512</td>
<td>1280-1535</td>
</tr>
<tr>
<td>6</td>
<td>EP2In</td>
<td>512</td>
<td>1536-1791</td>
</tr>
<tr>
<td>7</td>
<td>EP2In</td>
<td>512</td>
<td>1792-2047</td>
</tr>
<tr>
<td>8</td>
<td>EP2In</td>
<td>512</td>
<td>2048-2303</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel 0 LSB</td>
<td>Pixel 0 MSB</td>
<td>Pixel 1 LSB</td>
<td>Pixel 2 MSB</td>
</tr>
</tbody>
</table>

...  

<table>
<thead>
<tr>
<th>Byte 510</th>
<th>Byte 511</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel 255 LSB</td>
<td>Pixel 255 MSB</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>Packet #</th>
<th>End Point</th>
<th># Bytes</th>
<th>Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EP2In</td>
<td>64</td>
<td>0-31</td>
</tr>
<tr>
<td>1</td>
<td>EP2In</td>
<td>64</td>
<td>32-63</td>
</tr>
<tr>
<td>2</td>
<td>EP2In</td>
<td>64</td>
<td>64-95</td>
</tr>
<tr>
<td>...</td>
<td>EP2In</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>EP2In</td>
<td>64</td>
<td>2080-2111</td>
</tr>
<tr>
<td>66</td>
<td>EP2In</td>
<td>1</td>
<td>Sync Packet</td>
</tr>
</tbody>
</table>

**Packet 0**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel 0 LSB</td>
<td>Pixel 0 MSB</td>
<td>Pixel 1 LSB</td>
<td>Pixel 2 MSB</td>
</tr>
</tbody>
</table>

...  

<table>
<thead>
<tr>
<th>Byte 62</th>
<th>Byte 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel 31 LSB</td>
<td>Pixel 31 MSB</td>
</tr>
</tbody>
</table>

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

**Byte 0**

| 0x69 |
Set Trigger Mode

Sets the Maya Trigger mode to one of three states. If an unacceptable value is passed then the trigger state is unchanged (Refer to the External Triggering Options Instructions for a description of the trigger modes).

<table>
<thead>
<tr>
<th>Data Value</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal (Free running) Mode</td>
</tr>
<tr>
<td>1</td>
<td>Software Trigger Mode</td>
</tr>
<tr>
<td>2</td>
<td>Not Supported</td>
</tr>
<tr>
<td>3</td>
<td>Quasi Real-time Acquisition Mode</td>
</tr>
</tbody>
</table>

### Byte Format

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0A</td>
<td>Data Value LSB</td>
<td>Data Value MSB</td>
</tr>
</tbody>
</table>

**General I²C Read**

Performs a general purpose read on the I²C 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 I²C bus runs at 400KHz. The maximum number of bytes that can be read is 61.

### Command Byte Format

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x60</td>
<td>I²C Address</td>
<td>Bytes to Read</td>
</tr>
</tbody>
</table>

### Return Byte Format

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>...</th>
<th>Byte N+3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I²C Results</td>
<td>I²C Address</td>
<td>Bytes to Read</td>
<td>Data Byte 0</td>
<td>...</td>
<td>Data byte N</td>
</tr>
</tbody>
</table>

### I²C Result Value Description

<table>
<thead>
<tr>
<th>I²C Result Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>I²C bus Idle</td>
</tr>
<tr>
<td>1</td>
<td>I²C bus Sending Data</td>
</tr>
<tr>
<td>2</td>
<td>I²C bus Receiving Data</td>
</tr>
<tr>
<td>3</td>
<td>I²C bus Receiving first byte of string</td>
</tr>
<tr>
<td>5</td>
<td>I²C bus in waiting for STOP condition</td>
</tr>
<tr>
<td>6</td>
<td>I²C experienced Bit Error</td>
</tr>
<tr>
<td>7</td>
<td>I²C experience a Not Acknowledge (NAK) Condition</td>
</tr>
<tr>
<td>8</td>
<td>I²C experienced successful transfer</td>
</tr>
<tr>
<td>9</td>
<td>I²C bus timed out</td>
</tr>
</tbody>
</table>
General I\textsuperscript{2}C Write

Performs a general purpose write on the I\textsuperscript{2}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\textsuperscript{2}C bus runs at 400KHz. The results codes are described above.

**Command Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>...</th>
<th>Byte N+3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x61</td>
<td>\textsuperscript{I\textsubscript{2}C} Address</td>
<td>Bytes to Write</td>
<td>Data Byte 0</td>
<td>...</td>
<td>Data byte N</td>
</tr>
</tbody>
</table>

**Return Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textsuperscript{I\textsubscript{2}C} Results</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x6A</td>
<td>Register Value</td>
<td>Data Byte LSB</td>
<td>Data Byte MSB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Register Address</th>
<th>Description</th>
<th>Default Value</th>
<th>Min Value</th>
<th>Max Value</th>
<th>Time Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00\textsuperscript{1}</td>
<td>Master Clock Counter Divisor</td>
<td>6</td>
<td>1</td>
<td>0xFFFF F</td>
<td>48MHz</td>
</tr>
<tr>
<td>0x04</td>
<td>FPGA Firmware Version (Read Only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x08</td>
<td>Continuous Strobe Timer Interval Divisor</td>
<td>48000</td>
<td>0</td>
<td>0xFFFF F</td>
<td>Continuous Strobe Base Clock (see Register 0x0C)</td>
</tr>
<tr>
<td>0x0C</td>
<td>Continuous Strobe Base Clock Divisor</td>
<td>4800</td>
<td>0</td>
<td>0xFFFF F</td>
<td>48MHz</td>
</tr>
<tr>
<td>Register Address</td>
<td>Description</td>
<td>Default Value</td>
<td>Min Value</td>
<td>Max Value</td>
<td>Time Base</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>-----------</td>
<td>----------------------</td>
</tr>
<tr>
<td>0x10</td>
<td>Integration Period Base Clock Divisor</td>
<td>1000</td>
<td>0</td>
<td>0xFFF F</td>
<td>1MHz</td>
</tr>
<tr>
<td>0x14</td>
<td>Set base_clk or base_clkx2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>0x18</td>
<td>Integration Clock Timer Divisor</td>
<td>10</td>
<td>0</td>
<td>0xFFF F</td>
<td>Integration Period Base Clock (see Register 0x10)</td>
</tr>
<tr>
<td>0x20</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x28</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2C</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x30</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x38</td>
<td>Single Strobe High Clock Transition Delay Count</td>
<td>1</td>
<td>0</td>
<td>0xFFF F</td>
<td>1MHz</td>
</tr>
<tr>
<td>0x3C</td>
<td>Single Strobe Low Clock Transition Delay Count</td>
<td>5</td>
<td>0</td>
<td>0xFFF F</td>
<td>1MHz</td>
</tr>
<tr>
<td>0x40</td>
<td>Lamp Enable</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>0x48</td>
<td>GPIO Mux Register</td>
<td>0</td>
<td>0</td>
<td>0x03FF F</td>
<td>N/A</td>
</tr>
<tr>
<td>0x50</td>
<td>GPIO Output Enable</td>
<td>0</td>
<td>0</td>
<td>0x03FF F</td>
<td>N/A</td>
</tr>
<tr>
<td>0x54</td>
<td>GPIO Data Register</td>
<td>0</td>
<td>0</td>
<td>0x03FF F</td>
<td>N/A</td>
</tr>
<tr>
<td>0x58</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x60</td>
<td>Bit* (0) =&gt; Reserved</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Bit* (1) =&gt; Reserved</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Bit* (2) =&gt; Reserved</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x6B</td>
<td>Register Value</td>
</tr>
</tbody>
</table>

**Return Format (EP1In)**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register Value</td>
<td>Value MSB</td>
<td>Value LSB</td>
</tr>
</tbody>
</table>

Read Irradiance Factors

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

**Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x6D</td>
<td>EEPROM Address LSB</td>
<td>EEPROM Address MSB</td>
</tr>
</tbody>
</table>

**Return Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>...</th>
<th>Byte 59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte 0</td>
<td>Byte 1</td>
<td>...</td>
<td>Byte 59</td>
</tr>
</tbody>
</table>
Write Irradiance Factors

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

**Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>...</th>
<th>Byte 62</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x6E</td>
<td>EEPROM Address LSB</td>
<td>EEPROM Address MSB</td>
<td>Byte 0</td>
<td>...</td>
<td>Byte 59</td>
</tr>
</tbody>
</table>

Query Status

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

**Byte Format**

<table>
<thead>
<tr>
<th>Byte 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xFE</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Byte</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Number of Spectral Data Values – WORD(s)</td>
<td>LSB</td>
</tr>
<tr>
<td>2-5</td>
<td>Integration Time - WORD</td>
<td>Integration time in µs – LSW</td>
</tr>
<tr>
<td>6</td>
<td>Lamp Enable</td>
<td>0 – Signal LOW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Signal HIGH</td>
</tr>
<tr>
<td>7</td>
<td>Trigger Mode Value</td>
<td>For internal use</td>
</tr>
<tr>
<td>8</td>
<td>Spectral Acquisition Status</td>
<td>For internal use</td>
</tr>
<tr>
<td>9</td>
<td>Packets In Spectra</td>
<td>Returns the number of Packets in a Request Spectra Command.</td>
</tr>
<tr>
<td>10</td>
<td>Power Down Flag</td>
<td>0 – Circuit is powered down</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Circuit is powered up</td>
</tr>
<tr>
<td>11</td>
<td>Packet Count</td>
<td>Number of packets that have been loaded into End Point Memory</td>
</tr>
<tr>
<td>12</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>USB Communications Speed</td>
<td>0 – Full Speed (12Mbs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x80 – High Speed (480 Mpbs)</td>
</tr>
</tbody>
</table>