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Apex Data Sheet

Description

The Ocean Optics Apex 785 Raman Spectrometer includes the linear, back-thinned, FFT-CCD-array detector from Hamamatsu (product number S11510-1106) in an optical bench with all the circuits necessary for spectrometer operation. The result is a high-resolution, high-sensitivity scientific instrument for low-light level applications such as 785 nm Raman analysis and fluorescence. For complete details on this detector, visit **www.Hamamatsu.com**.

The Apex Spectrometer electronics have been designed for USB connection to various accessories and receives power from a computer through its USB interface. The Apex is a microcontroller-controlled spectrometer, thus all operating parameters are implemented through software interfacing to the unit.

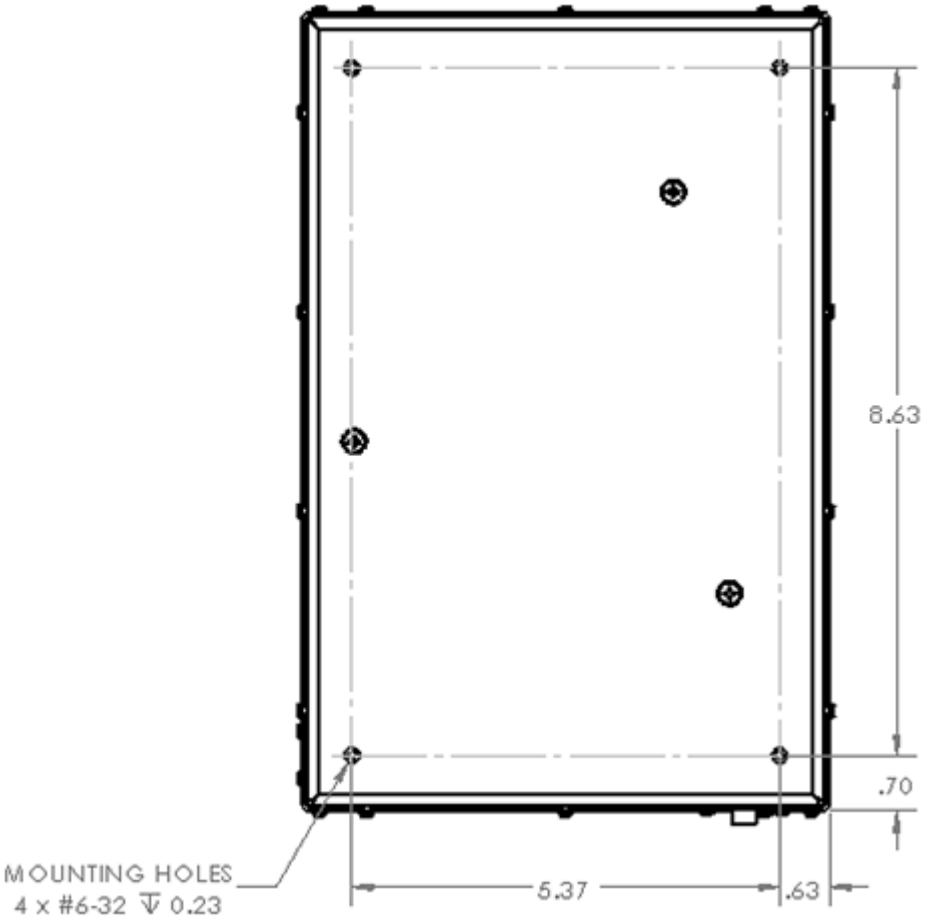
Features

- Back-thinned Hamamatsu uncooled detector S11510-1106
- High-throughput Virtual Slit
- Resolution (FWHM): <10 cm^{-1} @ 800 nm
- Electrical Performance
  - 16 bit A/D converter
- Communications: USB
- Software compatibility:
  - SpectraSuite (1 complimentary license included with purchase)
  - OmniDriver (sold separately)
  - USB Programmer (available free from Ocean Optics)
  - SeaBreeze (sold separately)
- Optical input: SMA 905
- Regulations:
  - CE Mark
  - RoHS

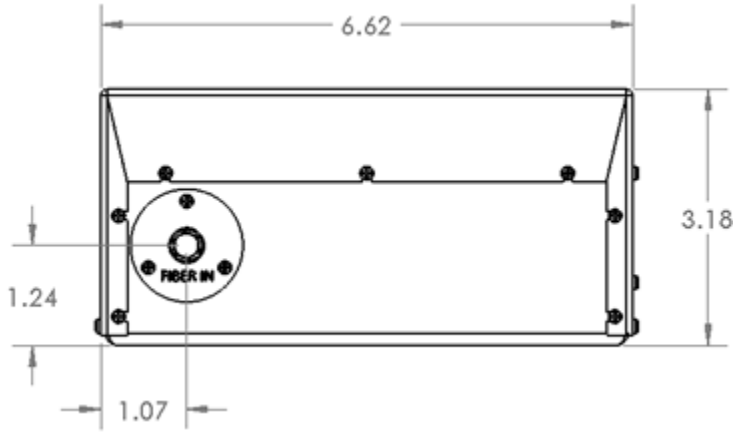
Specifications

Specifications	Criteria
Physical Specifications:	
Physical Dimensions (LxWxH)	254 mm (10 in.) x 167.6 mm (6.6 in.) x 81 mm (3.2 in.)
Spectrometer Weight	2.36 kg (5.2 lbs.)
Spectrometer:	
Focal length (input)	F/4 101.6 mm
Input Fiber Connector	SMA 905 to single-strand optical fiber (0.22 NA)
Detector	Hamamatsu S11510-1106 Back-thinned FFT-CCD
Pixels	2048 x 64 (effective); 2068 x 70 (total)
Pixel size	14µm^2
Spectral range	780 – 1120 nm (>3800 cm^{-1})
Well Depth	300 Ke-
Spectroscopic:	
Integration Time	7.2ms – 5s
Dynamic Range (Typical)	15000:1
Signal-to-Noise	450:1
Nonlinearity (uncorrected)	<1.0%
Environmental Conditions:	
Temperature	–30° to +70° C Storage & –0° to +50° C Operation
Humidity	0% – 90% noncondensing
Interfaces:	
USB	USB 2.0

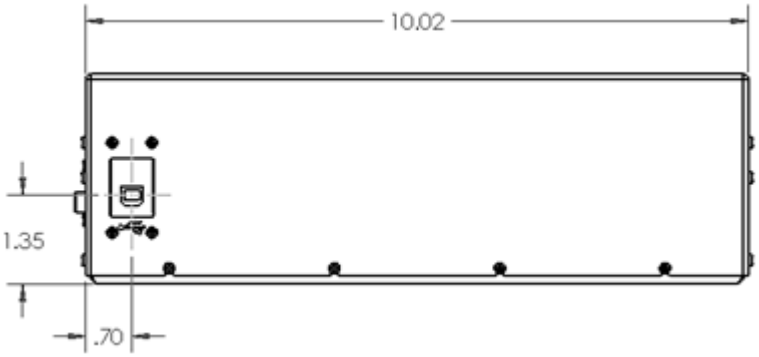
Mechanical Diagrams



Apex 785 – Bottom



Apex 785 – Front



Apex 785 – Right Side

Apex Spectrometer Detector

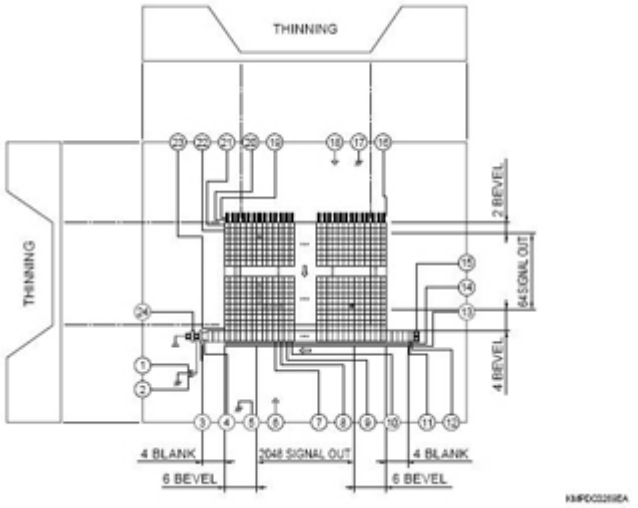
The Apex contains a Hamamatsu S11510-1106 two-dimensional CCD. The Apex electronics only support reading out the device as a 1-D array (e.g., all rows are summed together on chip). The structure of the Apex spectrometer Hamamatsu CCD is shown below. The device has 2048 x 64 active pixels and a total of 2068 x 70 pixels.

Pixel Definition

The following is a description of all of the pixels:

Apex Pixels

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



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

Apex USB Port Interface Communications and Control Information

The Apex 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 Apex 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 Apex. Only experienced USB programmers should attempt to interface to the Apex via these methods.

Hardware Description

The Apex 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^2PROM that are loaded at boot-up via the I^2C 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 0x1044.

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 Apex 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 Apex	1.01.0
0x02	Set Integration Time	1.01.0
0x05	Query Information	1.01.0
0x06	Write Information	1.01.0
0x09	Request Spectra	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 Apex 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 Apex

Initializes certain parameters on the Apex 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 Apex integration time in microseconds. The value is a 32-bit value whose acceptable range is 7200 – 65,000,000 µs (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

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 – 0th order Wavelength Calibration Coefficient
2 – 1st order Wavelength Calibration Coefficient
3 – 2nd order Wavelength Calibration Coefficient
4 – 3rd order Wavelength Calibration Coefficient
5 – Stray light constant
6 – 0th order non-linearity correction coefficient
7 – 1st order non-linearity correction coefficient
8 – 2nd order non-linearity correction coefficient
9 – 3rd order non-linearity correction coefficient
10 – 4th order non-linearity correction coefficient
11 – 5th order non-linearity correction coefficient
12 – 6th order non-linearity correction coefficient
13 – 7th 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 – Apex 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 Apex 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 Apex.

Note

Apex 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.

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

Write Register Information

Most all of the controllable parameters for the Apex are accessible through this command. 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)				
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				
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

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

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 (EP1In)

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 μs – LSW | MSW. Within each word order is LSB | MSB
6	Lamp Enable	0 – Signal LOW 1 – Signal HIGH
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 (12Mbs) 0x80 – High Speed (480 Mpbs)
15	Reserved	

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