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NIR Spectrometers Data Sheet

Description

The NIR512, NIR256-2.1 and NIR256-2.5 Near-infrared Spectrometers are designed for applications that require sensitivity in the near-infrared region such as tunable laser wavelength characterization and general NIR spectroscopy. The NIR spectrometers can communicate via the Universal Serial Bus or RS-232.

NIR-512

The NIR-512 Spectrometer's diffractive grating-based optical bench and 16-bit USB A/D converter are conveniently mounted in the same housing. This integrated design makes the NIR512 a 153 mm x 105 mm x 76 mm small-footprint system and eliminates the need for additional spectrometer-to-A/D converter cabling. A +5 VDC wall transformer (included) is required to operate the system's high-performance InGaAs array detector.

NIR256-2.1

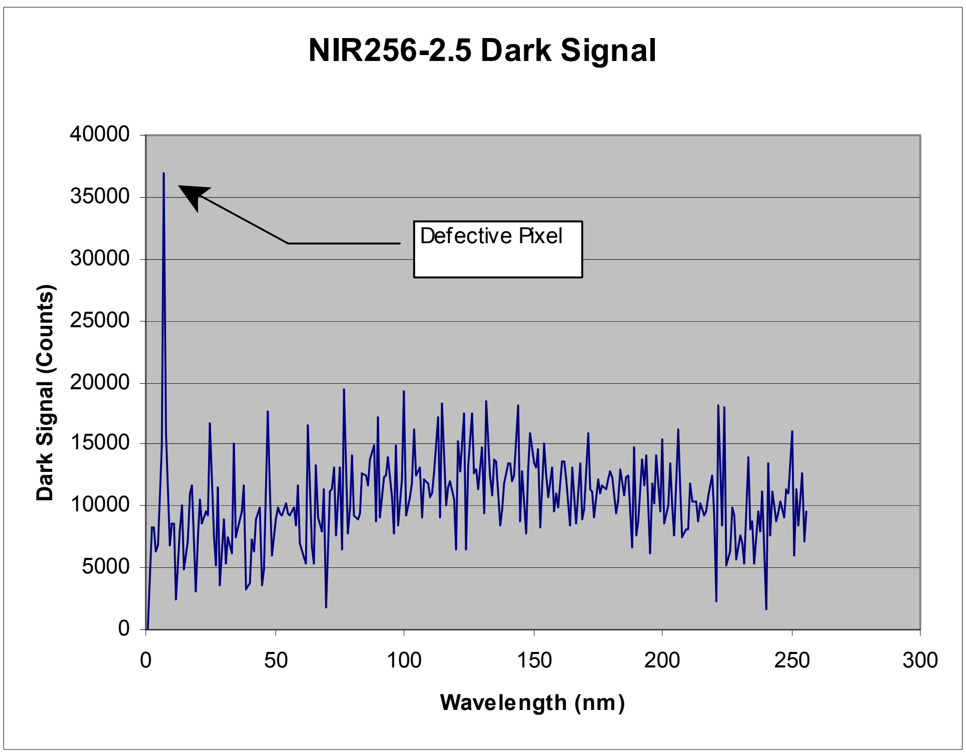
The NIR256-2.1 uses a 256-element InGaAs linear-array detector. With the NIR256 you have two grating options. With Grating N1, you have a 1200-2100 nm wavelength range. Grating N2 provides a 900-2100 nm wavelength range. The NR256-2.1 acquires data as fast as 10 milliseconds.

NIR256-2.5

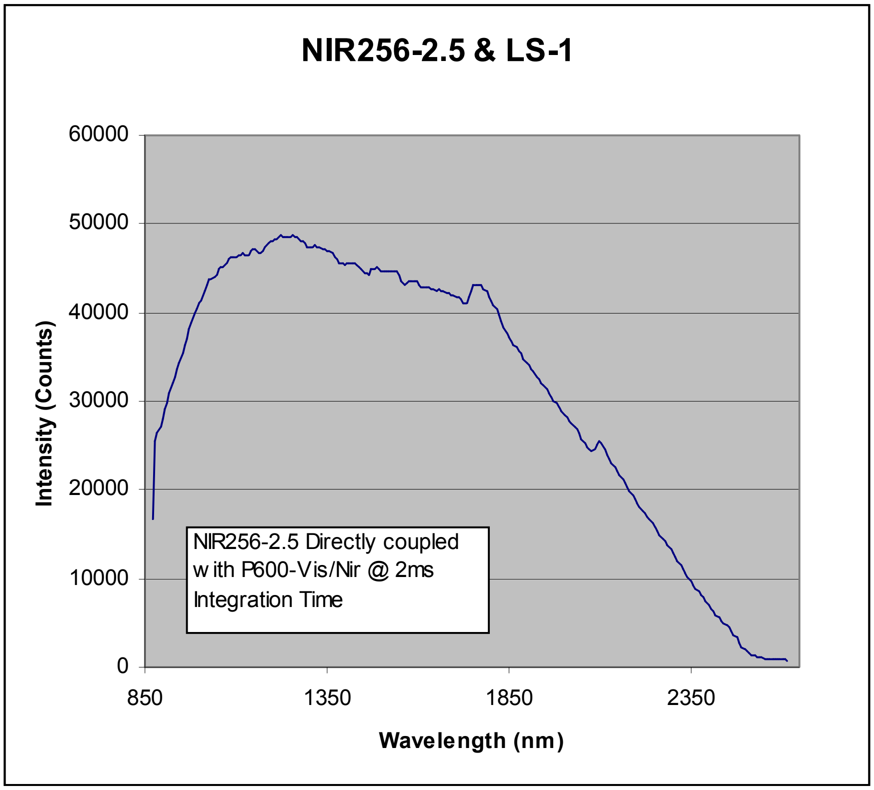
The NIR256-2.5 extends farther into the NIR, acquiring spectra up to 2.5 µm. The NIR256-2.5 features a temperature-regulated InGaAs detector array, which is internally cooled for optimum signal-to-noise and sensitivity. The NR256-2.5 acquires data as fast as 10 milliseconds.

When configuring a system for operation out to 2.5µm it's important to consider the following details:

- **Short Integration Times:** In order for the detector to be sensitive out to 2.5µm, the detectors band gap energy must be small. Unfortunately this raises the absolute level of the detectors dark signal. A typical dark signal at 34ms is shown below. While the detector functions at integration times greater than 50ms, this seems to be the a realistic limit.
- **Fiber Selection:** For maximum signal intensity, alternative fiber materials should be used for wavelengths greater than 2.2µm.

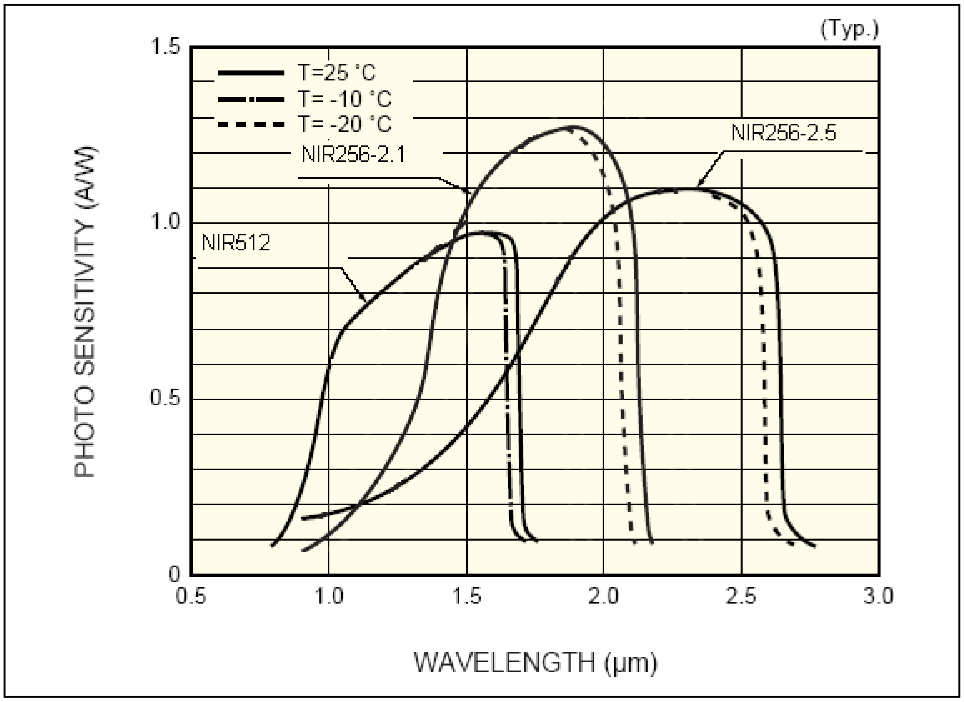


Dark signal at 24ms integration time. Full Scale is 65,535 counts. Spectra shows the presence of one defective pixel.

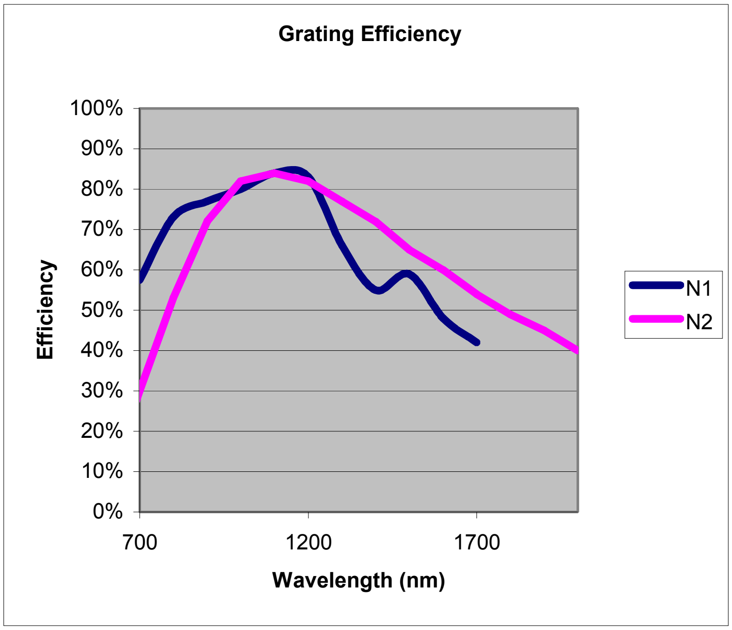


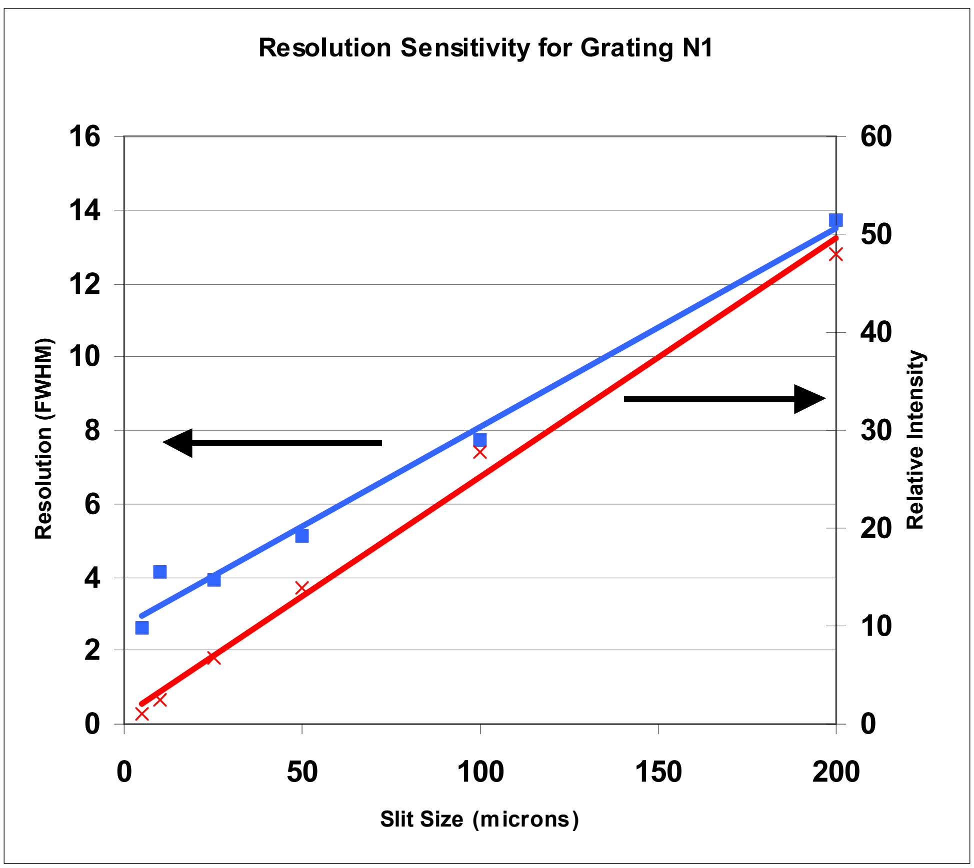
Relative intensity of NIR256-2.5 with a 25 µm slit directly coupled to an LS-1 with 600 µm fiber

Spectral Response Curves



Grating Efficiency Curves





Resolution and relative sensitivity for NIR512 versus slit size. Recommended minimum slit is 25um. Resolution for NIR256 & Grating N1 is twice the resolution shown.

Features

- Optical Characteristics
  - Proprietary Optical Bench Design
  - Magnification: 1.25
  - Grating (see below for efficiency curves):
    - Standard Range: Grating #N1: 300 l/mm blazed at 1um → 900-1700nm
    - Extended Range: Grating #N2: 150 l/mm blazed at 1.6um → 900-2500nm
      Or Grating #N1 → 1200-2100nm
  - Entrance Slit: 10, 25, 50, 100 & 200um slits (see figure for resolution)
- Electronics
  - 16 bit – 500KHz A/D rate → minimum integration time 1ms
  - Integration Time: 1ms - >3000ms
  - USB or RS232 Interface
  - Wavelength and other calibration coefficients stored in EEPROM
  - Trigger modes (free-running & software)
  - Data Transfer: 10ms for USB interface
  - Power: +5V@ 2A (3A for extended range)
- Detector

Feature	**NIR512**	**NIR256-2.1**	**NIR256-2.5**
Detector	Hamamatsu G9204-512	Hamamatsu G9206-256	Hamamatsu G9208-256
Number of Pixels	512	256	256
Pixel Size	25 x 500μm	50 x 250μm	50 x 250μm
Responsivity Range	0.85 – 1.7μm	0.9 – 2.05μm	0.9 – 2.55μm
Responsivity Peak	1.6μm	1.95μm	2.3μm
Dynamic Range	5000:1	5000:1	4000:1
Signal to Noise	4000:1	4000:1	4000:1
Dark Signal RMS [1]	<12 counts	<14 counts	<14 counts
Defective Pixels [2]	None Max Dark Current = 60pA @ 20°C	2% Max Dark Current = 120pA @ -15°C	5% Max Dark Current = 2000pA @ 15°C
Operating Temperature	-5°C	-15°C	-15°C
Above Zero Integration Time [3]	1000ms	N/A	N/A

Notes:

1. Does not include first or last pixels
2. Defective Pixels are specified at the specific test conditions
3. With increasing integration times, the dark value of a pixel may decrease. The "above zero integration time" is the maximum integration time which all pixels have a dark value greater than 0 A/D counts. Longer integration times are possible if these pixel's values are ignored/interpolated.

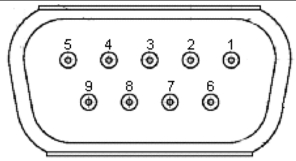
NIR Spectrometer Specifications

	NIR512	NIR256-2.1	NIR256-2.5
Dimensions	152 mm x 105 mm x 76 mm		
Weight	190 g (without cable)		
Power consumption	2A @ 5V DC	4A @ 5V DC	
Detector range	900 to 1700 nm	900 - 2100 nm with grating N2 1200 – 2100 nm with grating N1	900 nm to 2500 nm
Gratings	N1: 300 lines/mm blazed at 1 µm	N2: 150 lines/mm blazed at 1.6 µm or N1: 300 lines/mm blazed at 1 µm	N2: 150 lines/mm blazed at 1.6 µm
Entrance aperture	5, 10, 25, 50, 100, or 200 mm wide slits or fiber (no slit)		
Order-sorting filters	Installed longpass and bandpass filters		
Optical resolution (slit dependent)	4.2 – 14.0 nm FWHM	With Grating N1:4.5 – 14.0 FWHM With Grating N2: 7.5 – 25.0 nm FWHM	7.5 – 25.0 nm FWNM
Focal length	f/4, 40mm		
Dynamic range	5000:1 for a single scan		
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)		
A/D converter:	16-bit internal - 500 KHz		
Data transfer rate	Full scans into memory every 10 milliseconds (USB interface)		
Integration time	1 ms – 3 seconds	1 ms – 1 second	1 – 30 milliseconds
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)		
Operating systems	Windows 98/Me/2000/XP, Mac OS X & Linux - USB interface Any 32-bit Windows operating system – Serial port		

Electrical Pinout

9-pin RS-232 Serial Port Pinout

When facing the 9-pin RS-232 Serial Port connector on the NIR Spectrometer, the pins are numbered as:

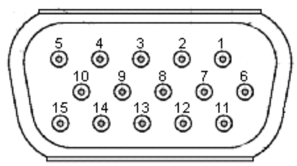


9-pin RS-232 Serial Port Connector – Pin Definitions

Pin #	Description
2	RS232 Transmit
3	RS232 Receive
5	Ground

15-pin Accessory Connector Pinout

When facing the 15-pin accessory connector on the NIR Spectrometer, the pins are numbered as:



15-pin Accessory Connector – Pin Definitions

Pin #	Description
3	+5V DC
8	External Software trigger pin
10	Ground

Hardware Description

The NIR utilizes a Cypress EZUSB-FX microcontroller that has a high speed 8051 combined with an USB 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 SRAM and 128K of external SRAM (due to memory mapping and paging constraints, only 96K of the external SRAM is useable). 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 Information

Ocean Optics Vendor ID number is 0x2457. The NIR512's Product ID's is 0x100C and the NIR256 Product ID is 0x1010. The NIR supports USB 1.1 interface which is specified at 12Mbps.

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 NIR through End Point 2 (EP2). All spectra data is acquired through End Point 2 In and all other queries are retrieved through End Point 7 In (EP7).

Pipe #	Description	Type	Full Speed Size (Bytes)	Endpoint Address
0	End Point 2 Out	Bulk	64	0x02
1	End Point 2 In	Bulk	64	0x82
2	End Point 7 Out (unused)	Bulk	64	0x07
3	End Point 7 In	Bulk	64	0x87

USB Command Summary

EP2 Command Byte Value	Description	Version
0x01	Initialize Device	1.00.0
0x02	Set Integration Time	1.00.0
0x03	Set Strobe Enable Status	1.00.0
0x04	Reserved	1.00.0
0x05	Query Information	1.00.0
0x06	Write Information	1.00.0
0x07	Write Serial Number	1.00.0
0x08	Get Serial Number	1.00.0
0x09	Request Spectra	1.00.0
0x0A	Set Trigger Mode	1.00.0
0x0B	Set TEC Controller State	1.00.0
0x0C	Set Detector Gain Mode	1.00.0
0x0D	Set Fan State	1.00.0
0x1E	Stop Spectral Acquisition	1.00.0
0x3E	TEC Controller Write	1.02.0
0x3F	TEC Controller Read	1.02.0
0xFE	Query Status	1.00.0

Command Descriptions

A detailed description of all NIR commands follows. While all commands are sent to EP2 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 NIR

Initializes the device and aborts a scan if in progress. This command should be called at the start of every session.

Byte Format

Byte 0
0x01

Set Integration Time

Sets the NIR's integration time in milliseconds. The acceptable range is 1 - 65535. If the value is less than 1ms then the integration time is set to 1ms.

Byte Format

Byte 0	Byte 1	Byte 2
0x02	Integration Time MSB	Integration Time LSB

Set Strobe Enable Status

Sets the NIR Lamp Enable line (DB15 pin 13) 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 19 stored spectrometer configuration variables. The Query command is sent to EP2 and the data is retrieved through End Point 7. 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 19 configuration variables are indexed as follows:

Data Byte - Description
1 – 0^{th} order Wavelength Calibration Coefficient
2 – 1^{st} order Wavelength Calibration Coefficient
3 – 2^{nd} order Wavelength Calibration Coefficient
4 – 3^{rd} order Wavelength Calibration Coefficient
5 – Stray light constant
6 – 0^{th} order non-linearity correction coefficient
7 – 1^{st} order non-linearity correction coefficient
8 – 2^{nd} order non-linearity correction coefficient
9 – 3^{rd} order non-linearity correction coefficient
10 – 4^{th} order non-linearity correction coefficient
11 – 5^{th} order non-linearity correction coefficient
12 – 6^{th} order non-linearity correction coefficient
13 – 7^{th} 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 – Detector Serial Number
17 – Reserved
18 – Reserved
19 – Reserved

Byte Format

Byte 0	**Byte 1**
0x05	Data byte

Return Format (EP7)

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

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. This command requires ~150ms to complete.

Byte Format

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

Write Serial Number

Writes the serial number to EEPROM. The information to be written is transferred as ASCII information. This command requires ~150ms to complete.

Byte Format

Byte 0	Byte 1	Byte 2	…	Byte 16
0x07	ASCII byte 0	ASCII byte 1	…	ASCII byte 15

Query Serial Number

Queries the unit's serial number. The Query command is sent to EP2 and the data is retrieved through End Point 7. The information to be read is transferred as ASCII information.

Byte Format

Byte 0
0x08

Return Format

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

Byte 0	Byte 1	Byte 2	…	Byte 16
0x08	ASCII byte 0	ASCII byte 1	…	ASCII byte 15

Request Spectra

Initiates a spectrum acquisition. The NIR will acquire a complete spectrum. The data is returned in bulk transfer mode through EP2 in packets each containing 64 bytes. The total number of bytes returned is twice the number of pixels (2 bytes per pixel) plus one trailing byte. The pixel values are decoded as described below.

Byte Format

Byte 0
0x09

Return Format

The data is returned in bulk transfer mode through EP2 in packets each containing 64 bytes. There is an additional packet containing one value that is used as a flag to insure proper synchronization between the PC and NIR. The data is read out in packets of 64 LSB bytes followed by 64 MSB bytes until the entire spectrum has been read out. The pixel values are decoded as described below.

Packet 0 – LSBs for first 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 0 LSB	Pixel 1 LSB	…	Pixel 63 LSB

Packet 1 – MSBs for first 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 0 MSB	Pixel 1 MSB	…	Pixel 63 MSB

Packet 2 – LSBs for 2nd group of 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 64 LSB	Pixel 65 LSB	…	Pixel 127 LSB

Packet 3 – MSBs for 2nd group of 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 64 MSB	Pixel 65 MSB	…	Pixel 127 MSB

…

Packet n-2 – LSB's for last group of 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 1984 LSB	Pixel 1985 LSB	…	Pixel 2047 LSB

Packet n-1 – MSB's for last group of 64 pixels

Byte 0	Byte 1	…	Byte 63
Pixel 1984 MSB	Pixel 1985 MSB	…	Pixel 2047 MSB

Packet n – Synchronization Packet

Byte 0
0x69

Set Trigger Mode

Sets the NIR Trigger mode. If an unacceptable value is passed then the trigger state is unchanged.

Data Value = 0 ➔ Normal (Free running) Mode Data Value = 1 ➔ Software Trigger Mode

Byte Format

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

Set TEC Controller State

Enables/Disables the detectors TEC controller.

Data Byte = 0 ➔ TEC Controller Disabled Data Byte = !0 ➔ TEC Controller Enabled

Byte Format

Byte 0	Byte 1	Byte 2
0x0C	Data byte LSB	Data Byte MSB

Set Detector Gain Mode

Sets the InGaAs Detectors gain mode. By default the detector utilizes an integrating capacitor of 10pf (gain mode = 0). If the gain mode is set to , then the integrating capacitor is set to 1pf. This provides a gain of 10X but noise figures also increase.

Data Byte = 0 ➔ Detector in Low Gain mode (default) Data Byte = !0 ➔ Detector in High Gain mode

Byte Format

Byte 0	Byte 1	Byte 2
0x0C	Data byte LSB	Data Byte MSB

Set Fan State

Description: Enables/Disables the FAN inside the NIR. The fan should run all of the time to insure proper cooling of the electronics and heat sink.

Data Byte = 0 ➔ Fan Off Data Byte = !0 ➔ Fan On

Byte Format

Byte 0	Byte 1	Byte 2
0x0D	Data byte LSB	Data Byte MSB

Stop Spectral Acquisition

Halts the current acquisition of spectral data.

Byte Format

Byte 0
0x1E

TEC Controller Write

Performs a write command to the TEC controller. This command is used to set the detectors TEC set point temperature. The set-point value is a signed 16-bit value that is expressed in tenths of a degree Celsius. For example to set the temperature to –5.0°C a value of –50 or 0xFFCD is sent. Set points are as follows:

- Maximum Set Point: 40.0°C
- Minimum Set Point: –40.0°C
- Increment/resolution: 1.040.0°C

Byte Format

Byte 0	Byte 1	Byte 2	Byte 3
0x3E	X (don't care)	Set-point MSB	Set-point LSB

TEC Controller Read

Returns the detector temperature, detector set-point and other TEC controller information. The TEC controller variables are only updated every 2 seconds, thus the calling program should not perform reads more often than this. This command is sent to EP2 and a total of 14 bytes data is retrieved through End Point 7.

Byte Format

Byte 0
0x3F

Return Format

Byte 0-3	Byte 4-5	Byte 6-7	Byte 8-9	Byte 10-14
Reserved	Detector Temp	Reserved	Detector Set-point	Reserved

The Detector Temperature and Set-point temperatures are 16-bit signed values representing tenths of a degree Celsius as described in the TEC Controller Write command.

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 7. The structure for the return information is as follows:

Byte	Description	Comments
0-1	Number of Pixels - WORD	MSB | LSB order
2-3	Integration Time - WORD	Integration time in ms – MSB | LSB
4	Lamp Enable	0 – Signal LOW 1 – Signal HIGH
5	Trigger Mode	
6	Request Spectra	0 – No Spectra Requested !0 – Spectral Request In progress
7	0	Always 0
8	Spectral Data Ready	0 – Data not yet available !0 – Data is present for transfer
9	0	Always 0
10	Power State	Bit 0: 1 if External 5V is present, 0 otherwise Bit 1: 1 if internal analog circuit is powered, 0 otherwise
11	Spectral Data Counter	Counter representing the last packet number which was loaded and ready for transfer
12	Detector Gain Select	0 – Detector in Low Gain Mode !0 – Detector in High Gain Mode
13	Fan & TEC state	Bit 0: 1 if TEC is on, 0 otherwise Bit 1: 1 if Fan is on, 0 otherwise
14 – 15	Reserved	Returns 0

Appendix A

NIR512/256 Serial Port Interface

Communications and Control Information

Overview

The NIR512/256 is a microcontroller-based Miniature Fiber Optic which can communicate via the Universal Serial Bus or RS-232. This document contains the necessary command information for controlling the NIR512/256 via the RS-232 interface.

Hardware Description

Overview

The NIR512/256 utilizes a Cypress FX microcontroller, which has a high speed 8051, combined with an USB ASIC. Program code and data coefficients are stored in external E2PROM which are loaded at boot-up via the I2C bus.

Spectral Memory Storage

The NIR512/256 can store up to 64 spectra in the spectral data section. The full spectrum (256 points) is stored. Spectra are organized in a stack formation (i.e., LIFO). Its important to realize that the spectral math (averaging and boxcar smoothing) is performed when the data is transmitted out and not when the spectra is acquired. This allows up to 4 scans to be acquired with one command (set A=4 and send the S command) and then read out on scan at a time (set A=1 and use Z1 command).

Instruction Set

Command Syntax

The list of the command are 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 NIR512/256 "echos" the command back out the RS-232 port. 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	2.00.0
B	Set Pixel Boxcar	2.00.0
C	Turn TEC On/Off	2.00.0
D	Set TEC set point temperature	2.00.0
E	Multiscan index position	2.00.0
F		
G	Set Data Compression	2.00.0
H	Set AD Channel	2.00.0
I	Sets integration time	2.00.0
J	Sets Lamp Enable Line	2.00.0
K	Changes baud rate	2.00.0
L	Clear Memory	
M	Set Data Storage Mode	2.00.0
N		
O		
P	Partial Pixel Mode	2.00.0
Q	Initialize NIR to POR state	2.00.0
R		
S	Starts spectral acquisition with previously set parameters	2.00.0
T	Sets trigger mode	2.00.0
U		
V		
W	Query scans in memory	2.00.0
X		

Letter	Description	Version
Y		
Z	Read out Scan from memory	2.00.0
a	Set ASCII mode for data values	2.00.0
b	Set binary mode for data values	2.00.0
k	Sets Checksum mode	2.00.0
v	Provides microcode version #	2.00.0
x	Sets calibration coefficients	2.00.0
?	Queries parameter values	2.00.0

Command Descriptions

A detailed description of all NIR512/256 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

Sets the number of discrete spectra to be summed together. Since this routine can add up to 4 spectra, each with a maximum intensity of 16383, the maximum returned intensity is 65535.

Command Syntax:	A{DATA WORD}
Response:	ACK or NAK
Range:	1-4
Default value:	1

Pixel Boxcar Width

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 ~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

Turn TEC On/Off

Turns the TEC cooler on and off.

Command Syntax:	C{DATA WORD}
Response:	ACK or NAK
Range:	0-1
Default value:	0

TEC Set Point Temperature

Sets the TEC cooler set point temperature. The format is x10. e.g. –5 Degrees C is represented by –50 when the command is sent. The whole command would be D-50CRLF.

Command Syntax:	D{DATA WORD}
Response:	ACK or NAK
Range:	-5 to -20
Default value:	-10

Set Data Compression

Specifies whether the data transmitted from the NIR512/256 should be compressed to speed data transfer rates. For more information on NIR512/256 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

Set A/D Channel

Sets which A/D channel to acquire data from.

Command Syntax:	H{DATA WORD}
Response:	ACK or NAK
Range:	0-7
Default value:	0

Integration Time

Sets the NIR512/256's integration time, in microseconds, to the value specified.

Command Syntax:	I{32 bit DATA WORD}
Response:	ACK or NAK
Range:	10 – 65,000,000
Default value:	10,000

Lamp Enable

Sets the NIR512/256'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

Sets the NIR512/256's baud rate.

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

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

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

Clear Memory

Clears spectral data memory based upon the value specified. Clearing memory is immediate since only pointer values are reinitialized.

Command Syntax:	L{DATA WORD}
Value:	0 = Clear Spectral memory 1 = Clear Spectral memory
Response:	ACK or NAK
Default value:	N/A

Data Storage Mode

Sets the data storage mode for future spectral acquisitions.

Command Syntax:	M{DATA WORD}
Value:	0 = Scans transmitted through the serial port 1 = Scans stored in spectral memory and not transmitted
Response:	ACK or NAK
Default value:	0

Pixel Mode

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 3840 pixels 1 = every nth 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 2047 (denoted p1, p2, … p10)	P 0 (spaces for clarity only) P 1<Enter> N<Enter> P 2 N/A 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	

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.

Initialize NIR to POR state

Sets all the variables to the POR reset state and reloads the Coefficients into memory.

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

Spectral Acquisition

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 channel number ALWAYS 0

WORD scan number ALWAYS 0

WORD scans in memory ALWAYS 0

DWORD integration time in microseconds

WORD pixel mode

WORDs if pixel mode not 0, indicates parameters passed to the Pixel Mode command (P)

WORDs spectral data

WORD 0xFFFD – end of spectrum

Trigger Mode

Sets the NIR512/256's external trigger mode to the value specified.

Command Syntax:	T{DATA WORD}
Value:	0 = Normal – Continuously scanning 1 = Software trigger
Response:	ACK or NAK
Default value:	0

Number of Scans in Memory

Returns the number of scans in spectral data memory.

Command Syntax:	W{DATA WORD}
Value:	1 = Return number of scans in fast memory
Response:	ACK or NAK
Default value	N/A

Read Out Scan from Memory

Reads out one scan from the type of memory specified. The data is returned with the header information as described in the Spectral Acquisition command (S).

Command Syntax:	Z{DATA WORD}
Value:	1 = Read scan from spectral memory
Response:	If successful, ACK followed by data (See Spectral Acquisition [S] for header information). If unsuccessful, NAK.
Default value:	N/A

ASCII Data Mode

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 NIR512/256 "echoes" the command and data values back out the RS-232 port.

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

! **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 NIR512/256 is in the ASCII data mode.

Binary Data Mode

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

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

Specifies whether the NIR512/256 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

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

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 – 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: gg fff sss gg – Grating #, fff – filter wavelength, sss – slit size 16 – NIR512/256 configuration: AWL V A – Array coating Mfg, W – Array wavelength (VIS, UV, OFLV), L – L2 lens installed, V – CPLD Version 17 – Reserved 18 – Reserved 19 – Reserved
Response:	ACK or NAK
Default value:	N/A

To query the constants, use the ?x{DATA WORD} format to specify the desired constant

Query Variable

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 bee 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 spectra from spectrometer channel 0 (master) with a 200ms integration time, set number of scan to add to 5 and operate at 57,600 Baud.

aA	(Set ASCII Data Mode)
K6<CR>	(Start baud rate change to 115,200)
	Wait for ACK, change to 115200, wait for 20ms
K5<CR>	(Verify command, communicate at 115200)
A2<CR>	(Add 5 spectra)
I20000<CR>	(Set integration time to 20ms)
S	(Acquire spectra)
…	Repeat as necessary

Application Tips

- During the software development phase of a project, the operating parameters of the NIR512/256 may become out-of-synch with the controlling program. It is good practice to cycle power on the NIR512/256 when errors occur.
- If you question the state of the NIR512/256, you can transmit a space (or another non-command) using a terminal emulator. If you receive a NAK, the NIR512/256 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:
  4. Bits per second (Baud rate): Set to desired rate
  5. Data bits: 8
  6. Parity: None
  7. Stop bits: 1
  8. Flow control: None
  9. Click OK in Port Settings and in Properties dialog boxes.

Technical Note 1

NIR512/256 Data Compression

Transmission of spectral data over the serial port is a relatively slow process. The NIR512/256 implements a data compression routine that minimizes the amount of data that needs to be transferred over the RS-232 connection. Using the “G” command (Compressed Mode) and passing it a parameter of 1 enables the data compression. Every scan transmitted by the NIR512/256 will then be compressed. The compression algorithm is as follows:

1. The first pixel (a 16-bit unsigned integer) is always transmitted uncompressed.
2. The next byte is compared to 0x80.
    - If the byte is equal to 0x80, the next two bytes are taken as the pixel value (16-bit **unsigned** integer).
    - If the byte is not equal to 0x80, the value of this byte is taken as the difference in intensity from the previous pixel. This difference is interpreted as an 8-bit **signed** integer.
3. Repeat step 2 until all pixels have been read.

Using this data compression algorithm greatly increases the data transfer speed of the NIR512/256. Compression rates of 35-48% can easily be achieved with this algorithm.

The following shows a section of a spectral line source spectrum and the results of the data compression algorithm.

Pixel Value	Value Difference	Transmitted Bytes
185	0	0x80 0x00 0xB9
2151	1966	0x80 0x08 0x67
836	-1315	0x80 0x03 0x44
453	-383	0x80 0x01 0xC5
210	-243	0x80 0x00 0xD2
118	-92	0xA4
90	-28	0xE4
89	-1	0xFF
87	-2	0xFE
89	2	0x02

Pixel Value	Value Difference	Transmitted Bytes
86	-3	0xFD
88	2	0x02
98	10	0x0A
121	23	0x17
383	262	0x80 0x01 0x7F
1162	779	0x80 0x04 0x8A
634	-528	0x80 0x02 0x7A
356	-278	0x80 0x01 0x64
211	-145	0x80 0x00 0xD3
132	-79	0xB1
88	-44	0xD4
83	-5	0xFB
86	3	0x03
82	-4	0xFC
91	9	0x09
92	1	0x01
81	-11	0xF5
80	-1	0xFF
84	4	0x04
84	0	0x00
85	1	0x01
83	-2	0xFE
80	-3	0xFD
80	0	0x00
88	8	0x08
94	6	0x06
90	-4	0xFC
103	13	0x0D
111	8	0x08
138	27	0x1B

In this example, spectral data for 40 pixels is transmitted using only 60 bytes. If the same data set were transmitted using uncompressed data, it would required 80 bytes.

Technical Note 2

NIR512/256 Checksum Calculation

For all uncompressed pixel modes, the checksum is simply the unsigned 16-bit sum (ignoring overflows) of all transmitted spectral points. For example, if the following 10 pixels are transferred, the calculation of the checksum would be as follows:

Pixel Number	Data (decimal)	Data (hex)
0	15	0x000F
1	23	0x0017
2	46	0x002E
3	98	0x0062
4	231	0x00E7
5	509	0x01FD
6	1023	0x03FF
7	2432	0x0980
8	3245	0x0CAD
9	1984	0x07C0

Checksum value: 0x2586

When using a data compression mode, the checksum becomes a bit more complicated. A compressed pixel is treated as a 16-bit **unsigned** integer, with the most significant byte set to 0. Using the same data set used in Technical Note 1, the following shows a section of a spectral line source spectrum and the results of the data compression algorithm.

Data Value	Value Difference	Transmitted Bytes	Value added to Checksum
185	0	0x80 0x00 0xB9	0x0139
2151	1966	0x80 0x08 0x67	0x08E7
836	-1315	0x80 0x03 0x44	0x03C4
453	-383	0x80 0x01 0xC5	0x0245

Data Value	Value Difference	Transmitted Bytes	Value added to Checksum
210	-243	0x80 0x00 0xD2	0x0152
118	-92	0xA4	0x00A4
90	-28	0xE4	0x00E4
89	-1	0xFF	0x00FF
87	-2	0xFE	0x00FE
89	2	0x02	0x0002
86	-3	0xFD	0x00FD
88	2	0x02	0x0002
98	10	0x0A	0x000A
121	23	0x17	0x0017
383	262	0x80 0x01 0x7F	0x01FF
1162	779	0x80 0x04 0x8A	0x050A
634	-528	0x80 0x02 0x7A	0x02FA
356	-278	0x80 0x01 0x64	0x01E4
211	-145	0x80 0x00 0xD3	0x0153
132	-79	0xB1	0x00B1
88	-44	0xD4	0x00D4
83	-5	0xFB	0x00FB
86	3	0x03	0x0003
82	-4	0xFC	0x00FC
91	9	0x09	0x0009
92	1	0x01	0x0001
81	-11	0xF5	0x00F5
80	-1	0xFF	0x00FF
84	4	0x04	0x0004
84	0	0x00	0x0000
85	1	0x01	0x0001
83	-2	0xFE	0x00FE
80	-3	0xFD	0x00FD
80	0	0x00	0x0000
88	8	0x08	0x0008
94	6	0x06	0x0006
90	-4	0xFC	0x00FC

Data Value	Value Difference	Transmitted Bytes	Value added to Checksum
103	13	0x0D	0x000D
111	8	0x08	0x0008
138	27	0x1B	0x001B

The checksum value is simply the sum of all entries in the last column, and evaluates to 0x2C13.