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NIRQuest NIR Spectrometers Data Sheet

Description

The NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-2.5, NIRQuest256-2.1 and NIRQuest256-2.5 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 NIRQuest spectrometers can communicate via the Universal Serial Bus.

NIRQuest-512

The NIRQuest-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 NIRQuest512 a 182 mm x 110 mm x 47 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. The NIRQuest-512 standard grating (NIR3) provides a wavelength range of 850-1700 nm. Five other gratings are available. The usable range is 900-1700 nm.

NIRQuest512-1.9

The NIRQuest512-1.9 has a wavelength range of 1100-1900 nm using the standard grating NIR3. Five other gratings are available.

NIRQuest512-2.5

The NIRQuest512-2.5 offers better resolution, with a wavelength range of 900-2550 nm using the standard grating NIR1. There are 6 other grating options available.

NIRQuest512-2.2

The NIRQuest512-2.2 offers better resolution, with a wavelength range of 900-2200 nm using the standard grating NIR2. There are 5 other grating options available.

NIRQuest256-2.1

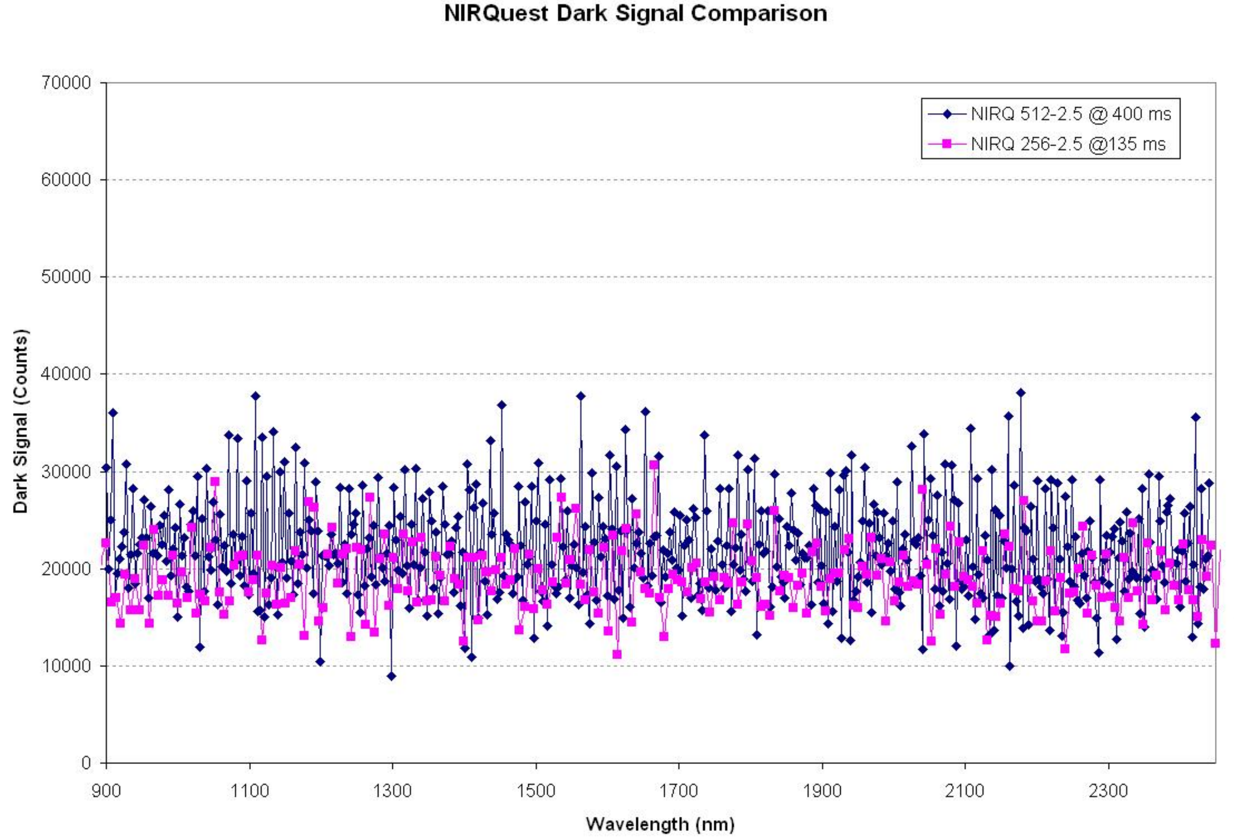
The NIRQuest256-2.1 uses a 256-element InGaAs linear-array detector. With the NIRQuest256-2.1 you have 6 grating options. Grating NIR2, is standard and provides a wavelength range of 900-2100 nm. The usable range is 900- 2050 nm. The NIRQuest256-2.1 acquires data as fast as 5 milliseconds with the USB 2.0 port.

NIRQuest256-2.5

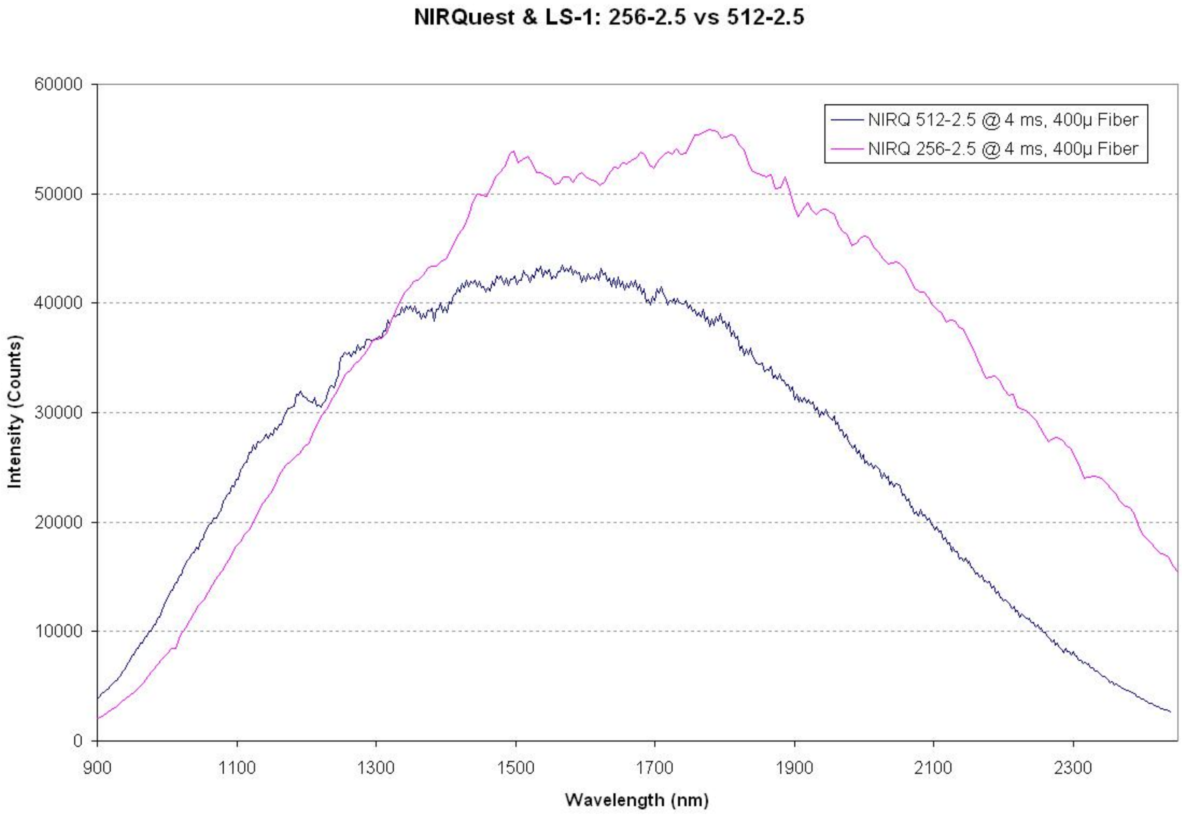
The NIRQuest256-2.5 extends farther into the NIR range, acquiring spectra up to 2.5 µm. The NIRQuest256-2.5 features a temperature-regulated InGaAs detector array, which is internally cooled for optimum signal-to-noise and sensitivity. The NR256-2.5 acquires data as fast as 5 milliseconds. The detector range is 900-2550 nm with a usable range of 900-2500 nm.

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 detector's band gap energy must be small. Unfortunately this raises the absolute level of the detectors dark signal. Typical dark signals at 400ms (NIRQuest512-2.5) and 135ms (NIRQuest256-2.5) are shown below.
- **Fiber Selection:** For maximum signal intensity, alternative fiber materials should be used for wavelengths greater than 2.2µm.



Dark Signal Comparison of NIRQuest 512-2.5 and NIRQuest 256-2.5



Relative intensity of NIRQuest 512-2.5 and a NIRQuest256-2.5 Spectrometer with a 25µm slit directly coupled to an LS-1 Light Source with a 400µm fiber

NIRQuest Gratings

The following tables show the NIRQuest gratings available for preconfigured (standard) setups and for all options. Additional grating options, adjustments to starting and ending wavelengths and similar customization may be available. Please contact an Applications Scientist for details.

NIRQuest Gratings for Preconfigured Setups

Spectrometer	Standard Grating	Groove Density (lines/mm)	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
NIRQuest512	NIR3	150	~800 nm	1100 nm	900-1700 nm
NIRQuest512-1.9	NIR3	150	~800 nm	1100 nm	1100-1900 nm
NIRQuest512-2.2	NIR2	100	1150 nm	1600 nm	900-2200 nm
NIRQuest512-2.5	NIR1	75	1425 nm	1700 nm	1075-2500 nm
NIRQuest256-2.1	NIR2	100	1150 nm	1600 nm	900-2050 nm
NIRQuest256-2.5	NIR1	75	1425 nm	1700 nm	1075-2500 nm

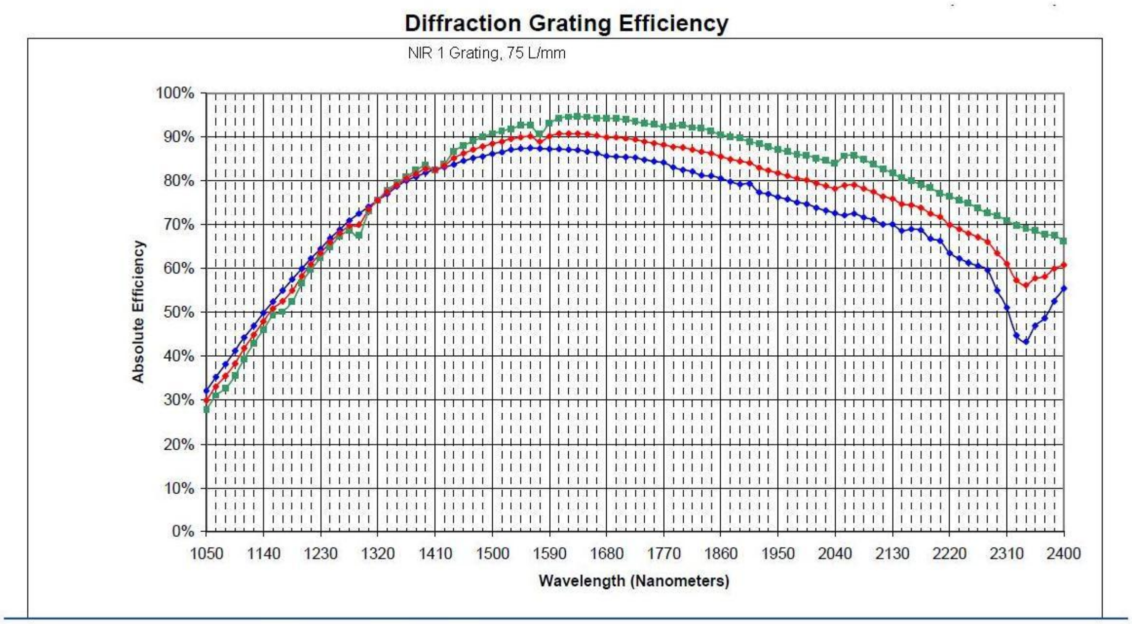
NIRQuest Gratings – All Options

Grating	Intended Use	Groove Density (lines/mm)	Spectral Range*	Blaze Wavelength	Best Efficiency (>30%)
NIR1	NIRQuest512-2.5 NIRQuest256-2.5	75	1600 nm	1700 nm	1075-2500 nm
NIR2	NIRQuest 512-2.2 NIRQuest512-2.5 NIRQuest256-2.1 NIRQuest256-2.5	100	1200 nm	1600 nm	900-2050 nm
NIR3	NIRQuest512, NIRQuest512-1.9 NIRQuest512-2.2 NIRQuest 512-2.5 NIRQuest256-2.1, NIRQuest256-2.5	150	~800 nm	1100 nm	900-1700 nm
NIR10	NIRQuest512, NIRQuest512-2.2 NIRQuest512-2.5 NIRQuest256-2.1 NIRQuest256-2.5	300	350-380 nm	1200 nm	750-2200 nm
NIR11	NIRQuest512, NIRQuest512-2.2 NIRQuest512-2.5 NIRQuest256-2.1 NIRQuest256-2.5	400	240-290 nm	1600 nm	980-2500 nm
NIR12	NIRQuest512, NIRQuest512-2.2 NIRQuest512-2.5 NIRQuest256-2.1 NIRQuest256-2.5	500	160-220 nm	1370 nm	900-2500 nm
NIR13	NIRQuest512, NIRQuest512-2.2 NIRQuest512-2.5 NIRQuest256-2.1 NIRQuest256-2.5	600	100-180 nm	1200 nm	800-2500 nm
NIR14	NIRQuest512	1000	50-90 nm	1310 nm	900-1700 nm

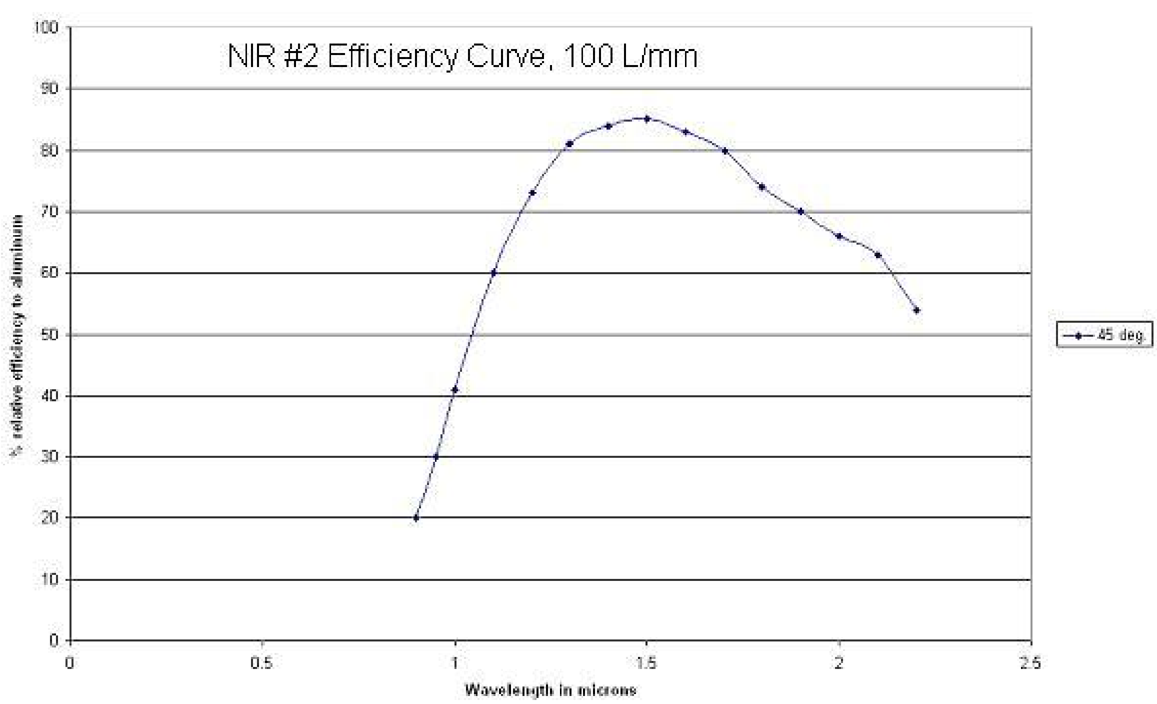
* The spectral range is a function of the starting wavelength; the longer (i.e., the farther out in the NIR) the starting wavelength, the smaller the spectral range possible.

Grating Efficiency Curves

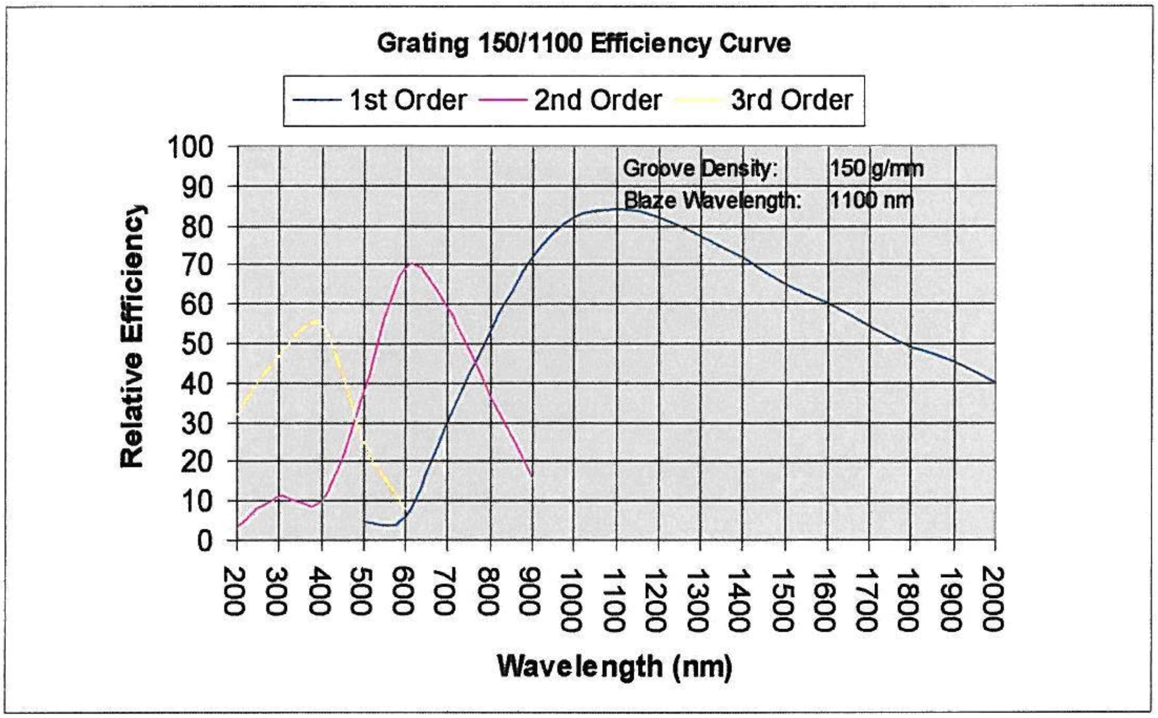
The following graphs show grating efficiency only. System sensitivity is due to several factors, including detector response and grating efficiency.



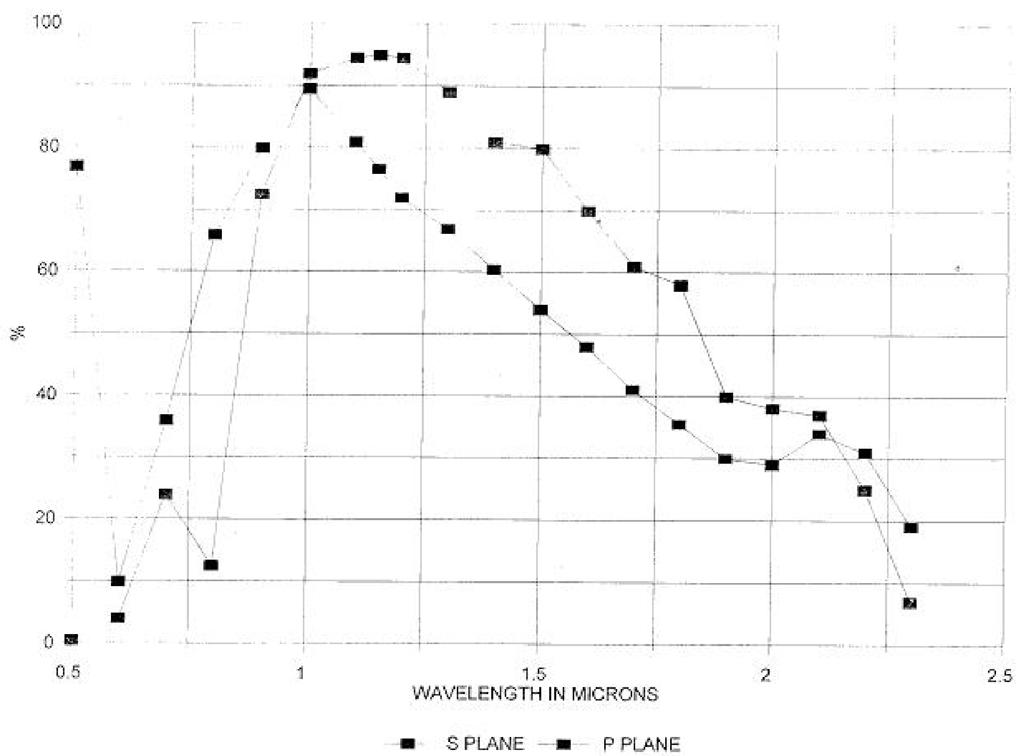
Grating NIR1, 1075 – 2500 nm, 75 l/mm, Blazed at 1700 nm



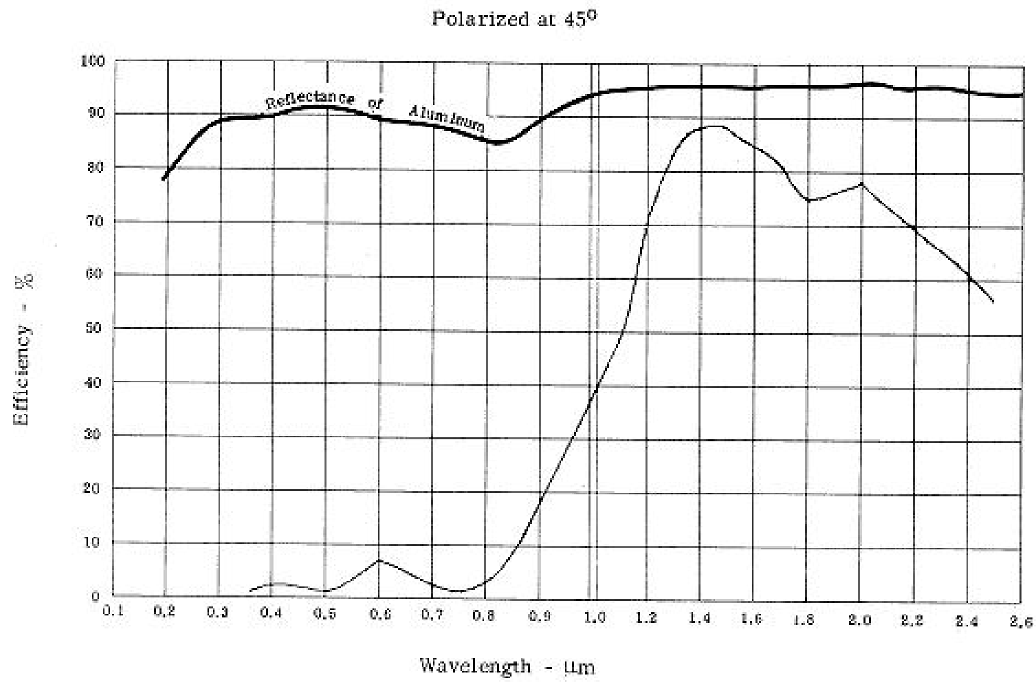
Grating NIR2, 900 – 2050 nm, 100 l/mm, Blazed at 1600 nm



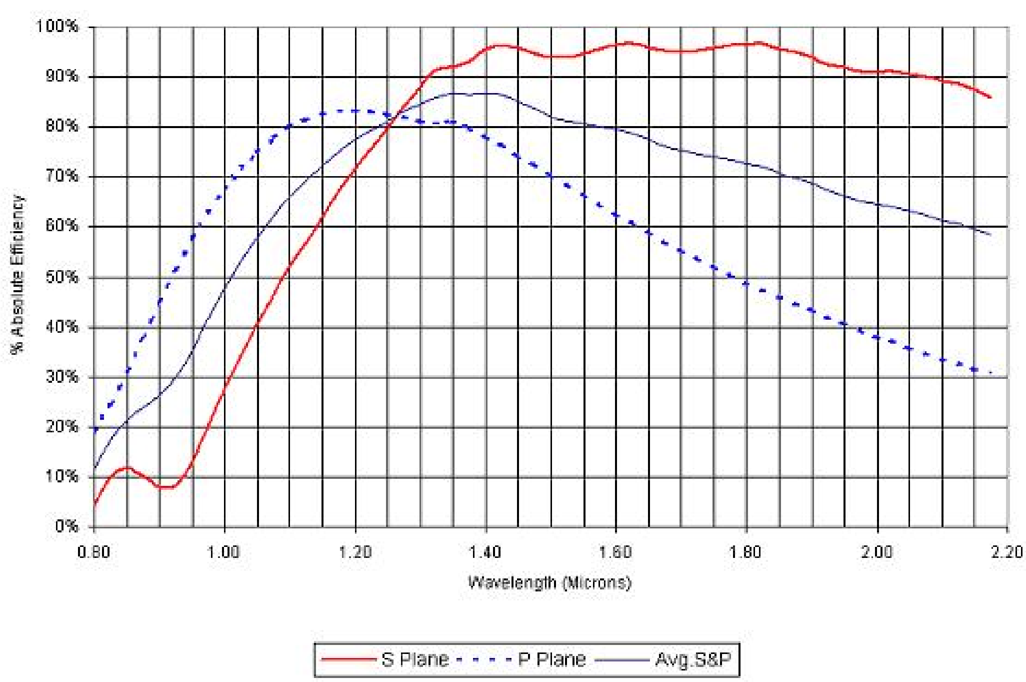
Grating NIR3, 900 – 1700 nm, 150 l/mm, Blazed at 1100 nm



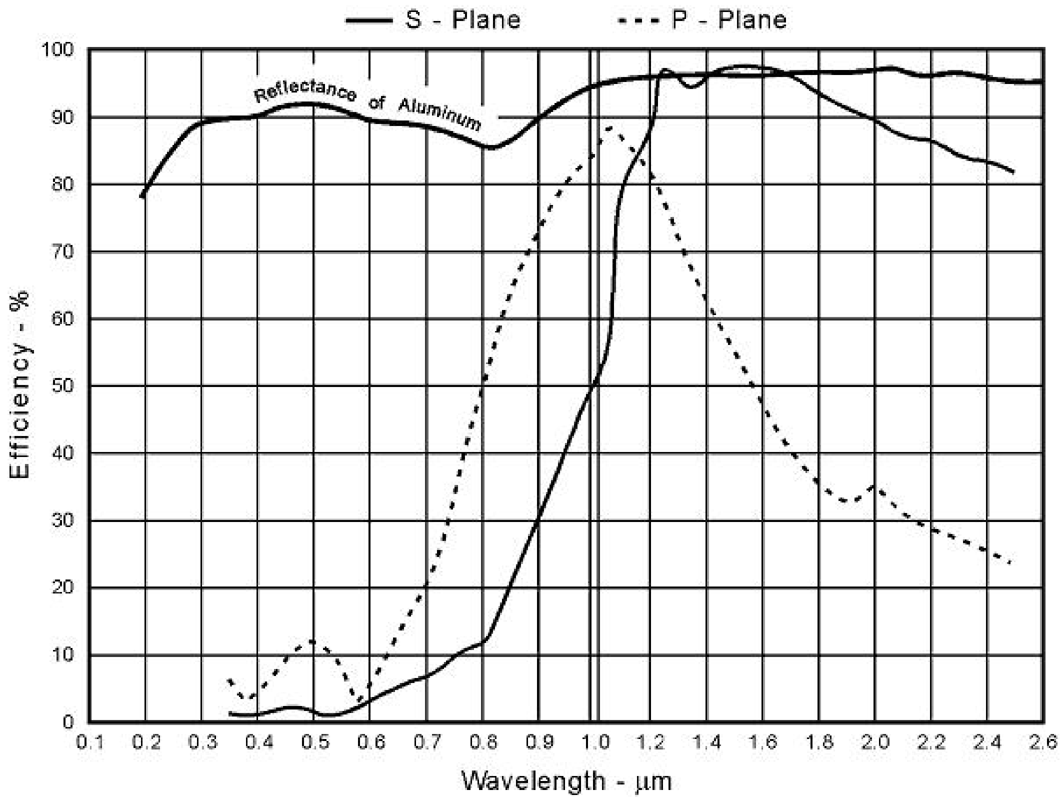
Grating NIR10, 750 – 2200 nm, 300 l/mm, Blazed at 1200 nm



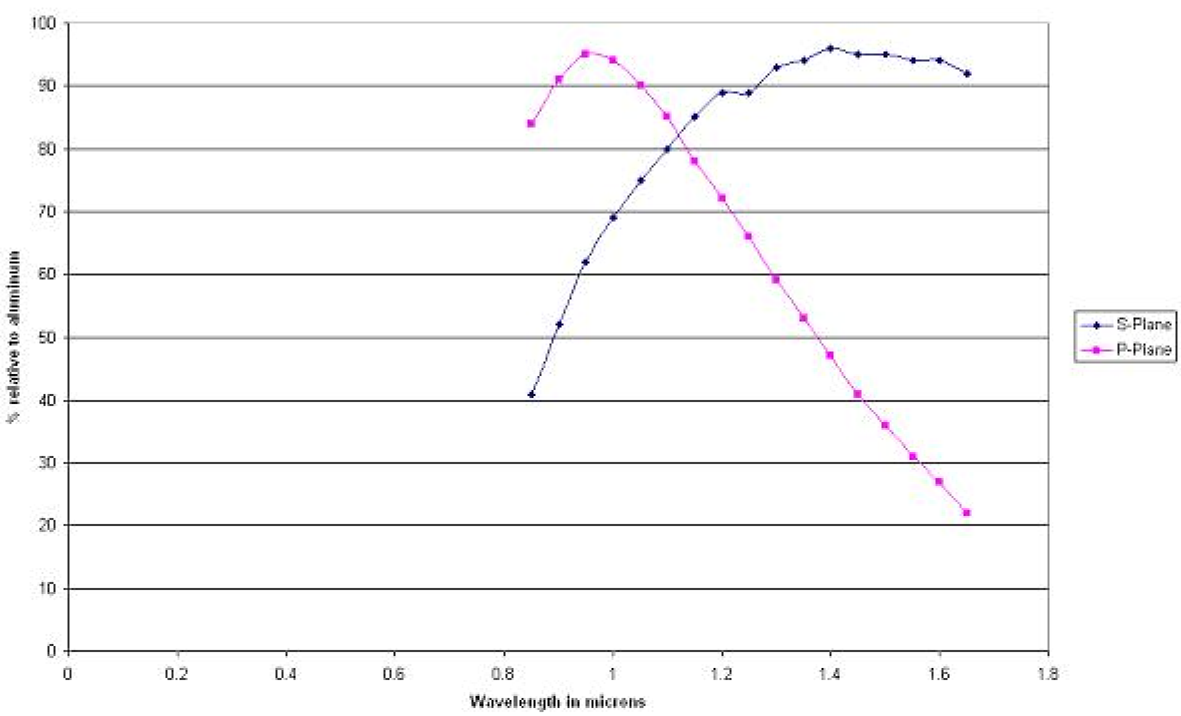
Grating NIR11, 980 – 2500 nm, 400 l/mm, Blazed at 1600 nm



Grating NIR12, 900 – 2500 nm, 500 l/mm, Blazed at 1370 nm



Grating NIR13, 800 – 2500 nm, 600 l/mm, Blazed at 1200 nm

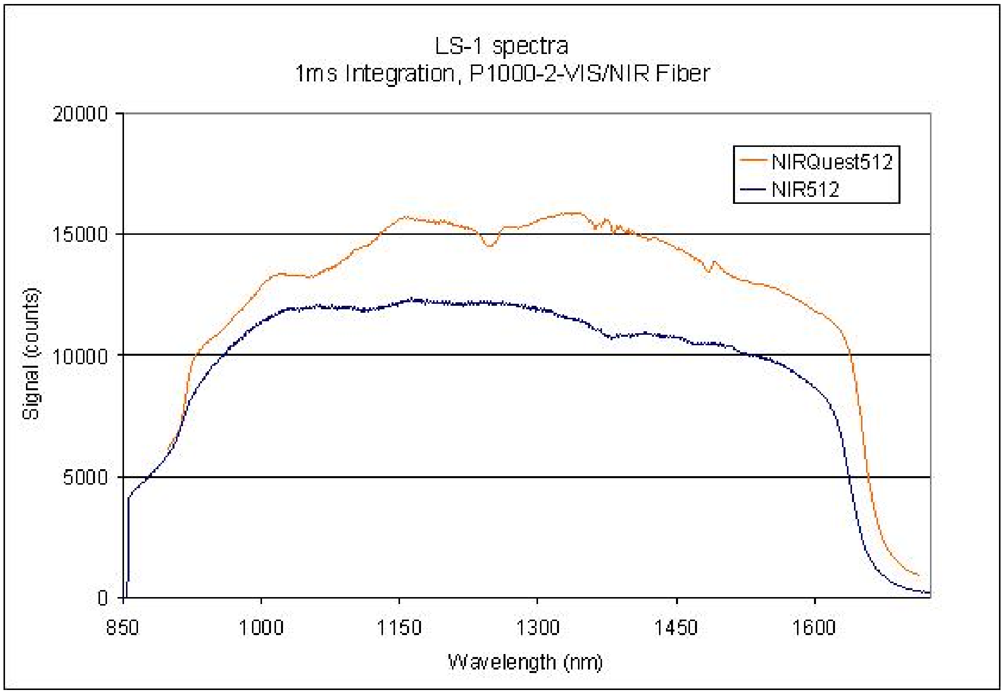


Grating NIR14, 900 – 1700 nm, 1000 l/mm, Blazed at 1310 nm

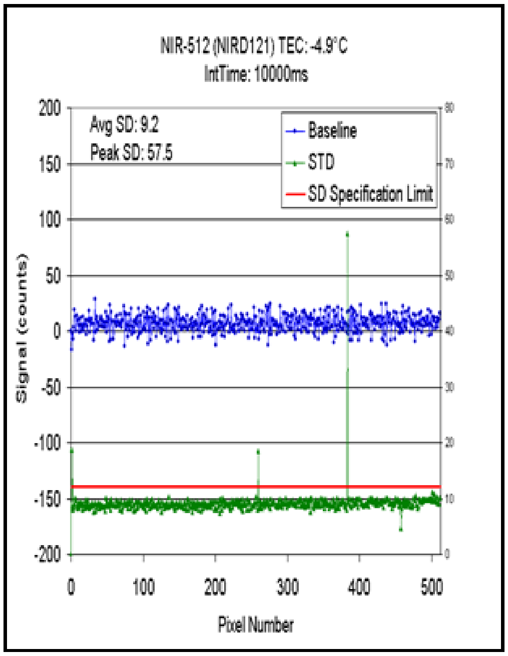
Advantages Over NIR Series Spectrometers

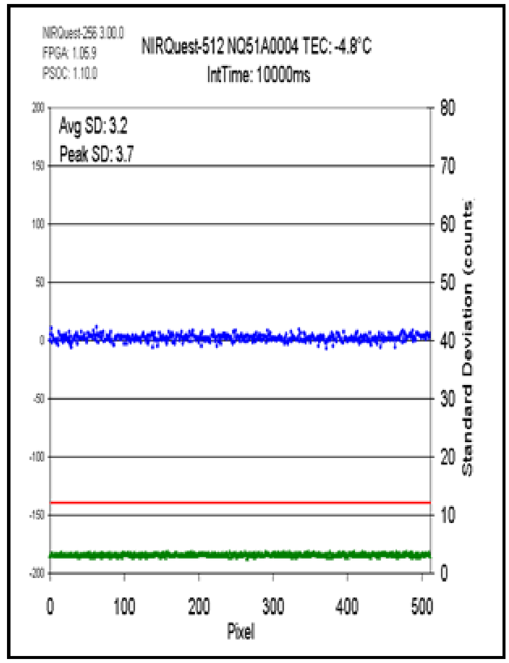
The NIRQuest Spectrometers offer a high-performance optical bench with low-noise electronics and more gratings than have been available in the past. The following list of improved features shows how the NIRQuest offers improved functionality over our previous NIR Spectrometers at a lower cost to you.

- 20 % Higher Throughput. Higher throughput means higher sensitivity and shorter integration times needed. The chart below compares spectra from the NIR512 with the NIRQuest 512.



- 2 to 3 Times Better Noise Performance. This permits integration for longer periods of time and detection of smaller changes in absorbance. The charts below show 3x noise improvement for the NIRQuest512 over the NIR512 at a 10-second integration time.





- Considerably Better Signal-to-Noise Ratio (now >15000:1 at 100 ms). This allows better detection in low light levels, use of a smaller slit size (provides higher optical resolution without sacrificing throughput), and simpler measurement of higher concentration samples.
- True External Trigger with a fixed 1-ms delay after an external event before integration begins.
- Thermoelectric Cooler stabilizes after 1 minute in the NIRQuest 512 vs. 2 minutes in the NIR512.
- More Grating Options are provided (up to 6) to better optimize your application setup.

Features

- Hamamatsu G9204-512 (NIRQuest512), G9205-512 (NIRQUEST512-1.9), G9206-512W (NIRQuest512-2.2), G9208-512W (NIRQuest512-2.5), G9206-256 (NIRQuest256-2.1), G9208-256 (NIRQuest256-2.5) InGaAs linear array detector
  - Back-thinned for good UV sensitivity
  - MPP operation for low noise
  - TE Cooled
- Spectrometer Design
  - Symmetrical Crossed Czerny Turner
  - 101mm focal length
  - 8 gratings (model-dependent)
  - 6 slit widths
- Electrical Performance
  - 16 bit, 500KHz A/D converter
  - Integration times from 1 ms to 120 seconds

- Embedded microcontroller allows programmed control of all operating parameters and standalone operation
  - USB 2.0 480Mbps
  - Multiple communication standards for digital accessories (SPI, I2C)
- Onboard Pulse Generator
  - 3 programmable strobe signals for triggering other devices
  - Software control of nearly all pulse parameters
- Onboard GPIO
  - 10 user-programmable digital I/Os
- EEPROM storage for
  - Wavelength Calibration Coefficients
  - Linearity Correction Coefficients
  - Absolute Irradiance Calibration (optional)
- Plug-and-play interface for PC applications
- 30-pin connector for interfacing to external products
- CE certification

NIRQuest Optical Resolution for Standard Setups

The following table lists the optical resolution (FWHM) by slit width for standard (preconfigured) setups. Optical resolution will vary by grating range and slit size.

Optical Resolution by Slit Width

Slit	NIRQuest512[1]	NIRQuest512-2.2[2]	NIRQuest512-2.5[3]	NIRQuest256-2.1[2]	NIRQuest256-2.5[3]
SLIT-10	~2.0 nm	~3.0 nm	~4.1 nm	~6.7 nm	~9.4 nm
SLIT-25	~3.1 nm	4.7 nm	~6.3 nm	~7.6 nm	~10.6 nm
SLIT-50	~3.6 nm	~5.4 nm	~7.2 nm	~8.9 nm	~12.5 nm
SLIT-100	~6.6 nm	~9.8 nm	~13.1 nm	~11.2 nm	~15.6 nm
SLIT-200	~12.3 nm	~18.5 nm	~25 nm	~17.9 nm	~25.0 nm

[1] Grating NIR3 used (900-1700 nm)
[2] Grating NIR2 used (900-2050 nm)
[3] Grating NIR1 used (900-2500 nm)

NIRQuest512 Spectrometer Specifications

	NIRQuest512	NIRQuest512-1.9	NIRQuest512-2.2	NIRQuest512-2.5
PHYSICAL				
Dimensions (mm):	182 x 110 x 47			
Weight (kg):	1.18 (w/o power supply)			
DETECTOR				
Detector:	Hamamatsu G9204-512 InGaAs linear array	Hamamatsu G9205-512 InGaAs linear array	Hamamatsu G9206-512 InGaAs linear array	Hamamatsu G9208-512W InGaAs linear array
Detector range:	850-1700 nm	1000-1900 nm	900-2200 nm	900-2550 nm
Useable range[1]:	900-1700 nm	1000-1900 nm	900-2200 nm	900-2500 nm
Pixels:	512			
Pixel size:	25 µm x 500 µm		25 µm x 250 µm	
Saturation charge:	30 pC (~188 Me- electrons)			
Defective pixels:	0 pixels	<20 pixels		
OPTICAL BENCH				
Design:	f/4, symmetrical crossed Czerny-Turner			
Entrance aperture (standard):	25 µm			
Entrance aperture (custom options):	10 µm, 50 µm, 100 µm and 200 µm (or no slit)			
Grating options (standard):	Grating NIR3, 150 l/mm, 900-1700 nm	Grating NIR3, 100 l/mm, 150 l/mm, 900-1700 nm	Grating NIR2, 100 l/mm, 900-2050 nm	Grating NIR1, 75 l/mm, 1075-2500 nm
Grating options (custom)[2]:	NIR10, NIR11, NIR12, NIR13 and NIR14		NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13	
Longpass filter[3]:	OF1-RG830 longpass NIR filter (optional)	OF1-CGA1000 longpass NIR filter (standard)	OF1-RG830 longpass NIR filter (optional)	
2nd Order filter[3]:	N/A	Standard		
Collimating and focusing mirrors:	Gold-coated for enhanced NIR reflectivity			
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber			

	NIRQuest512	NIRQuest512-1.9	NIRQuest512-2.2	NIRQuest512-2.5
SPECTROSCOPIC				
Wavelength range:	900-1700 nm w/Grating NIR3	1100-1900nm w/Grating NIR3	900-2200nm w/Grating NIR2	900-2500nm w/Grating NIR1
Optical resolution (FWHM)[4]:	~3.1 nm w/25 µm slit		~5 nm w/25 µm slit	~6.3 nm w/25 µm slit
Signal-to-noise ratio at full signal[5]:	>15000:1 @ 100 ms integration	>8000:1 @ 100ms integration	10000:1 @ 100 ms integration	
	>13000:1 @ 1000 ms integration			
A/D resolution:	16-bit			
Dark noise:	6 RMS counts @ 100 ms			16 RMS counts@ 10ms
	12 RMS counts @ 1000 ms	12 RMS counts @ 250 ms		24 RMS counts@ 30ms
Dynamic range:	15 x 10^6 (system); 15K:1 for a single acquisition	7.5 x 10^6 (system); 10K:1 for a single acquisition		100K (system); 7.5K:1 for a single acquisition
Integration time[6]:	1 ms – 120 s	1 ms – 2 s	1 ms – 1 s	1 ms – 30 ms
Corrected linearity:	>99.8%			>99.6%
Estimated Peak Noise Equivalent Power (NEP) (default configuration)	0.5 pW	10 pW	10 pW	100 pW
ELECTRONICS				
Power consumption	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum			
Data transfer speed:	Full scan to memory every 5 ms with USB 2.0 port			
Inputs/ Outputs:	External trigger input + single strobe output			
Breakout box compatibility:	Yes			
Trigger modes:	2 modes (Normal/Free Run + 1-ms External Hardware Trigger)			
Strobe functions:	Yes			
Gated delay:	Yes, with external hardware trigger delay			
Connector:	30-pin connector			

	NIRQuest512	NIRQuest512-1.9	NIRQuest512-2.2	NIRQuest512-2.5
TEMPERATURE & THERMOELECTRIC COOLING				
Temperature limits (environmental):	10-35 ºC (0-90% non-condensing)			
TEC set point (software controlled):	Control at -5ºC (up to 30ºC below ambient)	Control at -20 ºC (up to 45 ºC below ambient)		
TEC stability:	+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC			
COMPUTER				
Operating systems:	Windows 2000/XP and Vista (32-bit only); Mac OS X and Linux w/USB port; any 32-bit Windows OS with serial port			
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud (custom configuration)			
Peripheral interfaces:	I2C inter-integrated circuit; SPI (3-wire)			
WIRELESS/ETHERNET INTERFACE (optional add-on accessory)				
Wireless (Wi-Fi) interface:	Yes, with Remora adapter			
Wired Ethernet interface:	Yes, with Remora adapter			
Wi-Fi range:	25 meters in free space			
Web server:	Works with common browsers			

[1] "Useable range" is defined in the context of the NIRQuest model's detector response and its typical grating response. For example, the 512-element detector has response at 850 nm, but grating response begins at 900 nm. The G9206 256-element detector response is sensitive to TEC temperature, and has response only to 2050 nm when the TEC is set to -20 ºC. The G9208 256-element and 512-element detector has response to 2550 nm, but the grating efficiency drops off at 2500 nm.

[2] See *NIRQuest Gratings* for more information.

[3] Other filter options are available for order-sorting in the NIRQuest 512-2.5. NIRQuest 512-2.5 ship with a 2nd-order filter. See an Applications Scientist for details.

[4] Optical resolution (FWHM) depends on grating and slit selection.

[5] SNR will decrease at longer integration times.

[6] Maximum integration times are defined as the longest amount of time one can integrate the spectrometer before the dark level rises to half of full scale.

NIRQuest256 Spectrometer Specifications

	NIRQuest256-2.1	NIRQuest256-2.5
PHYSICAL		
Dimensions (mm):	182 x 110 x 47	
Weight (kg):	1.18 (w/o power supply)	
DETECTOR		
Detector:	Hamamatsu G9206-256 InGaAs linear array	Hamamatsu G9208-256 InGaAs linear array
Detector range:	900-2100 nm	900-2550 nm
Useable range[1]:	900-2050 nm	900-2500 nm
Pixels:	256	
Pixel size:	50 µm x 500 µm	
Saturation charge:	30 pC (~188 Me- electrons)	
Defective pixels:	<12 pixels	
OPTICAL BENCH		
Design:	f/4, symmetrical crossed Czerny-Turner	
Entrance aperture (standard):	25 µm	
Entrance aperture (custom options):	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	
Grating options (standard):	Grating NIR2, 100 l/mm, 900-2050 nm	Grating NIR1, 75 l/mm, 1075-2500 nm
Grating options (custom)[2]:	NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13	
Longpass filter[3]:	OF1-RG830 longpass NIR filter (optional)	
2nd Order filter[3]:	Standard	
Collimating and focusing mirrors:	Gold-coated for enhanced NIR reflectivity	
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber	
SPECTROSCOPIC		
Wavelength range:	900-2050 nm w/Grating NIR2	900-2500 nm w/Grating NIR1
Optical resolution (FWHM)[4]:	~7.6 nm w/25 µm slit	~ 9.5 nm w/25 µm slit
Signal-to-noise ratio at full signal[5]:	10000:1 @ 100 ms integration	7500:1 @ 10 ms integration

	NIRQuest256-2.1	NIRQuest256-2.5
A/D resolution:	16-bit	
Dark noise:	6 RMS counts @ 100 ms	8 RMS counts @ 10 ms
	12 RMS counts @ 250 ms	12 counts RMS @ 30 ms
Dynamic range:	15M (system); 10K:1 for a single acquisition	500K (system); 7.5K:1 for a single acquisition
Integration time[6]:	1 ms – 2 s	1 ms – 60 ms
Corrected linearity:	>99.8%	>99.6%
Estimated Peak Noise Equivalent Power (NEP) (default configuration)	5 pW	25 pW
ELECTRONICS		
Power consumption	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	
Data transfer speed:	Full scan to memory every 5 ms with USB 2.0 port	
Inputs/ Outputs:	External trigger input + single strobe output	
Breakout box compatibility:	Yes	
Trigger modes:	2 modes (Normal/Free Run + 1-ms External Hardware Trigger)	
Strobe functions:	Yes	
Gated delay:	Yes, with external hardware trigger delay	
Connector:	30-pin connector	
TEMPERATURE & THERMOELECTRIC COOLING		
Temperature limits (environmental):	10-35 ºC (0-90% non-condensing)	
TEC set point (software controlled):	Control at -20 ºC (up to 45 ºC below ambient)	
TEC stability:	+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC	
COMPUTER		
Operating systems:	Windows 2000/XP and Vista (32-bit only); Mac OS X and Linux w/USB port; any 32-bit Windows OS with serial port	
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud (custom configuration)	
Peripheral interfaces:	I2C inter-integrated circuit; SPI (3-wire)	
WIRELESS/ETHERNET INTERFACE (optional add-on accessory)		
Wireless (Wi-Fi) interface:	Yes, with Remora adapter	
Wired Ethernet interface:	Yes, with Remora adapter	
Wi-Fi range:	25 meters in free space	
Web server:	Works with common browsers	

[1] "Useable range" is defined in the context of the NIRQuest model's detector response and its typical grating response. For example, the 512-element detector has response at 850 nm, but grating response begins at 900 nm. The G9206 256-element detector response is sensitive to TEC temperature, and has response only to 2050 nm when the TEC is set to -20 ºC. The G9208 256-element and 512-element detector has response to 2550 nm, but the grating efficiency drops off at 2500 nm.

[2] See *NIRQuest Gratings* for more information.

[3] Other filter options are available for order-sorting in the NIRQuest256-2.1, NIRQuest256-2.5 and NIRQuest 512-2.5. NIRQuest256-2.5 and NIRQuest 512-2.5 ship with a 2^{nd}-order filter. See an Applications Scientist for details.

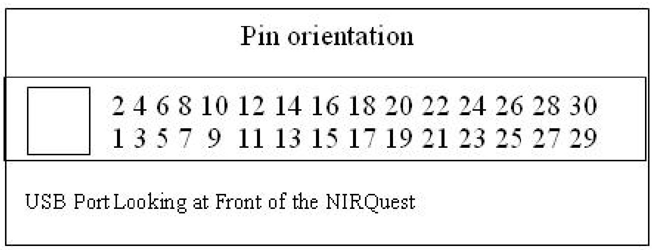
[4] Optical resolution (FWHM) depends on grating and slit selection.

[5] SNR will decrease at longer integration times.

[6] Maximum integration times are defined as the longest amount of time one can integrate the spectrometer before the dark level rises to half of full scale.

Electrical Pinout

30-pin Accessory Connector Pinout



Pin #	Function	Input/Output	Description
1	RS232 Rx	Input	RS-232 receive signal. RS-232 functionality is not implemented in software.
2	RS232 Tx	Output	RS-232 transmit signal. RS-232 functionality is not implemented in software.
3	GPIO (2)	Input/Output	A/D trigger
4	N/A	N/A	Reserved
5	Ground	Input/Output	Ground
6	I2C SCL	Input/Output	I2C clock signal for communication to other I2C peripherals
7	GPIO (0)	Input/Output	Acquire spectra (read Enable)
8	I2C SDA	Input/Output	I2C data signal for communication to other I2C peripherals
9	GPIO (1)	Input/Output	FIFO Write
10	Ext. Trigger In	Input	TTL input trigger signal
11	GPIO (3)	Input/Output	Detector SCLAMP
12	VCC or 5VIN	Input or	Input power pin– When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB

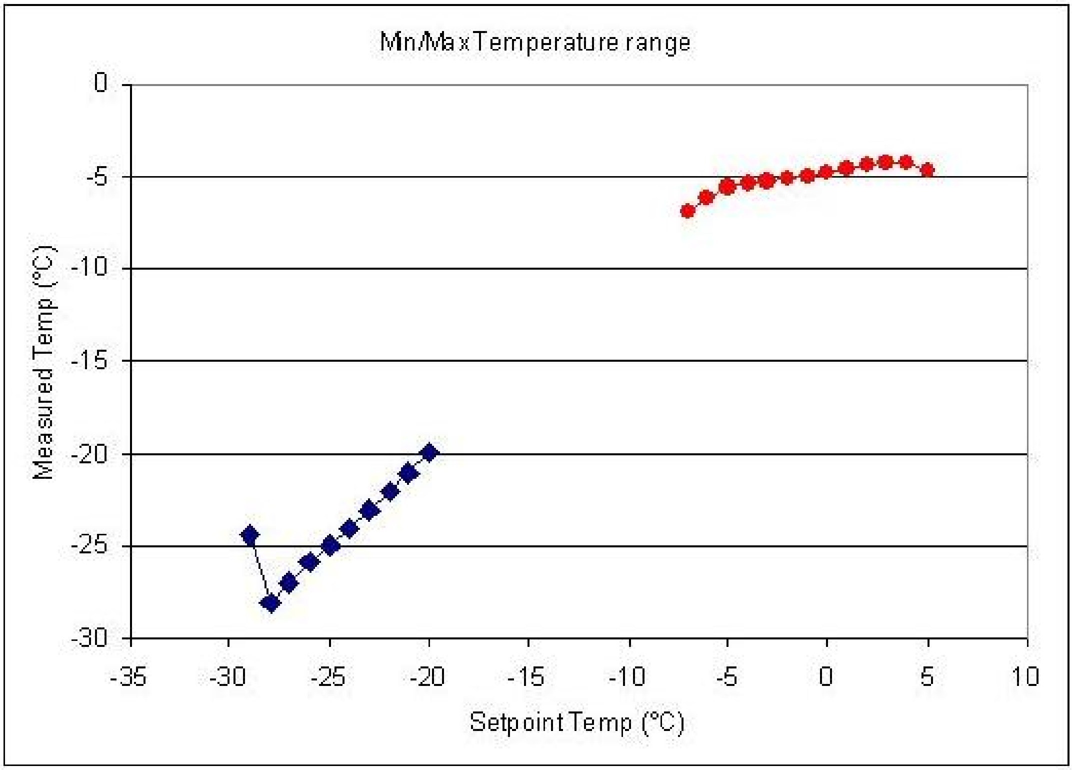
Pin #	Function	Input/Output	Description
		Output	specifications (no TEC power)
13	SPI Data Out	Output	SPI Master Out Slave In (MOSI) signal for communication to other SPI peripherals
14	VCC or 5VIN	Input or Output	Input power pin – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications (no TEC power)
15	SPI Data In	Input	SPI Master In Slave Out (MISO) signal for communication to other SPI peripherals
16	GPIO (4)	Input /Output	Reserved
17	Single Strobe	Output	TTL output pulse used as a strobe signal – Has a programmable delay relative to the beginning of the spectrometer integration period
18	GPIO (5)	Input/Output	Detector SODDCLK (inverted)
19	SPI Clock	Output	SPI clock signal for communication to other SPI peripherals
20	Continuous Strobe	Output	TTL output signal used to pulse a strobe – Divided down from the master clock signal
21	SPI Chip Select	Output	SPI Chip/Device Select signal for communication to other SPI peripherals
22	GPIO (6)	Input/Output	Detector SSWITCH (inverted)
23	N/A	N/A	Reserved
24	N/A	N/A	Reserved
25	Lamp Enable	Output	TTL signal driven Active HIGH when the Lamp Enable command is sent to the spectrometer
26	GPIO (7)	Input/Output	Detector SEVENCLK (inverted)
27	Ground	Input/Output	Ground
28	GPIO (8)	Input/Output	Detector SEVENRST (inverted)
29	Ground	Input/Output	Ground
30	GPIO (9)	Input/Output	Detector SODDRST (inverted)

Thermo-Electric Cooler (TEC)

The NIRQuest contains a TE cooled CCD and the electronics to driver it. The drive electronics were designed to only cool the device (no heating possible) and were optimized to generate the best cooling possible. The TE Cooler and electronics provide cooling for 30-43°C below ambient. Thus for an ambient temperature of 23°C, the cooling range is -7 to -20°C. The TE Cooler setpoint is user programmable in increments of 0.1°C over this range.

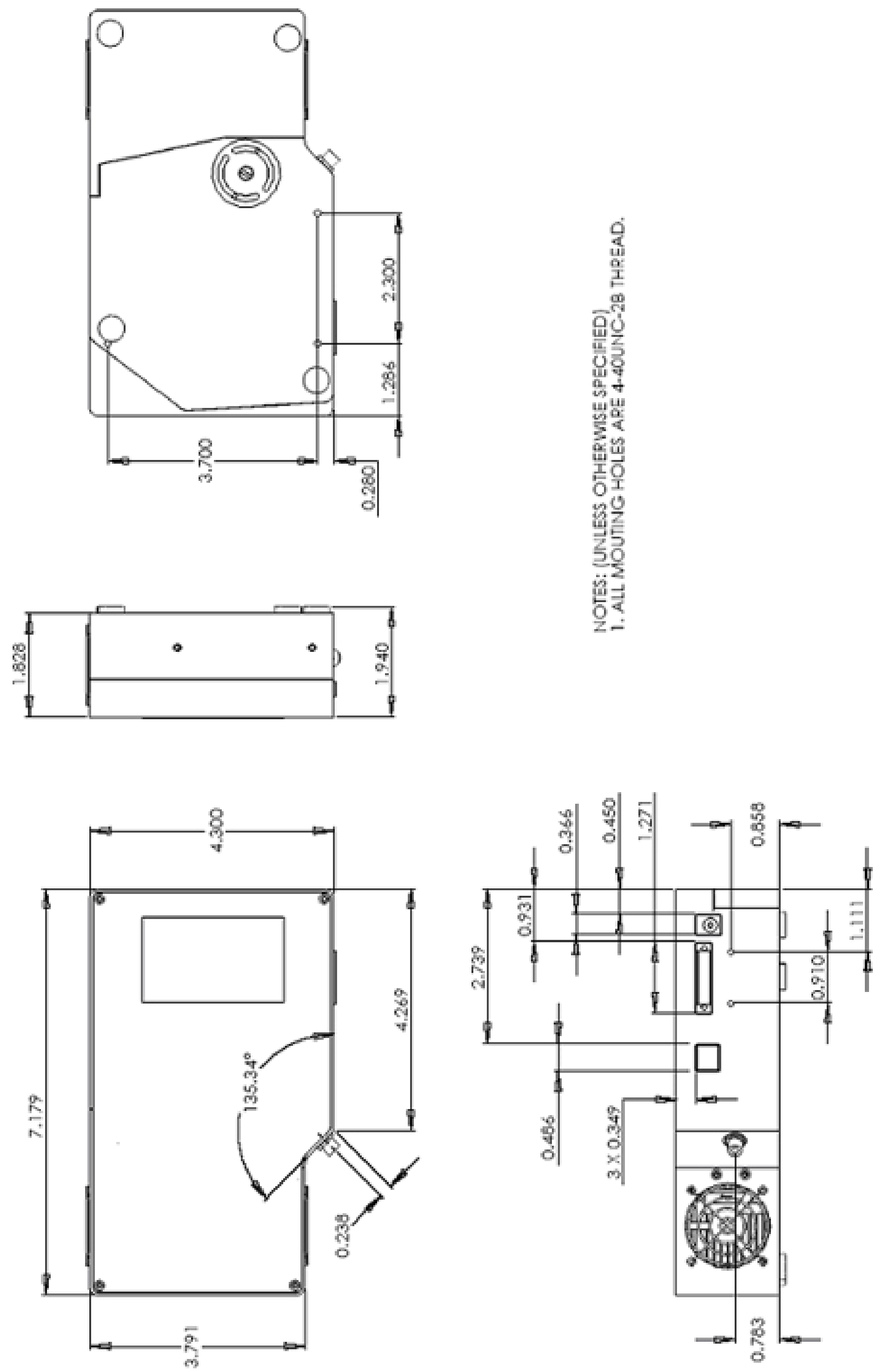
Tips for Using the TEC

- Ensure that the TEC power is always applied (TEC is enabled via SpectraSuite software) prior to USB power. When you first enable the TEC, wait a second before reading the temperature. If the TEC temperature is not decreasing, disable the TEC in software, wait a second and again enable the TEC. This ensures that the TEC always turns on.
- Don't query the TEC temperature more often than necessary. Doing so may cause the TEC to fail to report the correct temperature (although the TEC still remains in control at the last setpoint temperature). Changing temperature reporting to once a minute (once you've reached setpoint) should avoid the problem.
- Instability in the TEC setpoint temperature can result if trying to control the TEC temperature outside of the available range. A typical TEC plot of the TEC control range (22°C ambient) is shown below. For 22°C ambient, this unit will maintain control within the range -6°C to -28°C. However, if the ambient temperature were 32°C (e.g., as may happen if the spectrometer is installed within an enclosure), the control range would be expected to shift by +10°C (+4°C to -18°C) and the detector temperature would not be stable for a -20°C setpoint.



- When sending commands to the TEC, always wait 100ms between commands.

Mechanical Diagram



Hardware Description

The NIRQuest is controlled by a Cypress FX2LP microcontroller. This device has an 8051 processor core combined with an integrated USB 2.0 peripheral physical layer. Program code is stored in an external flash memory chip, and is loaded into the microcontroller at power-up via an I2C interface.

USB Information

Ocean Optics Vendor ID number is 0x2457. The NIRQuest512's Product ID is 0x1026 and the NIRQuest256 Product ID is 0x1028. The NIRQuest supports USB 2.0 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 NIRQuest through End Point 1 Out (EP1). Spectral data are acquired through End Point 2. All other queries are retrieved through End Point 1 In (EP1).

Pipe #	Description	Type	Full Speed Size (Bytes)	Endpoint Address
0	End Point 1 Out	Bulk	512	0x01
1	End Point 1 In	Bulk	512	0x82
2	End Point 6 In (unused)	Bulk	512	0x86
3	End Point 1 In	Bulk	512	0x81

USB Command Summary

EP2 Command Byte Value	Description	Version
0x01	Initialize Device	3.00.2
0x02	Set Integration Time	3.00.2
0x03	Set Strobe Enable Status	3.00.2
0x04	Reserved	3.00.2
0x05	Query Information	3.00.2
0x06	Write Information	3.00.2

EP2 Command Byte Value	Description	Version
0x07	Write Serial Number	3.00.2
0x08	Get Serial Number	3.00.2
0x09	Request Spectra	3.00.2
0x0A	Set Trigger Mode	3.00.2
0x71	Set TEC Controller State	3.00.2
0x0C	Set Detector Gain Mode	3.00.2
0x6C	Read PCB Temperature	
0x70	Set Fan State	3.00.2
0x1E	Stop Spectral Acquisition	3.00.2
0x73	TEC Controller Write	3.00.2
0x72	TEC Controller Read	3.00.2
0xFE	Query Status	3.00.2

Command Descriptions

A detailed description of all NIRQuest 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 NIRQuest

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 NIRQuest's integration time in milliseconds. The acceptable range is 1 – 1,600,000. If the value is less than 1ms then the integration time is set to 1ms.

Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0x02	Integration Time LSW LSB	Integration Time LSW MSB	Integration Time MSW LSB	Integration Time MSW MSB

Set Strobe Enable Status

Sets the NIRQuest 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 EP1 and the data is retrieved through EP1 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 19 configuration variables are indexed as follows:

Data Byte - Description
0 – Device 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 – Detector Serial Number
17 – Configuration Parameter Return
18 – Reserved
19 – Reserved

Byte Format

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4, 5	Byte 6, 7
0x05	Configuration Variable Return	0 = TEC Off 1 = TEC On	0 = TEC Off 1 = TEC On	LSB, MSB TEC Setpoint in tenths °C	LSB, MSB Saturation value*

*Saturation value is used to scale output at high signal and ~65K (minimum is 62K).

Return Format (EP1)

The data is returned in ASCII format and read in by the host through EP1 In.

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 EP1 and the data is retrieved through End Point 1. 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 1.

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

Request Spectrum

Initiates a spectrum acquisition. The NIRQuest will acquire a complete spectrum. The data is returned in bulk transfer mode through EP2 in packets each containing 64 bytes in USB 1.1 mode or 512 bytes in USB 2.0 mode. 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 (USB 1.1) or 512 bytes (USB 2.0). There is an additional packet containing one value that is used as a flag to insure proper synchronization between the PC and NIRQuest. Bit 15 has to be flipped before converting to an integer. The pixel values are decoded as described below.

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). NOTE: Bit 15 has to be flipped for every pixel before converting to an integer.

Packet 0

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

Packet 15 – Synchronization Packet (1 byte)

Byte 0
0x69

Autonulling

Slot 0x11 (17) contains autonulling information that has a scaling term used to adjust the magnitude of the entire spectrum. This can be read out by sending bytes 0x05 11 to the low-speed out endpoint (0x01) and then reading out 17 bytes from the low-speed in endpoint (0x81). The bytes of use are Byte offset 6 and 7. The 17 bytes will be formatted as follows:

0x05 11 XX XX XX XX SS SS XX XX XX XX XX XX XX XX XX

Where:

XX = reserved bytes (most are either unused or are only used internally to the device)

SS = saturation level of the device as two bytes (LSB followed by MSB).

These need to be assembled into a single 16-bit value. Any time that a spectrum is read from the spectrometer, each pixel's intensity value should be multiplied by (65535.0/saturation_level) to set the scale appropriately.

The contents of slot 0x11 are set at the factory and should not be altered.

Set Trigger Mode

Sets the NIRQuest Trigger mode to one of three states. If an unacceptable value is passed then the trigger state is unchanged (Refer to the NIRQuest manual for a description of the trigger modes).

Data Value = 0 ➔ Normal (Free running) Mode
Data Value = 3 ➔ External Hardware Trigger Mode

Byte Format

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

Read PCB/Read Heatsink Temperature

Description: Read the Printed Circuit Board Temperature and the heat sink temperature. The QE65000 contains two DS1721 temperature sensor chips—one of which is mounted to the main PCB and the other which is mounted close to the heat sink. This command is sent to End Point 1 Out and the data is retrieved through End Point 1 In. The values returned are two signed 16-bit A/D conversion value which is equated to temperature by:

Temperature (^{o}C) = .003906 * ADC Value

Byte Format

Byte 0
0x6C

Return Format (EP1In)

Byte 0	Byte 1	Byte 2
Read Result for PCB Temperature	ADC Value LSB	ADC Value MSB
Byte 3	Byte 4	Byte 5
Read Result for Heatsink Temperature	ADC Value LSB	ADC Value MSB

If the operation was successful, the Read Result byte value will be 0x08. All other values indicate the operation was unsuccessful

Set TEC Controller State

Enables/Disables the detectors TEC controller.

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

Byte Format

Byte 0	Byte 1	Byte 2
0x71	Data byte LSB	Data Byte MSB

Set Fan State

Description: Enables/Disables the FAN inside the NIRQuest. 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 = Nonzero ➔ Fan On

Byte Format

Byte 0	Byte 1	Byte 2
0x70	Data Byte LSB	Data Byte MSB

TEC Controller Write

Performs a write command to the TE 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.

Byte Format Set Point LSB

Byte 0	Byte 1	Byte 2
0x73	Set-point LSB	Set-point MSB

TEC Controller Read

Returns the detector temperature. The TE 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 EP1 and a total of 2 bytes data is retrieved through End Point 1 In.

Byte Format

Byte 0
0x72

Return Format

Byte 0	Byte 1
Temp LSB	Temp MSB

The Detector Temperature is a 16-bit signed value 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 1. 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 Spectrum	0 – No Spectrum 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

NIRQuest External Hardware Trigger and Single Strobe Performance

The NIRQuest FPGA has been enhanced to support External Hardware Trigger and Single Strobe Output generation. Under External Hardware Trigger Mode, the FPGA will hold off detector acquisition for the following start condition:

1. FX2 Microcontroller ready for new data (ReadEnable).
2. Rising edge on external input ExtTrigIn.
3. Programmed IntegrationDelay + Fixed DetRechgDly Time has elapsed.

The FPGA will also hold off Single Strobe Output generation for the following start condition:

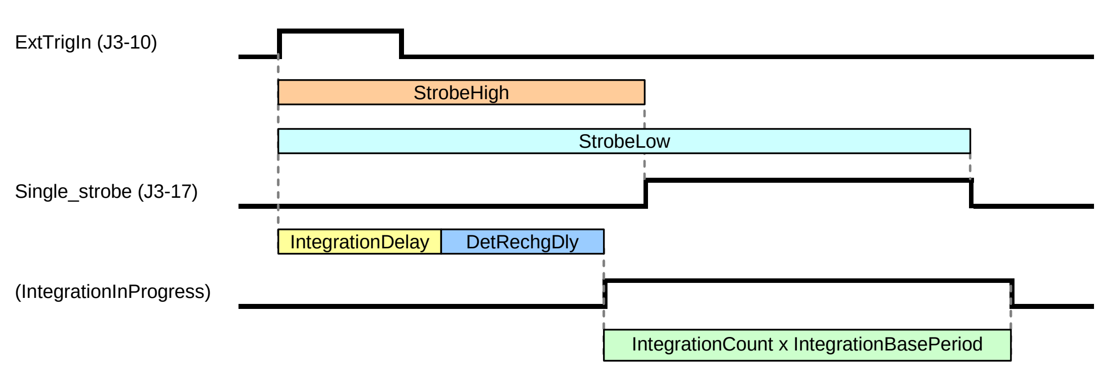
1. FX2 Microcontroller ready for new data (ReadEnable).
2. Rising edge on external input ExtTrigIn.
3. Programmed StrobeHi Time has elapsed before setting Single Strobe high.
4. Programmed StrobeLo Time has elapsed before returning Single Strobe low.

DetRechgDly is a minimum delay required to completely charge all of the detector's pixels before acquisition. This translates into a minimum trigger response time limitation (515 microseconds for NirQuest256 and 1030 microseconds for NirQuest512). The soonest the FPGA can start an acquisition would be the minimum trigger response time after the rising edge on ExtTrigIn.

An application can use the Single Strobe output to synchronize an event (for example, a light flashing) with the actual detector acquisition time. See the figure below:

SPI Register	Register Address	ns/count
IntegrationBasePeriod	0x10	1000
IntegrationCount	0x18	IntegrationBasePeriod
IntegrationDelay	0x28	500
TriggerMode	0x2C	0-Norm, 1-ExtTrig
StrobeHigh	0x38	500
StrobeLow	0x3C	500
LampEnable	0x40	0-LampOff, 1-LampOn

DetRechgDly (256 pixels) - 515 us
DetRechgDly (512 pixels) - 1030 .us



Example:

NIRQuest 256 (256 pixels)
Integration time of 2 ms

Example	EZ-USB command string	
Integration time of 2 ms	6A 10 E8 03	(1000 ns/IntegrationBasePeriod)
	6A 18 02 00	(2 IntegrationBasePeriods)
Start Integration 1.015 ms after rising edge of ExtTrigIn	6A 28 E8 03	(1000 x 500 ns + 515 us)
Start SingleStrobe 1.115 ms after rising edge of ExtTrigIn	6A 38 FC 08	(2300 x 500 ns)
Stop SingleStrobe 2.900 ms after rising edge of ExtTrigIn	6A 3C A8 16	(5800 x 500 ns)
Set TriggerMode to "ExtTrig"	6A 2C 01 00	(0-Norm, 1-ExtTrig)
Turn on "LampEnable"	6A 40 01 00	(0-LampOff, 1-LampOn)

Known Issues

CAUTION

Please be sure to download the latest version of SpectraSuite (2.0.140 released June 25, 2009 or later) for full functionality for the NIRQuest Spectrometer. Under certain situations (changing the default TEC temperature or changing the default Gain mode setting), internally stored information in the NIRQuest can be lost if you use an older version of Spectrasuite. Please contact your Ocean Optics representative for more information.

Other issues for the first release of NIRQuest include the following:

- High Gain mode requires independent linearity correction
- TEC Temperature continuous display update causes the scan to pause and can crash the system if the integration time is changed rapidly (e.g., scrolling with up/down arrows).
- TEC Temperature control can be lost after reading the temperature several hundred or several thousand times (and as a result the temperature will no longer be updated correctly). The TEC temperature is still controlled at the last setpoint under these conditions, but to fix the problem you must unplug both the USB and TEC power for 15s before repowering the device.

Appendix A:

NIRQuest Serial Port Interface Communications and Control Information

Overview

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

Hardware Description

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

Instruction Set

Command Syntax

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

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

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

Command Summary

Letter	Description	Version
A	Adds scans	2.00.0
B	Set Pixel Boxcar	2.00.0
C	Tec ON/OFF	2.00.0
D	Tec Setpoint	2.00.0
E		
F		
G	Set Data Compression	2.00.0
H		
I	Sets integration time(16-bit resolution)	2.00.0
J	Sets Lamp Enable Line	2.00.0
K	Changes baud rate	2.00.0
L	Clear Memory	
M		
N		
O		
P	Partial Pixel Mode	2.00.0
Q	Initialize Spectrometer	
R	Display Tec Current Temperature	2.00.0
S	Starts spectral acquisition with previously set parameters	2.00.0
T	Sets trigger mode	2.00.0
U		
V		
W	Write to FPGA Register	2.00.0
X		
Y		
Z		
a	Set ASCII mode for data values	2.00.0
b	Set binary mode for data values	2.00.0
i	Set integration time(32-bit resolution)	2.00.0
k	Sets Checksum mode	2.00.0
v	Provides microcode version #	2.00.0

Letter	Description	Version
x	Sets calibration coefficients	2.00.0
t	Reads the Board's temperature Degrees C	2.00.0
?	Queries parameter values	2.00.0

Command Descriptions

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

Add Scans

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

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

Pixel Boxcar Width

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

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

Turn TEC Cooler ON/OFF

Turns TEC on or off. If turned on , the TEC is driven to the set point value.

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

TEC Cooler Temperature Setpoint Degrees C°

Sets the TEC cooler temperature. The value passed is the temperature in tenths of a degree C.

Command Syntax:	D{DATA WORD}
Response:	ACK or NAK
Range:	-50 to –250* (Format is X10 e.g., –10ºC = -100)
Default value:	-100 (-10ºC)
Response:	ACK or NAK
* Typical control range for 22 ºC ambient is -7 to -20 ºC	

Set Data Compression

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

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

Integration Time

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

Command Syntax:	I{16 bit DATA WORD}
Response:	ACK or NAK
Range:	10 – 65,535
Default value:	10

Integration Time(32-Bit)

Same as above command(I) but uses 32-bit values.

Command Syntax:	i{DATA DWORD}
Value:	10 - 1600000000
Response:	ACK or NAK
Default value:	10

Lamp Enable

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

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

Baud Rate

Description: Sets the NIRQuest's baud rate.

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

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

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

Notes

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

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

Pixel Mode

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

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

Note

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

Read TEC Cooler Temperature in Degrees C°

Description: Returns the current temperature of the TEC Cooler.

Command Syntax:	R
Response:	ACK followed by {DATA WORD}
Default value	If stable then should reflect Setpoint. If not repeated R commands will show progression to setpoint temperature.

Spectral Acquisition

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

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

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

WORD 0xFFFF – start of spectrum

WORD 16Bit or 32Bit Flag. If 1 then DWORDS transmitted for spectral data values

WORD Add Scans

DWORD integration time in Milliseconds

WORD ALWAYS 0

WORD pixel mode

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

WORDs/DWORDs spectral data

WORD 0xFFFD – end of spectrum

Trigger Mode

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

Trigger Mode 4: This mode is called "Quasi-Real Time Acquisition" mode. In this mode we run the integration clock at a quick rate (150ms in the case of the NIRQuest). Once an acquisition is requested by the controller, the hardware waits until the current integration period expires and changes it to the desired rate which is typically much longer (i.e., many seconds). Once this integration period has expired, the integration time is changed back to the default rate and the detector is readout. In this mode, no external signal is required.

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

Write FPGA Register

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

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

Note

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

ASCII Data Mode

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

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

Notes

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

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

Binary Data Mode

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

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

Note

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

Checksum Mode

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

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

Version Number Query

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

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

Read Board Temperature

Returns the PCB temperature followed by the heatsink temperature in Degrees 100^{th}'s C. Response will x100 e.g. 25C = 2500

Command Syntax:	t
Value:	None
Response:	ACK followed by {DATA WORD}{DATA WORD}
Default value:	N/A

Calibration Constants

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

Command Syntax:	x{DATA WORD}{ASCII STRING}
Value:	DATA WORD Index description 0 – Serial Number 1 – 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 – NIRQuest configuration: AWL V A – Array coating Mfg, W – Array wavelength (VIS, UV, OFLV), L – L2 lens installed, V – CPLD Version 17 – Reserved 18 – Startup Baud Rate value 19 – Reserved
Response:	ACK or NAK
Default value:	N/A

Note

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

Query Variable

Description: Returns the current value of the parameter specified. The syntax of this command requires two ASCII characters. The second ASCII character corresponds to the command character which sets the parameter of interest (acceptable values are B, A, I, K, T, J, y). A special case of this command is ?x (lower case) which requires an additional data word 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 every 4^{th} pixel from the spectrometer with a 200ms integration time, set number of scan to add to 5 and operate at 115,200 Baud.

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

Application Tips

- During the software development phase of a project, the operating parameters of the NIRQuest may become out-of-synch with the controlling program. It is good practice to cycle power on the NIRQuest when errors occur.
- If you question the state of the NIRQuest, you can transmit a space (or another non-command) using a terminal emulator. If you receive a NAK, the NIRQuest 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:

5. Select **File | Properties**.
6. Under Connect using, select Direct to Com x.
7. Click Configure and match the following Port Settings:

   Bits per second (Baud rate): Set to desired rate

   Data bits: 8

   Parity: None

   Stop bits: 1

   Flow control: None

   Click **OK** in **Port Settings** and in **Properties** dialog boxes.

Technical Note 1: NIRQuest Data Compression

Transmission of spectral data over the serial port is a relatively slow process. Even at 115,200 baud, the transmission of a complete 3840 point spectrum takes around 600 msec. The NIRQuest 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 NIRQuest 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.
3. If the byte is equal to 0x80, the next two bytes are taken as the pixel value (16-bit **unsigned** integer).
4. 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.
5. Repeat step 2 until all pixels have been read.

Using this data compression algorithm greatly increases the data transfer speed of the NIRQuest. 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
86	-3	0xFD
88	2	0x02
98	10	0x0A
121	23	0x17

Pixel Value	Value Difference	Transmitted Bytes
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 require 80 bytes.

Technical Note 2: NIRQuest 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
210	-243	0x80 0x00 0xD2	0x0152
118	-92	0xA4	0x00A4
90	-28	0xE4	0x00E4
89	-1	0xFF	0x00FF

Data Value	Value Difference	Transmitted Bytes	Value added to Checksum
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
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.