AFBR-S20N1N256 Qneo Spectrometer Series

Qneo Industrial NIR Spectrometer

Data Sheet

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Chapter 1: Overview

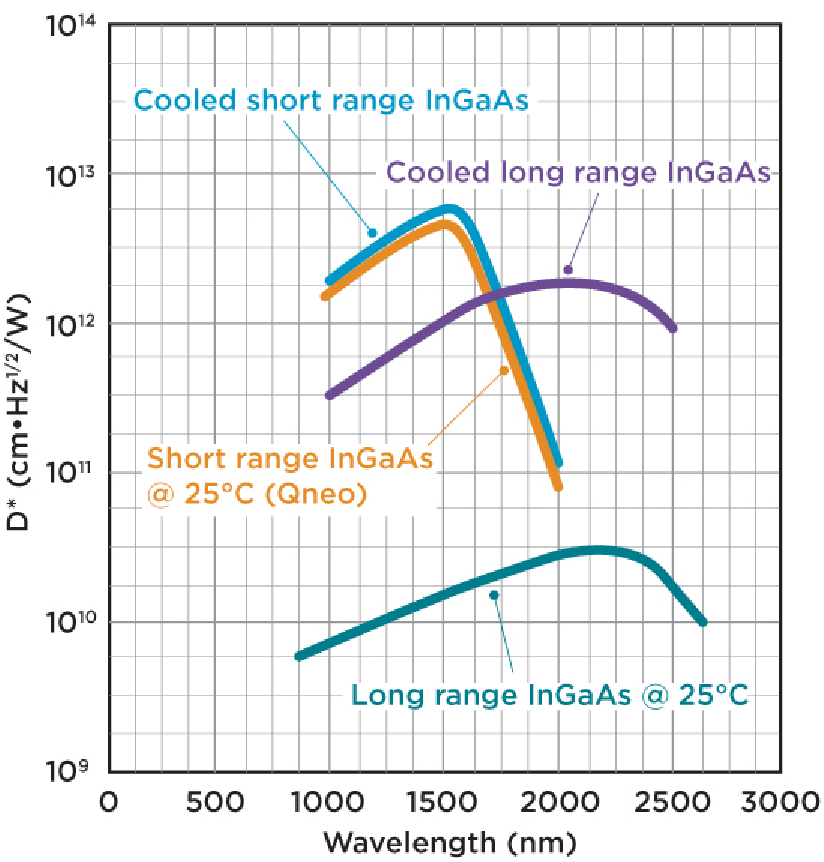
Spectroscopy is a powerful tool used to analyze the properties of materials and substances based on their interaction with light. In process analytics, mini spectrometers are used to monitor and control chemical reactions, assess the quality of materials, and optimize production processes. This chapter provides an overview of the Qneo NIR spectrometer, its specifications, possible applications, and package content.

1.1 Ordering Information

Table 1: Ordering Information

Part Number	Description	Wavelength Range	Typical Spectral Resolution (FWHM)	Blaze Wavelength
AFBR-S20N1N256	Qneo	950 nm to 1700 nm	8 nm	1250 nm

Figure 1: Typical Sensitivity Curve of IR Sensor Arrays



1.2 Features

This miniature near-infrared spectrometer is designed for flexible integration where space is limited. The Qneo offers high optical performance, is proven in industrial surroundings, is cost-effective, and features the following:

- Miniature design
- High spectral resolution
- High sensitivity and dynamic range
- Exceptional thermal stability
- 256-pixel linear uncooled InGaAs-Sensor
- Optical input via an SMA fiber connector or free focused beam
- Four I/O channels for external triggering, shutter control, and general-purpose I/O (GPIO)
- USB 2.0 (high speed), UART, and SPI communication interfaces
- Calibration data stored in internal memory
- Full processing of spectra in the device
- Averaging and smoothing
- Internal buffering of up to 75 spectra without binning
- Identical communication protocol for all interfaces

1.3 Applications

Broadcom spectrometers are the ideal tool for many optical measurement applications, such as the following:

- Light analysis
- Chemical research
- Raman spectroscopy
- Color measurement
- Quality control
- Counterfeit detection
- Environmental analysis
- Forensic analysis
- System integration
- Process control and monitoring

Chapter 2: Specifications

This chapter describes the full technical details of the Qneo spectrometer including optical, electrical, and mechanical specifications.

2.1 Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Max.	Unit	Notes
Supply Voltage	V_{DD}	—	–0.5	+5.5	V	a
Input Voltage	V_I	Trigger-I/O 0 through 3 and Enable USB input	–0.3	V_{DD}	V	
		All other pins on the auxiliary connector	–0.3	+3.6	V	
Storage Temperature	T_{STG}	—	–25	70	°C	
Operating Temperature	T_{OP}	Non-condensing	–15	55	°C	

a. V_{DD} supplied from USB or pin 1 (+5V_AUX_IN) on the auxiliary connector.

2.2 Optical Specifications

V_{DD} = +5V, T_{amb} = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Notes
Wavelength Range	R_{λ}	—	950	—	1700	nm	
Resolution (FWHM)	RES	—	—	8	—	nm	a
Wavelength Accuracy	—	—	—	2.7	—	nm	
Thermal Wavelength Drift	—	—	—	0.05	—	nm/°C	
Pixel Count	—	—	—	256	—	pixel	
Focal Length	—	—	—	40	—	mm	
Width of Entrance Slit	—	—	—	30	—	µm	
Numerical Aperture	NA	—	—	0.18	—	—	
Dynamic Range	DR	Single acquisition	—	12000:1	—	—	b
Bad Pixel	—	—	—	0	1	%	c
Signal-to-Noise Ratio	SNR	Value for each single pixel	10000:1	—	—	—	d
Stray Light	SL	—	—	0.1	—	%	e
Exposure Time	T_{EXP}	—	0.000004	—	300	s	
Trigger-to-Exposure Jitter	$Jitter_{Trigger}$	—	0	—	2	µs	

a. Valid only with a slit width of 30 µm.

b. DR (dynamic range) is defined as follows:
DR = saturation value / average readout noise

c. A hot or cold pixel is defined as a bad pixel. Two or more adjacent pixels are not allowed. The value refers to the complete pixel number of the used sensor.

d. SNR (signal-to-noise ratio) per pixel averaged over 100 single spectra is defined as follows:
SNR = saturation value / RMS noise

e. Measured with Long-Pass-Filter λ_{CutOn} = 1400 nm, FELH1400.

2.3 Electrical Specifications

V_{DD} = +5V, T_{amb} = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Notes
Supply Voltage	V_{DD}	—	+4.5	+5.0	+5.5	V	a
Input Voltage	V_I	Enable USB input	0	—	5.0	V	
		All other pins on the auxiliary connector	0	—	3.3	V	
HIGH-Level Input Voltage	V_{IH}	—	2.1	—	—	V	
LOW-Level Input Voltage	V_{IL}	—	—	—	0.7	V	
HIGH-Level Output Voltage	V_{OH}	—	2.6	3.3	—	V	
LOW-Level Output Voltage	V_{OL}	—	—	0	0.5	V	
Supply Current	I_I	—	—	30	—	mA	a, b
Output Current	I_O	All pins on the auxiliary connector	6	—	—	mA	
A/D Resolution	—	—	—	16	—	Bit	
A/D Sample Rate	—	—	—	770	—	kSa/s	
A/D Readout Time	—	Readout time of all pixels from the sensor	—	335	—	µs	
Pulsed Output Cycle Period	T_{PWMCP}	On each trigger-I/O	2000	50000	512000	µs	
Pulsed Output Duty Cycle	T_{PWMDC}	On each trigger-I/O	49	50	51	%	
UART Baud Rate	BR_{UART}	See Section 3.2.2 for more details.	300	57600	3000000	baud	
SPI Bit Rate	BR_{SPI}	See Section 3.2.3 for more details.	1	—	10	MHz	
Time to Reset the Device	T_{Reset}	Active low	1	—	—	ms	

a. V_{DD} supplied via USB or pin 1 (+5V_AUX_IN) on the auxiliary connector.

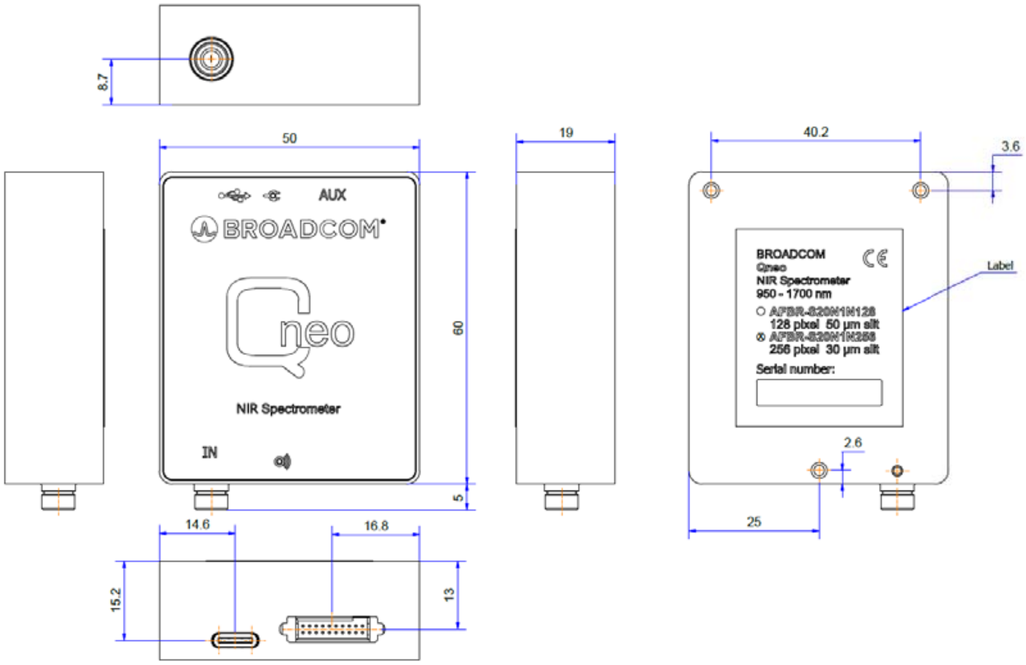
b. Device initialized and taking spectra; no additional connection or external load on the auxiliary connector.

2.4 Mechanical Specifications

Parameter	Symbol	Conditions	Typical	Unit
Weight	M	—	70	g
Dimensions	—	(L x W x H)	60.0 x 50.0 x 19.0	mm
Optical Input Connector	—	—	SMA 905	—

2.5 Technical Drawing

Figure 2: Broadcom Qneo NIR Spectrometer



2.6 Auxiliary Connector

The back-side connector of the spectrometer provides different input and output signals such as trigger-I/Os and standard serial communication interfaces such as USB, SPI, and UART.

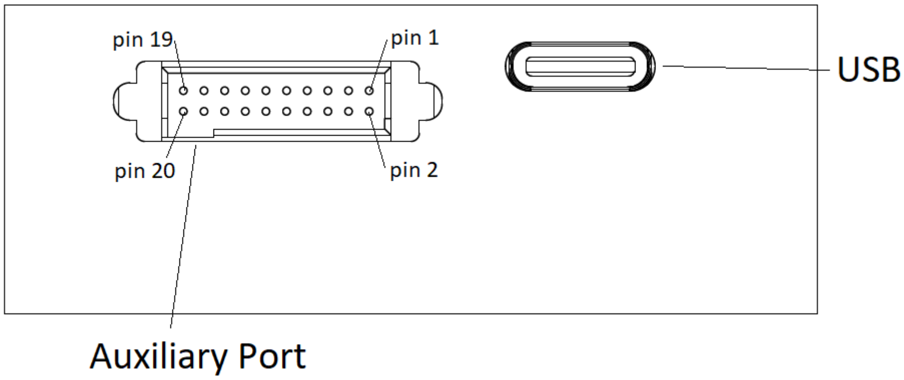
The connector used in the Qneo is a TFM-110-01-L-D-RE1-WT manufactured by Samtec.

The notch in the lower-left corner of the connector does not indicate the position of pin 1. Broadcom recommends using a wired connector.

Recommended mating connectors, which are fully loaded with 5-inch-long wires, are as follows:

- SFSD-10-28-G-05.00-SR (single-ended connector; open wires)
- SFSD-10-28-G-05.00-DR-NDX (double-ended connector; pin 1 to pin 1 connection)

Figure 3: 20-Pin Auxiliary Interface



The following table describes all of the interface pins. Contact Broadcom for additional information on the auxiliary interface.

Table 2: Auxiliary Interface Pin Descriptions

Pin Number	Signal Name	Type	Description	Notes
1	+5V_AUX_IN	PWR	Power input	
2	USB_DN	IO	USB bidirectional D– line	
3	GND	PWR	Ground	a
4	USB_DP	IO	USB bidirectional D+ line	
5	EN_USB	I	Enable USB on the auxiliary connector	b
6	TRIG_IO_0	IO	Low-latency trigger input/output	
7	TRIG_IO_1	IO	Low-latency trigger input/output	
8	TRIG_IO_2	IO	Low-latency trigger input/output	
9	TRIG_IO_3	IO	Low-latency trigger input/output	
10	GND	PWR	Ground	a
11	UART_RXD	I	Receiver input for UART	c
12	UART_TXD	O	Transmitter output for UART	
13	UART_CTS or I2C_SDA	I or IO	Clear to Send input for UART or Data input/output for I^2C	d
14	UART_RTS or I2C_SCL	O or I	Request to Send output for UART or Clock input for I^2C	d
15	GND	PWR	Ground	a
16	SPI_POCI	O	Peripheral Out Controller In for SPI	b
17	SPI_PICO	I	Peripheral In Controller Out for SPI	b
18	SPI_SCK	I	Serial Clock for SPI	b
19	SPI_CSn	I	Chip Select for SPI (low active)	c
20	RESETn	I	Reset input (low active)	c

a. Internally connected.
b. Internally pulled down.
c. Internally pulled up.
d. Not implemented in the current firmware. Contact Support for further information.

Chapter 3: Operation

The Qneo spectrometer is equipped with three serial communications interfaces (SPI, UART, and USB). This chapter describes this communication, other interactions such as trigger modes between, for example, light sources, and standard operation.

3.1 Trigger

Learn more about the trigger mode of the Qneo spectrometer.

3.1.1 Trigger Mode

The Qneo spectrometer provides a synchronous trigger. The exposure starts with the adjusted exposure time after receiving a trigger signal.

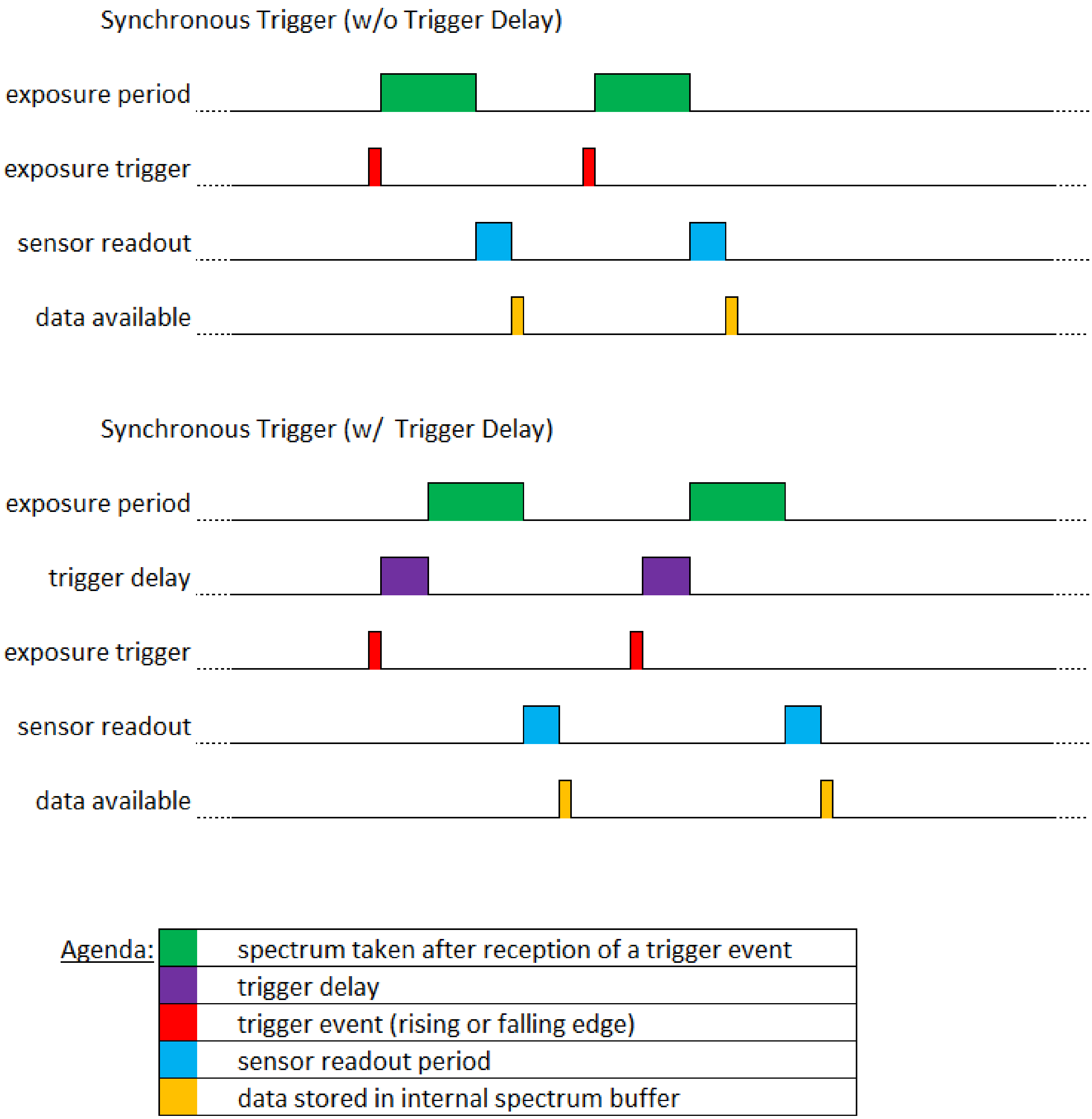
The trigger is usable via an internal (software) or external trigger event.

A trigger delay can be introduced between the trigger event and the actual start of the exposure. This can help to bypass the time a light source would need to provide a stable intensity.

After the exposure ends, the spectrometer reads the sensor data and stores it in the internal buffer memory.

Figure 4 shows the behavior of the trigger mode with and without the optional trigger delay. Each spectrum, which must be read out, must be triggered by a discrete trigger event. This means that in a series of spectra or if averaging is active, each single spectrum must be triggered for readout.

Figure 4: Trigger Mode Diagram



3.1.2 Trigger Pins

The auxiliary connector provides up to four trigger input and output pins (pin numbers 6 to 9). Regardless of the configured direction, the spectrometer can read the logical state of the pin.

Adjusted as an input, the pins detect logical voltage levels and can be used as an external trigger source. If a pin is configured as an output, several different output modes are supported, for example to control a shutter or a constant or flashing light source. The following table gives an overview of the output modes.

Table 3: Trigger Pin Configurations

Output Configuration	Description
Low	Output is always low.
High	Output is always high.
Low during exposure	Output is high and goes low during the exposure period.
High during exposure	Output is low and goes high during the exposure period.
Pulsed	Output is always pulsed with 50% duty cycle and the adjusted pulse period.
Pulsed low during exposure	Output is high and pulsed with 50% duty cycle and the adjusted pulse period during the exposure period.
Pulsed high during exposure	Output is low and pulsed with 50% duty cycle and the adjusted pulse period while exposure period.

For an external trigger event, each pin can be configured to receive the trigger event. The trigger is recognized on either the rising edge or the falling edge.

To use a channel as an external trigger source, perform the following steps (pin 2 is used in this explanation):

1. Configure trigger pin 2 as the input.
2. Set the trigger pin number to pin 2.
3. Select either the rising edge or the falling edge.
4. Set the trigger mode to external.

If a trigger pin is configured as an input and will receive external signals, it is recommended to directly connect a push-pull driver.

3.2 Communication Interfaces

The Qneo has three communication interfaces: USB, UART, and SPI. The communication is split into two layers: the interface layer and the message layer to control the spectrometer.

The interface layer is individual for each interface type, because it encapsulates the interface-specific properties. For USB, the USB stack implements the interface layer; and for UART and SPI, it is implemented in software. This layer has the message layer as a payload. The message layer contains the commands that control the spectrometer. It is the same for all interfaces. This makes it very simple to switch to another interface if application requirements change. For a detailed description, refer to the NioLink manual.

3.2.1 USB

The Qneo provides one 480 Mb/s USB 2.0 interface and one 12 Mb/s full speed USB 2.0 interface. The High speed interface comes with a USB Type-C connector, whereas the other one is integrated on the auxiliary connector for embedded integration. The two interfaces cannot be used at the same time. If both interfaces are connected, the USB interface on the auxiliary connector is preferred and the USB on the Type-C connector is disabled. To enable the USB interface on the auxiliary connector, 5V must be applied to pin 1 (+5V_AUX_IN) and pin 5 (EN_USB).

3.2.2 UART

The Universal Asynchronous Receiver/Transmitter interface is located on pins 11 and 12. The additional signals CTS and RTS for hardware flow control are located on pins 13 and 14. At this time, flow control is not supported by the firmware. If your application requires dedicated flow control, contact the Broadcom support team. Using an RS-232 level shifter, it is also possible to have a regular RS-232 interface for serial communication. The communication parameters are 8N1, which means 8 data bits, no parity and 1 stop bit. The following baud rates are available: 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200, 128000, 230400, 256000, 460800, 921600, and 3Mbaud. The standard baud rate is configured to 57600 baud and can be changed after device initialization. For the command description of the UART interface, refer to the NioLink protocol manual.

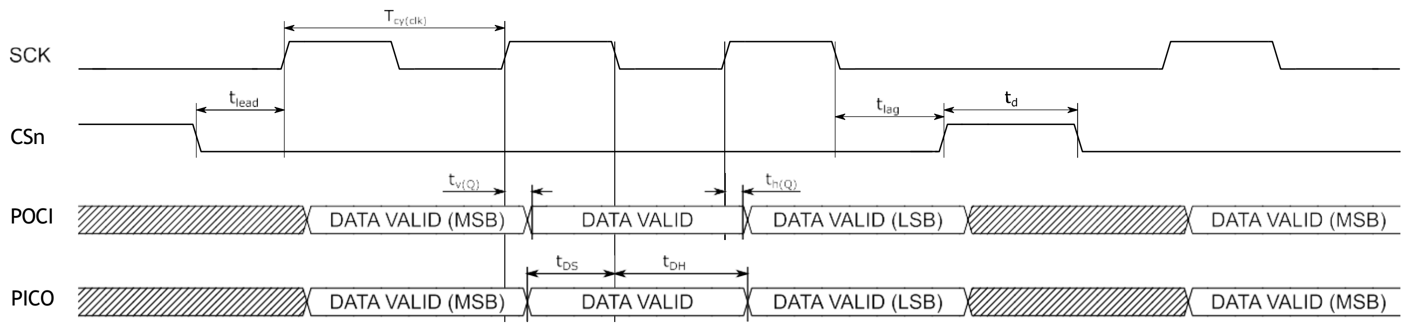
3.2.3 SPI

The Serial Peripheral Interface consists of four signals, PICO, POCI, SCLK, and CSn, which are located on the auxiliary connector from pin 11 to pin 14. The SPI interface is primarily intended to be used in embedded systems for communication with microcontrollers. The interface operates in SPI mode 1, which has a clock polarity (CPOL) = 0 and a clock phase (CPHA) = 1. Table 4 and Figure 5 show the communication timings. For a command description of the SPI interface, refer to the NioLink protocol manual.

Table 4: SPI Interface Timing Values

Parameter	Symbol	Min.	Max.	Unit
Clock Cycle Time	$t_{cy(clk)}$	100	1000	ns
Data Setup Time	t_{DS}	4	—	ns
Data Hold Time	t_{DH}	0	—	ns
Data Output Valid Time	$t_{v(Q)}$	6	15	ns
Data Output Hold Time	$t_{h(Q)}$	6	15	ns
Lead Time	t_{lead}	$t_{cy(clk)}$	—	ns
Lag Time	t_{lag}	0.5 x $t_{cy(clk)}$	—	ns
Delay Time	t_d	$t_{cy(clk)}$	—	ns

Figure 5: SPI Interface Timing Diagram



3.3 Other Signals on the Auxiliary Connector

If the spectrometer must be set back to the initial state, a reset input is available. Its polarity is active low, and connecting the pin to the GND signal will reset the device. All settings that were not stored persistent will be lost.

3.4 LEDs

The Qneo spectrometer integrates a green LED and a red LED to indicate different device states. The following table shows the meaning of the LEDs.

Table 5: LED Status

Red LED	Green LED	Description
Off	Off	Device is not supplied.
On	On	Device is supplied, but not enumerated or initialized.
Off	On	Device is enumerated or initialized and in the idle state.
Pulsed On	On	Device is in the operational state, and the sensor is exposed.
Pulsed On	Off	Device is in the bootloader state and awaiting new firmware.

3.5 Spectrum Processing

There are several spectrum processing steps available which can automatically applied to raw spectra before it is stored in the internal spectrum buffer. All steps can individually turned on and off. Without any processing you get the raw image sensor signal. The following table lists and describes these processing steps.

Table 6: Processing Steps

Processing Type	Description	Default Setting
Adjust Offset	Adjust the offset of the spectrum using the calibrated offset spectrum from the calibration data.	Yes
Correct Nonlinearity	Correct the nonlinearity of the intensity axis.	Yes
Remove Permanent Bad Pixels	Mask permanent bad pixels.	Yes
Subtract Dark	Adjust the dark signal of the spectrum using the calibrated dark spectra from the calibration data.	Yes
Remove Temporary Bad Pixels	Mask single pixel spikes (N/A for Qneo)	No
Compensate Stray Light	Estimate the amount of stray light and compensate it (N/A for Qneo).	No
Normalize Exposure Time	Normalize the spectrum to an exposure time of 1 second.	Yes
Sensitivity Calibration	Use the sensitivity calibration to correct the spectral sensitivity.	No
Correct PRNU	Correct the photo response nonuniformity.	Yes
Additional Filtering	Apply additional filtering (Savitzky-Golay 3rd order 5 pixels).	Yes
Scale to 16-Bit Range	Scale values to a range of 0 – 65534 and clip larger values to 65535.	No

3.6 Calibration

An individual calibration is performed in the final test of the production process. This data is stored in the internal memory of the Qneo. This so called user calibration can be overwritten by a customer-specific calibration. A second set of calibration data represents the factory calibration and is used only if the user calibration will be reset to the factory settings. The data of the user calibration is used to correct the raw spectra according to the activated processing steps.

Chapter 4: Software

4.1 Waves Spectroscopy Software

The Broadcom® free-to-use and feature-rich Waves spectroscopy software enables you to use our spectrometers for spectra acquisition, manipulating or analyzing spectra, adjusting the trigger pins, and much more. It also provides functions to do customer calibrations for wavelength, spectral sensitivity, nonlinearity, and more. For a more detailed description, refer to the Waves user manual on the Broadcom website.

4.2 Software Development Kit

The SDK for the spectrometer can be used to control it and take spectra from additional custom software. The SDK includes a Windows dynamic link library (DLL) for the .NET framework, documentation, and sample code. The SDK can be downloaded from the Broadcom website and is free to use.

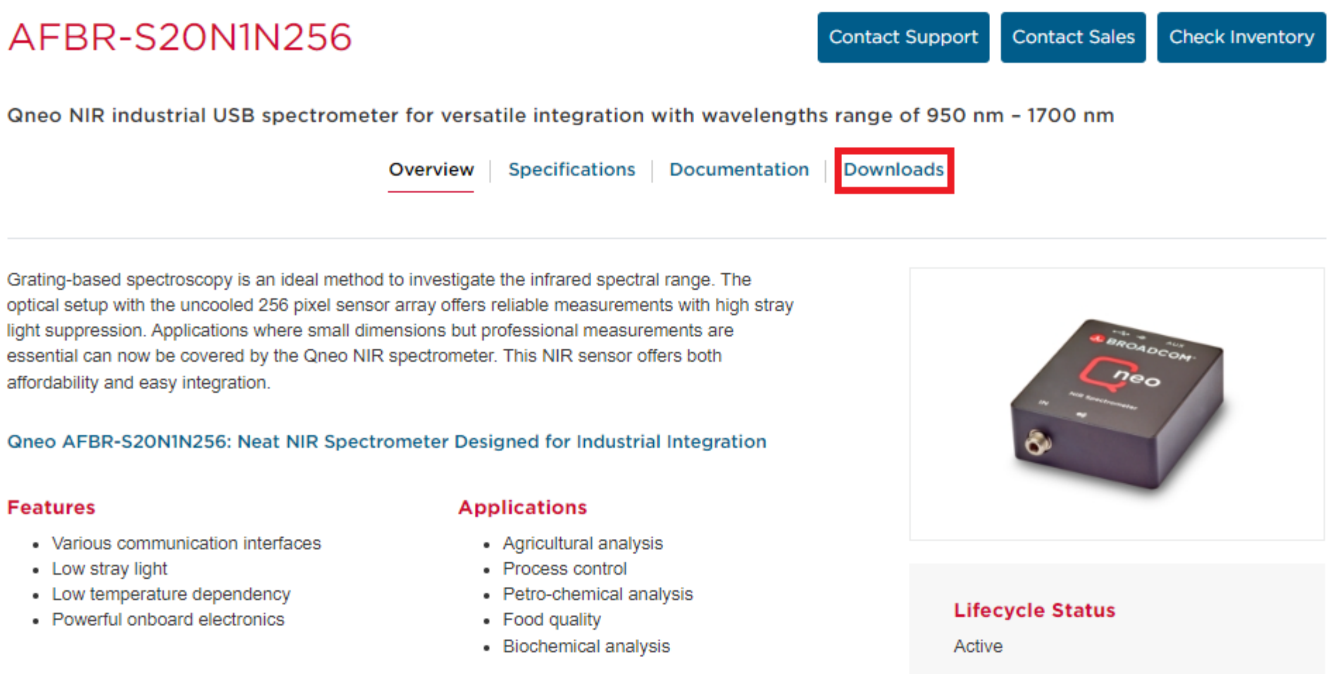
Alternatively, it is possible to directly communicate with the spectrometer from custom software including embedded systems. The open binary-based and intuitive-to-use communication protocol NioLink enables you to control the spectrometer in a very flexible way. See the communication protocol manuals in the SDK for additional details.

You can download the latest version of Waves and the SDK from each product page on the Broadcom website.

4.3 Software Updates

Software updates are available on the Broadcom website. Find the latest version on each product page.

https://www.broadcom.com/products/optical-sensors/spectrometers



Chapter 5: Technical Support

This chapter provides some information on troubleshooting and getting direct help from the support team, if you face any problems or need help to successfully evaluate the Broadcom Qneo spectrometer.

5.1 Package Contents

The package contains the spectrometer only. Powerful electronics are integrated into the spectrometer housing. Links to the documentation, software development kit (SDK), and software are written on a small note inside the spectrometer package.

5.2 Customization

If your application needs a special configuration, for example a different wavelength range, contact Broadcom to discuss your OEM module by sending an email to support.spectrometer@broadcom.com.

5.3 Getting Help

For any questions, comments, or requests concerning the spectrometer, Waves software, or the SDK, contact the Technical Support Team via email (support.spectrometer@broadcom.com).

5.4 Troubleshooting

This section helps identify problems connecting to the spectrometer and how to proceed.

5.4.1 Green and Red LEDs Are Continuously Lit

Green and red LEDs that are continuously lit indicate that the device driver is not installed or the initial USB enumeration was not completed. This behavior applies only to the USB interface that is used for spectrometer control. Check your USB cable and connection on your PC, and, if need be, try a different USB cable or USB connection. For the UART or SPI, check your connection or verify the correct command for initializing the spectrometer.

5.4.2 Software Cannot Find the Device

Disconnect and reconnect the spectrometer, wait a few seconds, and click the Rescan button to update the device list. If this does not resolve the issue, restart the PC and try again.

Check the website for software updates.

If the software still cannot find the device, check the Device Manager from the Windows Control Panel. The spectrometer should display as Qneo in the Measurement and Control category. If the spectrometer is marked with an exclamation or question mark, remove the device, uninstall the software from the Windows Control Panel, restart the PC, and install the software again.

If the spectrometer is not listed in the Device Manager, try a different USB port. If the device does not work on one PC, but works on other PCs, the USB port may not provide enough power for the spectrometer. In this case, use an externally powered USB hub.

If you use your own developed software, try to connect to the spectrometer with the Broadcom Waves software.

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