PEBBLE
Ultra Compact and High Performance Spectrometer from Ibsen Photonics

Ibsen photonics

PEBBLE Spectrometer – For Ultra Compact Instrumentation

The ultra compact PEBBLE spectrometers come in a VIS, VIS-NIR, and a NIR version. They combine small size with high resolution and sensitivity as well as environmental ruggedness. These miniature spectrometers are the ideal OEM solution for all those handheld and portable system applications, where performance cannot be sacrificed to obtain compactness and/or low cost.

Key Specifications of the PEBBLE

- Wavelength ranges:
  VIS range 360 – 830 nm
  VIS-NIR range 500 – 1100 nm
  NIR range 950 – 1700 nm
- Ultra compact size of only 20 x 15 x 8 mm (VIS/VIS-NIR) and 23 x 21 x 8 mm (NIR).
- Resolution from 6 nm (360 – 830 nm),
  8 nm (500 – 1100 nm) and 12 nm (950 – 1700 nm),
  The high NA combined with a high sensitive CMOS detector provides the advantage of high speed.
- Compact DISB electronics or optional OEM interface to the diode array through a flex connector
- Robust and athermal design

Layout and Design

The PEBBLE is based on Ibsen Photonics' LGL platform utilizing a collimating lens, a transmission grating and a focusing lens. The PEBBLE uses a high diffraction efficiency fused silica transmission grating produced by Ibsen Photonics internally.

The numerical aperture of the spectrometer is 0.22 (equivalent to a F-number of 2.2), which means that the spectrometer can accept a wide cone of light.

High Performance Spectrocopy in an Ultra Compact Size

The PEBBLE platform of ultra compact spectrometers has a form factor of only 20 x 15 x 8 mm for the VIS/VIS-NIR option and 23 x 21 x 8 mm for the NIR option. These spectrometers offer high resolution and sensitivity as well as environmental ruggedness.

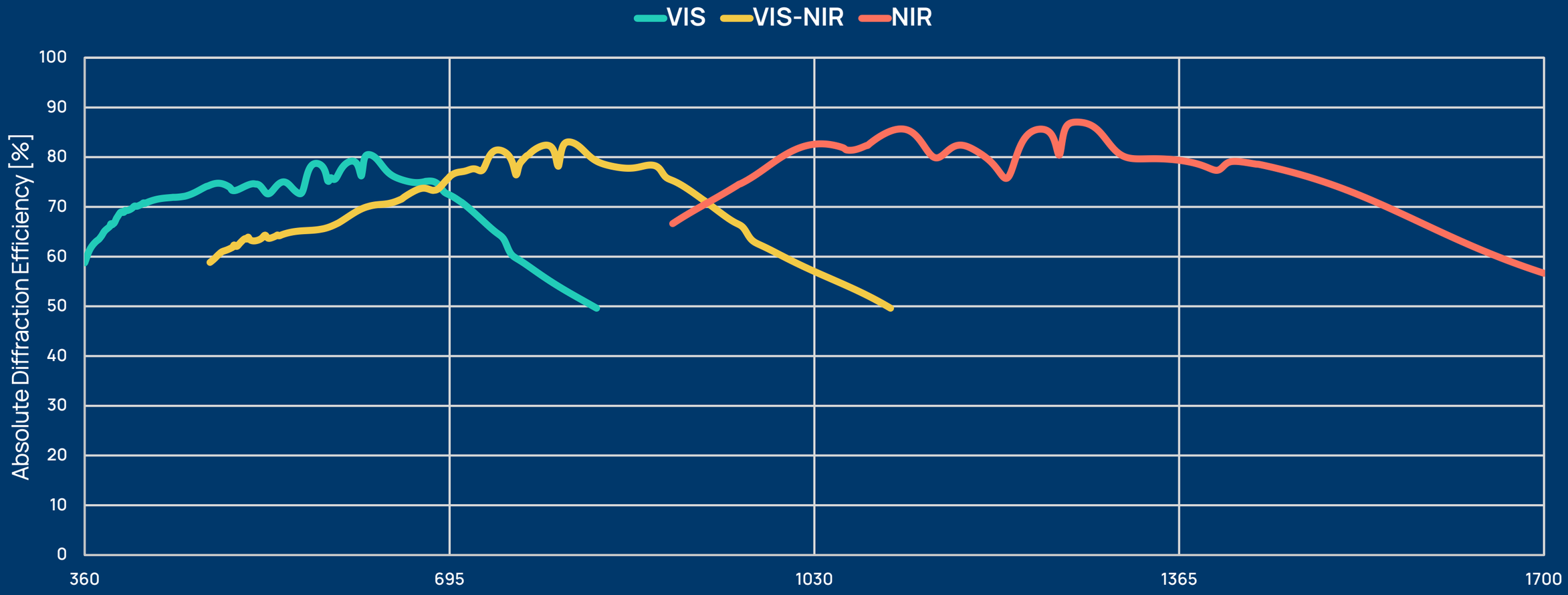
With our PEBBLE spectrometers, we are addressing the market demand for cost-efficient yet high performance spectral sensors with excellent transferability. The use of transmission-based optics inside PEBBLE ensures excellent thermal stability and makes it ideal for real-time measurements in the field. It also guarantees that PEBBLE can be manufactured in high quantities with low unit-to-unit performance variations.

The PEBBLE spectrometers offer a cost-effective and low-risk solution for integrators of handheld and portable multi-spectral instruments for biophotonics, medical, food, and precision agriculture applications based on fluorescence, color measurements or absorbance measurements.

Technical Specifications

		PEBBLE VIS	PEBBLE VIS-NIR	PEBBLE NIR
Spectral range		360 – 830 nm	500 – 1100 nm	950 – 1700 nm
Wavelength accuracy		<1 nm	<1 nm	<1 nm
Resolution*	Slit width 12.5 µm 25 µm 35 µm	5.2 nm 11.5 nm	6.7 nm 15.9 nm	9.5 nm 12.9 nm
Slit height		250 µm	250 µm	250 µm
Numerical aperture		0.22	0.22	0.22
Stray light	Monochromatic input	< 0.03 % (at +/- 10 x FWHM from peak)	< 0.03 % (at +/- 10 x FWHM from peak)	< 0.03 % (at +/- 10 x FWHM from peak)
Detector		Hamamatsu S14739-20 CMOS 256 14 x 200 µm SNR 380:1 Dynamic range 2150:1	Hamamatsu S14739-20 CMOS 256 14 x 200 µm SNR 380:1 Dynamic range 2150:1	Hamamatsu G13913 Un-cooled InGaAs 256 (Only the central 128 pixels are used) 25 x 250 µm SNR 1300:1 Dynamic range 12000:1
Interface		SPI or USB 2.0	SPI or USB 2.0	SPI or USB 2.0
Optical Input	The optical input has to be defined at the time of ordering and cannot be changed later on	Free space to slit/SMA fiber coupling	Free space to slit/SMA fiber coupling	Free space to slit/SMA fiber coupling
Electronics option		DISB-105	DISB-105	DISB-400
Temperature induced drift		< 0.02 nm/ °C	< 0.02 nm/ °C	< 0.06 nm/ °C
Operating temperature range	Non-condensing	0 to +50 °C	0 to +50 °C	0 to +50 °C
Storage temperature range	Non-condensing	-40 to +65 °C	-40 to +65 °C	-20 to +70 °C
Dimensions	Excluding electronics	20 mm x 15 mm x 8 mm	20 mm x 15 mm x 8 mm	23 mm x 21 mm x 8 mm
Weight	Excluding electronics	< 5 g	< 5 g	< 5 g

*Typical values



Transmission Gratings

The PEBBLE spectrometer platform utilizes the Ibsen Photonics' VIS, VIS-NIR, and NIR transmission gratings. The grating provides a high even diffraction efficiency, as evident by the absolute diffraction efficiency graph display above.

Additionally, the transmission grating itself, ensure great wavelength stability due to the inherent self-correction nature of transmission gratings, compensating for misalignment, shock or vibrations that the spectrometer may experience.

The design also provides very low polarization dependence as an added benefit.

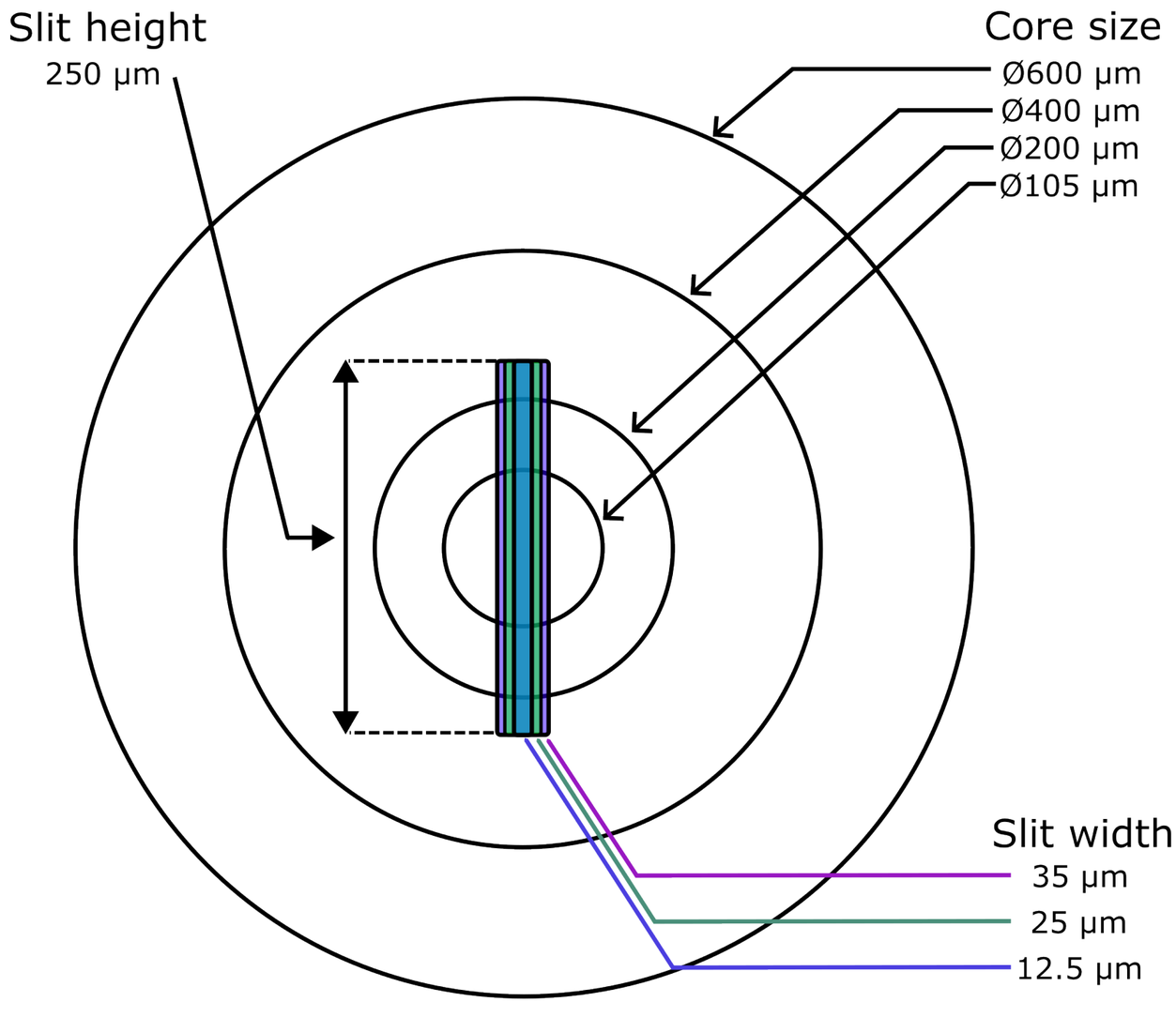
Every grating used in the PEBBLE spectrometer platform is a master grating, fabricated at Ibsen Photonics' clean-room facility in Denmark.

Optical Fiber Coupling

Optical fiber coupling is most often used for its convenience with regard to lack of alignment and ease of setup process. For best signal strength, the diameter of the optical fiber core should be chosen such that the entire slit is illuminated evenly.

The standard slit height of PEBBLE spectrometers is 250 µm, and the optical fiber core size should be larger than this to ensure the best performance.The common size available would be 400 µm or 600 µm diameter core.

The below illustration shows the different optical fiber sizes concerning the series of standard slit sizes, offered for the PEBBLE spectrometer platform.



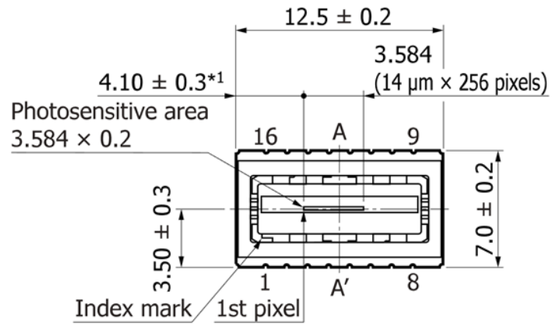
Detectors

The PEBBLE platform supports two different detectors as standard, specifically selected for allowing VIS and NIR spectroscopy in a compact and cost-effective package. These detectors are referred to via the last three numbers of the spectrometer product, namely 105 (for VIS/VIS-NIR) and 400 (NIR).

105 – Hamamatsu S14739-20

Access the same well-rounded performance of the S11639 CMOS detector, but in an even smaller package. With 256 x 1 pixels of 14 x 200 µm in size, the detector still allows for great coupling with the spectrometer slit dimensions while being extremely small and versatile.

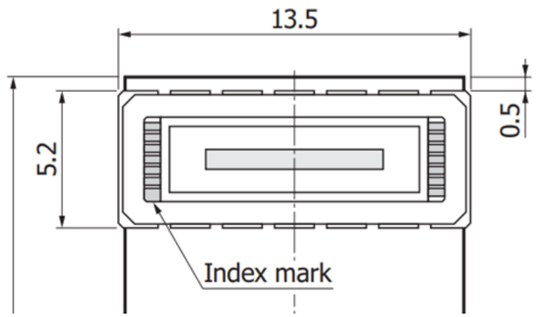
The quantum efficiency of the small CMOS detector remains high and a high conversion factor and shallow well depth make this detector particularly sensitive. This combined with the fast exposure time of 10.8 µs, robust nature and simple CMOS readout logic, makes it the detector of the choice for many applications.

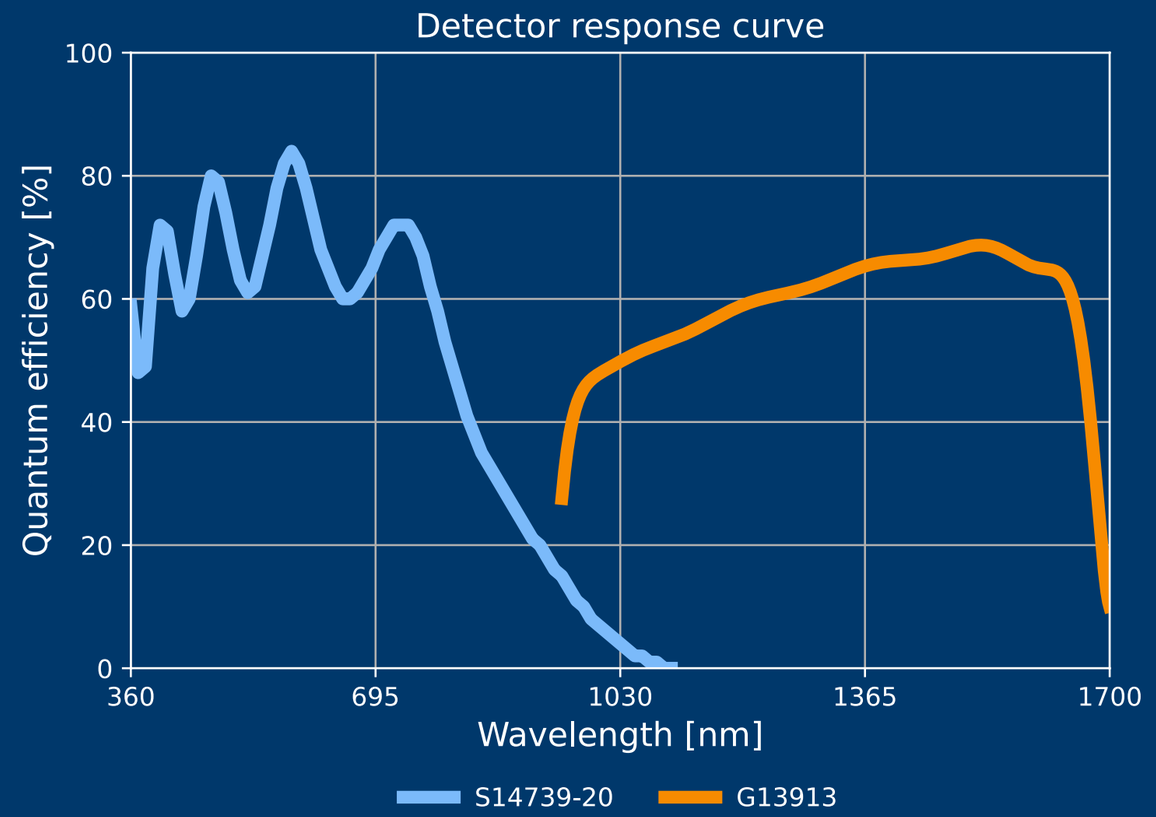


400 – Hamamatsu G13913

One of the smallest InGaAs-based detector arrays on the market, enabling system manufactures to unlock extremely cost-effective NIR spectroscopy. The 256 x 1 pixels of 25 x 250 µm in size allow for a reasonable resolution in a broad NIR wavelength area.

The detector exhibits low current consumption for easier integration into systems which are battery driven and the possibility of switching between two different conversion efficiency levels for increased dynamic range. While the dark current and thermal noise are higher for InGaAs-based detectors than Silicon based ones, the lower limit operating temperature of the detector allows for the detector to be cooled such that the dark current and thermal noise can be significantly decreased.





Electronics

Every PEBBLE spectrometer can be supplied with one of three different electronic configurations depending on the desired level of integration.

The spectrometer can be purchased without any accompanying electronics, giving direct access to the pins on the chosen detector. Alternatively, Ibsen Photonics can supply its Digital Image Sensor Boards (**DISB)**, designed to operate the detector of choice via hardware commands over a Serial Peripheral Interface (**SPI**). The DISB electronics can also be supplied with a **DISB to USB Bridge** board, which converts the SPI connection to a standard USB 2.0 for convenient connection to a PC.

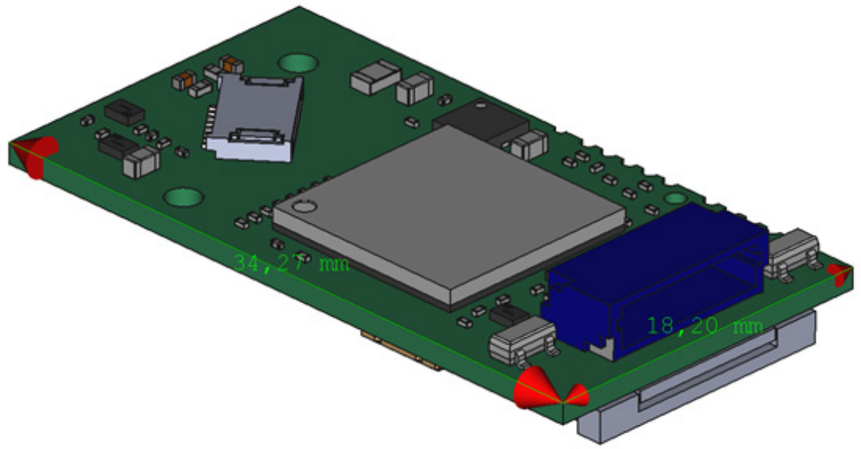
DISB electronics

The PEBBLE VIS and VIS-NIR spectrometers can be supplied with the DISB-105 electronics, which are specifically made for the Hamamatsu S14739-20 (105 detector), while the PEBBLE NIR spectrometer can be supplied with the DISB-400 electronics, which are specifically made for the Hamamatsu G13913 (400 detector).

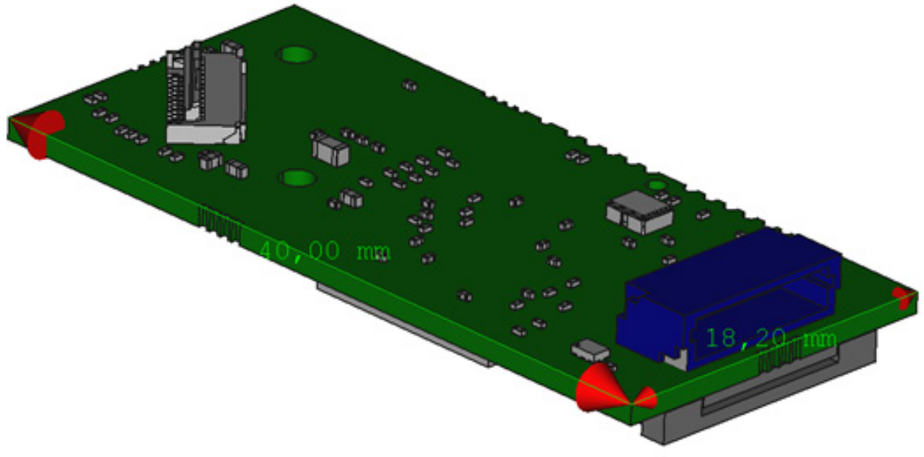
Both electronic boards are design with compactness in mind, while still having a lot of versatility, such as allowing region of interest readout of the detector pixels, which can increase the spectrum readout speed of the spectrometer.

	DISB-105	DISB-400
Read-out speed	4800 Hz (256 pixels)	3640 Hz (256 pixels)
A/D bit depth	16-bit	16-bit
Communication interface	SPI	SPI
Software trigger	Yes	Yes
Ext. hardware trigger	Yes	Yes
Min. trigger delay	1.2 µs	2.504 µs
Trigger jitter	10 ns	10 ns
Time increments	200 ns	0.5 µs
Exposure time	10.8 µs – 859 s	1 µs – 4293 s
On-Board calibration data	Yes	Yes
On-Board averaging	Yes	Yes
GPIO pinout	Yes	Yes
Programmable lamp control	Yes	Yes
Region of interest	Yes	Yes
Temperature sensor	Yes	Yes

DISB-105



DISB - 400



Software interfacing

The **DISB-to-USB bridge** board developed by Ibsen Photonics is an additional board that can be added to any spectrometer equipped with DISB electronics, to convert the DISB's SPI connection to a standard USB 2.0 connector, for convenient use via a standard PC.

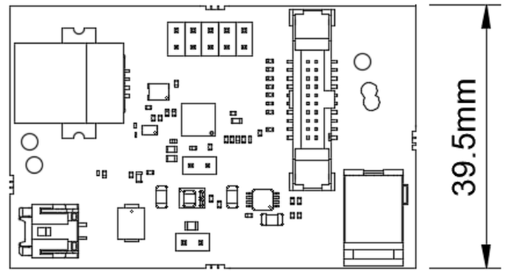
The DISB-to-USB board is based around the **FTDI FT4222H** chipset, with drivers available for Windows, Linux, or Mac. The entire USB protocol is handled in the chip with no requirement for specific complicated USB firmware programming.

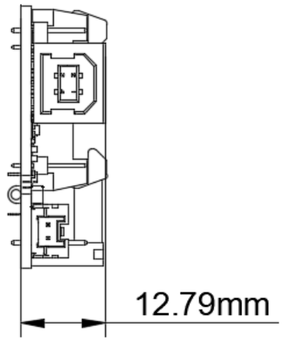
Ibsen Photonics supplies its LabVIEW-developed **Ibsen DISB-USB Evaluation software** as standard with the bridge board. This allows for the operation of the spectrometer and its features in a straightforward fashion using the Windows Operation system.

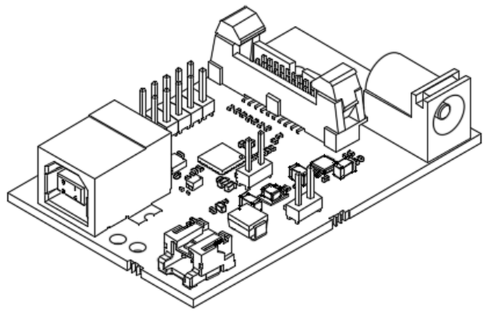
Additionally, an **SDK** is available for the Bridge board, allowing for simple, intuitive, and fast deployment of instruction sets and code via C/C++, C#, LabVIEW, Python, or MATLAB, via DLL and accompanying header files. The proprietary Ibsen command set allows for initialization, spectrum capturing, and closing of the spectrometer connection, with as little as three commands, as shown below.

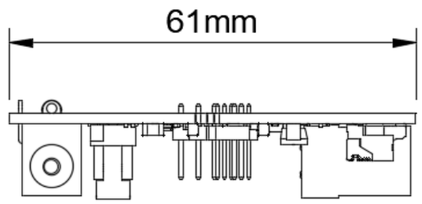
IBSEN_InitSpectrometer → **IBSEN_produceSpectra** → **IBSEN_closeDevice**

It is also possible to interface with FT4222H library files directly. Code samples using C/C++, C#, LabVIEW, and Python are available, if you need to develop your own implementation from the ground up.



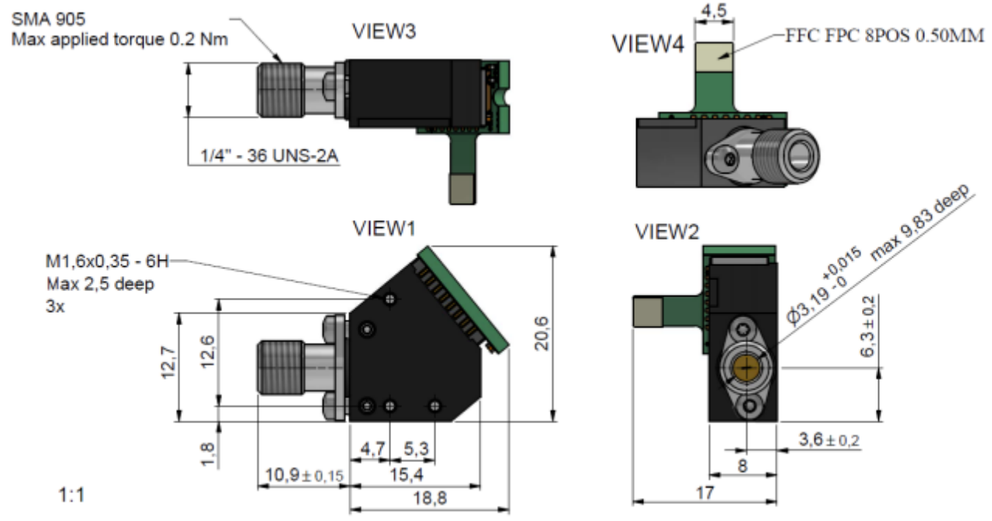




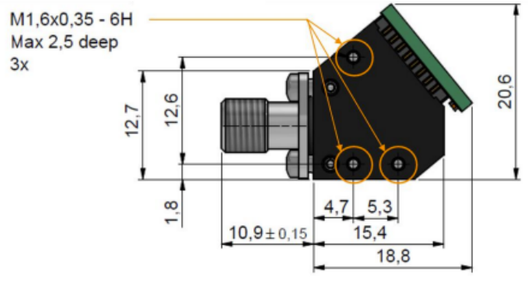


Mechanical Drawings

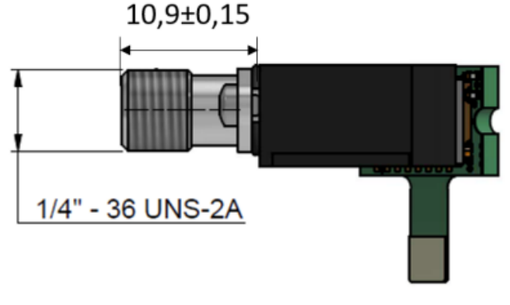
PEBBLE VIS and PEBBLE VIS-NIR



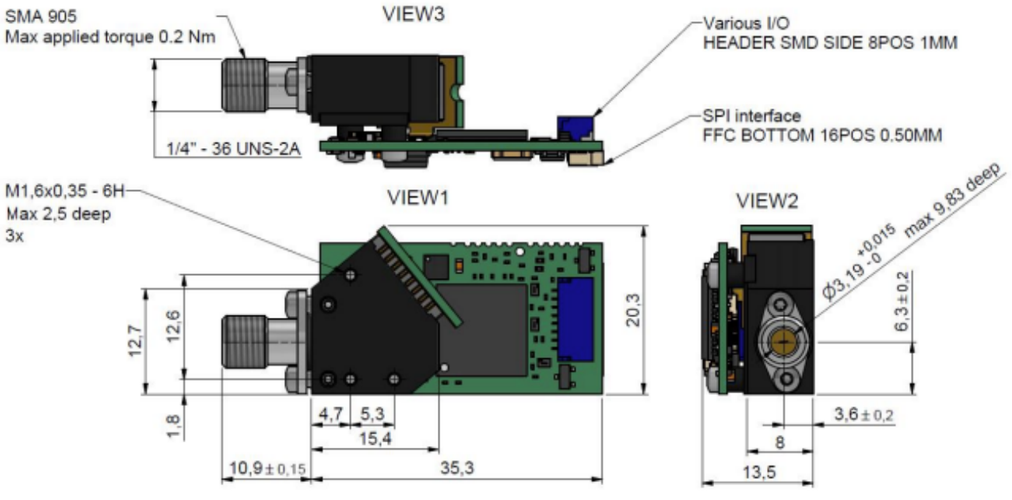
Package Dimensions Exemplified for PEBBLE VIS/VIS-NIR with SMA



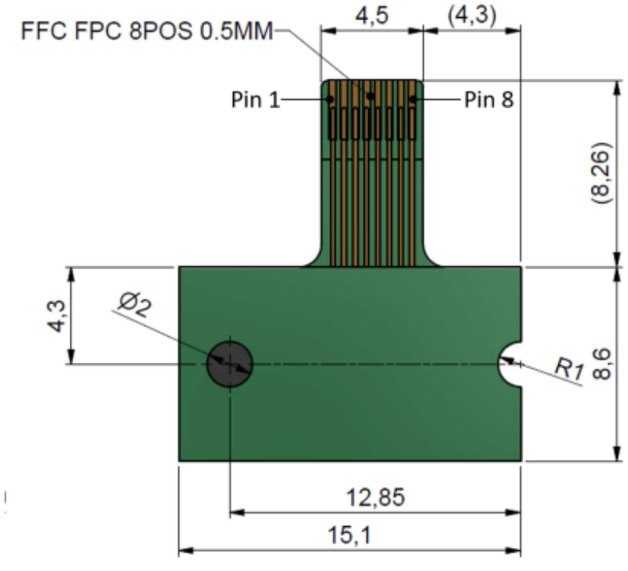
Spectrometer Mounting



Maximum Screw in Depth for SMA Hexagon Nut Types



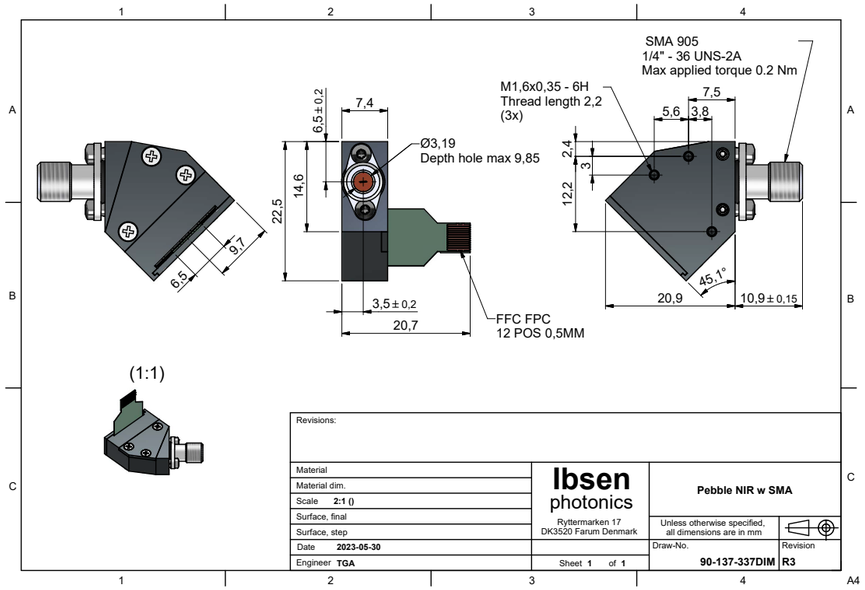
Package Dimensions Exemplified for PEBBLE VIS/VIS-NIR with SMA and DISB



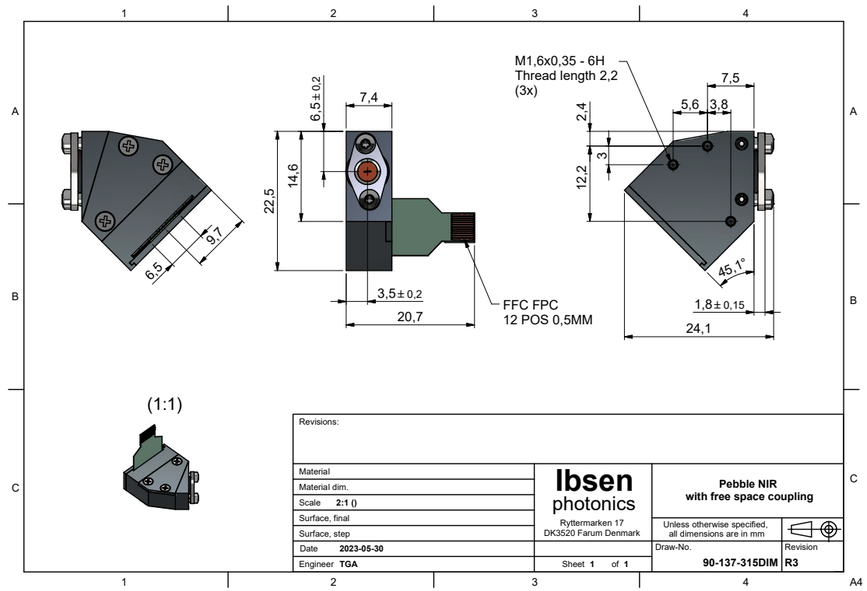
Flex Connector

Mechanical Drawings

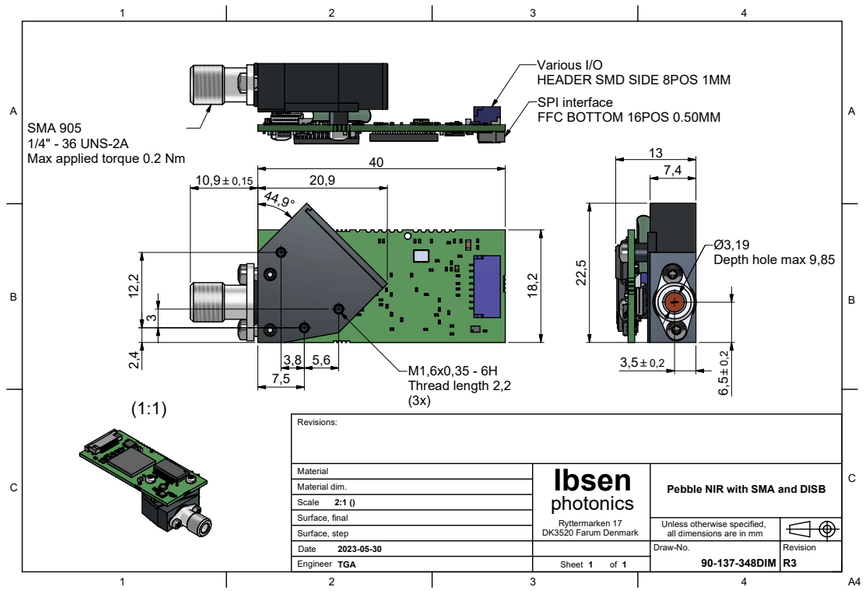
PEBBLE NIR with SMA



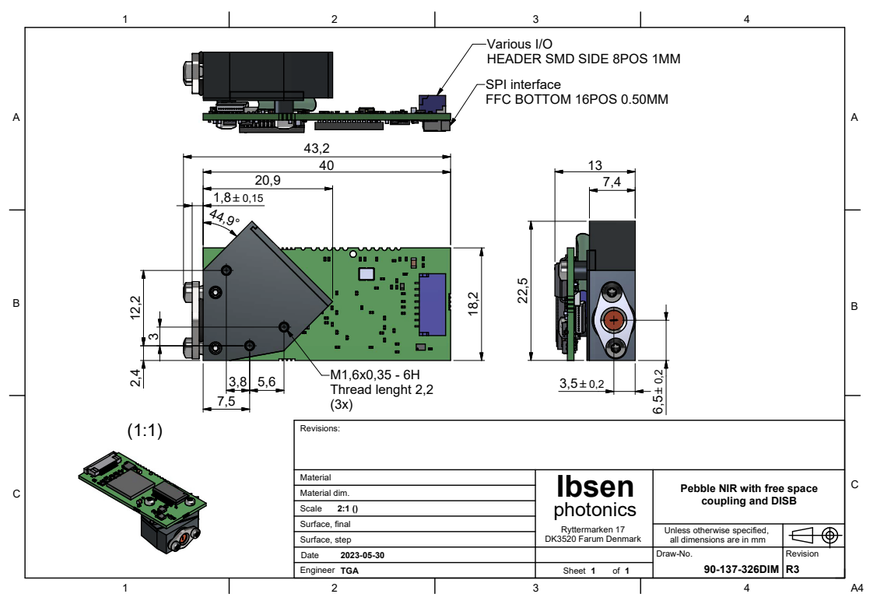
PEBBLE NIR with Free Space Coupling



PEBBLE NIR with SMA and DISB



PEBBLE NIR with Free Space Coupling and DISB



About Ibsen Photonics

Ibsen was founded in 1991 by Per Ibsen under the name of Ibsen Micro Structures A/S. Today 88% of Ibsen Photonics' share is majority owned by Foss A/S, a world leader in analytical solutions for the Food and Agricultural industries. Ibsen management and employees hold the remaining 12 % of the shares.

The Ibsen spirit combines the dynamic, entrepreneurial culture of a medium size company with a disciplined, operational mentality of a large corporation. With an average employee tenure of more than 10 years, Ibsen makes for a very effective organization that builds on more than 30 years of experience as a company.

Ibsen employs more than 90 people at our R&D and manufacturing facility in Denmark and has achieved a turnover of more than 180 MDKK in 2022.

Working with Ibsen Photonics

The core expertise of Ibsen Photonics lies in the opto-mechanical design, grating technology and metrology. We master the cycle from optics, grating simulation and design, through optical and semiconductor production technologies, to high volume assembly, packaging and testing. Over the years we have developed many new designs, technologies and processes - many patented.

Our customers are large to medium-sized manufacturers of advanced optical devices and instruments, into which our products are integrated. With a highly organized production process, we are able to help customers obtain smooth instrument production, low unit-to-unit variation, high level of right first time, no field returns, and a low level of rework.

Our grating production facilities are world-class, including class 10 cleanroom facilities that we designed and built in 2000/2001, in which all environmental parameters are under continuous surveillance.

Our spectrometers are produced under strict quality control in our assembly facility in Denmark. We have been granted ISO 9001, ISO 13485, ISO 14001 and ISO 45001. This confirms Ibsen's' consistent capability to produce high quality products that meet market standards and all regulatory requirements.

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