## Key Features

- Large active area up to 10 x 15 cm
- Up to 10 lp/mm resolution
- Gigabit Ethernet interface (Camera Link optional)
- 14-bit digital video output
- Energy range 10 - 225 kV
- Ready-to-run software and drivers

## Applications

- Industrial inspection, biomedical and scientific

# Shad-o-Box High Speed Industrial X-Ray Detectors

## Overview

Teledyne DALSA's *Shad-o-Box HS* product family of digital x-ray cameras offers users a high-speed, high-performance x-ray imaging detector with a fast, reliable Gigabit Ethernet interface. The cameras in this product line are capable of frame rates up to 66 fps (even higher in 2 x 2 binned mode), and communicate via a standard Cat6e data cable over lengths up to 100 m. The detectors are available with different scintillator options to address a range of resolution and sensitivity requirements, making this camera an ideal choice for industrial inspection, biomedical and scientific x-ray imaging applications.

The Shad-o-Box HS product line leverages Teledyne DALSA's advanced CMOS image sensing technology, which enables the delivery of low-dose x-ray images and yields higher image quality than a-Si flat panels and image intensifier devices. Camera features include: (1) large active area of up to 10 x 15 cm; (2) several different resolution (pixel size) options; (3) fast, real-time image transfer via Gigabit Ethernet interface; (4) 14-bit digitization of images; and (5) SDK's, drivers and programming support. The camera interface allows easy access to features such as adjusting the frame rate, single and multiple frame acquisitions, and control of advanced timing modes. Each camera ships with our ShadoCam Imaging application and Teledyne DALSA's CamExpert software, which provide simple, user-friendly tools for communicating with the camera and acquiring images.

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# Description

Shad-o-Box HS cameras contain a large-area, high-resolution CMOS detector with a photodiode pixel array featuring five standard size options of approximately 2x2, 2x6, 3x4, 4x6 and 5x5 inches. The cameras are available in different resolution models featuring either a 99µm or 49.5µm pixel size.
All detectors are capable of real-time, full-resolution imaging at frame rates up to 66 fps.

The detector array consists of a single CMOS die (no tiling) that contains multiple output taps to enable high frame rates. The video signal is digitized to 14 bits, reassembled (deinterlaced) within the camera's FPGA, and then transferred directly to the host memory via a high-speed Gigabit Ethernet interface.

The CMOS sensor inside the Shad-o-Box HS camera contains a direct-contact $Gd_2O_2S$ scintillator such as Carestream Min-R® 2190 or Mitsubishi Chemical DRZ (a CsI option is also available – please contact us for details). The scintillator converts x-ray photons into visible light that is sensed by the CMOS photodiodes. A thin graphite cover protects the sensor from accidental damage as well as ambient light. The Shad-o-Box HS camera also contains lead and steel shielding to protect the camera electronics from the x-ray radiation. The cameras are sensitive to x-ray energies as low as 15 keV and may be used with generators up to 225 kVp. Please refer to our application notes for additional information.

## Shad-o-Box HS Camera Options

| Device | Number of Pixels | Active Area | Resolution | Max. Frame Rate |
|---|---|---|---|---|
| **Shad-o-Box 1280 HS** | 1280 x 1280 | 12.8 x 12.8 cm | 99 µm | 40 fps[1] |
| **Shad-o-Box 688 HS** | 1032 x 688 | 10.2 x 6.8 cm | 99 µm | 66 fps |
| **Shad-o-Box 1548 HS** | 1032 x 1548 | 10.2 x 15.3 cm | 99 µm | 30 fps |
| **Shad-o-Box 1K HS** | 1152 x 1300 | 5.7 x 6.4 cm | 49.5 µm | 30 fps |
| **Shad-o-Box 2K HS** | 1152 x 2940 | 5.7 x 14.6 cm | 49.5 µm | 10 fps |
| **Shad-o-Box 3K HS** | 2304 x 1300 | 11.4 x 6.4 cm | 49.5 µm | 30 fps[1] |
| **Shad-o-Box 6K HS** | 2304 x 2940 | 11.4 x 14.6 cm | 49.5 µm | 15 fps[1] |

[1] Turbo Drive enabled.

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# Specifications

| Detector Specifications | Value | Units |
|---|---|---|
| Typ. dark current (23°C) [1][4] | 12 | ADU/s[2] |
| Read noise (rms) | 4-8 | ADU |
| Typ. dynamic range | 3000:1 | |
| Digitization | 14 | bits |
| Image lag | <0.1 | % |
| Non-linearity (10..90% FS) | <1.5 | % |
| Readout period [3][4] | 22 | ms |
| Max. frame rate (full res.) [4] | 30 | fps |
| Output data rate | 40 | MHz |

[1] dark current doubles approx. every 8°C
[2] ADU = Analog-Digital Unit = 1 LSB (Least Significant Bit)
[3] time required to transfer image from sensor to camera memory

| Camera Specifications | Value | Units |
|---|---|---|
| Typical supply voltage | 12.0 | Volts |
| Supply voltage range | 11 to 13 | Volts |
| Maximum supply current [4] | 1.0 | Amps |
| Typical power dissipation | < 10 | Watts |
| Camera interface | Gigabit Ethernet | |
| Trigger connector | TTL | |

| General Specifications | Value | Units |
|---|---|---|
| Operating temperature | 10 to 40 | °C |
| Storage temperature | -10 to +55 | °C |
| Humidity (non-condensing) | 10 to 80 | % R.H. |
| Weight [4][5] | < 3.5 | kg |

[4] depends on detector model
[5] Shad-o-Box 1K HS < 1 kg

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# Resolution & Sensitivity

The Shad-o-Box HS cameras are designed to work with x-ray sources operating at a wide range of kVp settings. X-ray energies as low as 10-15 keV can be detected. The cameras can be used with x-ray energies as high as 225kV, although we recommend the use of additional shielding and/or collimation at higher energies in order to protect the sensor element and electronics from damage.

The pixel spacing of each camera model determines the limiting resolution of the sensor. The actual Modulation Transfer Function (MTF) of the detector depends on the type of scintillator that is installed. A thicker phosphor screen will produce more signal, but at the expense of high-frequency contrast. Typical MTF curves for the two standard scintillator options are shown in the graph below.

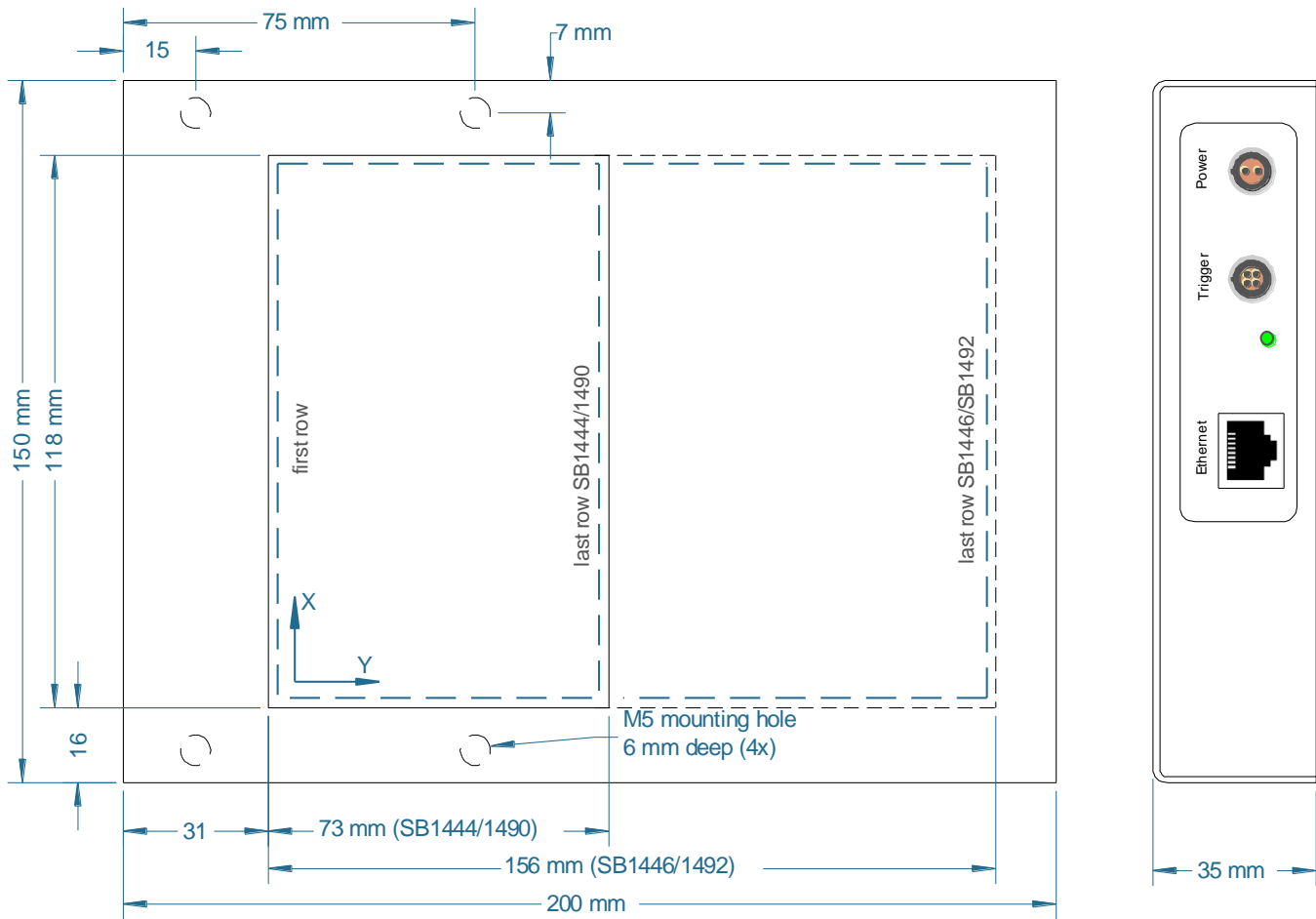| Detector | Typical Sensitivity [1] |
|---|---|
| 688/1548 HS (with Min-R 2190) | 3.8 ADU/µR @ 50kVp<br>5.0 ADU/µR @ 80kVp |
| 688/1548/1280 HS (with DRZ-Std) | 9.7 ADU/µR @ 50kVp<br>13.7 ADU/µR @ 80kVp |
| 1K/2K/3K/6K HS (with Min-R 2190) | 0.8 ADU/µR @ 50kVp |



MTF for Shad-o-Box HS Detectors
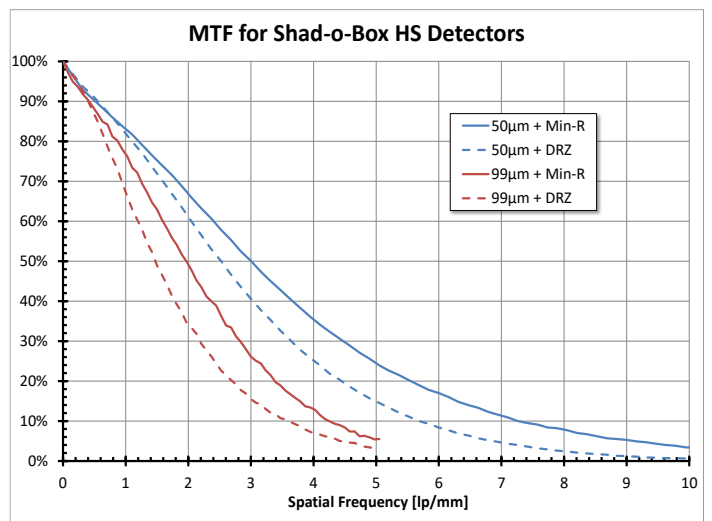
[1] W target, 2 mm glass window, no filtration

# Software

Each Shad-o-Box HS camera ships with our ShadoCam Imaging application, Teledyne DALSA's CamExpert software and a Gigabit Ethernet driver. The software is compatible with Windows 7, 8 and 10. Check with your sales representative for compatibility with other Windows versions or with the Linux operating system. The camera can be connected on a network, but for optimal performance a dedicated network adapter is highly recommended.

For writing custom applications to acquire images from the camera, we recommend using Teledyne DALSA's Sapera Essential, or the Sapera LT SDK (free download available at http://www.teledynedalsa.com/imaging/products/software/sapera/lt/).

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# Mechanical Drawing: 688/1548/3K/6K Models



75 mm
15
7 mm
150 mm
118 mm
16
first row
last row SB1444/1490
last row SB1446/SB1492
X
Y
M5 mounting hole
6 mm deep (4x)
31
73 mm (SB1444/1490)
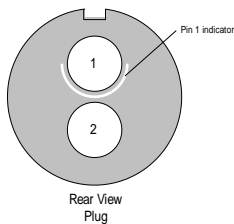156 mm (SB1446/1492)
200 mm

Power
Trigger
Ethernet
35 mm

**Data Connector:**

RJ45 HALO HFJ11-1G16E-L12RL

**Power Connector:**

2-pin LEMO EGG.0B.0302
Pin 1   +12 VDC
Pin 2   ground

Power Connector

Pin 1 indicator
1
2
Rear View
Plug

**Trigger I/O Connector:**

4-pin LEMO EGG.0B.0304
TTL (open collector),
opto-isolated
Pin 1   Trig out+
Pin 2   Trig out–
Pin 3   Trig in+
Pin 4   Trig in–

I/O Connector

Pin 1 indicator
1      4
2      3
Rear View
Plug

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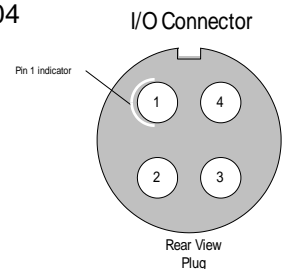
# Mechanical Drawing: Shad-o-Box 1280 HS



**Data Connector:**

RJ45 HALO HFJ11-1G16E-L12RL

**Power Connector:**

2-pin LEMO EGG.0B.0302

Pin 1   +12 VDC
Pin 2   ground

Power Connector

Pin 1 indicator

Rear View
Plug

**Trigger I/O Connector:**

4-pin LEMO EGG.0B.0304
TTL (open collector), opto-isolated
Pin 1   Trig out+
Pin 2   Trig out–
Pin 3   Trig in+
Pin 4   Trig in–

I/O Connector

Pin 1 indicator

Rear View
Plug

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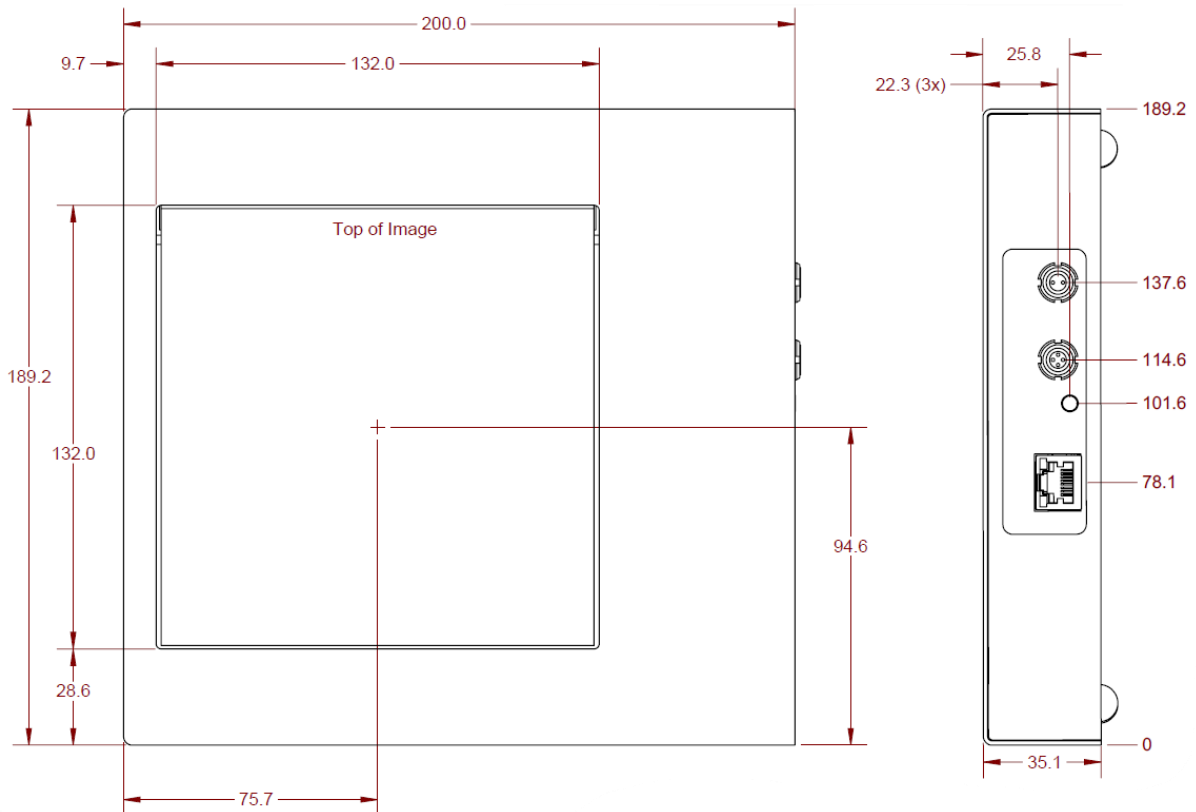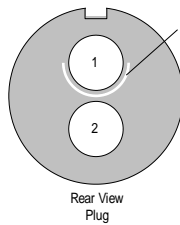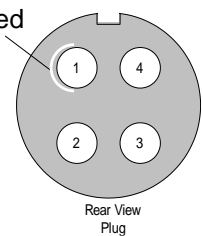
# Mechanical Drawing: Shad-o-Box 1K HS



**Data Connector:**

RJ45 HALO HFJ11-1G16E-L12RL

**Power Connector:**

2-pin LEMO EGG.0B.0302
Pin 1   +12 VDC
Pin 2   ground

Power Connector



Pin 1 indicator

Rear View
Plug

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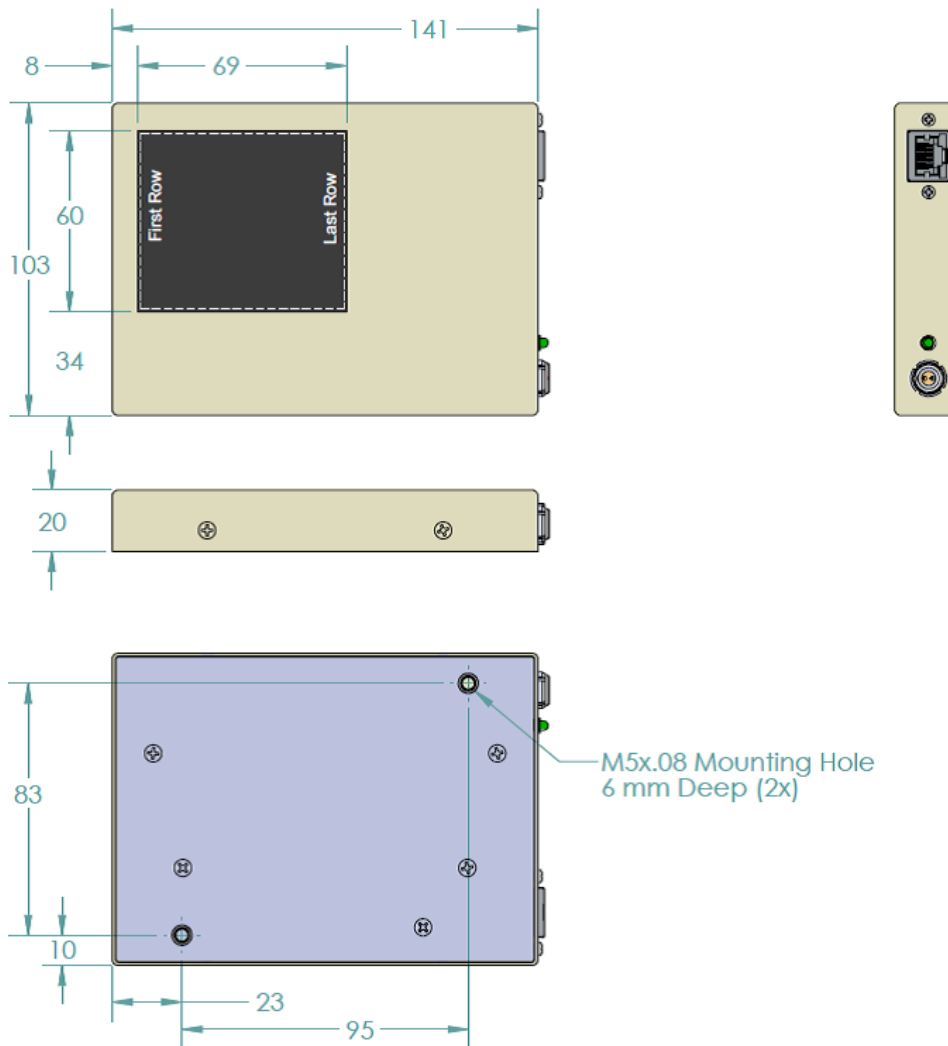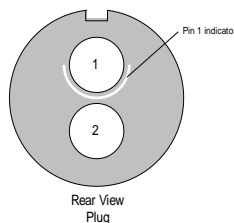
# Mechanical Drawing: Shad-o-Box 2K HS



**Data Connector:**

RJ45 HALO HFJ11-1G16E-L12RL

**Power Connector:**

2-pin LEMO EGG.0B.0302
Pin 1    +12 VDC
Pin 2    ground

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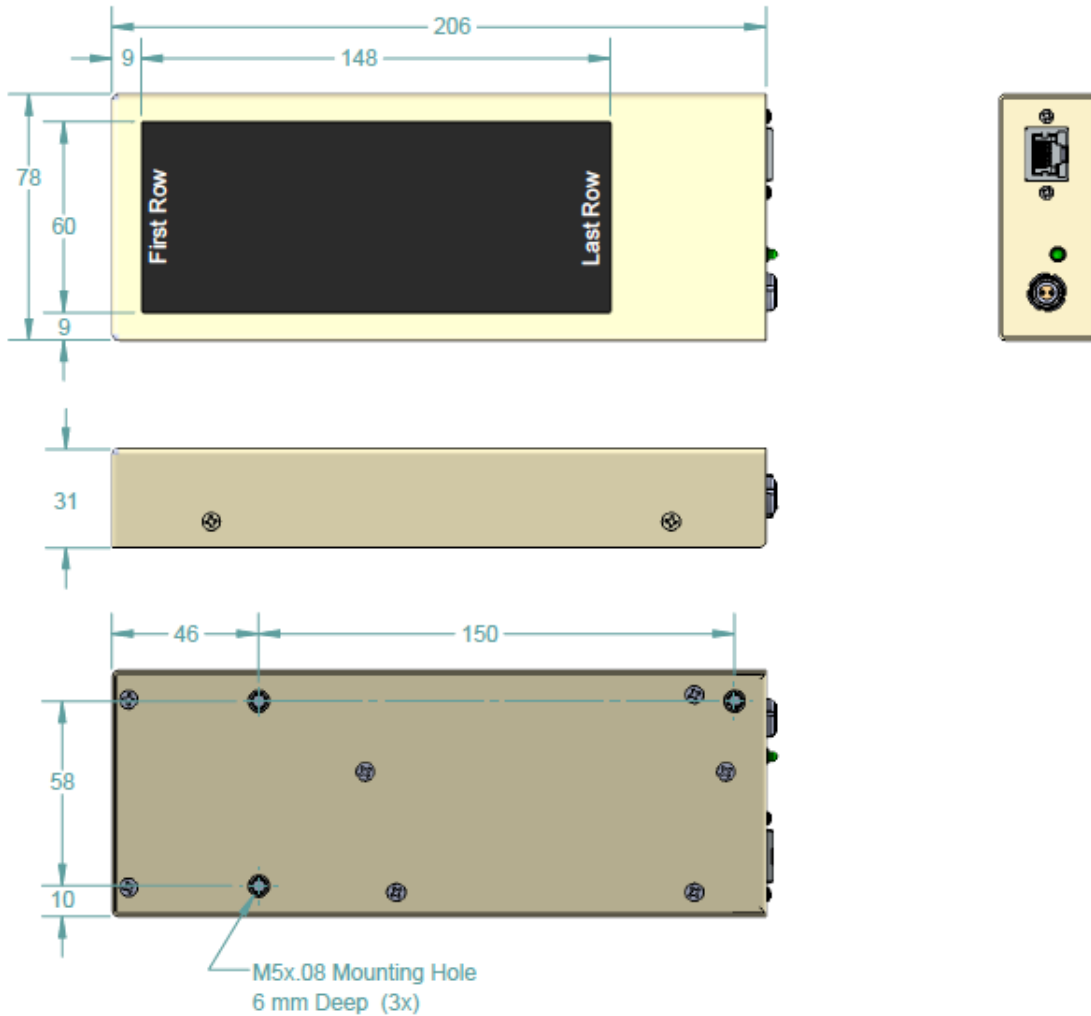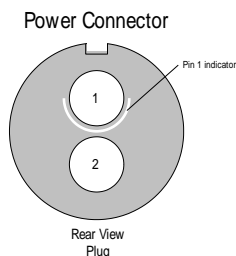
# Ordering Information

Shad-o-Box HS cameras are available in a single, industrial image quality grade (blemish specification available on request). Specify option -01 for the Carestream Min-R® 2190 scintillator, or option -02 for a Mitsubishi Chemical DRZ-Std (99 µm models) or DRZ-Fine (49.5 µm models) scintillator. Additional scintillator options may be available by request.

All cameras ship with a universal input power supply (90-264V, 50-60Hz), power cord, Ethernet cable, software CD and User's Manual. For international orders, please specify the type of power cord you require.

| P/N | Description |
|---|---|
| SB1644 | Shad-o-Box 1280 HS Camera (13 x 13 cm, 99 µm pixel) |
| SB1444 | Shad-o-Box 688 HS Camera (7 x 10 cm, 99 µm pixel) |
| SB1446 | Shad-o-Box 1548 HS Camera (10 x 15 cm, 99 µm pixel) |
| SB1573 | Shad-o-Box 1K HS Camera (7 x 6 cm, 49.5 µm pixel) |
| SB1586 | Shad-o-Box 2K HS Camera (6 x 15 cm, 49.5 µm pixel) |
| SB1490 | Shad-o-Box 3K HS Camera (7 x 11 cm, 49.5 µm pixel) |
| SB1492 | Shad-o-Box 6K HS Camera (11 x 15 cm, 49.5 µm pixel) |

# Contact Information

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