

Shad-o-Box Product Family



Overview

Teledyne Rad-icon's Shad-o-Box product family of digital x-ray cameras offers end users a high-performance, high-resolution imaging detector with a standard LVDS frame grabber interface. The cameras in this product line are equipped with a 68-pin parallel data port that can connect to a variety of standard digital frame grabbers. The cameras are available with different direct-contact scintillator options covering both the standard (10-50 kV) and extended (10-160 kV) energy ranges, making this camera an ideal choice for applications ranging from industrial inspection to biomedical imaging.

Key Features

- Large active area up to 10x10 cm
- 10 lp/mm (48µm) resolution
- Standard LVDS frame grabber interface
- 14-bit digital video output
- Energy range from 10 to 160 kV
- Ready-to-run software and drivers

The Shad-o-Box product line leverages CMOS image sensing technology, which enables the delivery of lower-dose x-ray images and yields higher image quality than a-Si flat panels and image intensifier devices. Shad-o-Box features include: (1) large active area of up to 10 x 10 cm; (2) superior resolution of 10 lp/mm (48 µm pixel size); (3) fast, real-time image transfer via high-speed parallel LVDS interface; (4) 12 or 14-bit digitization of images; and (5) SDK's, drivers and programming support. The camera interface allows easy access to features such as integration time setting, single and multiple frame acquisitions, and control of advanced timing modes. Each Shad-o-Box camera ships with our ShadoCam Imaging application, which provides a user-friendly interface for communicating with the camera and acquiring images.





Description

Shad-o-Box cameras contain a large-area high-resolution CMOS detector with a photodiode pixel array featuring several size options up to 2000 rows and 2048 columns. With a standard pixel pitch of 48 μm , the active area of these detectors ranges from 5 cm to 10 cm with a diagonal of up to 140 mm. The Shad-o-Box HS (High Speed) series features larger pixel sizes that can be scanned more quickly at frame rates up to 20 fps.

The detector array consists of one or more RadEye1 sensors that are tiled side-by-side and read out through separate electronic channels. The signal from each sensor is digitized to 14 bits and then transferred directly to the host memory via a fast LVDS frame grabber interface.

The CMOS sensor inside the Shad-o-Box camera contains a direct-contact $\text{Gd}_2\text{O}_2\text{S}$ scintillator such as Kodak Lanex[®] Fine or Min-R[®] 2190. 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 camera also contains lead and steel shielding to protect the camera electronics from the x-ray radiation. The base-model Shad-o-Box cameras are optimized for the standard energy range (10 - 50 kV), whereas the Shad-o-Box EV and HS models are designed for the extended energy range of 10 -160 kV. Please refer to our application notes for additional information.

Shad-o-Box Camera Options

Device	Pixels	Active Area	Resolution	Data Rate
Shad-o-Box 512	512 x 1024	24.6 x 49.2 mm	48 μm	1.5 MHz
Shad-o-Box 1024	1024 x 1024	49.3 x 49.2 mm	48 μm	3.0 MHz
Shad-o-Box 2048	2048 x 1024	98.6 x 49.2 mm	48 μm	6.0 MHz
Shad-o-Box 4K	2048 x 2000	98.6 x 96.1 mm	48 μm	12.0 MHz

Specifications

Detector Specifications	Standard	Hi-Gain	Units
Typ. dark current (23°C) ⁽¹⁾	40	80	ADU/s ⁽²⁾
Read noise (rms)	2-3	3-4	ADU
Dynamic range (typ)	6000:1	5000:1	
Digitization	14		bits
Typical fill factor	85		%
Conversion gain	125	62	elec/ADU
Saturation signal	2.0	1.0	x10 ⁶ elec.
Typ. sensitivity ⁽³⁾	100	200	ADU/mR

⁽¹⁾ dark current doubles approx. every 8°C

⁽²⁾ ADU = Analog-Digital Unit = 1 LSB (Least Significant Bit)

⁽³⁾ EV model, 50kVp W source, 0.5mm Al filter, Min-R 2190 scintillator

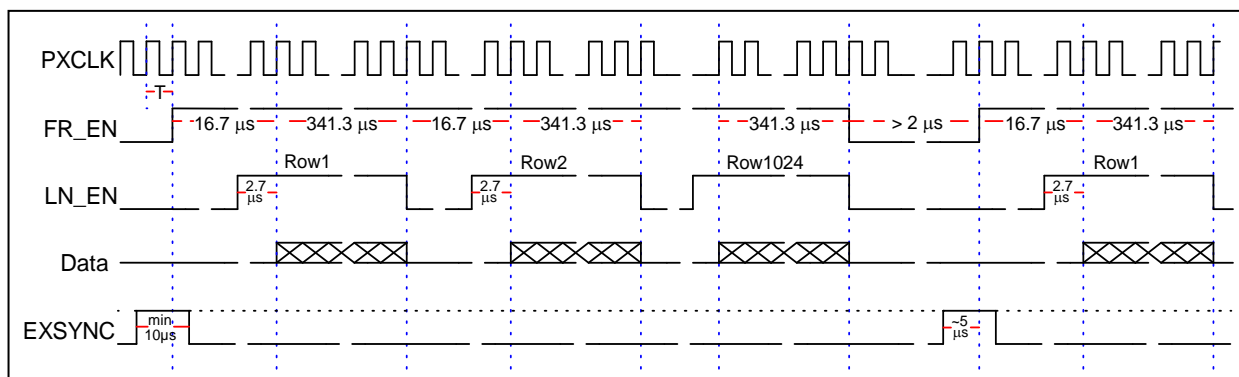
Camera Specifications	Units
Typical supply voltage	6.5 Volts
Supply voltage range	6.0 to 8.0 Volts
Maximum supply current ⁽⁴⁾	750 mA
Typical power dissipation ⁽⁴⁾	< 5 Watts
Readout period	367 ms
Max. frame rate	2.7 Hz
Parallel digital interface	EIA-644
SMA connector interface	TTL

General Specifications	Units
Operating temperature	0 to 50 °C
Storage temperature	-25 to +85 °C
Humidity (non-condensing)	10 to 80 % R.H.
Weight ⁽⁴⁾	< 3.5 kg

⁽⁴⁾ depends on camera model

Shad-o-Box Camera Timing

The camera frame rate can be controlled through the external frame sync inputs on either the parallel interface (EXSYNC) or the separate SMA receptacle. If these inputs are pulled high (SMA not connected) the camera will run continuously at its maximum frame rate of 2.7 fps. If either one of the frame sync inputs is pulled low, the camera controller will wait for a rising edge on this input before starting the next frame readout. To avoid conflicts, only one of these inputs should be used at a time. In a typical configuration, the EXSYNC input will be controlled by a timer on the frame grabber board. The timer should be programmed to supply pulses at regular intervals to prevent saturation of the photodiodes.



Signal	Parameter	Value	Unit
EXSYNC	min. pulse width	10	μs
	max. pulse width	365 / 95 [#] / 20 ^{##}	ms
	delay to FR_EN rising edge (typ.)	5	μs
FR_EN	high period (frame active)	366.6 / 95.9 [#] / 21.2 ^{##}	ms
	low period (EXSYNC high)	2	μs
	low period (EXSYNC low)	until next edge on EXSYNC	
LN_EN	delay to LN_EN rising edge	14	μs
	high period (line active)	344.0 / 173.3 [#] / 6.7 ^{##}	μs
	low period (between lines)	14	μs
	low period (between frames)	14μs + FR_EN low period	

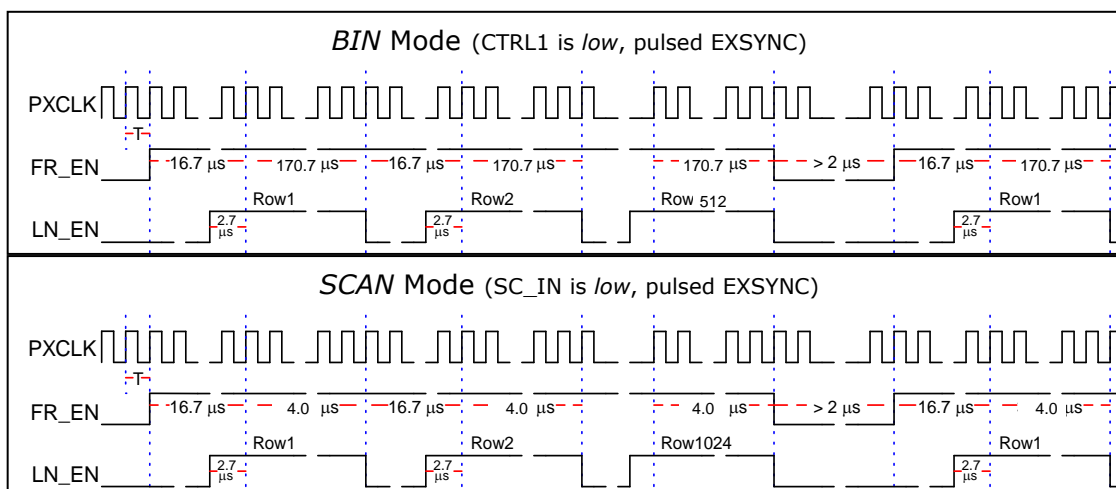
[#]BIN Mode (CTRL1 input low)

^{##}SCAN Mode (SC_IN input low)

The digital data on the parallel interface are valid when the pixel clock (PXCLK) is high. To minimize transmission errors, the data should be sampled on its falling edge. The line enable signal (LN_EN) goes high eight clock cycles before the first valid pixel. It is low for 42 pixel clock cycles during the horizontal blanking interval.

It is also low for a minimum of 48 cycles between frames. Frame enable (FR_EN) goes low during the vertical blanking interval to signal the beginning of a new frame. This signal is also available on one of the SMA connectors and can be used to synchronize external events to the camera.

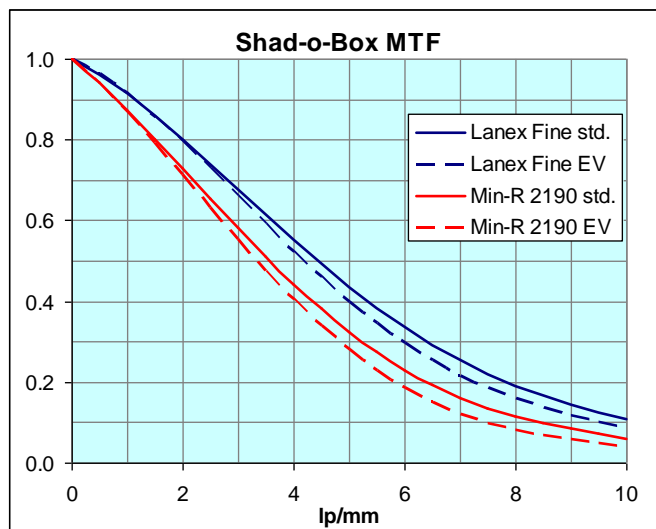
The binning (CTRL1) and fast scan (SC_IN) control inputs offer additional functionality in the camera. The bin mode (CTRL1 *low*) causes the readout to skip every other row and column. This shortens the readout time and raises the maximum frame rate of the camera to 10.4 fps. The resulting sub-sampled image contains 512 columns by 512 rows.



A *low* level on the SC_IN input puts the camera into a rapid-readout mode in which only the first six pixels of each sensor row are read. In this mode it is possible to scan all 1024 rows of the sensor in just 21 ms. This feature can be used to rapidly reset the dark signal prior to an exposure.

Resolution

The intrinsic resolution of the Shad-o-Box detector is 48 μm, which corresponds to just over 10 line pairs per mm. The actual Modulation Transfer Function (MTF) for two different scintillators is shown in the graph to the right. A thicker phosphor screen will produce more signal, but at the expense of high-frequency contrast. Please refer to our appnote AN07 for more information on scintillator performance and tradeoffs.



Data Connector Pinout

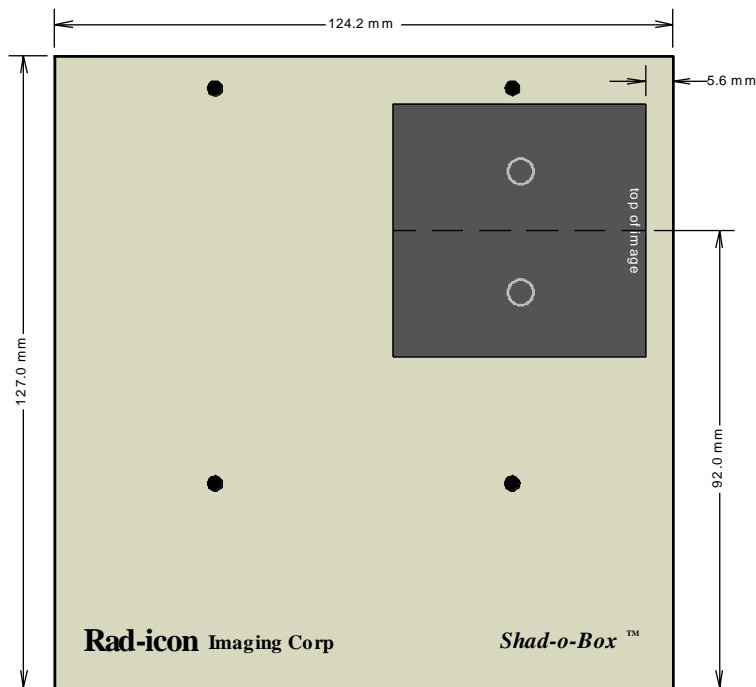
Signal	Description	I/O	+pin#	-pin#
D15	Data Bit 15 (tied low)	O	2	36
D14	Data Bit 14 (tied low)	O	3	37
D13	Data Bit 13 (MSB)	O	4	38
D12	Data Bit 12	O	5	39
D11	Data Bit 11	O	6	40
D10	Data Bit 10	O	7	41
D9	Data Bit 9	O	8	42
D8	Data Bit 8	O	9	43
D7	Data Bit 7	O	10	44
D6	Data Bit 6	O	11	45
D5	Data Bit 5	O	13	47
D4	Data Bit 4	O	14	48
D3	Data Bit 3	O	15	49
D2	Data Bit 2 ⁽¹⁾	O	16	50
D1	Data Bit 1 ⁽²⁾	O	19	53
D0	Data Bit 0 (LSB) ⁽²⁾	O	20	54
FR_EN	Frame (vert.) Sync	O	25	59
LN_EN	Line (hor.) Sync	O	26	60
PXCLK	Pixel Clock	O	29	63
EXSYNC	Ext. Frame Sync	I	30	64
SC_IN	Fast Scan Control	I	23	57
SC_OUT	(rsrvd for future use)	O	22	56
CTRL1	Binning Control	I	31	65
CTRL2	(rsrvd for future use)	I	32	66
GND	Signal Ground	pins 1,12,34,35,46,68		

Note: Camera inputs (I) must be tied to logic "high" if not in use.

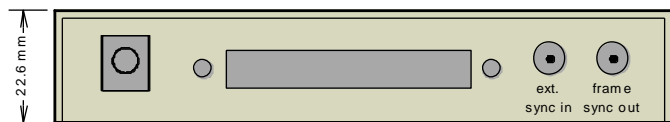
⁽¹⁾ LSB in 12-bit model

⁽²⁾ tied low in 12-bit model

Mechanical Drawings

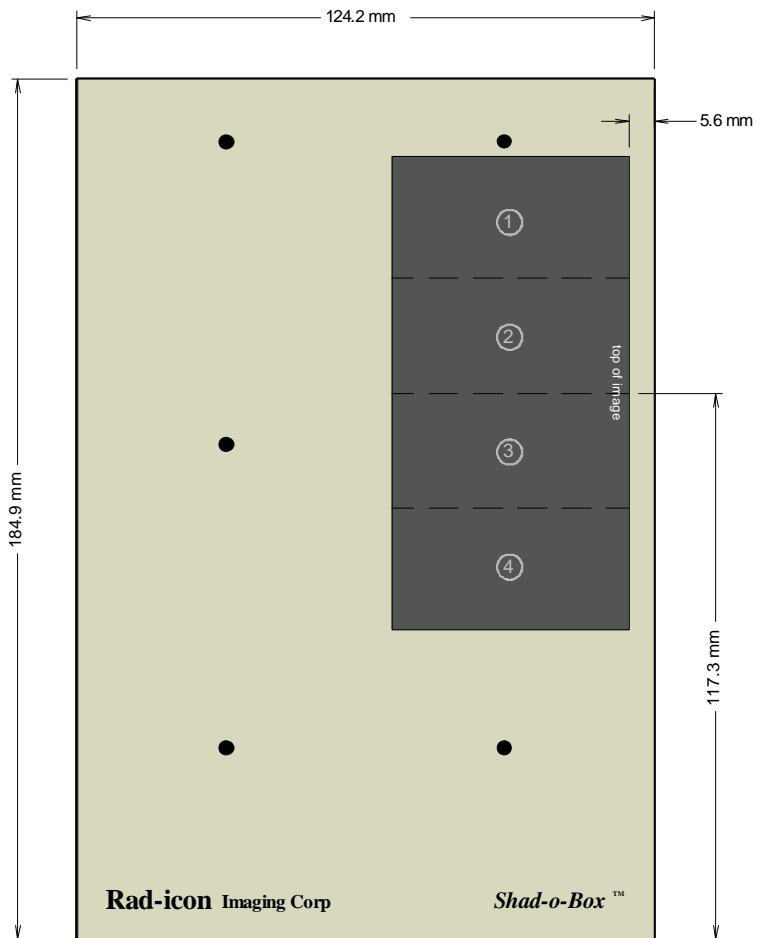


top view



front view

Shad-o-Box 1024 / 512 HS

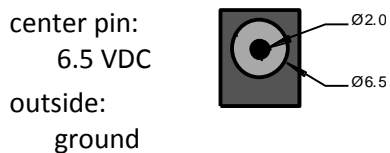


top view

Shad-o-Box 2048 / 1024 HS

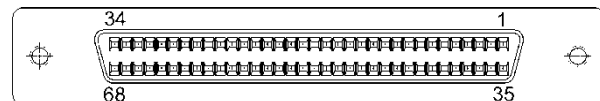
Power Connector:

DC power jack, 2 mm center pin



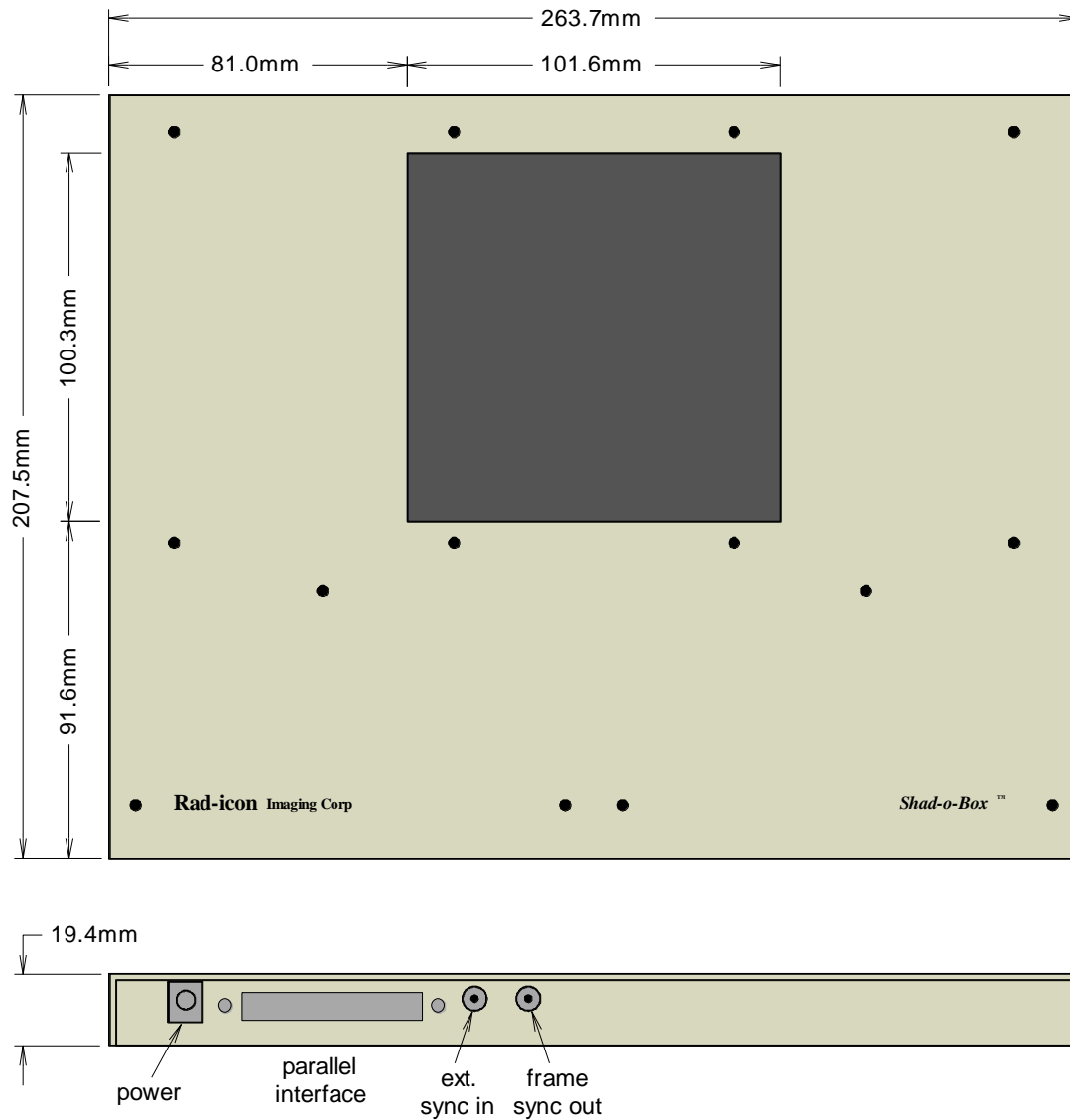
Data Connector:

68-pin mini-D (SCSI-3) receptacle



mating connector: AMP 749621-7 (or equiv.)
shell: AMP 786152-3 or 750752-1 (jackscrews)

Mechanical Drawings (cont.)



Shad-o-Box 4K



Ordering Information

Shad-o-Box cameras have two image quality grades (Standard and Premium), and can be ordered either with a Kodak Min-R® 2190 or Lanex® Fine scintillator. Additional scintillators may be available on request.

All cameras ship with a universal-input power supply (90-264V, 50-60Hz) and power cord, a software CD, and a manual. A frame grabber and data cable must be ordered separately. When ordering, please specify the type of power cord and any optional features as needed.

P/N	Std. Energy Range (10-50 kV)	P/N	Ext. Energy Range (10-160 kV)
SB1010	Shad-o-Box 512	SB1126	Shad-o-Box 512 EV
SB1011	Shad-o-Box 1024	SB1065	Shad-o-Box 1024 EV
SB1036	Shad-o-Box 2048	SB1067	Shad-o-Box 2048 EV
SB1136	Shad-o-Box 4K	SB1138	Shad-o-Box 4K EV

About Teledyne Rad-icon

Teledyne Rad-icon Imaging is a leading provider of high-performance CMOS image sensors and cameras for the digital radiography market worldwide. Our products enable medical practitioners, industrial manufacturers, and scientific researchers to create superior image quality, high resolution, and large active area images based on our CMOS active pixel sensor (APS) technology. Rad-icon's products address diverse applications such as tissue biopsy, non-destructive testing, circuit board testing, and x-ray crystallography. Our customers are able to implement cost-effective and high-performance digital imaging solutions. Teledyne Rad-icon Imaging is a division of Teledyne DALSA, Inc., a wholly owned subsidiary of Teledyne Technologies Incorporated. Based in Sunnyvale, CA, Teledyne Rad-icon Imaging has integration partners and distributors worldwide.

For more information on our products and technologies, please visit our website at <http://www.rad-icon.com> or <http://www.teledynedalsa.com/imaging/products/x-ray> or call us at (408) 736-6000.