

## Shad-o-Box™ HS

### Real-time X-Ray Camera



#### *Key Features:*

- 50 mm / 100 mm active area
- **Frame rate up to 20 fps**
- 5.2 lp/mm (96  $\mu$ m) resolution
- 12-bit digital video output
- Energy range from 10 to 160 kV
- Small, convenient form factor
- Standard frame grabber interface
- Ready-to-run software and drivers

The Shad-o-Box™ HS x-ray camera is a stand-alone, high-resolution radiation imaging device complete with 12-bit digital interface. Two versions are available, offering either a 49.2mm by 49.2mm sensing area (512 x 512 pixels) or an even larger 49.2mm by 98.6mm photodiode array sensor (512 x 1024 pixels). Both feature 96  $\mu$ m pixel spacing. The camera is configured for real-time (up to 20 fps) operation and features low noise and excellent image uniformity, making it an ideal choice for use in a wide range of medical, industrial and scientific imaging applications.

## Description:

The Shad-o-Box™ HS is a real-time x-ray camera intended to replace small image intensifiers and similar real-time detectors for digital radiography applications. At the heart of the Shad-o-Box camera is a two-dimensional photodiode array that consists of a 512x512 or 512x1024 pixel matrix on 96 μm centers. A Gd<sub>2</sub>O<sub>2</sub>S scintillator screen, placed in direct contact with the photodiode array, converts incident x-ray photons to light, which in turn is detected by the photodiodes. A carbon-fiber window shields against ambient light and protects the sensitive electronics from accidental damage.

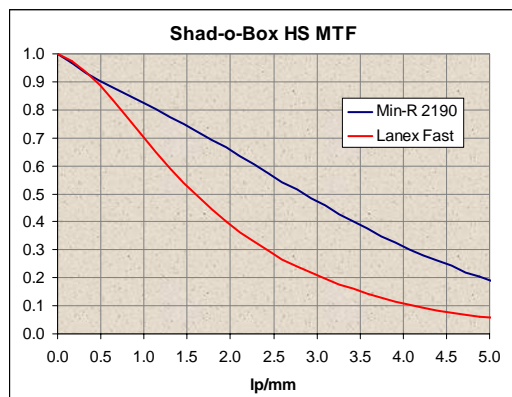
The analog signal from the sensor is digitized to 12-bit resolution in up to four parallel A/D channels, and then interleaved for maximum transmission speed across a high-speed parallel digital interface. This interface consists of a 68-pin mini-D (SCSI-2) receptacle and conforms to the AIA (Automated Imaging Association) A15.08 specification. Pixel clock, line enable and frame enable signals are available at the connector to facilitate acquiring the image data with a standard digital frame grabber. The camera frame rate can be controlled via the frame grabber interface or through an external SMA connection.

The Shad-o-Box HS is available with two different scintillator types, offering a sensitivity-to-resolution tradeoff that can be optimized for a particular application. All systems feature extremely low read noise (250 electrons rms), excellent image uniformity (<0.5% PRNU after flat-field correction) and superb sensitivity (~50 ADU/mR for Min-R 2190 and ~110 ADU/mR for Lanex Fast<sup>#</sup>).

## Resolution:

The Shad-o-Box HS detector features a pixel spacing of 96 μm, which translates to an intrinsic resolution of 5.2 line pairs per mm. The actual Modulation Transfer Function (MTF) for two different scintillators is shown in the graph below. A thicker phosphor screen such as Lanex Fast will produce more signal, but at the expense of high-frequency contrast. By comparison, the thinner Min-R 2190 scintillator features excellent contrast but only half the signal output.

Additional scintillators may be available by special order. Please refer to our application note AN07 for more information on scintillator performance and tradeoffs.



## Specifications:

Detector Specifications		Units
Typ. dark current (23°C)*	20	ADU/s**
Read noise (rms)	~ 1	ADU
Dynamic range	4000:1	
Digitization	12	bits
Conversion gain	250	electrons/ADU
Readout period	48	ms
Max. frame rate	20.8	Hz
Output data rate	6 / 12 <sup>##</sup>	MHz

\* dark current doubles approx. every 8°C

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

Camera Specifications		Units
Analog supply voltage	12 ± 0.6	Volts
Max. analog supply current	150 / 300 <sup>##</sup>	mA
Digital supply voltage	5 ± 0.25	Volts
Max. digital supply current	250	mA
Typical power dissipation	2.5 / 4.0 <sup>##</sup>	Watts
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	1.5 / 2.0 <sup>##</sup>	kg

<sup>#</sup> 50 kVp, W source, 0.5 mm Al filter

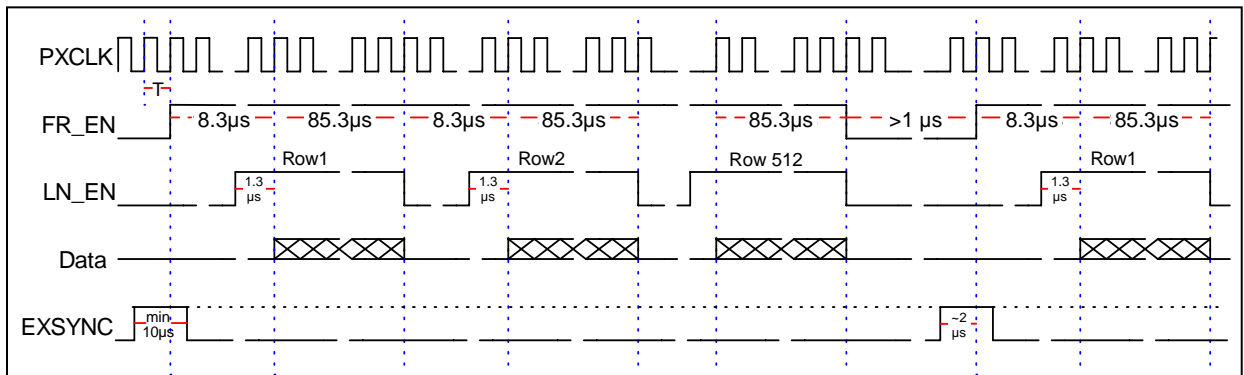
<sup>##</sup> SB1204 model

## Camera Timing:

The camera frame rate must be controlled through the external frame sync inputs on either the parallel interface (EXSYNC) or the SMA connector. The maximum supported frame rate is 20 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.

The digital data on the parallel interface should be sampled on the falling edge of the pixel clock signal (PXCLK). The line enable signal (LN\_EN) goes high 8 (16<sup>#</sup>) clock cycles before the first valid pixel. It is low for 42 (84<sup>#</sup>) pixel clock cycles during the horizontal blanking interval. It is also low for a minimum of 48 (96<sup>#</sup>) 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.

# SB1204 Model



Signal	Parameter	Value	Unit
EXSYNC	min. pulse width	10	µs
	max. pulse width	45	ms
	delay to FR_EN rising edge (typ.)	2	µs
FR_EN	high period (frame active)	47.9	ms
	low period (EXSYNC high)	1	µs
	low period (EXSYNC low)	until next edge on EXSYNC	
	delay to LN_EN rising edge	7	µs
LN_EN	high period (line active)	86.6	µs
	low period (between lines)	7	µs
	low period (between frames)	7µs + FR_EN low period	
PXCLK	period (T) – SB1201 Model	166.7	ns
	SB1204 Model	83.3	ns
	duty cycle	50	%

## Data Connector Pinout:

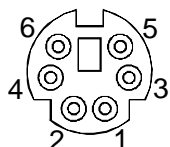
Signal	Description	I/O	+pin#	-pin#
D15	Data Bit 15 (tied low)	O	2	36
D14	Data Bit 14 (tied low)	O	3	37
D13	Data Bit 13 (MSB)	O	4	38
D12	Data Bit 12	O	5	39
D11	Data Bit 11	O	6	40
D10	Data Bit 10	O	7	41
D9	Data Bit 9	O	8	42
D8	Data Bit 8	O	9	43
D7	Data Bit 7	O	10	44
D6	Data Bit 6	O	11	45
D5	Data Bit 5	O	13	47
D4	Data Bit 4	O	14	48
D3	Data Bit 3	O	15	49
D2	Data Bit 2 (LSB)	O	16	50
D1	Data Bit 1 (tied low)	O	19	53
D0	Data Bit 0 (tied low)	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	(rsrvd for future use)	I	23	57
SC_OUT	(rsrvd for future use)	O	22	56
CTRL1	(rsrvd for future use)	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) should be tied to logic "high" if not in use.

## Power Connector:

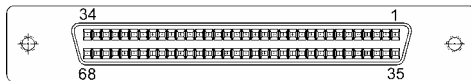
6-pos. mini-DIN receptacle

pin	signal
1,5	ground
2,3	n/c
4	12 V (ana.)
6	5 V (dig.)



## Data Connector:

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

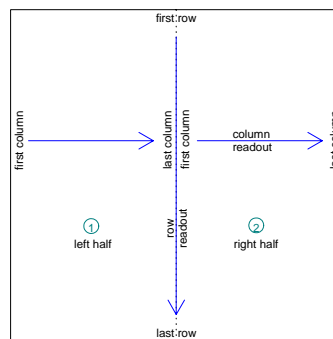


mating connector: AMP 749621-7 (or equiv.)  
shell: AMP 786152-3 or 750752-1 (jackscrews)

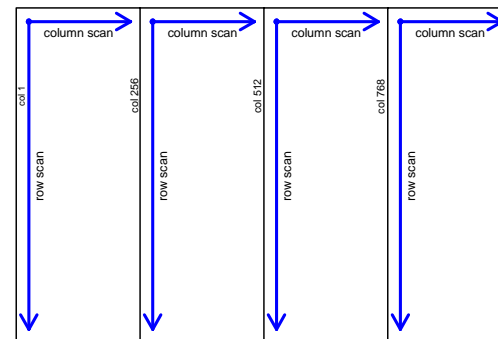
## Readout Sequence:

The image area of the Shad-o-Box sensor is scanned through several parallel channels. As indicated in the figures below, the row scan starts at the top of the active area and scans toward the bottom. Each line is scanned in up to four sections, starting at the leftmost column of each section and moving towards the right. The sensor sections are scanned in parallel and then interleaved for transmission. The data must be deinterlaced in software in order to restore the image.

A small gap approximately one pixel wide separates the individual sensor sections. This space can either be corrected, or, for most applications, ignored. (Please refer to our application note AN03 for more details on image correction.)



SB1201 (512x512)



SB1204 (512x1024)

## Ordering Information:

Shad-o-Box cameras have two image quality grades (Standard and Premium), and can be ordered either with Kodak Min-R<sup>®</sup> 2190 or Lanex<sup>®</sup> Fast. We recommend the Lanex Fast scintillator for optimum resolution and sensitivity.

All cameras include a universal desktop power supply:

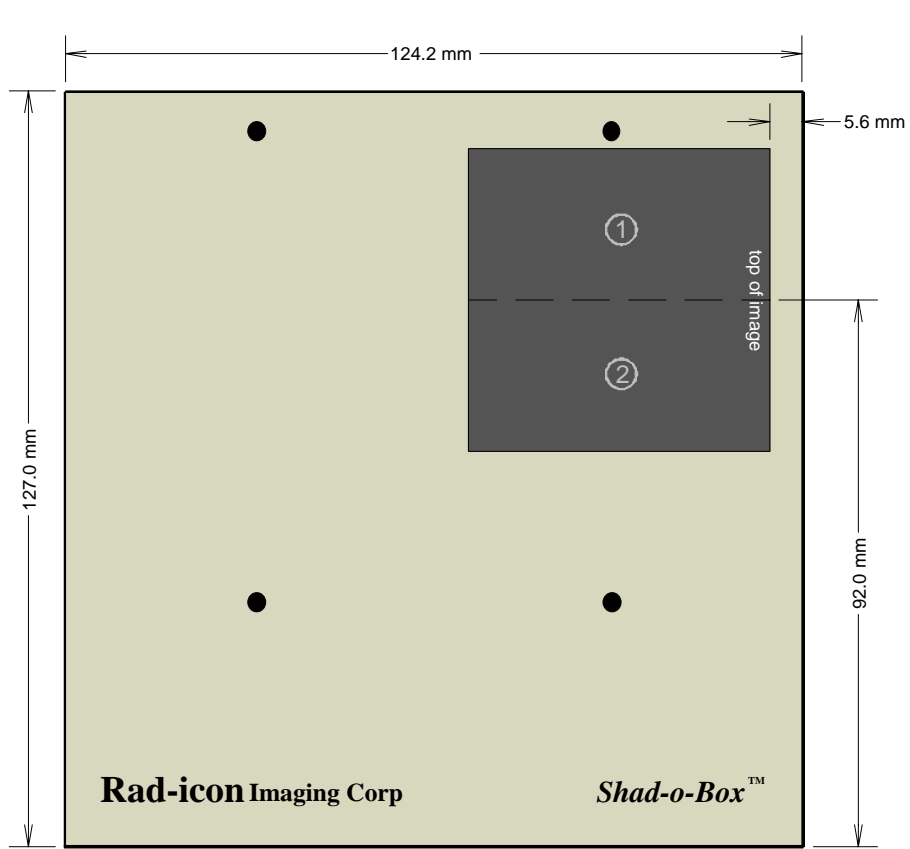
90-264V, 50-60Hz.

Please specify the type of power cord you require.

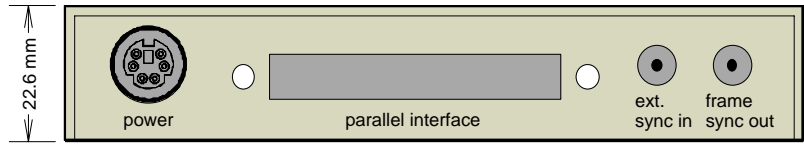
P/N	Description
SB1201	Shad-o-Box HS Camera (512x512)
SB1204	Shad-o-Box HS Camera (512x1024)
-01	Premium Grade <sup>1</sup> , Min-R 2190
-02	Standard Grade <sup>2</sup> , Min-R 2190
-03	Premium Grade, Lanex Fast
-04	Standard Grade, Lanex Fast

<sup>1</sup> no line defects    <sup>2</sup> up to three line defects

**Mechanical Dimensions:**

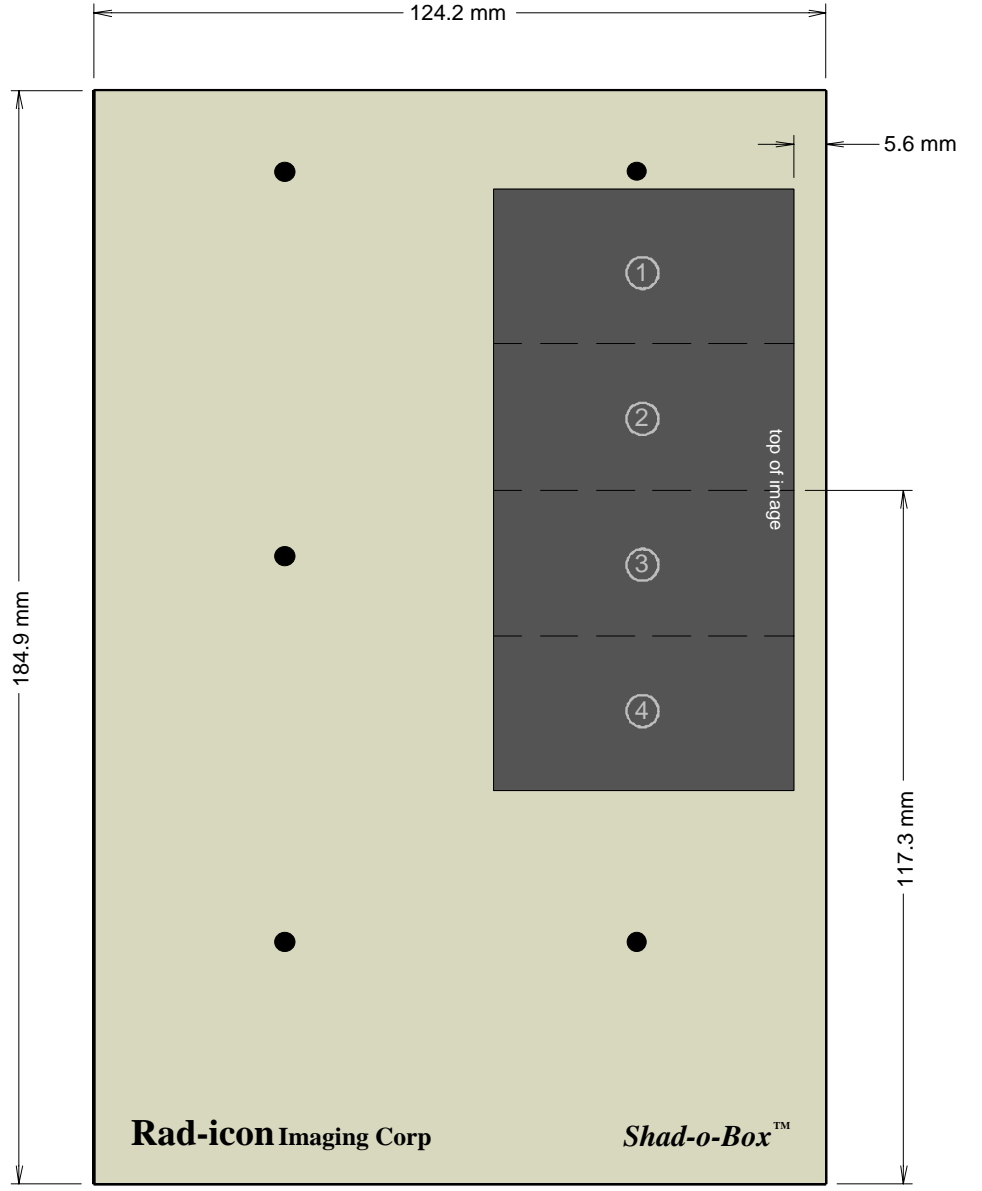


top view



front view

SB1201 Model (512x512)



top view

SB1204 Model (512x1024)