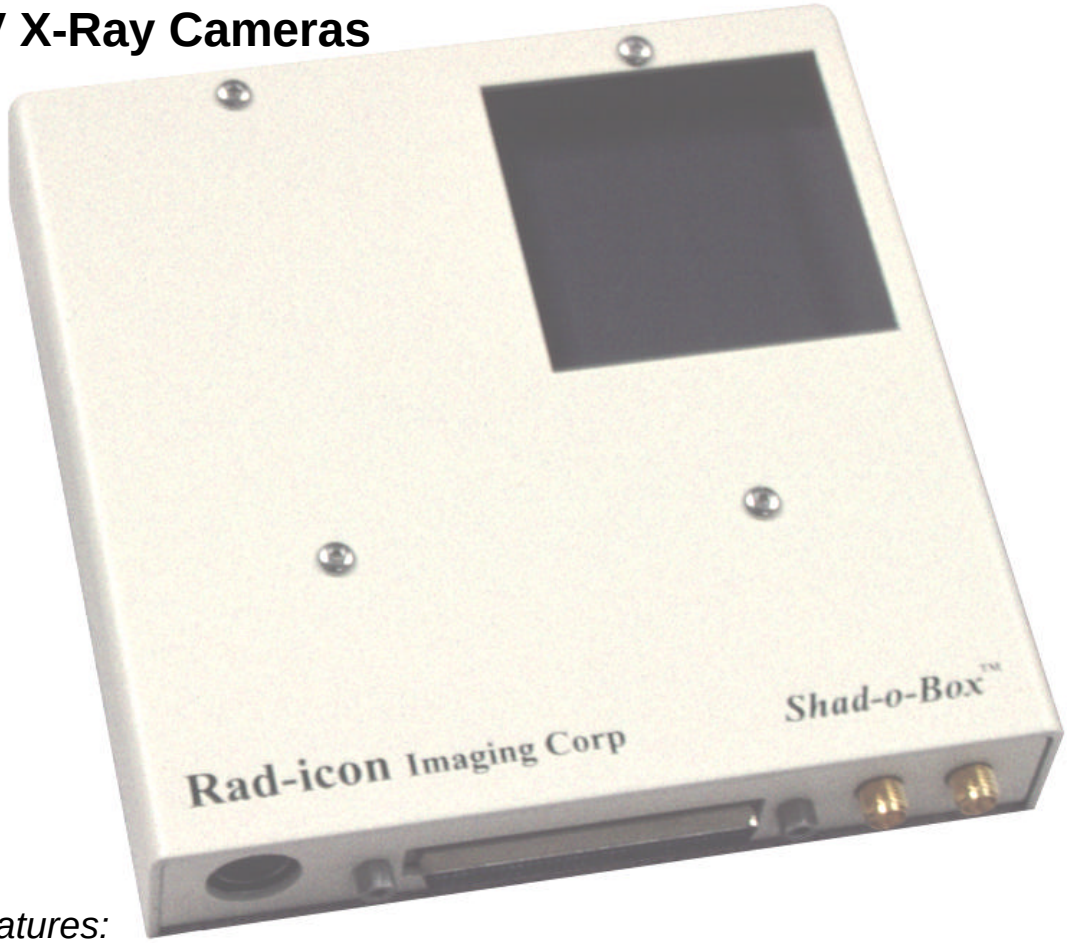
Rad-icon Imaging Corp
3193 Belick Street, Unit 1, Santa Clara, CA 95054
Tel: 408-486-0886
Fax: 408-486-0882
www.rad-icon.com

Shad-o-Box™ EV Series

High kV X-Ray Cameras



Key Features:

- Extended voltage range up to 160 kV
- Active area from 5 x 5 cm (2" x 2") up to 5 x 10 cm (2" x 4")
- 10 lp/mm resolution
- 12-bit digital video output
- Small, convenient form factor
- Standard frame grabber interface
- Ready-to-run software and drivers

The Shad-o-Box™ EV series x-ray cameras are complete, high-resolution radiation imaging devices now featuring an extended voltage range for imaging up to 160 kV. Available in 50 by 50 mm, 50 by 75 mm, and 50 by 100 mm active areas, each camera incorporates a large-area photodiode array sensor with 48 µm pixel spacing. An integral phosphor screen shields the sensor from ambient light and converts incident x-rays or energetic particles to visible light that is sensed by the silicon photodiodes. The EV series Shad-o-Box™ cameras have been specifically designed for industrial x-ray imaging applications such as inspection of welds, castings and similar components.

Rev. 01/02-02

Description:

The Shad-o-Box™ EV series x-ray cameras present an ideal solution for high-energy, high-resolution radiation imaging. The heart of each Shad-o-Box camera is a two-dimensional photo-diode array containing up to two million pixels on 48 µm centers. The Shad-o-Box 1024 EV features a 1024 by 1024 pixel matrix with an active area of 49.2 mm squared. The Shad-o-Box 1536 EV camera has a 2:3 aspect ratio with 1024 by 1536 pixels. Finally, the largest member of the EV series, the Shad-o-Box 2048 EV contains 1024 by 2048 pixels with an active area of nearly 50 cm^2. In each camera, a Gd_2O_2S scintillator screen is used to convert incident x-ray photons to light, which in turn is detected by the photodiodes. A graphite window shields against ambient light and protects the sensitive electronics from accidental damage.

The analog signal from the photodiode sensors is digitized to 12-bit resolution in several 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-3) 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. Both RS-422 and LVDS (EIA-644) versions of the digital interface are available.

The standard version of the Shad-o-Box EV camera delivers 4000:1 dynamic range (defined as the maximum signal divided by the read noise) at a maximum frame rate of 2.7 frames per second. A special high-gain version boosts the sensitivity of the analog front end by almost a factor of five, at the expense of slightly lower dynamic range and a reduced data rate. All versions operate from a standard +5V/+12V desktop power supply.

Specifications:

Detector Size	*1024 EV*	*1536 EV*	*2048 EV*
Number of rows	1024	1024	1024
Number of columns	1024	1536	2048
Active area height (mm)	49.2	49.2	49.2
Active area width (mm)	49.2	73.9	98.6

Detector Specifications	*Standard*	*High Gain*	*Units*
Avg. dark current (23°C)*	8	36	ADU/s**
Read noise (rms)	< 1	1.35	ADU
Dynamic range	4000:1	3000:1	
Digitization	12	12	bits
Conversion gain	500	110	electr/ADU
Readout period	367	733	ms
Max. frame rate	2.7	1.4	Hz
Output data rate			
Shad-o-Box 1024 EV	3.0	1.5	MHz
Shad-o-Box 1536/2048 EV	6.0	3.0	MHz

* dark current doubles approx. every 8°C
** ADU = Analog-Digital Unit ≡ 1 LSB (Least Significant Bit)

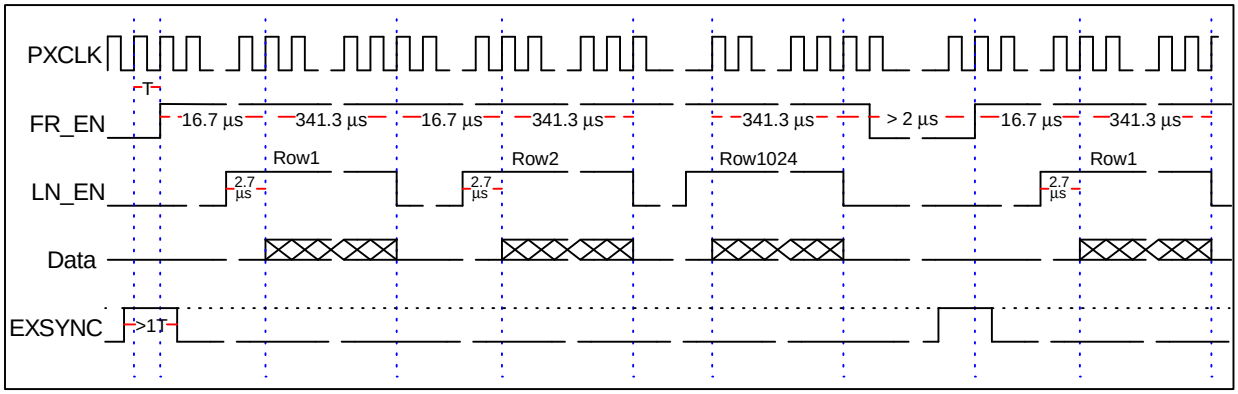
Camera Specifications	*Standard*	*LVDS*	*Units*
Analog supply voltage	12 ± 0.6	12 ± 0.6	Volts
Max. analog supply current			
Shad-o-Box 1024 EV	150	150	mA
Shad-o-Box 1536/2048 EV	350	350	mA
Digital supply voltage	5 ± 0.25	5 ± 0.25	Volts
Max. digital supply current	750	150	mA
Typical power dissipation			
Shad-o-Box 1024 EV	4.5	1.8	Watts
Shad-o-Box 1536/2048 EV	6.5	3.8	Watts
Parallel digital interface	RS-422	EIA-644	
SMA connector interface	TTL	TTL	

General Specifications	*All Versions*	*Units*
Operating Temperature	0 to 50	°C
Storage Temperature	-25 to +85	°C
Humidity (non-condensing)	10 to 80	% R.H.
Weight		
Shad-o-Box 1024 EV	1.5	kg
Shad-o-Box 1536/2048 EV	2.0	kg

Timing:

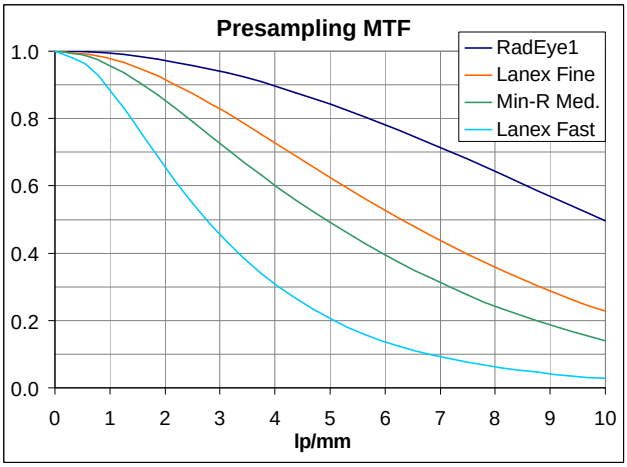
The camera frame rate can be controlled through the external frame sync inputs on either the parallel interface (EXSYNC) or the separate SMA receptacle. If these inputs are pulled high (SMA not connected) the camera will run continuously at its maximum frame rate of 2.7 fps. If either one of the frame 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.

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 2.7 µs before the first valid pixel. It is low for 14 µs during the horizontal blanking interval. It is also low for a minimum of 16 µs 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.



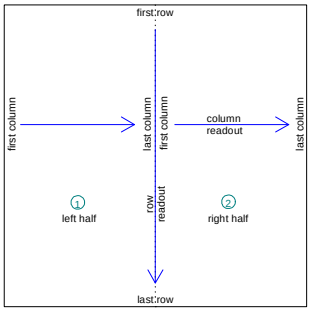
Resolution:

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 several different scintillators is shown in the graph below. A thicker phosphor screen will produce more signal, but at the expense of high-frequency contrast. The line labeled RadEye1 shows the MTF of the sensor for direct detection of x-rays.



Readout Sequence:

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

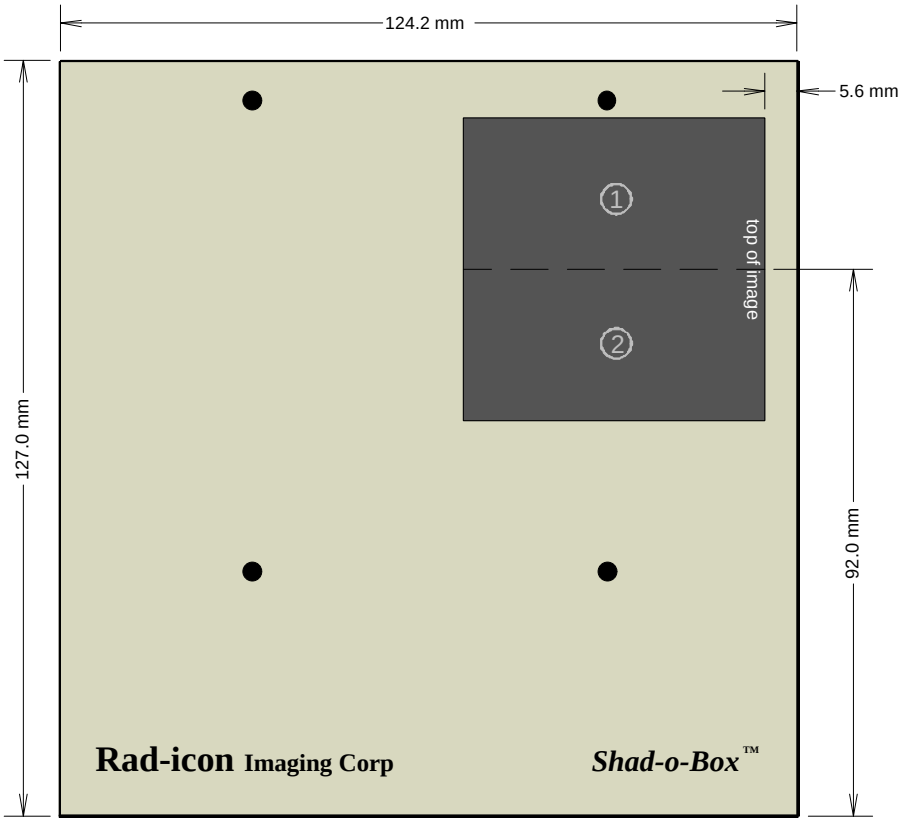


Shad-o-Box 1024 EV

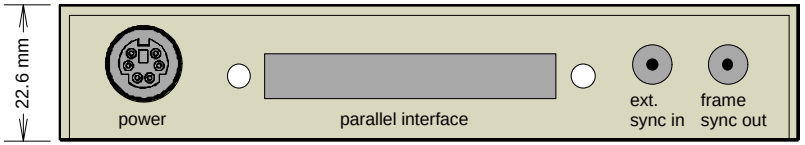
Adjacent sections in the active area are separated by a two-pixel gap. This space needs to be considered when reconstructing the image from the data stream. (Please refer to Rad-icon Appnote AN03 for more details on image correction.)

Mechanical Dimensions:

Shad-o-Box 1024 EV

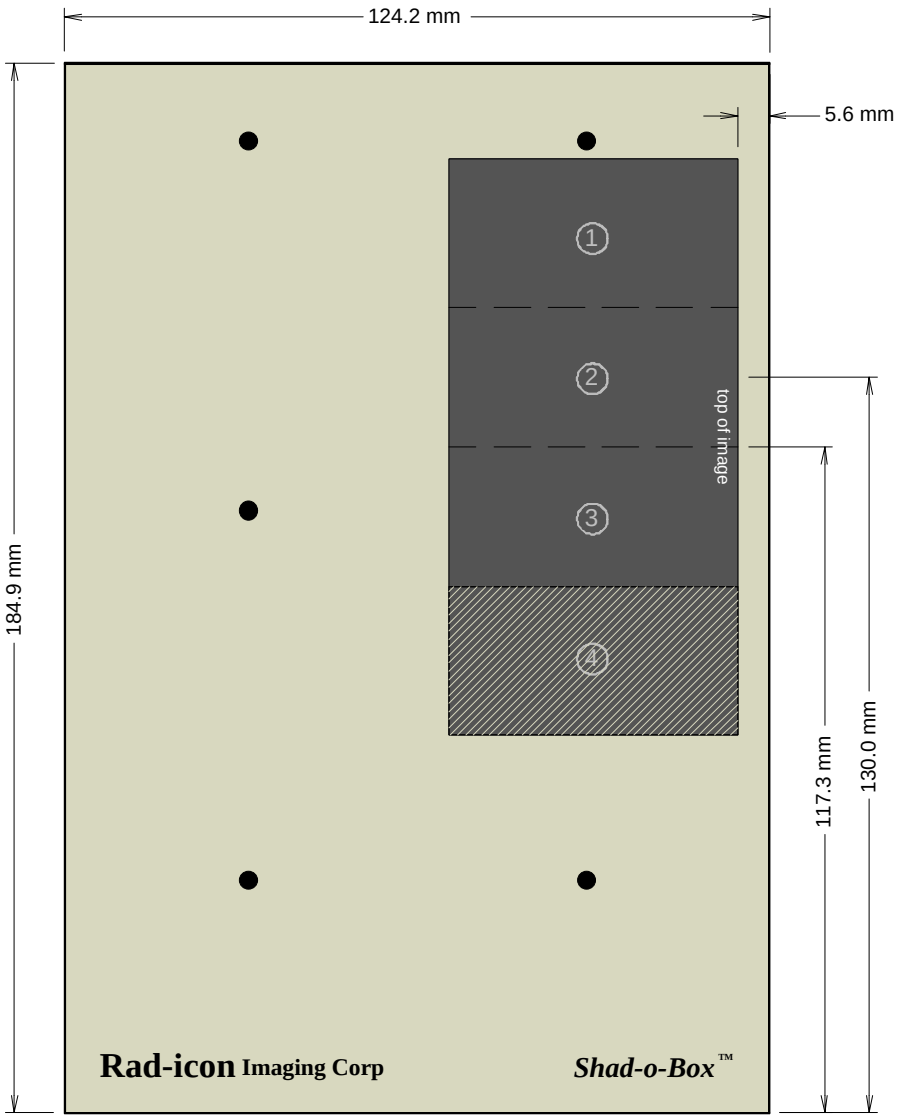


top view



front view

Shad-o-Box 1536 / 2048 EV



top view

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	O	16	50
D1	Data Bit 1 (tied low)	O	19	53
D0	Bit 0 (LSB, 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	Camera Reset	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		

Ordering Information:

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

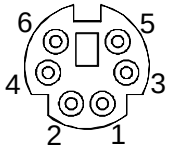
All cameras ship with a desktop power supply and cables for 120V/60Hz operation. Specify option –E if you require a universal input power supply instead.

P/N	Description
1065	Shad-o-Box 1024 EV Camera
1066	Shad-o-Box 1536 EV Camera
1067	Shad-o-Box 2048 EV Camera
-01	Premium Grade[1], Min-R Medium
-02	Standard Grade[2], Min-R Medium
-03	Premium Grade, Lanex Fine
-04	Standard Grade, Lanex Fine
-G	High Gain Version
-L	LVDS Version (call for availability)
-E	90-264V / 50-60Hz Power Supply

[1] no line defects [2] up to three (1024), five (1536) or seven (2048) line defects

Power Connector:

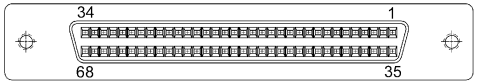
6-pos. mini-DIN receptacle



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 (2-56 jackscrews)