

## Shad-o-Box™ 4K

### Large-Area X-Ray Camera



#### *Key Features:*

- Large active area of 10 x 10 cm
- 10 lp/mm (48  $\mu$ m) resolution
- Over four million pixels
- 12-bit digital video output
- Thin, flat-panel form factor
- LVDS frame grabber interface with real-time video up to 2.7 fps
- Ready-to-run software and drivers

The Shad-o-Box 4K x-ray camera is a stand-alone, high-resolution radiation-imaging device complete with 12-bit digital interface. As the largest member of this product line, the Shad-o-Box 4K features the large-area RadEye™ 8 CMOS photodiode image sensor with 10 lp/mm resolution (48  $\mu$ m pixel spacing) in a 2000 by 2048 pixel array. The sensor has an integrated direct-contact scintillator and is available for both the standard (10-50 kV) and extended (10-160 kV) energy ranges, making the Shad-o-Box 4K an ideal choice for applications including medical diagnostics, industrial inspection (NDT) and scientific imaging.

## Description:

The Shad-o-Box™ x-ray camera is a complete detection system for high-resolution radiation imaging. At the heart of the Shad-o-Box 4K is a two-dimensional photodiode array that contains over four million pixels on 48 µm centers. The total active area of the sensor adds up to nearly 10 cm per side. The camera electronics deliver 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. They operate from a standard 6-8 V desktop power supply and consume less than 5 Watts of power.

The detector array consists of eight RadEye1 sensors that are tiled in a 2x4 matrix and read out through separate electronic channels. The analog signals from the photodiode sensors are digitized to 12-bit resolution in eight 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 LVDS (EIA-644) digital frame grabber. A custom cable will be required for most frame grabber models.

The CMOS sensor inside the Shad-o-Box camera contains a direct-contact Gd<sub>2</sub>O<sub>2</sub>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 Shad-o-Box 4K camera is optimized for the standard energy range (10-50 kV), whereas the Shad-o-Box 4K EV model is designed for the extended energy range (10-160 kV). Please refer to our application notes for additional information.

## Specifications:

<b>Detector Specifications</b>		<b>Units</b>
Number of rows	2000	pixels
Number of columns	2048	pixels
Active area height	96.1	mm
Active area width	98.6	mm
Pixel spacing (pitch)	0.048	mm
Typical fill factor	85	%
Avg. dark current (23°C) <sup>(1)</sup>	8	ADU/s <sup>(2)</sup>
Read noise (rms)	< 1	ADU
Dynamic range	4000:1	
Digitization	12	bits
Conversion gain	500	electr/ADU
Readout period <sup>(3)</sup>	367	ms
Max. frame rate	2.7	Hz
Output data rate	12	MHz

<sup>(1)</sup> dark current doubles approx. every 8°C

<sup>(2)</sup> ADU = Analog-Digital Unit = 1 LSB (Least Significant Bit)

<sup>(3)</sup> time required to transfer image from sensor to camera memory

<b>Camera Specifications</b>		<b>Units</b>
Typical supply voltage	6.5	Volts
Supply voltage range	6.0 to 8.0	Volts
Maximum supply current	750	mA
Typical power dissipation	< 5	Watts
Data interface	EIA-644	
SMA connector interface	TTL	

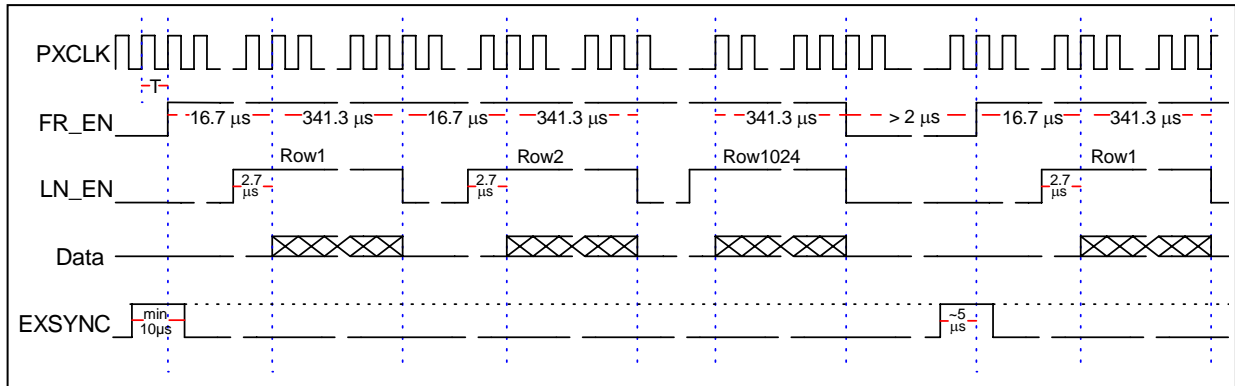
<b>General Specifications</b>		<b>Units</b>
Operating Temperature	0 to 50	°C
Storage Temperature	-25 to +85	°C
Humidity (non-condensing)	10 to 80	% R.H.
Weight	3.5	kg

<b>Software</b>
The Shad-o-Box camera ships with our ShadoCam Imaging Software, which runs under Windows® 98, 2000, NT and XP. Check with your frame grabber manufacturer for compatibility with these and other operating systems.

## 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. To ensure proper synchronization, it is recommended that either one (but not both!) of the frame sync inputs be used to control the frame rate. The camera controller will wait for a rising edge on this input before starting the next frame readout.

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 32 clock cycles before the first valid pixel. It is low for 168 pixel clock cycles during the horizontal blanking interval. It is also low for a minimum of 192 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.



## Readout Sequence:

The image area of the RadEye8 sensor is scanned through eight parallel channels. The row scan starts at the center of the active area and scans simultaneously toward the top and the bottom. Each line is scanned in eight sections. The four bottom sections scan left to right, and the top sections scan right to left. All eight sections are scanned in parallel and then interleaved for transmission. The data must be deinterlaced in software to restore the image.

A two-pixel gap separates the individual sections of the active area. This space should be taken into account when reconstructing the image from the data stream. (Please refer to Rad-Icon Appnote AN03 for more details on image correction.)

## Resolution:

The Shad-o-Box 4K detector features a pixel spacing of 48 μm, which corresponds to a resolution of just over 10 line pairs per mm. 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. (Please refer to our appnotes for more information on scintillator performance and tradeoffs.)

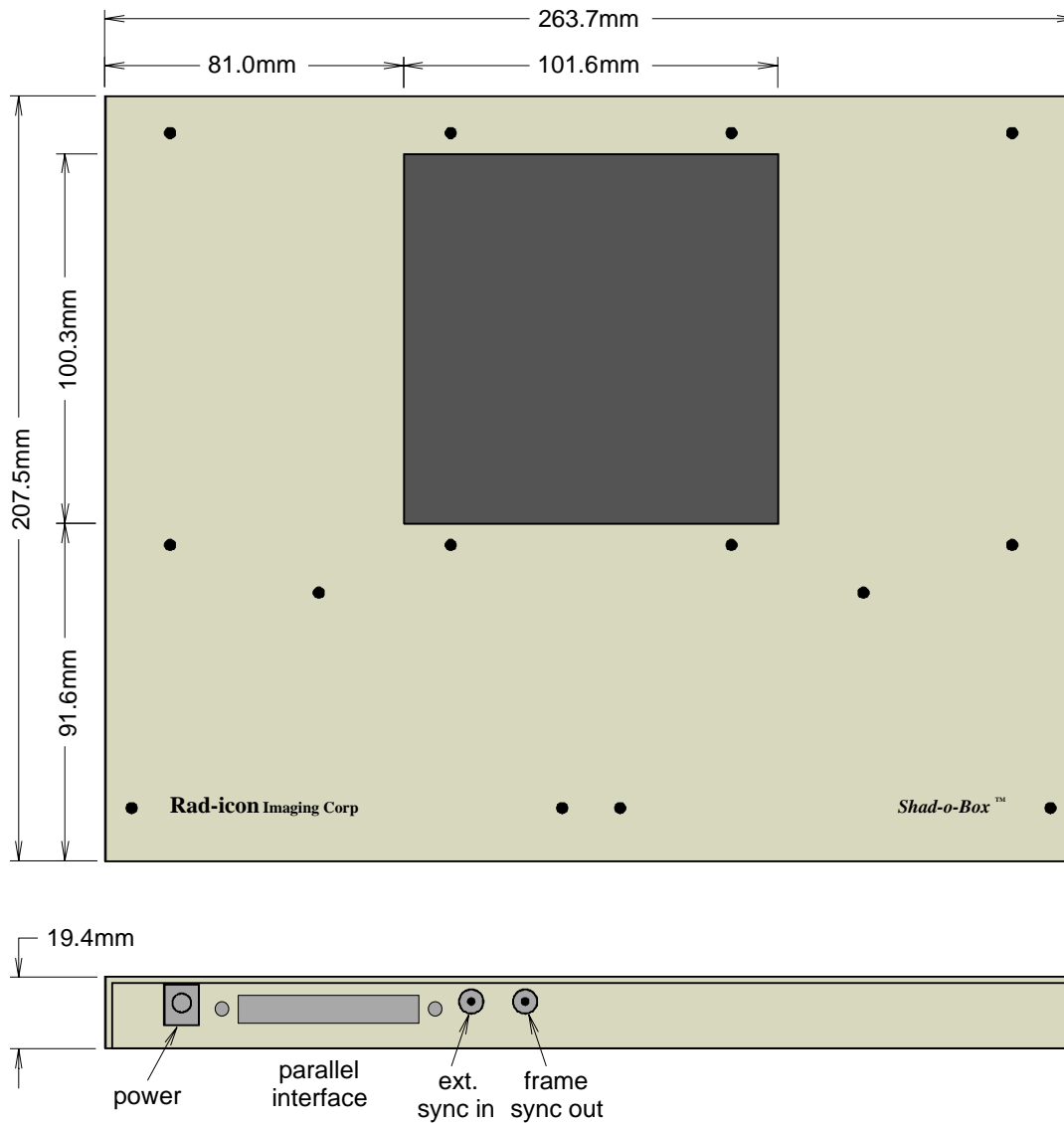
## Ordering Information:

Shad-o-Box cameras have two image quality grades (Standard and Premium), and can be ordered either with a Kodak Min-R<sup>®</sup> 2190 or Lanex<sup>®</sup> Fine scintillator. Additional scintillators may be available by special order. All cameras ship with a universal input power supply (90-264V, 50-60Hz). For international orders, please specify the type of power cord you require.

P/N	Description
SB1136	Shad-o-Box 4K Camera (10-50 kV)
SB1138	Shad-o-Box 4K EV (10-160 kV)
-01	Premium Grade <sup>1</sup> , Min-R 2190
-02	Standard Grade <sup>2</sup> , Min-R 2190
-03	Premium Grade, Lanex Fine
-04	Standard Grade, Lanex Fine

<sup>1</sup> no line defects <sup>2</sup> up to 15 line defects

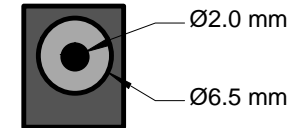
## Mechanical Drawing:



## Power Connector:

DC power jack, 2.0 mm center pin diameter. Fits standard female power plug with 2.1 mm inside diameter and 5.5 mm outside diameter.

center pin:  
6.5 VDC  
outside:  
ground



## 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)

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	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	

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