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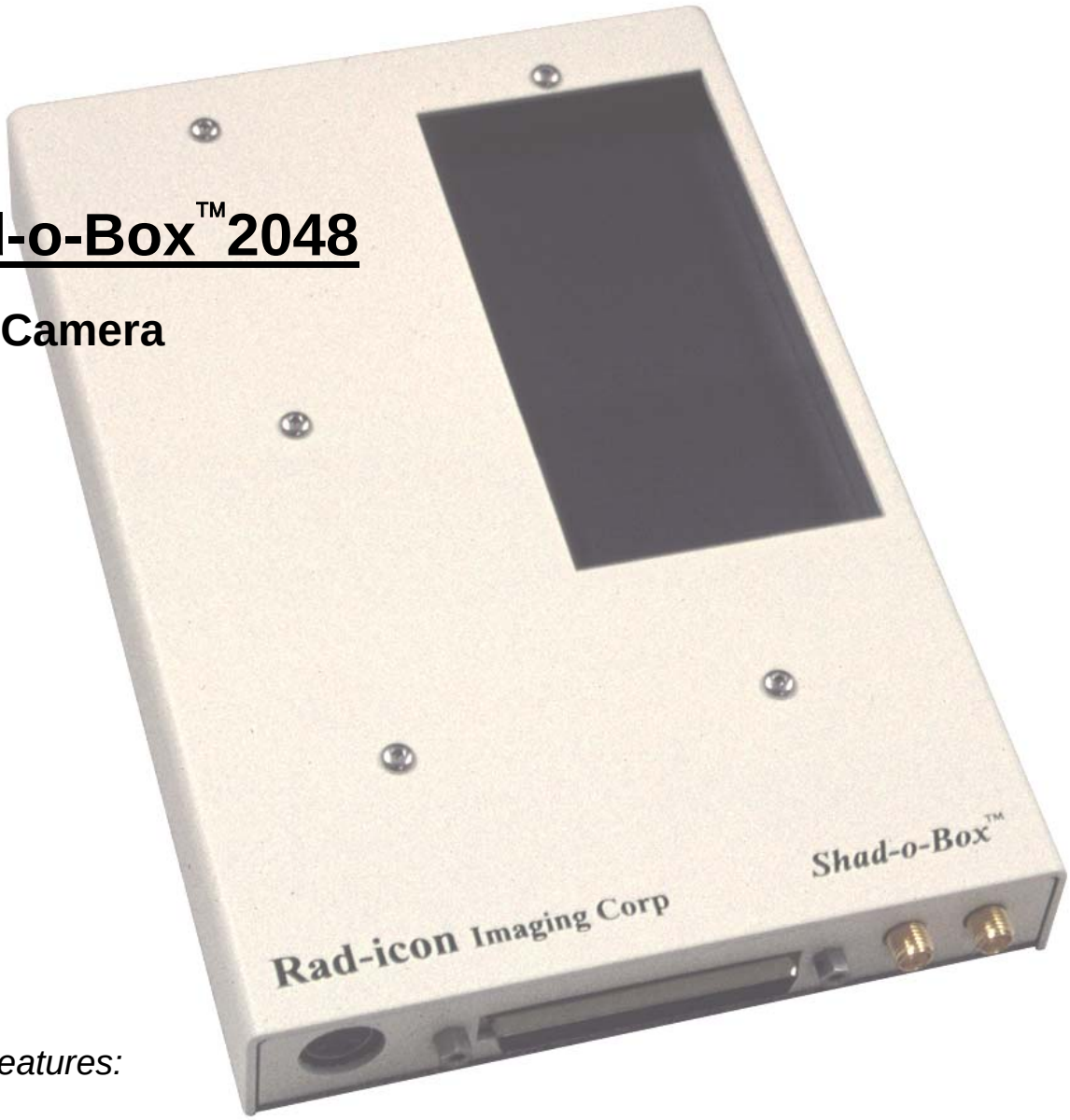
Shad-o-Box™ 2048

X-Ray Camera



Key Features:

- Large 5 x 10 cm active area
- Over two million pixels
- 10 lp/mm (48µm) resolution
- 12-bit digital video output
- Energy range from 10 to 160 kV
- Variable frame rate from 0.01 to 2.7 fps
- Standard frame grabber interface
- Ready-to-run software and drivers

The Shad-o-Box™ 2048 x-ray camera is a stand-alone, high-resolution radiation imaging device complete with 12-bit digital interface. The 49.2 mm by 98.6 mm image sensor features a 1024 by 2048 pixel photodiode array 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 photodiodes. Two models are available for low x-ray energies (10-50 kV) and an extended energy range (10-160 kV), making the Shad-o-Box™ 2048 an ideal choice for applications ranging from biomedical imaging to x-ray crystallography and non-destructive testing.

Rev. 04/12-05

Description:

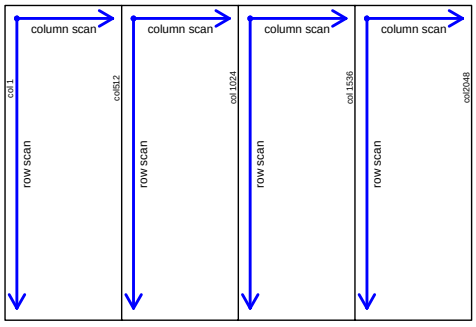
The Shad-o-Box™ 2048 x-ray camera is a complete detection system for high-resolution radiation imaging. The heart of the Shad-o-Box camera is a two-dimensional photodiode array containing 1024 by 2048 pixels on 48 µm centers. A Gd_2O_2S scintillator screen, placed in direct contact with the photodiode 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 photodiode sensor is digitized to 12-bit resolution in 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-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 2048 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 doubles the sensitivity of the analog front end, at the expense of a slight increase in noise and image non-uniformity. All versions operate from a standard +5V/+12V desktop power supply and consume less than 6.5 Watts of power.

Readout Sequence:

The image area of the Shad-o-Box 2048 camera is scanned through four 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 four sections, starting at the leftmost column in each section and moving towards the right. The four sections are scanned in parallel and then interleaved together for transmission.



Three small gaps (each approximately 100 µm wide) separate the four sections that make up the active area. This space should be taken into account when reconstructing the image from the data stream. (Please refer to Rad-icon Application Note AN03 for more details on image correction.)

Specifications:

Detector Specifications	*Standard*	*High Gain*	*Units*
Avg. dark current (23°C)*	8	16	ADU/s**
Read noise (rms)	< 1	< 1	ADU
Dynamic range	4000:1	4000:1	
Digitization	12	12	bits
Conversion gain	500	250	electr/ADU
Readout period	367	367	ms
Max. frame rate	2.7	2.7	Hz
Output data rate	6.0	6.0	MHz

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

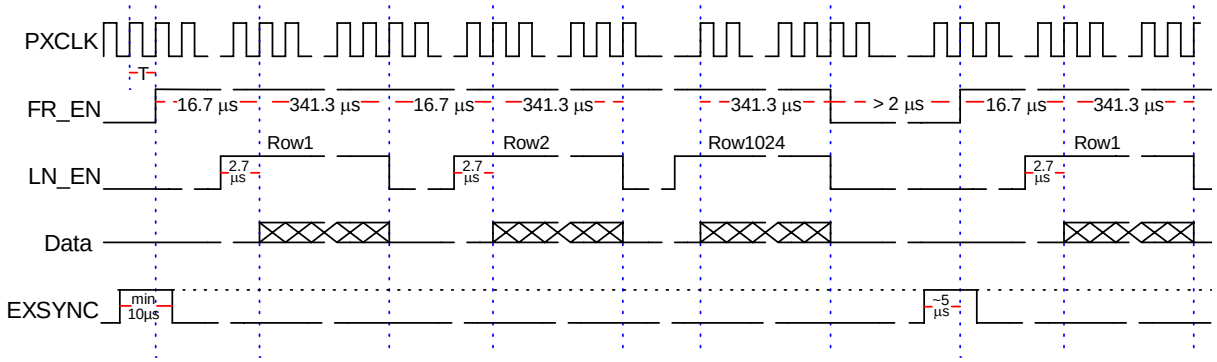
Camera Specifications	*Standard*	*LVDS*	*Units*
Analog supply voltage	12 ± 0.6	12 ± 0.6	Volts
Max. analog supply current	350	350	mA
Digital supply voltage	5 ± 0.25	5 ± 0.25	Volts
Max. digital supply current	750	150	mA
Typical power dissipation	6.5	3.8	Watts
Parallel digital interface	RS-422	EIA-644	
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	2.0	kg

Timing:

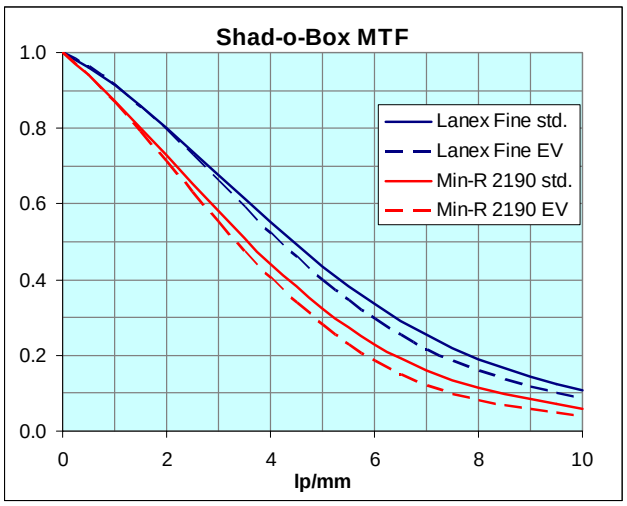
The camera frame rate can be controlled through the external frame sync inputs on either the parallel interface (EXSYNC) or the separate SMA receptacle. If these inputs are pulled high (SMA not connected) the camera will run continuously at its maximum frame rate of 2.7 fps. If either one of the frame 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 16 clock cycles before the first valid pixel. It is low for 84 pixel clock cycles during the horizontal blanking interval. It is also low for a minimum of 96 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.



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 below. 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.



Ordering Information:

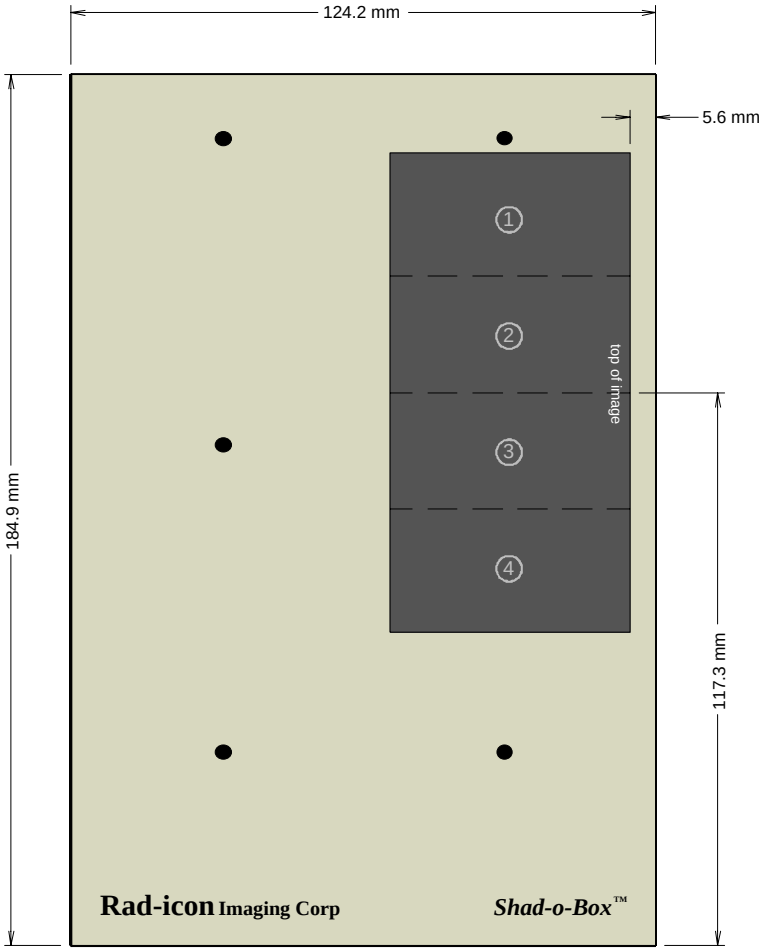
Shad-o-Box cameras have two image quality grades (Standard and Premium), and can be ordered either with a Kodak Min-R® 2190 or Lanex® Fine scintillator. Additional scintillators may be available by special order.

All domestic cameras ship with a desktop power supply and cables for 120V/60Hz. For international orders, a universal input power supply (90-264V, 50-60Hz) is available. Please specify the type of power cord you require.

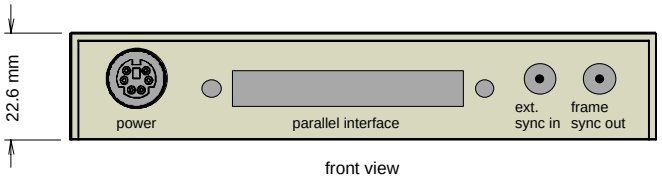
P/N	Description
SB1036	Shad-o-Box 2048 (10-50 kV)
SB1067	Shad-o-Box 2048 EV (10-160kV)
-01	Premium Grade[1], Min-R 2190
-02	Standard Grade[2], Min-R 2190
-03	Premium Grade, Lanex Fine
-04	Standard Grade, Lanex Fine

[1] no line defects [2] up to seven line defects

Mechanical Dimensions:



top view



front view

Data Connector Pinout:

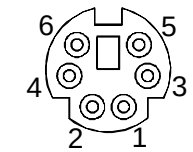
Signal	Description	I/O	+pin#	-pin#
D15	Data Bit 15 (tied low)	O	2	36
D14	Data Bit 14 (tied low)	O	3	37
D13	Data Bit 13 (MSB)	O	4	38
D12	Data Bit 12	O	5	39
D11	Data Bit 11	O	6	40
D10	Data Bit 10	O	7	41
D9	Data Bit 9	O	8	42
D8	Data Bit 8	O	9	43
D7	Data Bit 7	O	10	44
D6	Data Bit 6	O	11	45
D5	Data Bit 5	O	13	47
D4	Data Bit 4	O	14	48
D3	Data Bit 3	O	15	49
D2	Data Bit 2 (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.

Power Connector:

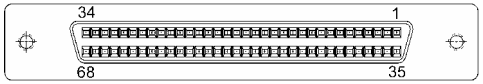
6-pos. mini-DIN receptacle

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)