SUMIX corporation

Megapixel Gigabit Ethernet CMOS

CAMERA

Data Sheet

SMX-12A2x Series Gigabit Ethernet Cameras

SMX-12A2x Series Gigabit Ethernet Cameras Data Sheet

Revision 2.0

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Introduction

SMX-12A2x Series Cameras are 2.1 megapixel CMOS cameras with Gigabit Ethernet interface and Full HD 1080/60p resolution (1920 x 1080).

The **SMX-12A2x Series Cameras** are available in two models:

- SMX-12A2M - monochrome
- SMX-12A2C - color

The cameras have 2/3" sensor and feature high speed - 60 fps (75/150MHz, full resolution) and Gigabit Ethernet full duplex mode interface.

Capturing of initial live streaming video images and still images is provided via the 1000BASE-T, IEEE 802.3af interface.

Key Features

- 2/3" optical format
- 1920 x 1080 Imaging at Standard 2/3" Optical Format
- 12 b Output with >11 b Dynamic Range
- High Efficiency Microlens Array
- RGB Color Filter Array (for SMX-12A2C)
- Electronic Focal Plane Rolling Shutter
- Progressive Readout with Rolling Shutter
- Green Responsivity (550 nm): >5000 LSB/lx-s
- Patented Low-Noise, High-Speed Video Architecture
- Frame Rate up to 60 fps progressive, with maximum sensor resolution
- Output Bayer Raw Data 12 and 8 bit per pixel
- Extended Sensitivity 60 fps at 1280 x 720 (2/3 inch)
- 120 fps at 1280 x 720 (1/2 inch)
- Variable Electronic Shutter:
  - Synchronizable to External Shutter/Flash
  - Synchronizable to External Frame Synchronization clocks
- Dynamic Noise Reduction (DNR)
- Vertical Line-Mixing including 3->2, 2->1, 3->1, and 4->1 Modes
- Horizontal Pixel-Binning including 1.5->1, 2->1, 3->1, and 4->1 Modes
- Enhanced Sensitivity 2/3-inch Video Using Pixel Binning and/or Line Mixing

- Video Gain from -24 up to 72 dB; independent control of R, G and B channels (for SMX-12A2C)
- Sub-Sampling Modes Optionally Provide 1.5, 2, 3 or 4x lower resolution
- Windowing with 16 Column and 9 Row Resolution
- Gigabit Ethernet full duplex mode Interface
- Ethernet cable length up to 100 m
- Power over Ethernet IEEE 802.3af compliant or external power: 5 V (500 mA)
- Hardware image processing (gamma, brightness, contrast, median filter, lossless image compression)
- Hardware Conversion Table from 11 bits (12 bits output with >11 bits dynamic range) to 8 bit per pixel
- Hardware lookup table separately for R, G and B colors

Specifications

Table 1-1 *Camera specifications*

Output video and camera control characteristics		
	SMX-12A2M	**SMX-12A2C**
Maximum resolutions of output window	HDTV Resolution 1936 x 1090 Effective Pixels 2008 x 1094 Total Pixels	HDTV Resolution 1936 x 1090 Effective Pixels 2008 x 1094 Total Pixels
Frame rate at resolution (48MHz)* with 8 bit	60 fps at 1920 x 1080 (75/150 MHz) 120 fps at 1280 x 720 (1/2 inch) Extended Sensitivity: 60 fps at 1280 x 720 (2/3 inch)	60 fps at 1920 x 1080 (75/150 MHz) 120 fps at 1280 x 720 (1/2 inch) Extended Sensitivity: 60 fps at 1280 x 720 (2/3 inch)
Output bits per pixel	Selectable, 8 bit or 12 bit	Selectable, 8 bit or 12 bit
Lookup table	Downloadable for user selected 8 bits mode: converts 11 bits (12 bits output with >11 bits dynamic range) of imaging chip's ADC to 8 bits of output	Downloadable for user selected 8 bits mode: converts 11 bits (12 bits output with >11 bits dynamic range) of imaging chip's ADC to 8 bits of output separately for each color channel (R, G, B)
Pixel rates	Double at: 10 MHz, 18 MHz, 20 MHz, 25 MHz, 36 MHz, 50 MHz, 64.8 MHz, 74.76 MHz	Double at: 10 MHz, 18 MHz, 20 MHz, 25 MHz, 36 MHz, 50 MHz, 64.8 MHz, 74.76 MHz
Pixel gain control	Programmable Gain at 0.006, 3 and 6 dB resolution Video Gain from -24 to 72 dB	Programmable Gain at 0.006, 3 and 6 dB resolution Video Gain from -24 to 72 dB; Independent controls of R, G and B channels
Output window modes	Viewport from 1920x1080 to 16x9; Vertical Line-Mixing including 3->2, 2->1, 3->1 and 4->1 Modes; Horizontal Pixel-Binning including 1.5->1, 2->1, 3->1 and 4->1 Modes; Enhanced Sensitivity 2/3-inch Video Using Pixel Binning and/or Line Mixing Extended Sensitivity 720/60p (2/3-inch)	Viewport from 1920x1080 to 16x9; Vertical Line-Mixing including 3->2, 2->1, 3->1 and 4->1 Modes; Horizontal Pixel-Binning including 1.5->1, 2->1, 3->1 and 4->1 Modes; Enhanced Sensitivity 2/3-inch Video Using Pixel Binning and/or Line Mixing Extended Sensitivity 720/60p (2/3-inch)
Gamma, brightness and contrast control	Programmable with lookup table Hardware Gamma correction	Programmable with lookup table Hardware Gamma correction

Table 1-1 *Camera specifications*

* Listed frame rate values at the defined resolutions are not the maximal possible. Increasing of frame rate can be done by reducing the current Exposure value (the lower Exposure, the higher frame rate), hiding the active video window from the display, running the camera with a fast speed computer, etc.		
Imaging chip characteristics		
Type	Monochrome 2.1 megapixel CMOS sensor with an optical format of 2/3 inch, manufactured by AltaSens, Inc. (http://www.altasens.com)	Color 2.1 megapixel CMOS sensor with an optical format of 2/3 inch, manufactured by AltaSens, Inc. (http://www.altasens.com)
Pixel size	5 µm x 5 µm	5 µm x 5 µm
Shutter type	Electronic Focal Plane Rolling Shutter	Electronic Focal Plane Rolling Shutter
Scanning mode	Progressive	Progressive
ADC resolution	12 bit	12 bit
Sensitivity	Green Responsivity (550 nm): >5000 LSB/lx-s	Green Responsivity (550 nm): >5000 LSB/lx-s
Dynamic range	72 dB	72 dB
Camera electrical characteristics		
Supply voltage	Power Over Ethernet IEEE 802.3af compliant or external power: 5 V	Power Over Ethernet IEEE 802.3af compliant or external power: 5 V
Supply current	500 mA (at 5.0 V)	500 mA (at 5.0 V)
Power consumption	2,5 W at 74.25 MHz Video Rate	2,5 W at 74.25 MHz Video Rate
Camera interface characteristics		
Interface Type	1000BASE-T	1000BASE-T
Connector Type	RJ 45 standard Ethernet connector	RJ 45 standard Ethernet connector
System requirements		
Operating System	Windows XP SP1+/2003/Vista (32 bit)/2008/7 recommended: Windows 7 or XP 1+	Windows XP SP1+/2003/Vista (32 bit)/2008/7 recommended: Windows 7 or XP 1+
Processor	Core 2 Duo, recommended 2 GHz or higher	Core 2 Duo, recommended 2 GHz or higher
RAM	512 MB or higher	512 MB or higher

Table 1-1 *Camera specifications*

Hard Disk Space	About 15 MB for installation plus additional space for captured images for capturing at maximum video rate recommended the RAID-0 HDD configuration	About 15 MB for installation plus additional space for captured images for capturing at maximum video rate recommended the RAID-0 HDD configuration
Video	Video chipset: ATI 9X series (or higher) or NVidia GeForce 4x (or higher); up to date Video card drivers	Video chipset: ATI 9X series (or higher) or NVidia GeForce 4x (or higher); up to date Video card drivers
Hardware Interface	At least one free 1-Gigabit Ethernet port of the computer, recommended: Intel 1000 Pro PCI-Express adapters	At least one free 1-Gigabit Ethernet port of the computer, recommended: Intel 1000 Pro PCI-Express adapters
Camera physical characteristics		
Operating temperature	0 to +60°C	0 to +60°C
Lens mount type	C-mount	C-mount
Weight (without lens)	198 g	198 g
Dimensions (W x L x H)	50 x 80 x 50 mm	50 x 80 x 50 mm
Camera housing material	Duralumin	Duralumin

Camera Mechanicals

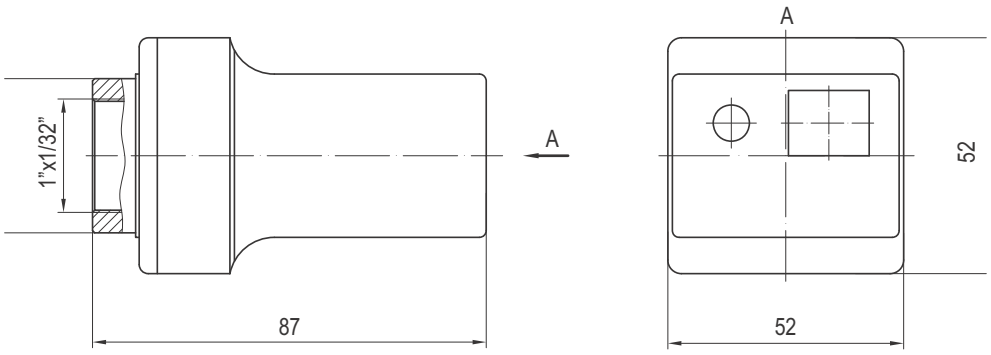


Figure 1-1 *Camera drawing*

Figure 1-2 *SMX-12A2x Series camera outlook*

General Sensor Specification

Overview

The SMX-12A2x Series Cameras use the ProCamHD™ 2.1Mpixel CMOS sensor with an optical format of 2/3 inch.

This sensors family specifically supports progressive imaging of 2.1 Mpixels at 60 Hz. In addition to HDTV at 1080/60p and 720/120p, the sensor produces extended sensitivity video at 720/60p. The architecture simultaneously facilitates high video rate and fill factor at low read noise. System-on-Chip integration includes analog and digital signal processing, low-power 12-bit A/D converter, digital state machine, analog and digital gain amplifiers, programmable memory, and clock and bias generation.

RGB Color Filter Pattern

The SMX-12A2x cameras sensor is supplied with a standard Bayer color filter array having RGB matrix. The Pixel 1,1 is green, Pixel 1,2 is blue and Pixel 2,1 is red (See Figure 1-3).

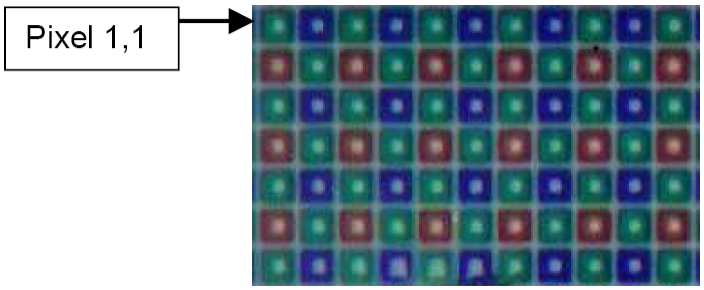


Figure 1-3 *RGB Bayer Pattern*

Tapered Reset

The SMX-12A2x cameras sensor provides high optical fill factor and low read noise via the tapered reset technique. Tapered reset suppresses the kTC noise that is

fundamentally generated as a by-product of resetting the photodiode capacitance - without having to invoke correlated double sampling. This simultaneously maximizes the light-gathering area of each pixel and greatly reduces the complexity of the camera electronics. There is no need for external memory. The sensor operates at the high date rates incumbent with HDTV with lower read noise. The figure 1-4 shows how the pixel interacts with the supporting circuits to suppress noise via the system-on-chip functionality (See Figure 1-4).

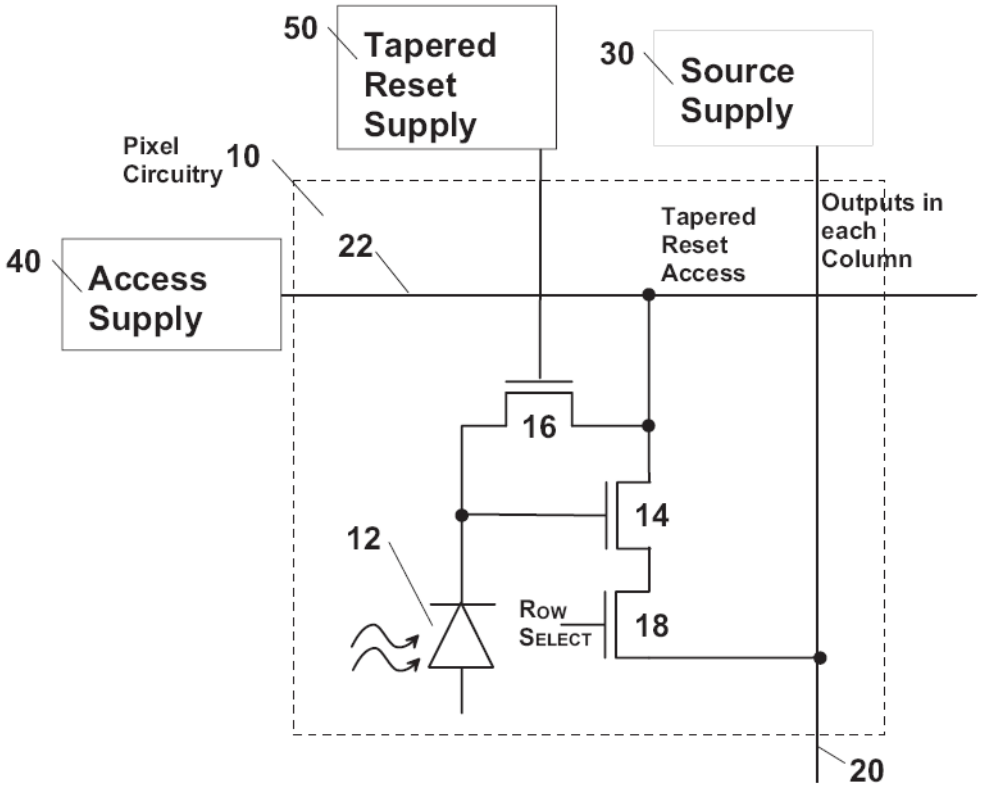


Figure 1-4 *Tapered Reset implementation using imaging System-on-Chip integration*

Sub-sampling Readout

The SMX-12A2x cameras sensor directly supports four subsampling modes to provide 1.5X, 2X, 3X and 4X lower resolution as shown on the figure below (See Figure 1-5).

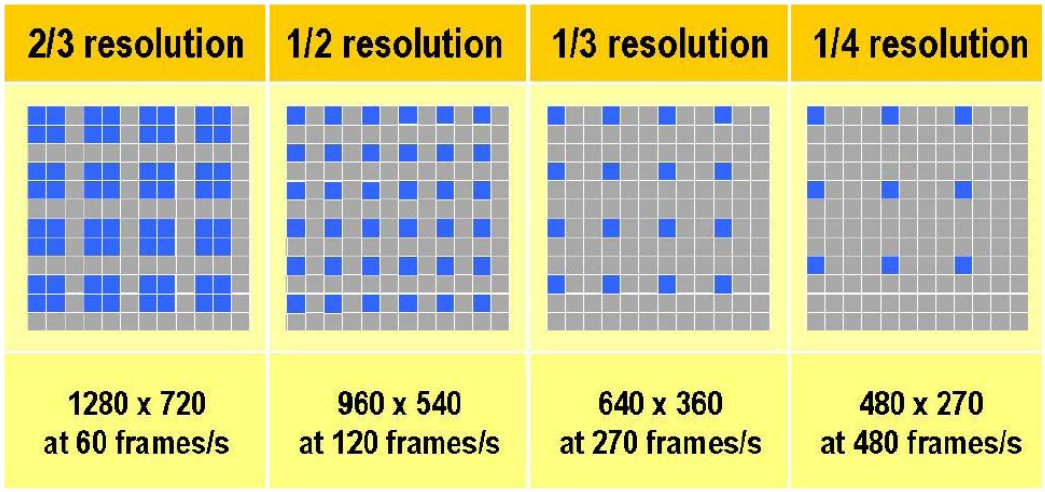


Figure 1-5 *Sub-sampling Readout*

Windowing Readout

Windowing is directly supported with programming resolution of 16 lines in the horizontal direction and 9 columns in the vertical direction. The maximum frame rate of the subwindow is given by 74.125 MHz divided by the number of pixels in the window. The smaller window reflects a smaller effective format. For example, a 1280 x 720 window corresponding to the 720p standard is supported at 60 frames per second. A 1280 x 720 window can also be read at 120 Hz (See Figure 1-6).

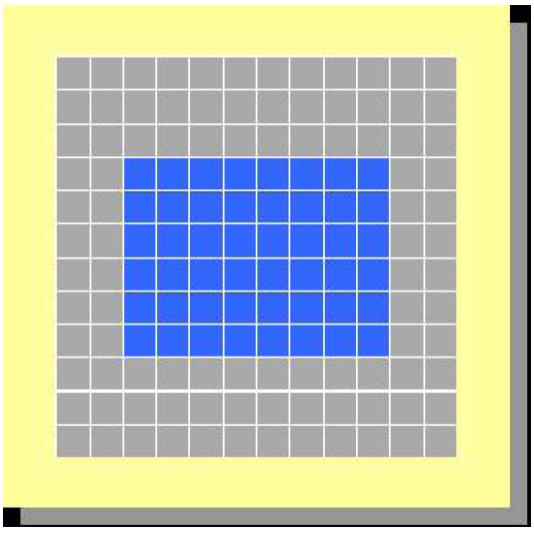


Figure 1-6 *Windowing Readout*

Line-Mixing Readout

The SMX-12A2x cameras sensor supports simple line mixing imaging modes. Line mixing is enabled in both interlaced and progressive readout in combinations of 1.5, 2, 3 or 4 video lines.

Progressive Operation. The mixing of 2 progressive lines per frame is done to boost sensitivity for progressive image readout. In each frame lines 1 and 2 are added to enhance the sensitivity of the resulting line 1. Lines 2 and 3 are then added to produce enhanced sensitivity (ES) line 2, etc.

Sensitivity hences doubles and S/N ratio increases. The SMX-12A2x cameras sensor also supports progressive-mode mixing of 3 and 4 lines.

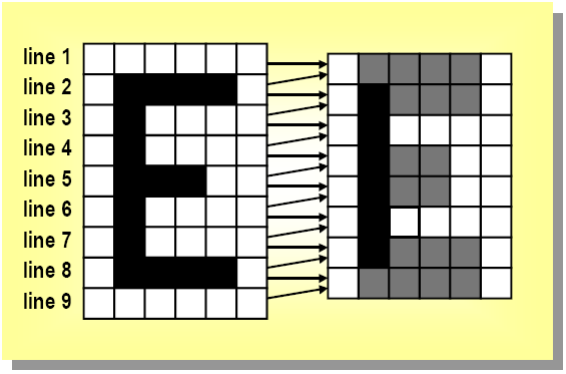


Figure 1-7 *Progressive operation*

Horizontal Binning Readout. In addition to line mixing, the SMX-12A2x cameras sensor supports pixel binning in the horizontal direction. By binning and/or line mixing, the information of multiple neighboring pixels is combined into one superpixel. While this reduces effective resolution, these modes increase signal-to-noise ratio. The binning modes include 1.5->1, 2->1, 3->1, 4->1.

Note: *Binning does not increase the frame rate (in contrast to subsampling or windowing)*

Binning is supported only for monochrome operation

Maximum full resolution frame rate with binning is limited by the A/D conversion rate of 150 MHz to 60p or 60i

Enhanced Sensitivity Readout at Constant Optical Format. Constant optical format is maintained while enhancing sensitivity by enabling both line mixing and pixel binning. For example, the 1920 x 1080 format is 2/3-inch at full resolution. By enabling 1.5->1 binning and line mixing, the on-chip signal processing converts the 2/3-inch format to 2/3 lower resolution (1280 x 720) with enhanced sensitivity. The figure 1-8 shows how the pixel information is combined to form the resulting image (See Figure 1-8). The figure 1-9 shows the trade in resolution to enhance sensitivity for imaging at lower level of ambient lighting (See Figure 1-9).

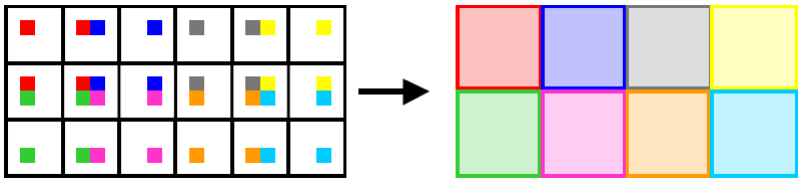


Figure 1-8 *Combined pixel information to form the resulting image*

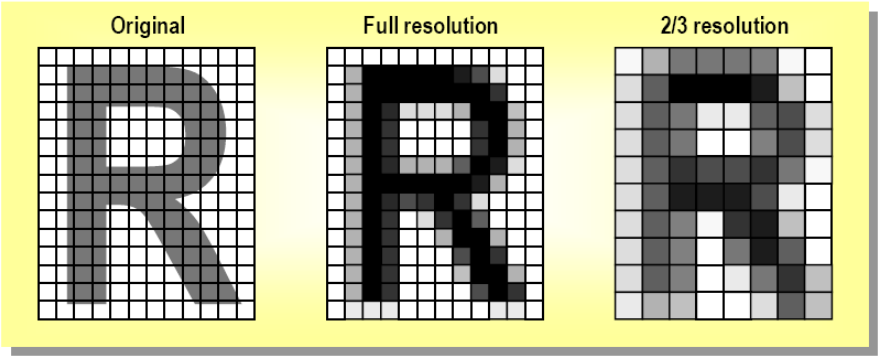


Figure 1-9 *The trade in resolution to enhance sensitivity*

Binning for 1/2 resolution and 4x sensitivity is shown in the two figures below (See Figure 1-10, See Figure 1-11). Here the resolution for 2/3-inch optical format, for example, becomes 960 x 540. If the starting resolution is instead programmed to 1280 x 960 (1/2-inch optical format), the resulting resolution is 640 x 480.

Four pixels are effectively combined into one super pixel.

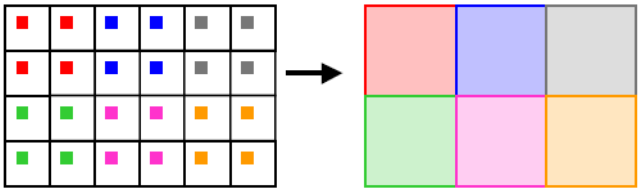


Figure 1-10 *Combining four pixels into one super pixel*

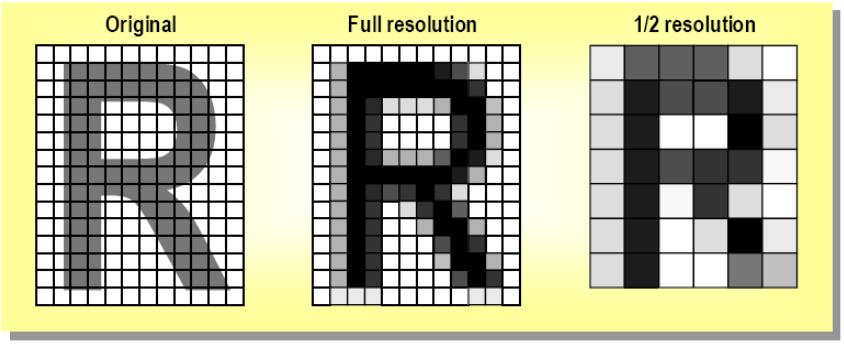


Figure 1-11 *Binning for 1/2 resolution and 4x sensitivity*

Binning for 1/3rd resolution and 9x sensitivity is shown in the two figures below (See Figure 1-12, See Figure 1-13). Here a starting resolution of 1920 by 1080 at 2/3-inch optical format, for example, becomes 640 by 360. If the starting resolution is instead programmed to 960 by 960, the resulting resolution is 320 by 320. Nine pixels are combined into one super pixel.

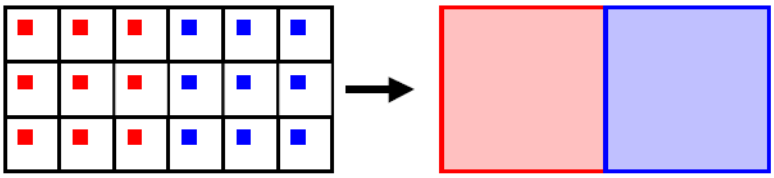


Figure 1-12 *Combining nine pixels into one super pixel*

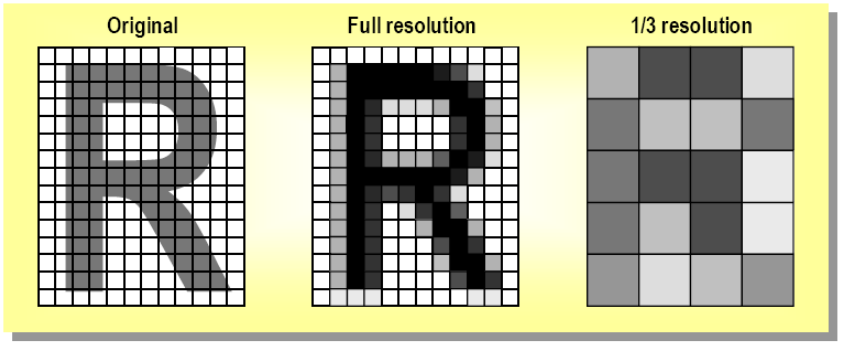


Figure 1-13 *Binning for 1/3rd resolution and 9x sensitivity*

Conversion Gain and Dynamic Range Setup

The SMX-12A2x cameras sensor is tuned to minimize read noise, maximize dynamic range, set the conversion factor, maximize linearity or to generally optimize overall performance. The nominal programming settings supplied with the sensor result in conversion factor of ~11 e-/LSB, as shown in the next figure for 1080/60p operation. Adjusting the gain and the ADC input range for alternative optimizations enables tuning the sensor to decrease conversion factor or widen the imaging dynamic range.

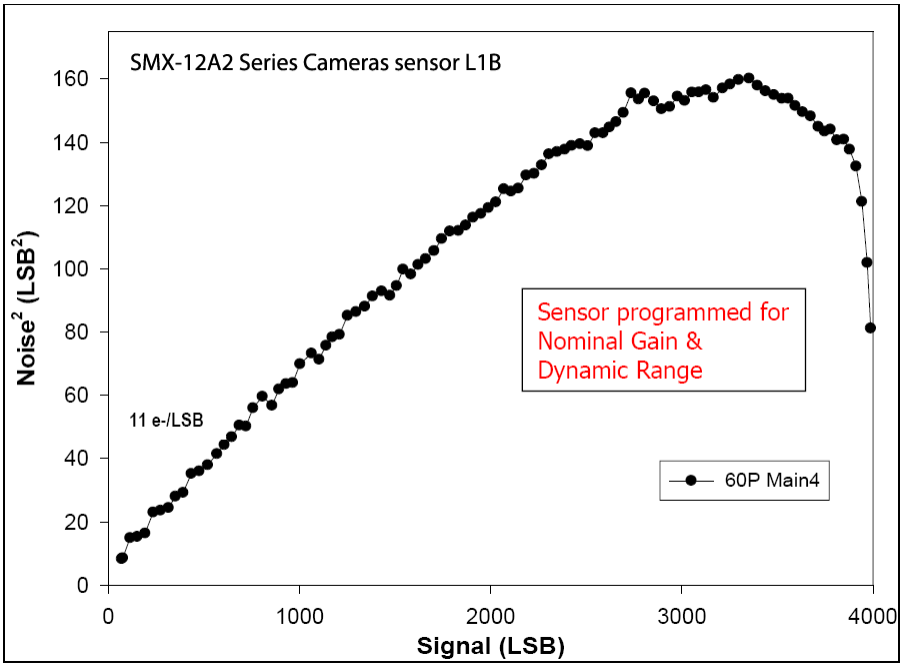


Figure 1-14 *Transfer Characteristic for Nominal Settings*

Image Sensor Electro-Optical Characteristics

Quantum efficiency and horizontal MTF for the base sensor configuration with standard microlens and cover glass are shown in the figures below. Bare sensors without microlens and color filter have peak quantum efficiency >40% at 620 nm.

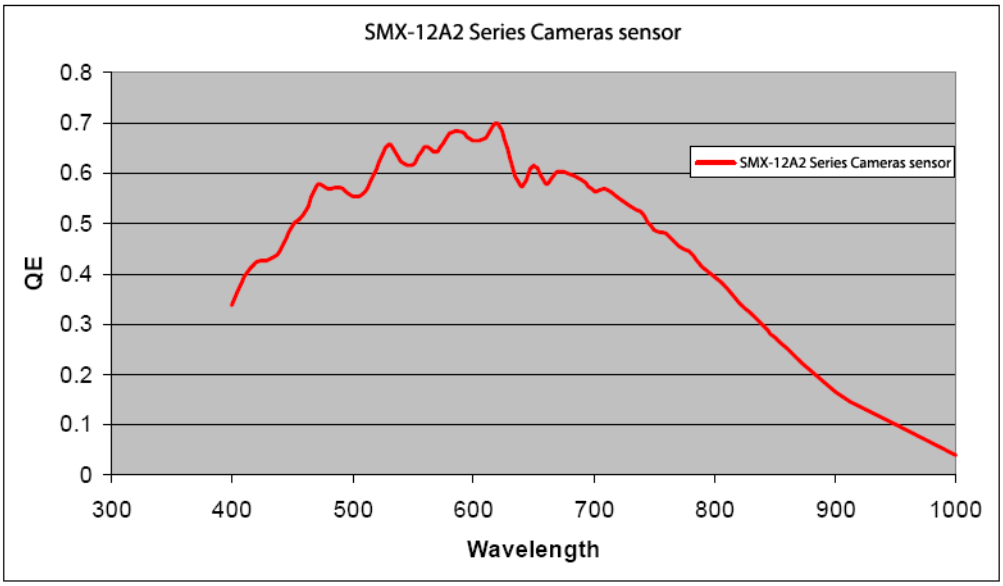


Figure 1-15 *Quantum Efficiency with standard microlens and cover glass*

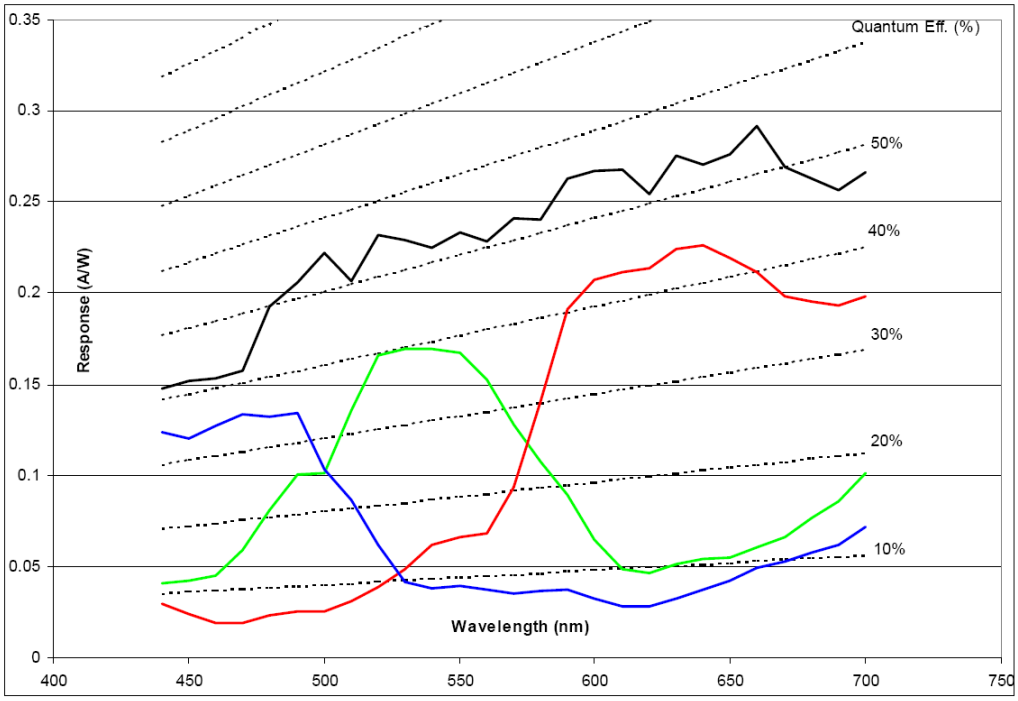


Figure 1-16 *Spectral Response of the SMX-12A2x cameras sensor (Monochrome and Color)*

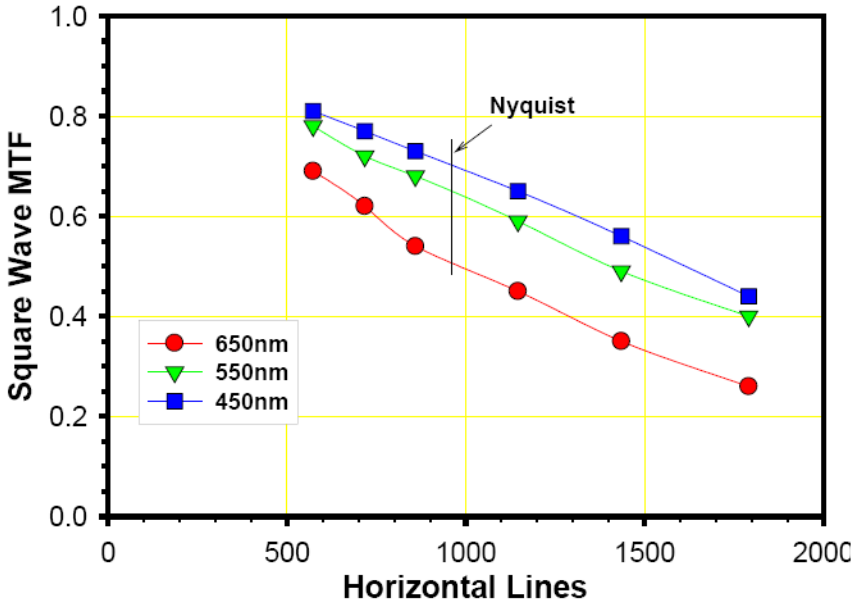


Figure 1-17 *Horizontal MTF with standard microlens and cover glass*

Maximum nonlinearity is ±2.5%; the figure below shows typical I/O response and nonlinearity for 1080/60p operation.

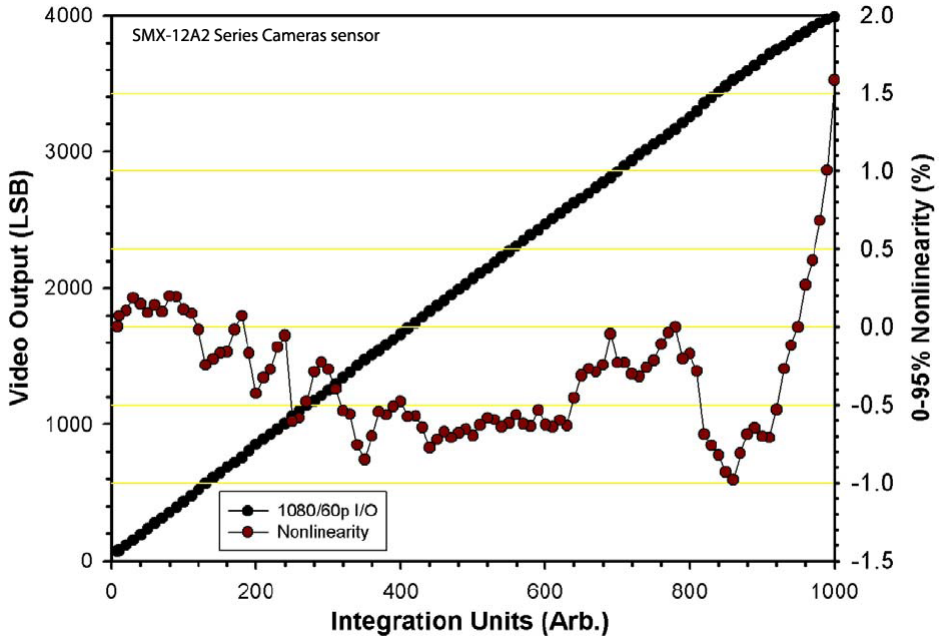


Figure 1-18 *1080/60p iSoC Linearity*

SMX-12A2x Software Package

The SMX-12A2x cameras go with software package that contains a Standard Application, Driver, User Guide, and SDK (API, examples, documentation).

The Standard Application provides control of set-up commands demonstrating cameras performance.

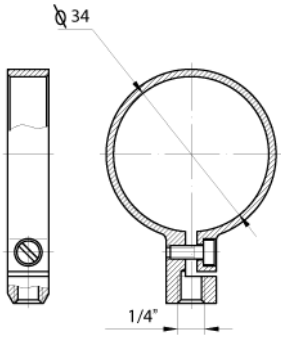
API allows full control of all camera features and along with examples and documentation enable easy integration of the camera into the customers' applications.

Figure 1-19 *SMX-12A2x Camera Application*

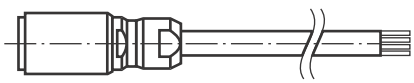
Camera Accessories

The SMX-12A2 Series Gigabit Ethernet cameras usually go with:

1. Tripod adapter. The lightweight duralumin adapter allows quick and easy camera fixing to the tripod, offering additional protection of the camera



2. 6 pin Hirose trigger connector (without a cable)



3. IR-cut filter and Ring-adapter (for SMX-12A2C)

The SMX-12A2 color cameras are sensitive to IR-light. IR-cut filter will block the (near) infrared light and make the colors of the image more realistic.

When the camera is used with the IR-cut filter, the focus distance is increased to 0.66 mm. To restore the original value of focus distance (when the camera is used with no IR-cut filter ring and no ring-adapter), the ring-adapter is used.

Figures