

**SI-6600-M & RGB MegaCamera™**  
**6.6 Megapixel, 10-Bit, 60MHz**  
**Ultra-High Resolution Portrait Digital Camera**

Silicon Imaging Inc.



**Silicon Imaging** is proud to continue its innovation in ultra-high resolution machine vision camera. Driven by the growing demand for consumer Digital Still Cameras, CMOS sensors are continuing to break technical barriers and surpass the performance characteristics of CCD's in many photonic, imaging and consumer applications. By utilizing a single highly integrated CMOS device, which incorporates Megapixel sensing areas, timing generation, signal processing and high bandwidth outputs, Silicon Imaging has developed a very compact, low-power, ultra high speed Megapixel digital camera system.

**2210 x 3002 Megapixel - Ultra Resolution**

The SI-6600 is an all-digital CMOS camera that delivers 6.6 Million pixels of resolution and is capable of running at 6 frames/second at its full 2210 x 3012 resolution and over 500 frames/per second at 320 x 240 resolution. The entire package is only 45 x 52 x 50mm (33 x 40mm x 22mm in PCB) and is small enough to placed on a robot for semiconductor machine vision inspection or placed in an outdoor housing for remote surveillance. It is ideal for live visualization of documents or films and scanning of biometrics for handprint or facial recognition.

**10-Bit Pixel Sampling – Sub-Pixel Accuracy**

The SI-6600 MegaCamera™ uses 10-Bit digitizers to sample the pixel data. Converting the pixel data directly to digital at the sensor head eliminates pixel-sampling jitter and enables accurate sub-pixel metrology, image analysis and improved live video reconstruction. A programmable clock which ranges from 20–60MHz allows for trade-offs in speed versus exposure time and lower noise.

**1000 FPS - Windowing & Subsampling**

Ideal for object tracking and high-speed Motion analysis, the SI-6600 is capable of generating imagery at over 1000 frames per second by reducing the size of the readout image (ex. 100x100). This windowed Region-of-Interest (ROI) can be moved dynamically, creating an entirely electronic pan/tilt/zoom function within the camera field-of-view.

**Dual Slope Exposure - "Super-Dynamic"**

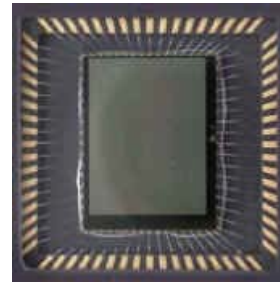
The SI-6600 can be used in a dual slope bi-linear mode, extending the useful dynamic range in scenes where detail in bright areas are to be preserved at the same time as maintaining details in darker regions. In normal linear response, a camera requires a short exposure to keep the bright areas from saturation. However, the darker regions of the image would not have enough time to integrate charge. If the exposure is set longer the detail in the dark areas will become visible by the brighter areas will become saturated. The dual-slope operation combines the transfer of nominal integration time (steep slope, high sensitivity) with the transfer curve obtained from a short electronic shutter (shorter exposure time, lower sensitivity), into a single exposing operation.

**CameraLink™ Digital Interfaces**

An industry standard forum has adopted Camera Link, for low cost connectivity and cabling of cameras and frame grabbers at very high speeds (over 1.2GB/sec). The SI-6600-CL utilizes the high speed CameraLink interface to output 2210 x 3002, 10 bit data at 50MHz continuously to a frame grabber and directly into PC memory for further processing. The single cable includes image data, vertical and horizontal synch, LVDS Triggering and 9600 baud Serial communication. As this camera complies with the standard, it is compatible with many popular frame grabber and image processing hardware devices and fiber-optic extender for extended distance transmission.

**GigE-Cameralink – Gigabit Ethernet Connectivity**

Now you can capture high-speed MegaCamera images to your PC from distance of a 100-meters using CAT-5 wire using the Silicon Imaging [GigE-CameraLink](#) Interface. The GigE-Cameralink captures MegaCamera digital images and transmits them via 10/100/1000 Gigabit Ethernet directly to your PC at speeds over 100MB/sec.



**FEATURES**

- 2210 x 3002 Resolution (6.6 Million Pixels)
- Rolling Shutter, Progressive scan
- 1" Imaging Format , 3.5um Square Pixel
- Windowing and Subsampling
- 10 Bits per Pixel, 50MHz Sampling
- High Speed Readout (8 ~ 1000FPS)
- Region-of-Interest (ROI) windowing
- Progressive Rolling Shutter Mode
- Gamma & NDR Modes
- Programmable Gain, Offset, Clock, Shutter & ROI
- External Clock Synchronization (FrameLock)
- Monochrome & Color Bayer RGB Models
- 5VDC Low Power, Small Package
- C-Mount Housing or PCB versions
- CameraLink Interface

**SI-6600 MegaCamera CameraLink Specifications**

**Image Sensor**

Active Pixels	2210 H x 3002 V
Pixel Size (pitch)	3.5µm x 3.5µm
Optical Format	1" (7.7 x 10.5 mm)
Pixel Type	CMOS, 3-T
Aspect Ratio	1 : 1
Spectral Response	400 ~ 1000 nm
Fill Factor	35% (Peak QE x FF = 20% @ 630nm)
Responsivity	250 V per Ws/m 0.1 A/W (Spectral Response * FF)

**CameraLink Frame Grabber Control:**

Serial Communication	RS-232 Protocol 9600bps (57.6k)
Signaling	TX & RX (LVDS)
Asynchronous Triggers	LVDS – CC1 (-CL) TTL Trigger-In / Strobe-Out(option)
Region-of-Interest	Programmable Horiz & Vertical
Programmable Modes	Gain, Windowing, Clock rates, Exposure, Subsampling, black level, Column Balance, NDR.
Gains	Range: 1~14.67X
Setting Timing	Next top of Frame

Conversion Gain	33 $\mu\text{V}/\text{e}^-$
Dark Current	30 mV/sec @ 21C
Temporal Noise	24 e <sup>-</sup> @ 40MHz
SNR	45dB
Saturation Charge	26,500 e <sup>-</sup>
Output swing	0.8V at Unity Gain
Dynamic range	61 dB (1100:1)
PRNU	1.5%rms Photoresponse nonuniformity
Windowing (ROI)	H & V. Vertical speed increase only
Sub-sampling	Full, 1/4, 1/9, 1/16, 1/36 (COLOR)
Gain MAX	1 ~ 14.67X
Readout Method	Progressive Scan
Black Level	Programmable
Min Row Time	142 clocks (Horizontal Blanking)
Vertical Blanking	1 Row

#### A/D Conversion & Pixel Clock Synthesizer

A/D Conversion	Nominal 40MHz (5.3fps @ 6.6MP)
Vertical Resolution	10 Bit (Format = 12bit-CL 1-Tap)
Clock Frequency	20 ~ 60 Mhz Programmable
Adjustments	Black Level, Column Balance, Gamma Curve

#### Digital Video Output

Readout Rate	20 ~ 60Mhz x 12bit format	
Readout Format	CL-12 Bit, 1-Tap	
Frame Rate	40MHz	60MHz
2200 x 3000	5	8
1106 x 1502	21	32
738 x 1002	45	68
2048 x 1536	12	18
1280 x 1024	27	41
640 x 480	104	155
320 x 240	344	517
160 x 120	1029	1543
Frame Time	2210 x 3002 @ 40MHz = 187.5msec	

Ext Clock Sync	Clock in or Clock Out (-X Option)
----------------	-----------------------------------

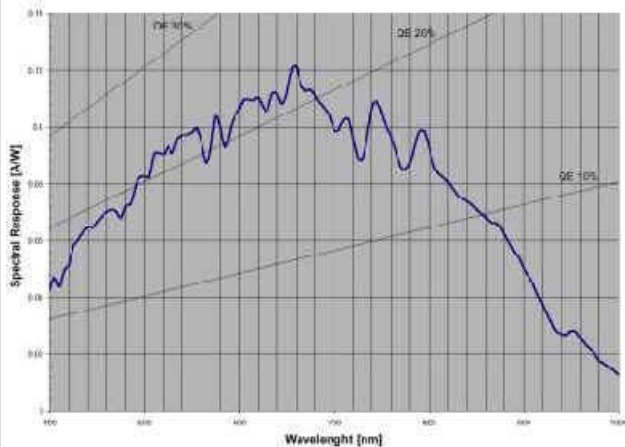
#### Power

Input Voltage	+5 VDC +/- 10%
Power	2.5 Watts
Power/Trigger Connection	Tajimi RO3-PB3M 3Pin (-CL) Tajimi RO3-PB5M 5Pin (-X)

#### Mechanical

Lens Mount	C-Mount, 7mm Back focus Adj.
Enclosure Size	45mm W x 52mm H x 50mm L
Weight	12 oz.
Camera Mount	1/4" x 20 standard tripod mount
Cable Connector	Cameralink MDR-26

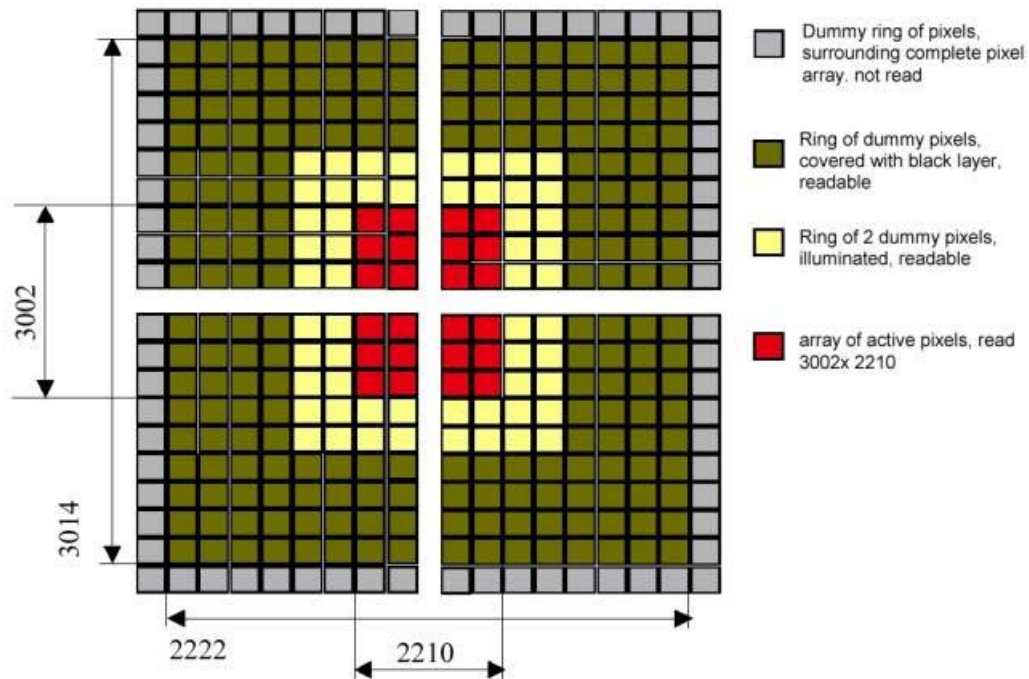
#### Spectral Response Curve (Monochrome)



## 6.6 Megapixel CMOS Image Sensor

The MegaCamera SI-6600 utilizes a proprietary portrait style 6.6 Million pixel high-speed CMOS image sensor. Each pixel is 3.5 $\mu\text{m}$  square, ideal for image processing, and the entire array fits the 1" format for flexible optic choices. This reduction in process geometry allows for both an increase in transistors and fill factor without compromising performance, plus offers more advanced readout controls, greater speeds and lower power dissipation. This new sensor technology offers a more responsive pixel design with added circuitry for increased dynamic range, greater sensitivity, decreased fixed pattern noise and low dark current for long exposure applications. Unlike CCD, which leak charge to adjacent pixels when the registers overflow (blooms), the SI-6600 provides inherent anti-blooming protection in each pixel, so that there is no blooming.

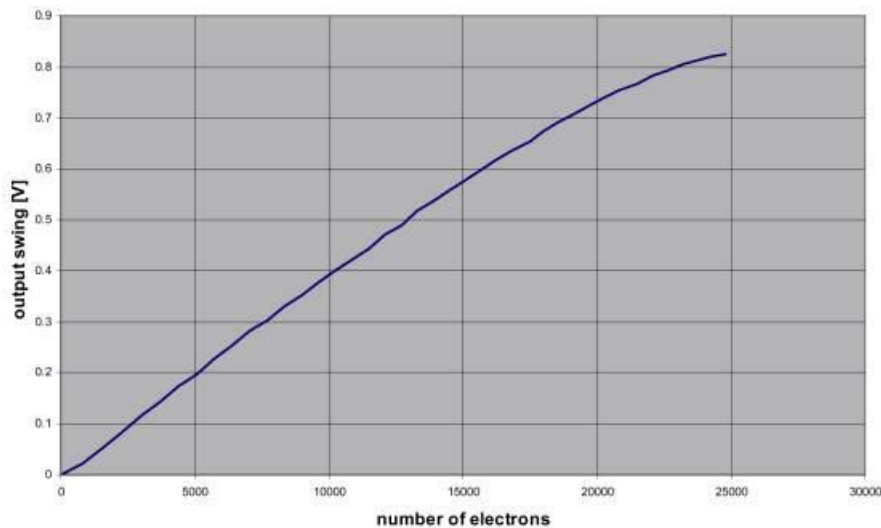
The array has 2210 pixels on a line and 3002 rows, which result in a near 3:4 portrait aspect ratio. The SI-6600 outputs 2208 x 2960, using 42 rows for interframe blanking. The image can be rotated 90-degrees to obtain a 4:3 image. In addition, by using the windowing feature, a 16:9 aspect ratio (eg. 1280x 720) or 1:1 aspect ratio (1024 x 1024) are available. At smaller ROI sizes (eg. 128 x 128) frame rates in excess of 1000fps.



The SI-6600 MegaCamera achieves high data rates by simultaneously accessing two adjacent pixels at a time and reading them out sequentially. These pixel values feed thru a gain & offset amplifier and then to on-board dual 10-Bit A/D converters and placed onto a 12-bit data bus for transmission. The entire imager field of view can also be readout using subsampling. In this mode, 2 pixels are readout and a group of pixels are skipped. As fewer pixel are output, the frame rate increases

In a color model, a Bayer filter covers each of the pixels to produce a pattern of values that represent the color information, which must be processed and interpolated to obtain an RGB value per pixel. The 12-bit output format from the camera is identical for monochrome and color models.

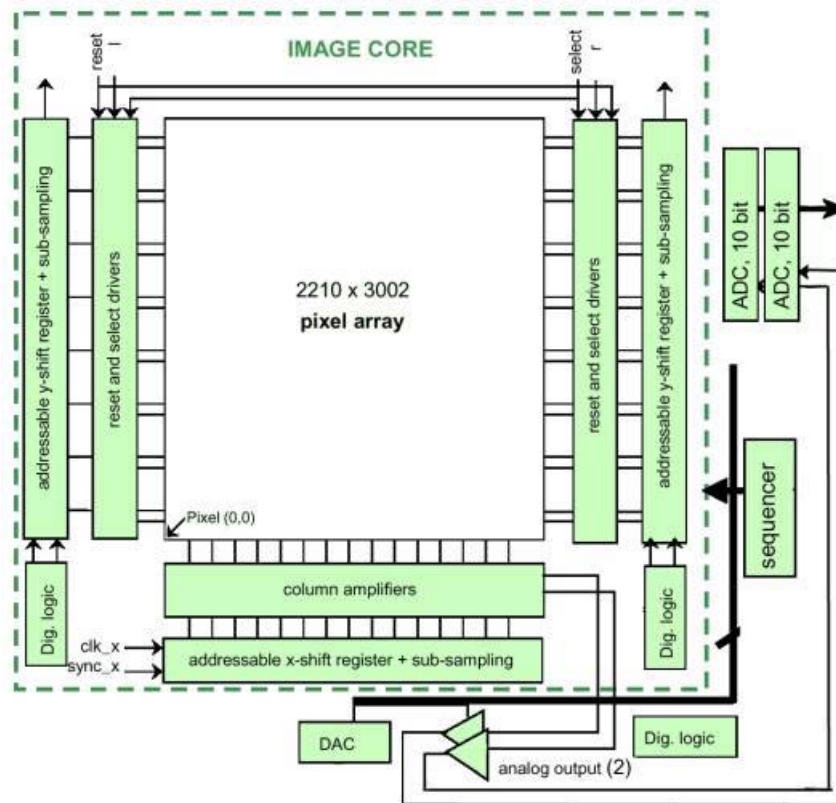
The camera sensor is light sensitive between 400 and 1000 nm. The peak QE \* FF is 22.5% approximately between 500 and 700 nm. In view of a fill factor of 35%, the QE is thus close to 70% between 500 and 700 nm.



The figure above shows the pixel response curve in linear response mode. This curve is the relation between the electrons detected in the pixel and the output signal. The resulting voltage-electron curve is independent of any parameters (integration time, etc). The voltage to electrons conversion gain is 37 μV/electron.

### 10-Bit Digital Sampling System

A 10-Bit Analog-to-digital (A/D) converter samples each pixel value and quantizes it into 1024 levels, as it is clocked out of the sensor. Pixel clock sampling ensures precise measurement of the photonic charge without the jitter and sampling uncertainty associated with traditional analog video systems, such as RS-170 and CCIR. The camera produces images which can deliver improved photometry accuracy and sub-pixel metrology. The use of 10-bit converters versus traditional 8-bit systems further enhances the image dynamic range. The combination of 10-bit vertical resolution and pixel clock sampling provide precise sub-pixel measurement accuracy (ex. 1/10 pixel).



## Digital Clock Synthesizer

A wide range of master clock frequencies (eg. 20 to 60MHz) can be precisely generated using the Digital Clock Synthesizer. The Frame Grabber, which is used with the camera, must be capable of receiving 12bit at 60MHz to achieve the highest data rates. Without any byte packing of the 12-bit word the data rate would be 120MHz (2pixel x 2bytes/pixel x 60MHz). In standard 32Bit/33MHz PCI computers the maximum data rate directly to host memory is usually below 120Mbytes/sec (from 132MB/sec bus) without system interrupts. However, 100MB/sec is more reasonable rate to achieve with other system devices operating (eg. display, clock, mouse etc.). Under these conditions the 12-bit data can be mapped to 8-bits/pixel to reduce the bus traffic or the clock rate can be reduced to and still maintain 12bits/pixel. The frequency of the clock synthesizer can be set by serial command. A table with associated clock frequency is found in the serial programming section of the manual. Due to minimum frequency restriction on the digital transmission link, the pixel clock frequency cannot be lower than 20MHz.

## Embedded Microprocessor

A microprocessor in the camera provides the control interface between the PC and the functional block in the camera (Sensor, Clock Synthesizer, Register Memory, Channel Link Interface & Serial port (CameraLink)). The Microprocessor receives commands through the LVDS level serial port and issues commands to the other devices. It also can store preset values for camera settings, which can be recalled with single ASCII character commands. Several digital I/O or analog sampling signals are available on the processor from PCB header points for custom OEM applications.

## 12-Bit CameraLink Interface (Base Configuration)

*Camera Link* is a new digital transmission method designed by imaging component manufacturers as an easy and standard way to connect digital cameras to frame grabbers. The *Camera Link* specification includes greater than 1.2Gb/sec data transmission as well as camera control and asynchronous serial communications all on a single cable with high-density 26pin connector. Only two connections are required to quickly interface your digital camera to a multitude of frame grabbers. This standardization will ultimately reduce the cost of high performance digital cameras through open market competition and a simple migration path to faster and higher resolution systems.

As a standard that has been defined by industry members, Camera Link provides the following benefits:

- **Standard Interface:** Every *Camera Link* product will use the same cable and signaling. Cameras and frame grabbers can easily be interchanged using the same cable.
- **Simple Connection:** Only two connections will be required to interface a camera and frame grabber: Power and Camera Link.
- **Lower Cost:** Because *Camera Link* is an industry-wide standard, consumers will be able to take advantage of lower cable prices.

- **Smaller connectors & cables:** The technology used in Camera Link reduces the number of wires required to transmit data over traditional LVDS or RS-422 parallel interfaces, allowing for smaller cables. Smaller cables are more robust and less prone to breakage.
- **Higher data rates:** The technology used in Camera Link has a maximum data rate of 2.3GB/s, for use in the most demanding high definition, high frame rate and line scan.

The standard Camera Link cable uses a MDR 26-pin connector (3M Part# 10226-6212VC) provides the following signaling:

- Video Data (4 Pairs using 28:4 Mux, 24 Video, 4 Control)
- Camera control signals (1 Pair)
- Serial communication (2 Pairs)
- Power (3 pair) – Optional Control signals 2, 3, 4

The 24 bit image data (2 words x 12 bit) and 4 control bits are transmitted over only 4 differential pairs using a 28:4 multiplexer (National Semiconductor DS90CR285 Channel Link device). The Four enable signals are defined as:

- FVAL—Frame Valid (FVAL) is defined HIGH for valid lines.
- LVAL—Line Valid (LVAL) is defined HIGH for valid pixels.
- DVAL—Data Valid (DVAL) is defined HIGH when data is valid.
- Spare—A spare has been defined for future use.

All four enables are provided on the camera, via the Channel Link chip. The unused data bits are tied to a known value by the camera. For more information on image data bit allocations, see page 11, *CameraLink Base Configuration Bit Assignment Configuration*.

Two LVDS pairs have been allocated for asynchronous serial communication to and from the camera and frame grabber. Cameras and frame grabbers should support at least 9600 baud. These signals are

- SerTFG—Differential pair with serial communications to the frame grabber.
- SerTC—Differential pair with serial communications to the camera.

The serial interface operates at 9600 baud, one start bit, one stop bit, no parity, and no handshaking. For applications requiring high serial throughput, such as real time windowing update at over 200FPS, the camera can support a serial link mode at 57kbs (not specified in CameraLink spec). The frame grabber serial communication must be set to match this speed.

## Camera Control Signals & Power

Four LVDS pairs are reserved for general-purpose camera control. They are defined as camera inputs and frame grabber outputs. Camera manufacturers can define these signals to meet their needs for a particular product. The signals are:

- Camera Control 1 (CC1) - Used to do triggered image capture
- Camera Control 2 (CC2) for external master clock (optional)

[SI-6600 Cameralink Manual](#) (PDF 1.5MB)

Command	Clock MHz	6.6MP	3.2MP	2.1MP	1.3MP	SVGA	VGA	QVGA	QQVGA
		2200 x 3000	2048 x 1536	1600 x 1200	1280 x 1024	800 x 600	640 x 480	320 x 240	160 x 120
lc306886	20	3	6	9	14	35	52	172	514
lc30b689	25	4	7	12	17	43	65	215	643
lc37cb8f	30	4	9	14	20	52	78	258	772
lc35d40b	35	5	10	17	24	61	91	301	900
lc306882	40	6	12	19	27	69	104	344	1029
lc35e709	45	6	13	21	30	78	117	387	1157
lc34b689	50	7	15	24	34	86	130	430	1286
lc34b688	55	8	16	26	37	95	143	473	1415
lc36cb8f	60	8	18	28	41	104	155	517	1543

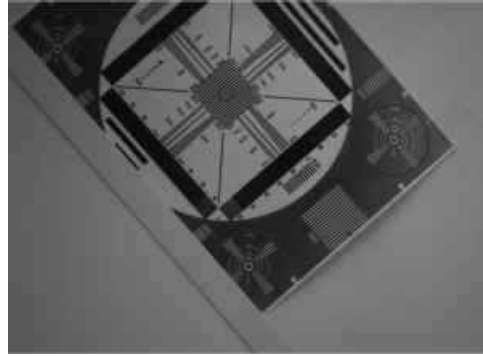
## Subsampling Frame Rates

Subsampling	Resolution	40MHz (fps)	45MHz (fps)	50MHz (fps)	55MHz (fps)	60MHz (fps)
1:1	2210 x 3002	6	6	7	8	8
1:4	1106 x 1502	21	24	26	29	29
1:9	738 x 1002	44	50	55	61	31
1:16	554 x 752	74	83	93	102	66
1:36	370 x 502	149	168	187	205	224

Sample Test Images (2200 x 3000)



*Click on images to enlarge*



*Click on images to enlarge (raw bayer)*



6.6MP Mono Full Size Image- 2.5MB & 1.7MB JPG! (click)



**Kane Computing Ltd**  
7 Theatre Court, London Road,  
Northwich, Cheshire, CW9 5HB, UK.  
Tel: +44(0)1606 351006  
Fax: +44(0)1606 351007/8  
Email: [sales@kanecomputing.com](mailto:sales@kanecomputing.com)  
Web: [www.kanecomputing.co.uk](http://www.kanecomputing.co.uk)