

# SI-1920HD MegaCameraHD™

1920 x 1080, 2.1 MP, 1080P/24/30/60 & 720p  
12-bit, 150 MP/sec High-Definition Camera

Silicon Imaging Inc.



**Silicon Imaging** is proud to continue its innovation in ultra-high speed vision technology. The Silicon Imaging MegaCameraHDä (SI-1920HD) unleashes a new generation of high-performance HDTV CMOS camera power that not only replaces traditional CCD cameras, but surpasses their capability in single chip high-quality HD video applications including broadcast sports, animation, matte work, miniatures, Stereoscopic 3D and slow-motion special effects.

### HDTV 1920 x 1080 at 60FPS (SMPTE 274M 1080P Timing)

By integrated a 2/3" optical format 2.1 Megapixel HDTV CMOS imaging sensor with multi-tap 12-bit A/D conversion, digital signal processing, programmable timing generation and high-speed cameraink digital outputs, Silicon Imaging has developed the worlds smallest 1920 x 1080 60Hz progressive scan (SMPTE274M timing) HD camera.

### 68dB Wide Dynamic Range (> 11bits)

Perhaps one of the most important characteristics of this CMOS camera is its ability to produce high-quality images even under adverse illumination. Unlike CCD cameras which can bloom and reduce their dynamic range with increased data rates (generally 50-55db), the SI-1920HD delivers excellent performance at low light levels with >11 bits of dynamic range. The total noise for this camera is limited to a S/N to 52dB at 0dB gain. Increasing sensor gain to 6dB boosts the S/N to 57.5dB. At Pixel-limited read noise of only three electrons, at a gain of 18dB yields an S/N of 68dB and an ISO speed approaching 1600.

### VariScanHD™ - 16:9 & 4:3 Aspect Switching and Variable Rate

The VariScanHD feature enables the camera to produce HD video in multiple formats with applicable timing and resolution standards including SMPTE 274M, 296M, 293M and ITU-R 601. It takes advantage of the windowing capability of CMOS arrays to directly capture "native" 1080i, 1080p/30, and 720p, or switch between 4:3 and 16:9, while maintaining correct clock timing for the desired format.

### 720P Slow-Motion, Stereoscopic 3-D & Special Effects at 120fps

In 720P mode the camera is capable of achieving selected frame rates from: 4-fps up to 120-fps. When acquiring for 24-fps projects, higher than 24-fps operation can be processed for slow motion effects while slower than 24-fps operation can be processed to speed up motion. Combining the variable frame rate and a variable shutter speed can create interesting ghost like motion blur effects, warp speed zoom effects, and long exposure still shots typical of what one might see in music videos, sci-fi dramas and dream sequences. For high speed motion capture, the 720p mode at 120fps produces images without blur. Using the SI-1920HD-3D stereo pair configuration, left/right eye images can be captured in synch to create high-definition 3-D stereoscopic sequences.

### Enhanced Sensitivity with Binning & Line Mixing

For monochrome application, a constant optical format can be maintained while enhancing sensitivity by enabling both line mixing and pixel binning. Using a 1.5@1 binning and line-mixing, the on-chip signal processing converts the full 2/3-inch format 1920 by 1080 to lower resolution (1280 by 720) with enhanced sensitivity.

### 12-Bits Uncompressed Bayer Color at 150Mpixel/sec

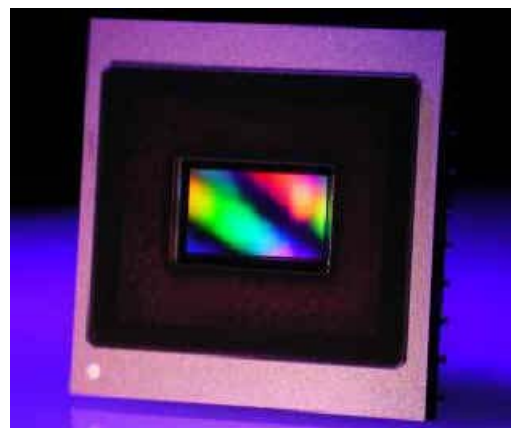
Unlike traditional broadcast and video cameras, which colorize and encode the image data for transmission on analog or digital (HD-SDI) output, the MegaCameraHD™ outputs raw 12-bits/pixel at 150MHz (1.8Gb/sec). The image data is transmitted to a recording system using a dual-tap (2x12-bit 75MHz) base cameraink interface and frame grabber. The image data can then be expanded into an RGB per pixel (4:4:4) format with interpolation and color matrix for display on PC graphic or industry standard HD-SDI playback hardware. As the 12-bit original data is always maintained, no detail is lost in encoding, transcoding or recording.

### 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 2 GB/sec). The SI-1290HD-CL utilizes the high speed CameraLink interface to output 1920x1080, 12 bit data at 75MHz 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-Cameraink – 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-Cameraink](#) Interface. The GigE-Cameraink captures MegaCamera digital images and transmits them via 10/100/1000 Gigabit Ethernet directly to your PC at speeds over 100MB/sec.



### FEATURES

- 1920 x 1080 Resolution (2.1 Million Pixels)
- 2/3" Imaging 16:9 Format , 5 um Square Pixel
- 1080P @ 24/25/30/60 FPS
- 720P Slow-Motion & Special Effects at 120fps
- 12 Bits per Pixel, 75MHz Sampling (150 MP/sec)
- High Speed Readout (30 ~ 3000FPS)
- Region-of-Interest (ROI) windowing
- Monochrome Binning & Line Mixing
- Long Integration using external Triggering
- Programmable Gain, Offset, Clock, Shutter & ROI
- External Frame Synchronization (FrameLock)
- Stereoscopic 3-D Capture with 2 cameras
- Monochrome & Color Bayer RGB Models
- 5VDC Low Power, Small Package
- C-Mount Housing or PCB versions
- Cameraink (CL) & GigE Remote (GR) Models

## SI-1920HD MegaCamera Specifications

### 1920HD Sensor

Active Pixels	1920 (H) x 1080 (V)
Optical Imaging Format	2/3" Wide (9.68 x 5.45 mm <sup>2</sup> )
Pixel Size (pitch)	5 µm x 5 µm
Pixel Type	CMOS (UMC 0.25 µm Process)
Aspect Ratio	1 : 1

### CameraLink Frame Grabber Control:

Serial Communication	RS-232 Protocol 9600bps
Signaling	TX & RX (LVDS)
Triggers & Genlock	LVDS – CC1 (-CL) TTL Trigger-In & Strobe-Out (optional)

Spectral Response	350 ~ 1000 nm
Peak QE	>55% Monochrome (>40% RGB) @ 600nm
FPN (on chip corrected)	<0.02%
Maximum Noise (rms)	3 counts
Read Noise	<15e- (@ 24dB gain)
Saturation Charge	60,000 e <sup>-</sup> max
Dynamic range	>68dB
Windowing (ROI)	steps of 32 columns and 9 rows
Mono Sub-sampling	- No readout of every third line/column - Readout of every 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> line/column - Independent horizontal and vertical ratios
Pixel Binning	1, 5, 2, 3 or 4 horizontal pixels
Line Mixing	3:2, 2, 3 or 4 vertical lines
Dynamic Noise Reduction	Correlated Double Sampling (CDS) Tapered Reset & Soft Reset
Readout Method	Progressive Scan
Hot Pixel	Real-time Detection & Elimination (mono only)
Shutter	Rolling Shutter
Shutter Speed / Integration	Variable, 1 to 1086 Line times
Minimum Blanking	280 Clocks/line

Programmable Modes	Exposure, Clock, Black Level, Analog Gain, Digital Gain, Window ROI, Subsampling, FPN, DPC Line Mixing, Genlock Mode, Presets.
Gains (R,G,G,B or Mono)	Analog gain stage1: 0 to +24 dB (3 dB steps) Digital gain stage (multiplier): -24dB to +72dB (0.006 & 6 dB steps)
Region-of-Interest	Programmable Horiz & Vertical
Setting Timing	Next top of Frame
Ext Clock Sync	Clock in or Clock Out (-X Option)

### A/D Conversion & Pixel Clock Synthesizer

A/D Conversion	150MHz (nominal) optional 74.25 MHz (SMPTE 274M)
Vertical Resolution	12 Bit (Dual-Outputs) – 4096 counts
Pixel Clock Frequency	20 ~ 85Mhz Programmable
Adjustment Method	Serial command Protocol
Mean Black Level	64 Counts (default)

### Digital Video Output

Readout Rate	60 Hz progressive or 120 Hz interlaced at full resolution		
Readout Format	CL-12 Bit (Ports A, B)		
Frame Rate @ Max Clock	PCI-8Bit	PCI-12bit	PCI-X(64/66M)
1920 x 1080	40	20	60
1280 x 1024	60	30	90
1280 x 720	84	42	130
640 x 480	220	110	335
512 x 512	240	120	360
360 x 300	510	255	775
320 x 240	590	295	895
256 x 256	720	360	1080
Minimum Blanking	280 Clocks/line		

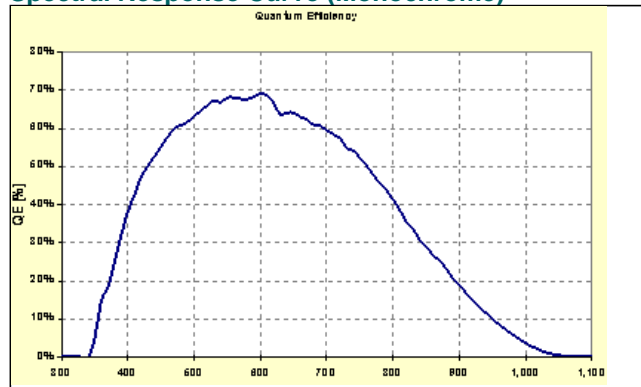
### Power

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

### Mechanical

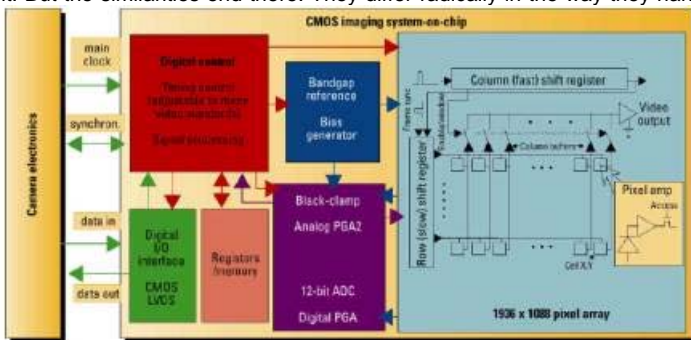
Lens Mount	C-Mount, 7mm Back focus Adj.
Enclosure Size	45mm W x 52mm H x 50mm L
Weight	12 oz.
Camera Mount	¼" x 20 standard tripod mount
Cable Connector	Cameralink MDR-26 (-CL)

### Spectral Response Curve (Monochrome)



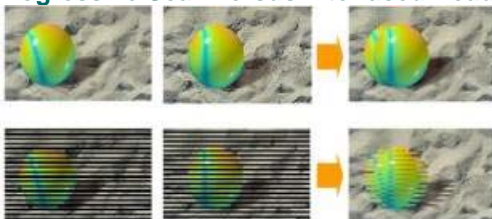
## CMOS versus CCD Imaging: Changing the standards in HDTV

CMOS-based image sensors, like the ubiquitous charge-coupled devices (CCDs), are made with silicon and use photodiodes to detect light. But the similarities end there. They differ radically in the way they handle the resulting electric charges. CCD's noiselessly shift the photo-generated charge from one charge-handling bucket to the next until the packet reaches the output structure. After applying correlated double sampling, to suppress kTC noise, the largest remaining noise source is the video amplifier's thermal noise. CCD's operating at low frequencies perform near the theoretical minimum because these devices are often cooled and heavily band-limited. However, at the video frequencies, the CCD's output stage amplifier must operate at increased gains and the random electronic noise begins to dominate. This noise rises with frequency at about 3dB per octave and restricts the camera's signal-to-noise ratio (S/N). At HDTV rates, typical CCD cameras exhibit a SNR of approximately 56dB (< 100e- noise floor).



By contrast, the CMOS pixel readout is achieved with a pixel amplifier and a relatively low line rate transfer to the output. Successive stages of analog and digital processing in the cameras imaging system-on-chip (SOC) suppress the temporal and spatial noise to the levels well below the CCD. At standard HDTV rates, the SI1920HD achieves a read noise of <25e- and a resulting dynamic range > 68dB.

### Progressive Scan versus Interlaced Readout



The HD scanning formats include both interlaced and progressive standards. Early adopters had selected 1080i interlaced over 720p to increase vertical resolution while maintaining similar bandwidth use. In practice, the progressive scan formats have shown to deliver better results, but have been limited in temporal resolution of 24 or 30 fps at 1080P. The SI-1920HD combines 1080P progressive resolution with 60 frames per second image capture, for best of class operation. (Figure: Image Sequence – Progressive versus Interlaced)

## VariScanHD - 16:9 and 4:3 Aspect & Multi-Format Timing

The VariScanHD feature enables the camera to produce HD video in multiple formats with applicable timing and resolution standards including SMPTE 274M, 296M, 293M and ITU-R 601. It takes advantage of the windowing capability of the CMOS arrays to directly address "native" 1080i, 1080P/30, and 720P portions of the array, including switching between 4:3 and 16:9 aspect ratios, while maintaining correct clock timing for the desired format.



## High Speed Capture at 120fps

Combining the variable frame rate and a variable shutter speed can create interesting ghost like motion blur effects, warp speed zoom effects, and long exposure still shots typical of what one might see in music videos, sci-fi dramas and dream sequences. For high-speed motion capture, the 720p mode at 120fps produces images without blur.



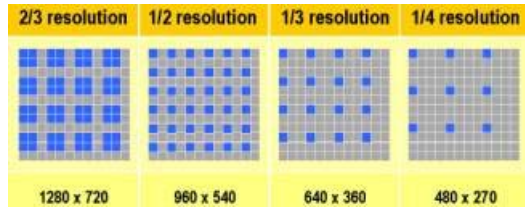
*Motion blur typical of 24 or 30fps capture rates*



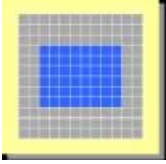
*Enhanced motion clarity at 120 frames per second*

## Sub-sampling Readout

Subsampling can be used to readout fewer pixels in the imager at increased frame rates. Four subsampling modes to provide 1.5X, 2X, 3X and 4X lower resolution as shown (1280x720 @ 120 fps, 960x540 @ 240fps, 640x360 @ 540 fps, 480x270 @ 960 fps). Due to the use of bayer patterns, only the 3x subsampling can be used to produce a color image.



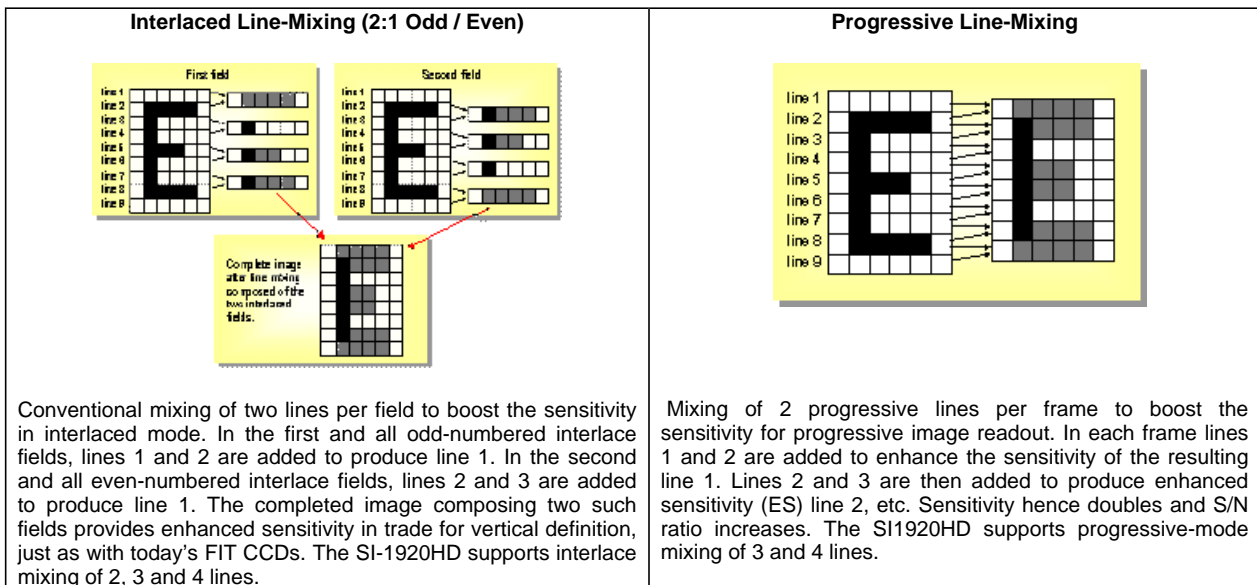
## Windowing Readout – Faster Speeds



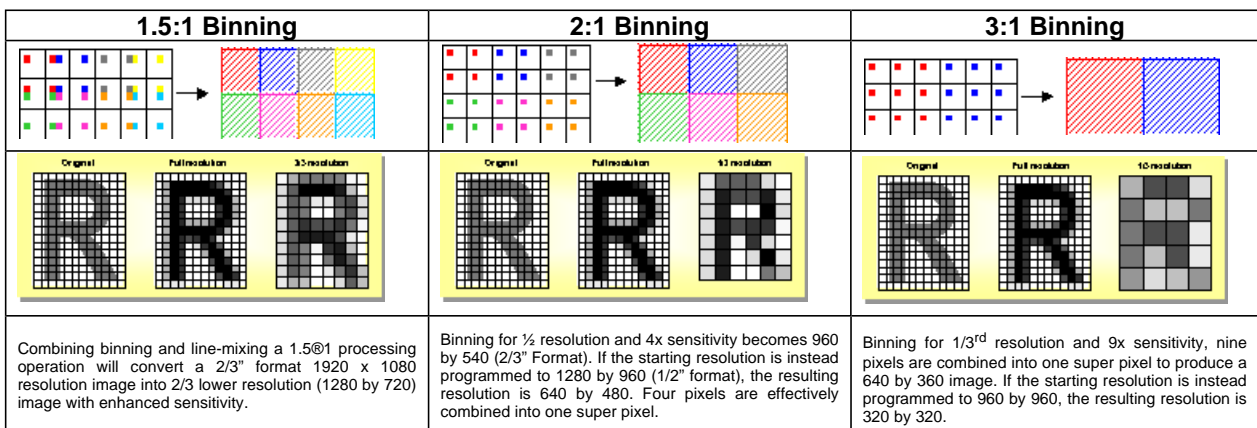
Windowing is directly supported with programming resolution of 16 lines in the horizontal direction and 9 columns in the vertical direction. The maximum frame rate of the subwindow is given by 148.5 MHz divided by the number of pixels in the window. The smaller window reflects a smaller effective format. For example, a 1280 x 720 window corresponding to the 720p standard is supported at 120 frames per second.

## Line Mixing & Binning – Enhanced Sensitivity

Binning and/or line-mixing, combines the information of multiple neighboring pixels into one super-pixel. While this reduces the effective resolution, the optical format or field of view is maintained, while increase signal-to-noise ratio. Line-mixing can be enabled in both interlaced and progressive readout in combinations of 1.5, 2, 3 or 4 video lines. The figures below show how the pixel information is combined to form the resulting image and its trade off in resolution to enhance sensitivity for imaging at lower ambient light levels.

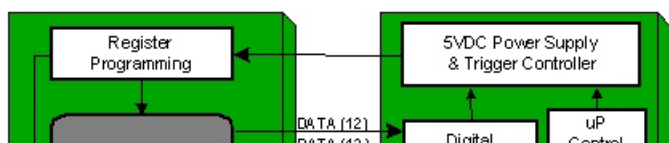


The binning modes include 1.5:1, 2:1, 3:1, 4:1. Binning does not increase the frame rate (in contrast to subsampling or windowing) and is only supported in monochrome models:



## SI-1920HD Camera Block Diagram

The SI-1920HD consists of 2 internal PC boards (33 x 40mm): The imaging sensor PCB (sensor, digital clock synthesizers, Register programming) and Processor PCB board (power regulation, microprocessor, digital control



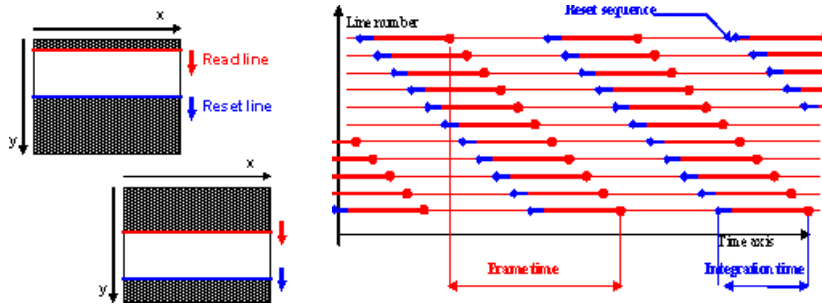
logic, and CameraLink transmission interface).

The camera is programmed via there serial interface. timing and exposure modes can be controlled and Programmable clock synthesizer, 5VDC Power Regulation, Microprocessor for programming and control and Cameralink Transmission.

### High-Speed Rolling Shutter

In Rolling shutter, each line in the image has the same amount of integration, however the start and end time of integration is shifted in time as the image is scanned (rolled) out of the sensor array, similar to a curtain shutter of a SLR film camera. Although it is a pure electronic operation, the shutter seems to slide over the image.

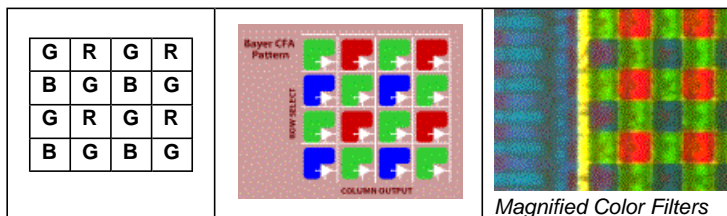
An object, which moves during the typical 1/30sec readout time, can display a stretched or skewed perspective, in the direction of motion. For example, a vertical line can appear tilted if the object moves several horizontal pixels during readout.



The faster the object moves the larger the tilt. The crispness or detail of the line is determined by the shutter speed (integration time). The extreme high-speed readout of the MegaCameraHD any such motion artifacts are minimized. The benefit of rolling shutter mode, is that exposure and readout are overlapping, enabling full frame exposures without reducing frame rate.

### Monochrome (Panachromatic) & RGB Color Bayer Data

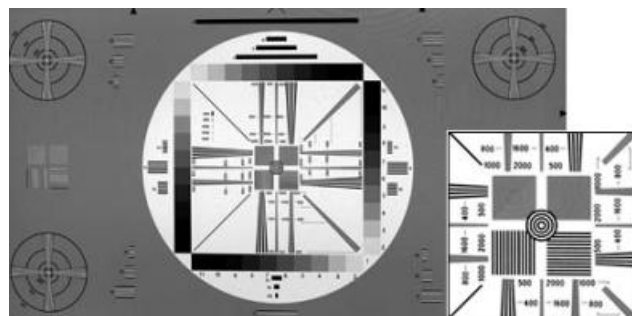
The MegaCameraHD is available in Monochrome (M) and Color Bayer (RGB) models. The Bayer color filter array is a popular format for digital acquisition of single chip color images. Microlenses and a metal opaque layer above the silicon funnel light to the photo-sensitive portion of each pixel. On their way, the photons of light pass through the bayer color filter array (CFA) where the process begins obtaining color from the inherently "monochrome" sensor chip. (Actually, "panchromatic" as the sensors respond across the spectrum). The pattern of the color filters is shown below.



Half of the total number of pixels are green (G), while a quarter of the total number is assigned to both red (R) and blue (B). As each pixel has been made sensitive only to one color (one spectral band), the overall sensitivity of a color image sensor is lower than a monochrome (panchromatic) sensor, and in fact is typically 3x less sensitive. As a result, monochrome sensors are better for low-light applications. When the image sensor is read out, line by line, the pixel sequence comes out GRGRGR, etc., and then the alternate line sequence is BGBGBG, etc. Once the raw color encoded pixel data is captured into host memory it can be processed into a 24-bit RGB value per pixel (4:4:4) using neighborhood pixel interpolation. White Balance and Color matrix corrections can be done to paint the scene, while still maintaining the original raw bayer image data.

### Video Capture & Recording Systems

As this process expands the data set from the raw 12bits per pixel to 24bits it is preferable to store the data in a raw format directly to HDD. PCI Bandwidth choice are (32/33MHz & 64/66MHz). In order to move the full 150MP/sec (187MB/sec 12bits packed) requires the use of 64/66MHz systems with HDD controllers. The new SATA standard allows rates of up 150MB/sec per interface, however HDD speeds have not yet reached this throughput.



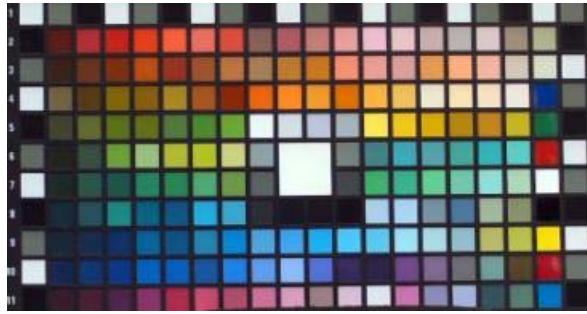
SI-1920HD Monochrome Test Pattern

Therefore, 4 to 6 HDD at 10,000RPM are utilized to achieve

the require throughput. For applications requiring only short bursts of images at full frame rates can capture into PC memory first, then offload the clip to HDD at a slower rate.

### Color Bayer Conversion & Flat Field Correction

Bayer color Image data from the SI-1920HD-RGB is converted to 24Bit RGB using the most advanced signal color conversion algorithm available. AWB Automatic White Balance functions are implemented to match the true world color to the calculated and displayed values.



SI-1920HD Bayer Colorized Test Pattern

### SOLUTIONS and SUPPORT

The Silicon Imaging team can provide turnkey solutions and support for high-speed capture recording, processing and visualization hardware and software systems. Please contact us to discuss your application requirements.



### SI-1920HD Frame Rate

Command	Clock Rate	Pixel Rate	Frame Rate					
			2200 x 1125	1920 x 1080	1280 x 1024	1648x750	640x480	320x240
lcxxxx <cr>	MHz	MHz						
lc306886	20	40	16	17	26	32	64	96
lc30b689	25	50	20	21	32	40	80	119
lc37cb8f	30	60	24	26	39	49	96	143
lc35d40b	35	70	28	30	45	57	113	167
lc34d20f	37.12	75	30	32	49	61	121	179
lc306882	40	80	32	34	52	65	129	191
lc35e709	45	90	36	39	58	73	145	215
lc35e03	48	96	39	41	62	78	154	229
lc34b689	50	100	40	43	65	81	161	239
lc34b688	55	110	44	47	71	89	177	263
lc36cb8f	60	120	48	52	78	97	193	287
lc367307	65	130	53	56	84	105	209	311
lc36ee0f	70	140	57	60	91	113	225	335
lc36f88f	73	146	59	63	94	118	235	349
lc34ae05	75	150	61	64	97	121	241	358
lc346882	80	160	65	69	104	129	257	382
lc31c00f	85	170	69	73	110	138	273	406



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  
 Web: www.kanecomputing.co.uk