

PULNiX Color AccuPiXEL™

Color AccuPiXEL Series Cameras

New Product Summary

- High-resolution, high-speed progressive scan interline transfer CCD imagers
- Digital Camera Link, RS-644 (LVDS) output and analog output
- Bayer color filter arrays
- Maximum dynamic range control with built-in look-up table (Gamma, knee, user parameters)
- Full-frame integration, partial scan, two-row binning
- Smaller, lightweight housing with high-rel connector
- Full-frame shutter up to 1/16,000 sec.
- Asynchronous reset, no-delay shutter, read-out-inhibit control
- RS-232 or Camera Link external control
- Excellent color reproduction with various color interpolation software

General Description

The PULNiX AccuPiXEL series color cameras are high-resolution, high-speed progressive scan CCD cameras. The interline transfer, progressive scan CCD permits full vertical and horizontal resolution of images acquired at very high shutter speeds. The electronic shutter, which has speeds to 1/16,000 sec., can be reset asynchronously by external pulse control. Uniform square pixels provide superior image definition in any orientation. On-chip micro lenses mean increased sensitivity.

Color Filter Array

PULNiX AccuPiXEL cameras use Bayer CFA (color filter array) as their standard primary color filter. This filter provides the most popular color interpolation supported by numerous software suppliers.

The digital format, either Camera Link or RS-644, allows the camera to output accurate pixel data, including the color information. When the data is stored in the frame buffer of a frame grabber or computer, the color information is easily manipulated to restore the original color images. Because the color filter array contains only a single R, G or B color in each pixel, the restored image has to fill in colors in the missing pixel locations. The software uses neighboring pixel information to “guess” the missing colors to make smooth, clear images. This is called “Color Interpolation.” Today’s high-speed computers allow such color interpolation to be done almost in real time. Because these cameras do not contain internal color-processing circuitry, they are smaller and less expensive than full-function color cameras.



Actual image taken with the TMC-1320

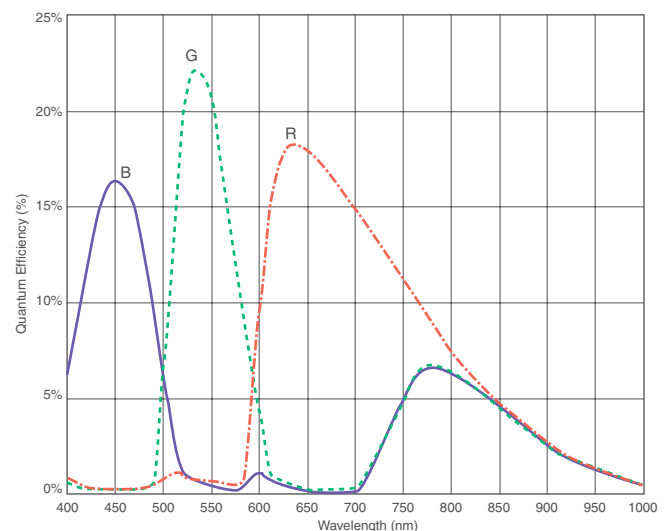


Bayer Color Filter Array (CFA)

The Bayer CFA is an R, G, B primary color filter array. This is the most widely accepted CFA for the single-chip CCD progressive scan format. This type of array layout has a specific order for each color’s pixels. Since the human eye’s resolution and color recognition are highest at green, the CFA contains two greens per each red and blue.

It is critical for the frame grabber and color interpolation to know where the individual color pixels exist relative to sync (LDV and FDV) timing.

This requirement makes digital output the preferred choice, because the timing relationships are very accurate.



Starting Pixel Configuration

All manufacturers produce identical Bayer CFAs, but there are slight differences between the CCDs produced by different manufacturers. The first line is generally R and G, except for the Kodak CCD, which starts with G. The Sony CCD starts with R. The camera timing can be adjusted to start with either G or R by skipping the very first pixels at each line. The majority of color interpolation software can select between a variety of pixel relations, such as R/G start or G/R start, as well as G/B start and B/G start. Once the correct scanning is configured, the rest of the interpolation will be exactly the same.

Please contact JAI PULNiX for further information regarding CCD manufacturers.

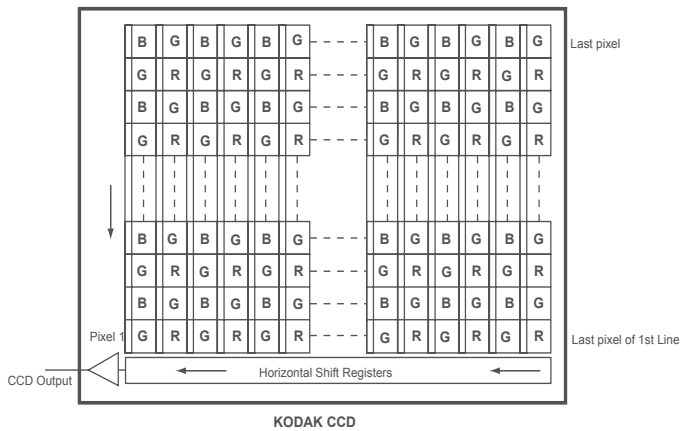


Fig. A

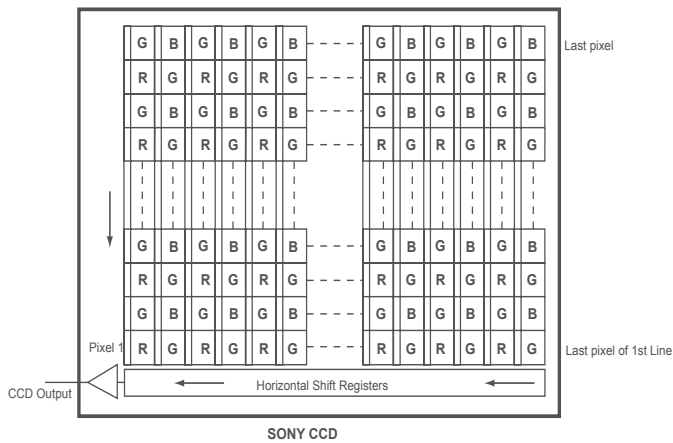


Fig. B

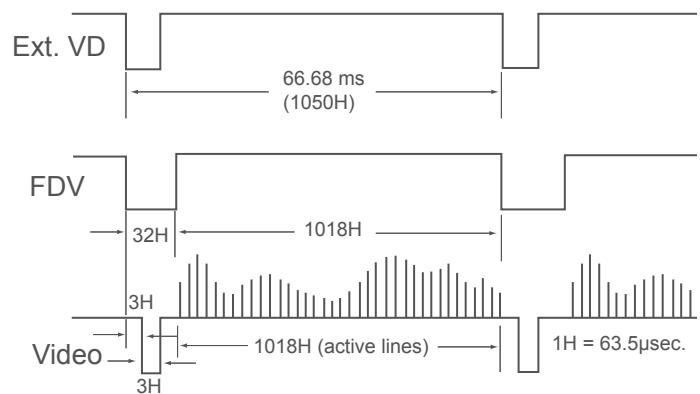
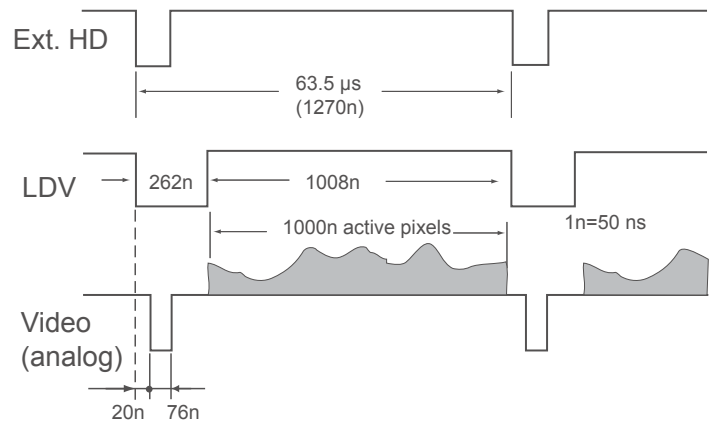
Sync and Data

The individual color data is exactly the same as the pixel data. This means that the timing relationships of the color cameras are also the same as of the B/W cameras.

For a detailed timing chart, please refer to each B/W camera's data sheet and manual.

If the frame grabber has a standard B/W configuration file, then AccuPIXEL color cameras can use that configuration file to operate. The configuration file may vary, depending on whether the output is standard (RS-644) or Camera Link. Please consult JAI PULNiX, or your frame grabber supplier for compatibility information.

The following diagram is an example of the TMC-1020-15 (same as TM-1020-15).



It is important to meet the exact starting pixel at LDV and the starting line of FDV. If the starting pixel or line is shifted due to the image capture configuration, then the interpolation software can be adjusted for the correct starting point. In figure A, if the first pixel is shifted (missed), the color interpolation should start with R-G. If the first line is missed in A, the interpolation order will be B-G.

Camera Functions

AccuPiXEL color cameras perform all functions the same way as B/W cameras. However, because of color characteristics, the following issues are different:

1. Two-row binning scan

When two rows are mixed in the CCD, the Bayer color is no longer valid. It provides color information but cannot be interpolated as a Bayer CFA.

2. LUT (Look-up Table)

LUT is a powerful tool to adjust the dynamic range as well as color dynamic range. Since human color perception is non-linear, LUT selection can help optimize color contrast by selecting the LUT value. Gamma 0.45 is logarithmic and is closed to human perception.

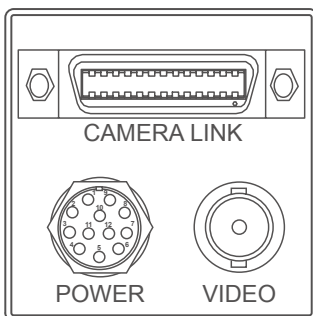
When LUT is selected, black-level adjustment must be more accurate than for B/W cameras.

For a detailed timing chart, please refer to the standard AccuPiXEL camera data sheet, or contact JAI PULNiX.

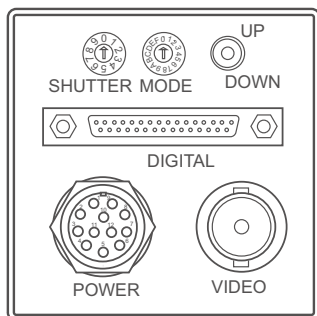
Basic Mode Selections (For Non-CL Versions)*

Mode Switch	Up/Down Switch	Functions
0 Switch Disabled	Switch Disabled	None
1 Set Gain	Up / Down	Change gain
2 Set Vtop (A/D)	Up / Down	Change A/D ref. top
3 Set Vbottom (A/D)	Up / Down	Change A/D ref bottom
4 Gain Selection #1	Up: 9dB, Down: 12dB	Lower gain selection
5 Gain Selection #2	Up: 18dB, Down: 22dB	Higher gain selection
6 Linear LUT	Up	Back to linear table
7 Knee Selection	Up / Down (Scroll)	Scroll 10 different LUTs
8 Async Reset Mode	Up: Normal, Dwn: Async	Async and normal shutter
9 Factory Default Recall	Up / Down: Recall	Factory setting
A Power up Setting	Up: Recall, Dwn: Save	Power up page setting
B User Page Storage#1	Up: Recall, Dwn: Save	User page storage setting
C User Page Storage#2	Up: Recall, Dwn: Save	User page storage setting
D Direct Shutter Control	Up / Down	Shutter speed increment by 1H
E Scan Format2	Up: Optional, Dwn: Binning	Two-row binning selection
F Scan Format1	Up: Normal, Dwn: Optional	Custom option scanning

*These mode descriptions may change from camera model to camera model slightly. The same functions are controlled by RS-232 or Camera Link software.



Camera Link model rear panel



LVDS model rear panel.
Does not apply to TMC-4000

Interpolation Software

Major frame grabber manufacturers with digital capability (Camera Link, RS-644) provide color interpolation software. Some independent image process software suppliers provide software as well.

The following table lists a few examples.

Manufacturer	Frame Grabber	Software
Matrox	Meteor II Digi, CL	MIL
Bitflow	Road Runner CL	Bay View
Coreco	T64	Application software
Data Cube	MaxRevolution	Visual Chip Studio
Epix	PIXCI	Application software
Euresys	GrabLink	Easygrab EasyColor
Matrix Vision	MV-Titan/CL	Impact
Silicon Software	microEnable III	microDisplay

Color Interpolation

The Bayer pattern color filter array (CFA) consists of R, G, and B primary colors. Each pixel represents one of three colors. In order to display or print color images, the signal has to be converted to RGB output, which has three independent channels (outputs) and sync signals.

Color interpolation software or firmware performs the color preprocessing by filling the missing color pixels with neighboring pixels. It then separates the stream of data, (8-bit or 10-bit) into 3 (RGB) data (8-bit x 3) and adds the color matrix to adjust and balance each of the R, G, and B channels (white balance or color balance).

Green	Red	Green
Blue	Green	Blue
Green	Red	Green

The image quality depends on the camera's own pixel data (including pixel data independency from neighboring pixels, noise and color filter), and interpolation of the software algorithm such as 3 x 3 interpolation, 2 x 2 interpolation, color matrix, white balance capability, etc.

All AccuPiXEL color cameras are carefully designed for maximum color performance. JAI PULNiX strongly suggests that you use digital output for the best performance.

Some software is used on board (FPGA or DSP) to perform the interpolation. Other software simply uses the host computer's memory and CPU. The process speed may vary depending on the architecture and speed of the computer.

Color AccuPiXEL Cameras

Camera models AccuPiXEL Color	CCD	Resolution	Frame Rate (frame/sec)	Data Clock (MHz)	Data	Analog Video	Size (HxWxL in mm)
TMC-6760	1/2"	648 x 484	60	25.0/12.50	8-bit	BNC: VGA video	44 x 44 x 64
TMC-6760CL	1/2"	648 x 484	60	25.0/12.50	Ch-A 8-bit	BNC: VGA video	44 x 44 x 64
TMC-1400	1/2"	1392 x 1040	15/30	33.3	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1400CL	1/2"	1392 x 1040	15/30	33.3	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1320A-15	2/3"	1300 x 1030	15	25.0	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1320A-15CL	2/3"	1300 x 1030	15	25.0	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1320A-24	2/3"	1300 x 1030	24	40.0	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1320A-24CL	2/3"	1300 x 1030	24	40.0	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1325	2/3"	1392 x 1040	15/30	33.3	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1325CL	2/3"	1392 x 1040	15/30	33.3	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1020A-15	1"	1008 x 1018	15	20.0	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-1020A-15CL	1"	1008 x 1018	15	20.0	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-2016-8	1"	1920 x 1080	8	20.0	8-bit	BNC: progressive scan	44 x 44 x 64
TMC-2016-8CL	1"	1920 x 1080	8	20.0	Ch-A 8-bit	BNC: progressive scan	44 x 44 x 64
TMC-4000CL	1.2"	2048 x 2048	15	40.0	Ch-A & B 8-bit x 2	BNC: progressive scan	51 x 51 x 82

CL: Camera Link

Please contact PULNiX for availability. For detailed camera specifications, please refer to the standard camera data sheet for each model.

For product updates and data sheets see our web site:

www.jaipulnix.com



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