Features

- **3-CCD Prismatic Color Linescan Camera**
- **High Sensitivity and High SNR Performance Linear CCD Sensors**
- **1024 Pixels: 10 x 10 µm or 14 x 14 µm**
- **2048 Pixels: 10 x 10 µm**
- **Excellent CCD Alignment Accuracy**
- **CameraLink Data Format (Base Configuration)**
- **Data Rate: 20 or 30 Mpixels/s**
- **Dynamic Range: 8- or 10-bit Channel**
- **Single Power Supply: 20 to 36 Vdc**
- **Easy Camera Control with Programmable Settings**
- **Memory for Storing up to 60 Configurations**
- **High Reliability – CE and FCC Compliant**

Description

The AKYLA is a rugged, high performance, fully digital, color linescan camera for demanding industrial applications. It includes a high accuracy 3-CCD architecture with a choice of either 1024 or 2048 pixel sensors at speeds of up to 30 million pixels per second per color channel. The AKYLA cameras are optimized for high sensitivity and precise color recognition.

Applications

- Web Inspection
- Inspection of Natural Materials Like Food, Wood, Ore, Minerals and Lumber
- Recycling
- Quality Control in Printing Processes
- Texture Recognition

CameraLink™ 3-CDD Color Camera

AKYLA™ MD20/30

1010/1014/2010 CL

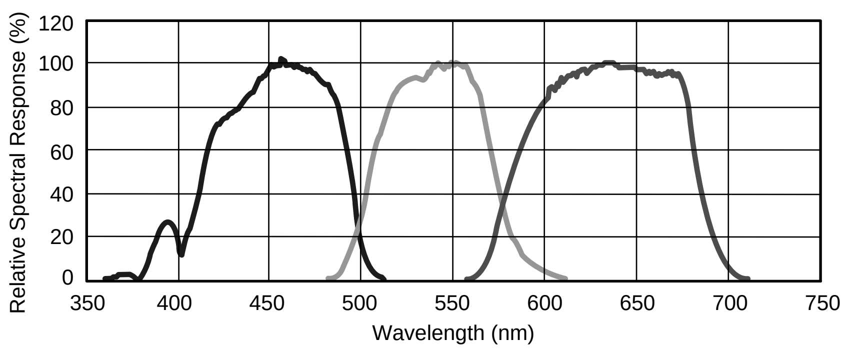
Preliminary

Rev. 5303A–IMAGE–03/11/03

Camera Characteristics Overview

Table 1. Camera Characteristics Overview

<table>
<tr><th>Parameter</th><th colspan="6">Value</th><th>Unit</th></tr>
<tr><td colspan="8">Sensor Characteristics at Maximum Pixel Rate</td></tr>
<tr><td>Two possibilities</td><td colspan="3">Model 20 MHz</td><td colspan="3">Model 30 MHz</td><td>–</td></tr>
<tr><td>Resolution</td><td colspan="2">1024</td><td>2048</td><td colspan="2">1024</td><td>2048</td><td>pixels</td></tr>
<tr><td>Max Line rate in parallel mode</td><td colspan="2">18</td><td>9.4</td><td colspan="2">27</td><td>14</td><td>kHz</td></tr>
<tr><td>Pixel size (square)</td><td>10</td><td>14</td><td>10</td><td>10</td><td>14</td><td>10</td><td>µm</td></tr>
<tr><td>Antiblooming</td><td colspan="6">x 150</td><td>–</td></tr>
<tr><td colspan="8">Radiometric Characteristics</td></tr>
<tr><td>Dynamic range</td><td colspan="6">8 - 10</td><td>bit</td></tr>
<tr><td>Spectral range</td><td colspan="6">350 - 750</td><td>nm</td></tr>
<tr><td>Non Linearity</td><td colspan="6">< 0.1</td><td>%</td></tr>
<tr><td>Typical gain range</td><td colspan="3">Gmin
0</td><td colspan="3">Gmax
27</td><td>dB</td></tr>
<tr><td>Typical peak response
Red
Green
Blue</td><td colspan="2">10 µm pitch
10
5.4
4.1</td><td>14 µm pitch
26
14
10.7</td><td colspan="2">10 µm pitch
240
130
100</td><td>14 µm pitch
624
338
260</td><td>
LSB/nJ/cm^2
LSB/nJ/cm^2
LSB/nJ/cm^2</td></tr>
<tr><td colspan="8">Mechanical and Electrical Interface</td></tr>
<tr><td>Size (w x h x l)</td><td colspan="6">115 x 106 x 140</td><td>mm</td></tr>
<tr><td>Lens mount</td><td colspan="6">F</td><td>–</td></tr>
<tr><td>Sensor alignment</td><td colspan="6">< 2 max, 0.1 typical</td><td>µm</td></tr>
<tr><td>Power supply</td><td colspan="6">DC, single 20 to 36V</td><td>V</td></tr>
<tr><td>Power dissipation</td><td colspan="6">< 26</td><td>W</td></tr>
<tr><td>Operating temperature</td><td colspan="6">5 to 35 (non condensing)</td><td>°C</td></tr>
<tr><td>Storage temperature</td><td colspan="6">-10 to 55 (non condensing)</td><td>°C</td></tr>
<tr><td colspan="8">Spectral Response</td></tr>
</table>



Precautions

Read the Manual

Please read the manual carefully before using the camera for the first time.

Do Not Drop Camera

The camera is a sensitive optical device, handle with care at all times. Do not drop the camera and avoid mechanical shock to the camera.

Keep Foreign Matters Outside the Camera

Do not spill liquids on the camera. The camera is not liquid or waterproof.

Do not drop metallic objects into the camera. This might cause a short-circuit and damage the camera.

Cleaning

Keep the shade cap on the camera head when it is not in use to avoid contaminating the prism.

It is recommended that the camera be serviced by Atmel if the front surface of the prism is very dirty because the surface area of the prism cannot be fully accessed from the front.

If there are small amounts of contaminants or dust on the prism surface, use a clean lint free cotton swab or other non abrasive medium dipped in acetone or pure alcohol to clean the prism surface. Shake excess solvent off before touching the surface of the prism to avoid streaking. Atmel is not responsible for any scratches or damage inflicted by the customer to the front surface of the prism.

To clean the exterior casing of the camera, use a soft, dry cloth. In case of severe stains use a small amount of pure alcohol or isopropyl alcohol. Do not use acetone or other volatile solvents such as benzene or thinners.

Do Not Open the Camera

Do not open camera. The warranty of the camera expires immediately upon opening. Only authorized service personnel may open the camera.

Ventilation

Allow sufficient air circulation around the camera. If this condition is not met, the camera might shut down during operation because it is designed to do so in order to prevent damage to the optical assemblies since a further temperature increase may damage the camera.

Storage

Do not store the camera in temperatures over +55°C. There is a permanent temperature indicator inside the camera, which is installed to ensure that if the camera is damaged due to over temperature, the warranty of the camera may be void.

Electromagnetic Fields

Do not operate the camera in the vicinity of strong electromagnetic fields (above the requirements of CE conformity). This may cause erroneous operation of the camera.

Transporting

Transport the camera in its original packaging. If the original packaging has been discarded, package the camera with care in a thick layer of soft, preferably anti-static material when transporting. Do not use material that allows the camera to fall to the bottom of the package while transporting. Do not transport with optics attached.

Standard Conformity

The cameras have been tested in the following conditions:

- Shielded power supply cable.
- CameraLink ™ data transfer cable ref. 14B26-SZLB-500-OLC (3M).
- Linear AC-DC power supply.
- Atmel recommends using the same configuration to ensure the compliance with the following standards.

CE Conformity

AKYLA Cameras comply with the requirements of the EMC (European) directive 89/336/EEC, EMC (Electromagnetic Compatibility). We herewith declare that this product complies with the following provisions applying to it.

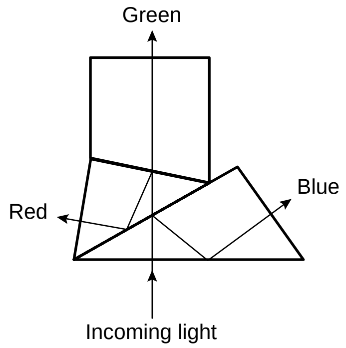
- Emission CISPR 22 (1997)
- Immunity IEC 61000-6-2 (1999)

Camera Overview

Color Separation

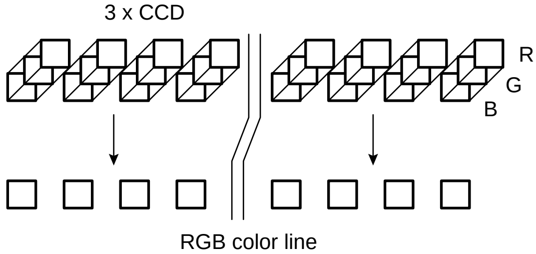
The incoming light is separated to three (Red, Green and Blue) color images by an RGB beam splitter (Figure 1). The spectral distribution of each color is standardized and well known. By attaching a CCD to each of these color outputs, it is possible to measure the intensity of each color image.

Figure 1. RGB Color Separation Beam Splitter



The CCDs are aligned to each other to get the perfect image of the three measured color components. All three CCDs see exactly the same area of the object at the same time. Corresponding pixels of all three sensors are very precisely positioned optically in the same place (Figure 2). This makes the color analysis simpler and does not require any line matching or synchronizing. The resolution of the camera is the same as for the individual CCD array.

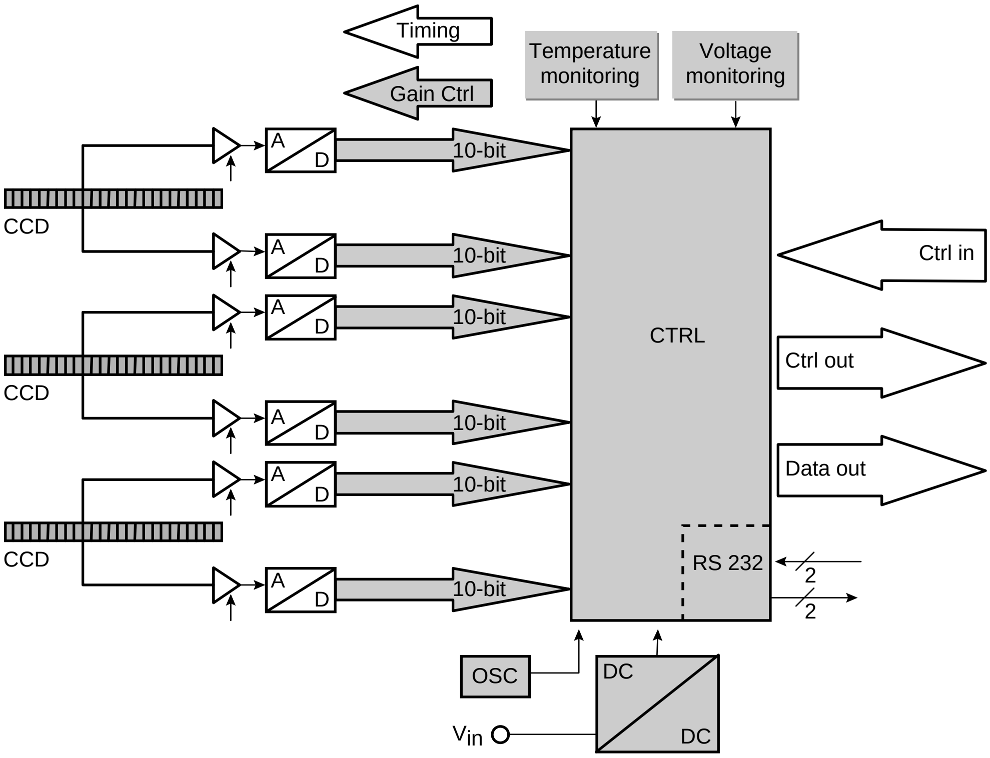
Figure 2. Alignment of the CCD Linear Arrays



Camera Operation

The CCDs convert the incoming light to electrical charges. The amount of charge generated in each of the individual pixels is directly proportional to the intensity of light they receive. The resulting charge packets are transferred into two high-speed CCD shift registers and transferred to the output charge-to-voltage converters of the CCDs. The output video generated is Correlate Double Sampled (CDS) and the result is amplified by the user accessible gain factor prior to digitization to 10-bit.

Figure 3. Camera Synoptic



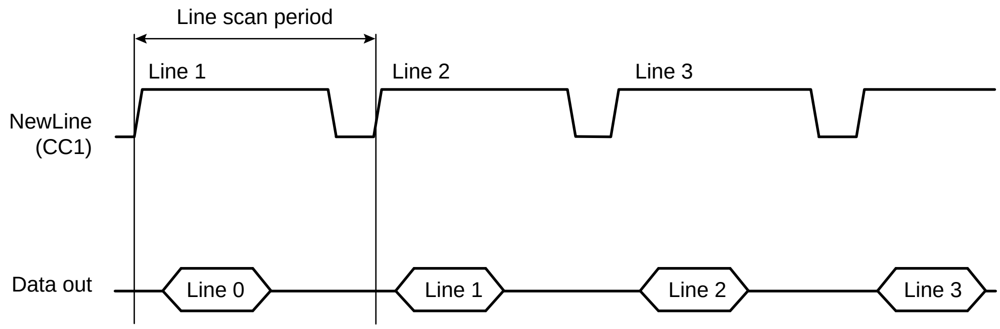
The AKYLA cameras operate in a mono-shot mode. For each rising edge of the NewLine signal the camera responds by sending out the digital data stream of the previous exposure time. The output frequency is constant. The distance in time between two NewLine edges can be set to any value above the specified minimum. The reciprocal of this time is the line rate (Hz).

Other programmable functions include:

- Color channel specific programmable exposure control
- Color channel specific programmable analog gain
- Color channel specific programmable digital gain
- Programmable offset
- Retrieval of the PROM version number
- Non-volatile memory banks for programmable settings

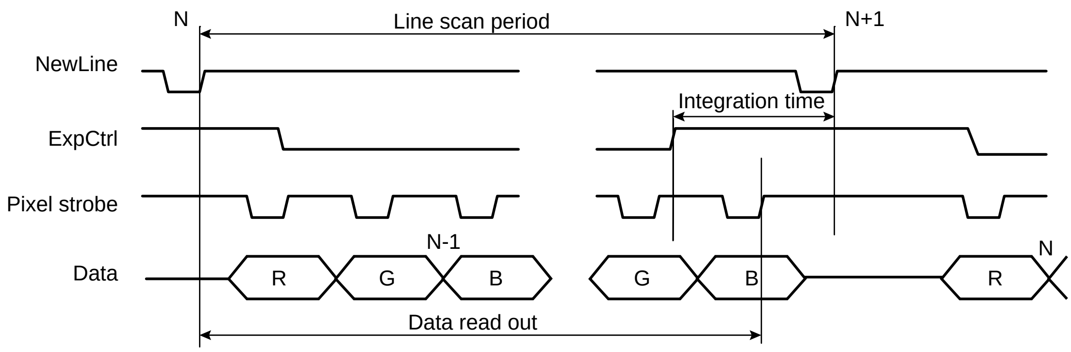
Timing

Figure 4. Relationship between the Data Output and NewLine (CC1) Signals



The effective integration time can be made shorter than the actual linescan period (time between two consecutive NewLine pulses) by holding the ExpCtrl (CC2) signal in its active state until the beginning of the targeted interception period. Within the linescan period, whenever the ExpCtrl input is held low, no charge can be collected into the pixels. This is why the actual integration time is the time span between the (last) rising edge of the ExpCtrl input signal and the next rising edge of the NewLine input.

Figure 5. Line Rate and Integration Time



The two most common modes of operation of linescan cameras are free-run mode or encoder input-driven mode.

In the free-run mode both the linescan period and the integration time can be precisely controlled. But if the linescan period is determined by encoder input, the integration time can best be kept constant by using the encoder input pulse for generating the ExpCtrl signal. The NewLine pulse is sent after a constant delay (refer to “Exposure Control Mode (Address 76)” on page 29).

The AKYLA camera is constantly monitoring all the internal supply voltages and the internal temperature of the camera. Temperature warnings can be monitored via the LEDs at the rear panel and the Temperature output signal of the data connector.

AKYLA M30 1010/14 CL

Figure 6. Parallel Color Channel Mode, 30 MHz per Channel – Version: 1.2 – Date: 5/27/02 – PROM: B04

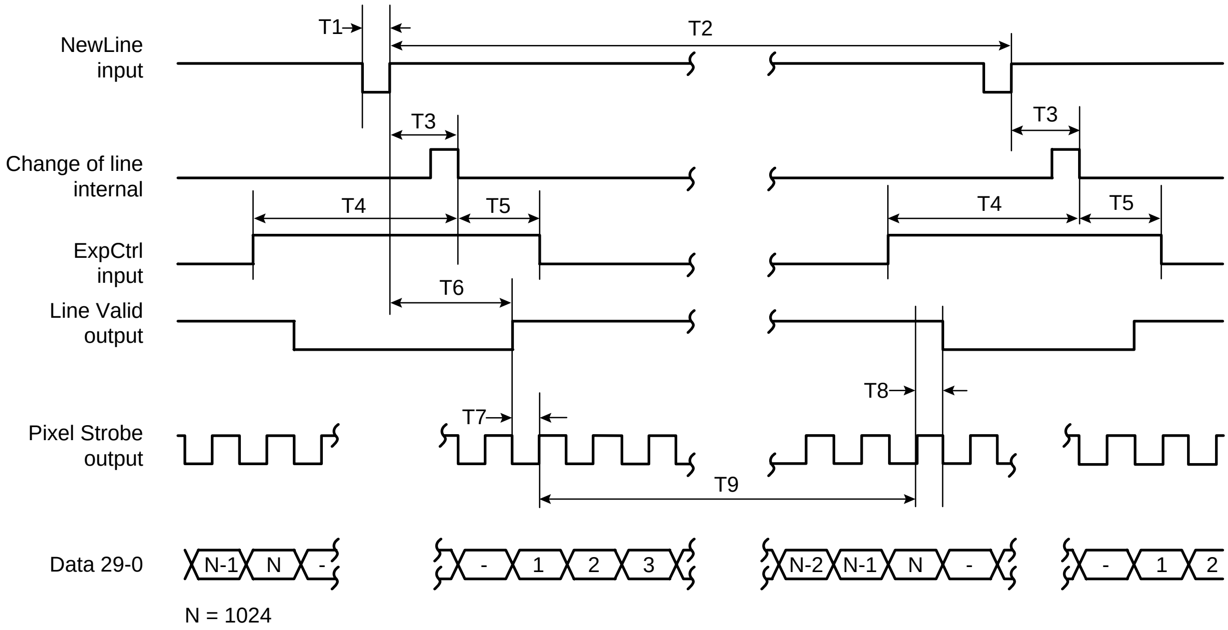


Figure 7. Timing Diagram

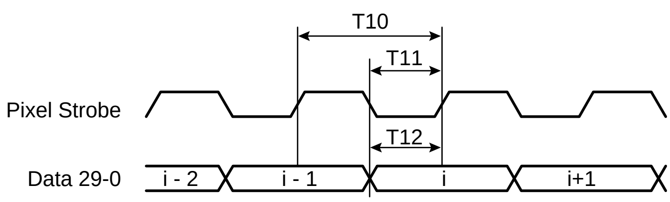


Table 2. AKYLA 1010/14 CL – 30 MHz

Symbol	Parameter	Min	Nom	Max	Unit
T1	NewLine low	0.05	10	–	µs
T2	Linescan period	37	–	–	µs
T3	Delay to Change of Line	0.58	–	0.7	µs
T4	Integration Time	2	–	–	µs
T5	Delay to ExpCtrl	2	–	–	µs
T6	Delay to Line Valid high	1.36	–	1.48	µs
T7	Line Valid high to first data	–	17	–	µs
T8	Last data to Line Valid low	–	16	–	µs
T9	Transfer Time	–	34	–	µs
T10	Pixel Strobe period	–	33.3	–	ns
T11	Pixel Strobe low	–	17	–	ns
T12	Data Setup Time	–	14	–	ns

Figure 8. Parallel Color Channel Mode, 30 MHz per Channel – Version: 1.2 – Date: 5/27/02 – PROM: B04

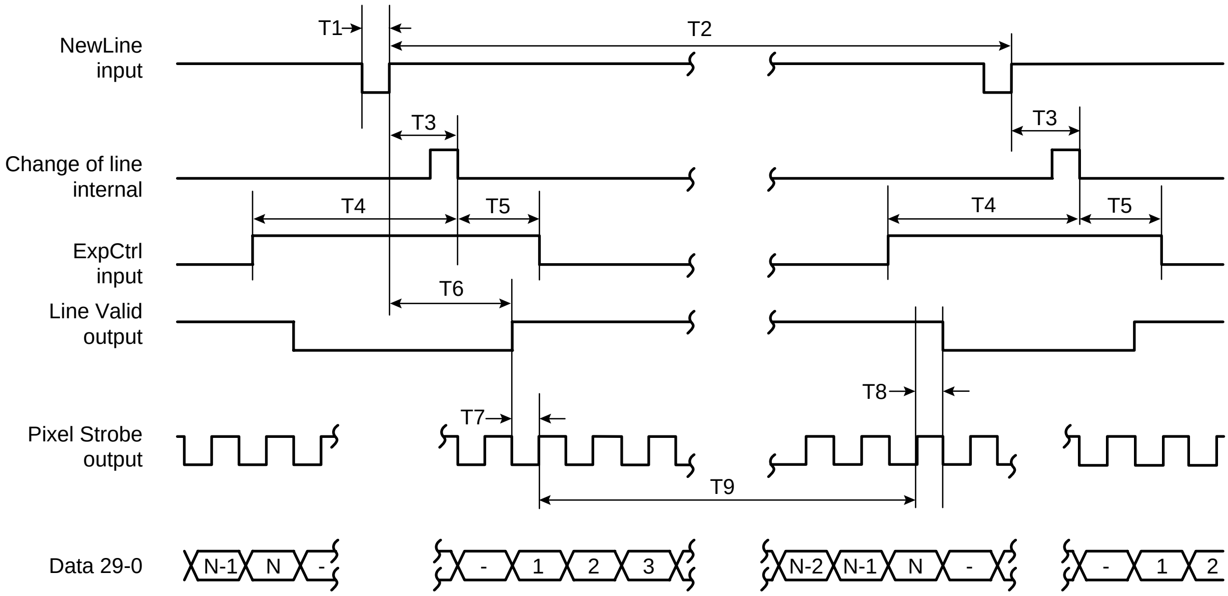


Figure 9. Timing Diagram

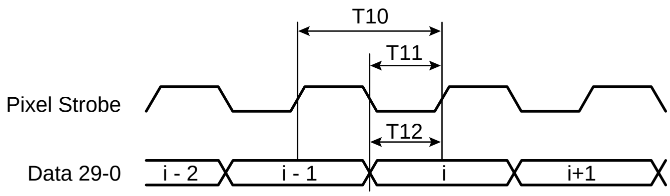


Table 3. AKYLA 2010 CL – 30 MHz

Symbol	Parameter	Min	Nom	Max	Unit
T1	NewLine low	0.05	10	–	µs
T2	Linescan period	71	–	–	µs
T3	Delay to Change of Line	0.58	–	0.7	µs
T4	Integration Time	2	–	–	µs
T5	Delay to ExpCtrl	2	–	–	µs
T6	Delay to Line Valid high	1.36	–	1.48	µs
T7	Line Valid high to first data	–	17	–	µs
T8	Last data to Line Valid low	–	16	–	µs
T9	Transfer Time	–	68	–	µs
T10	Pixel Strobe period	–	33.3	–	ns
T11	Pixel Strobe low	–	17	–	ns
T12	Data Setup Time	–	14	–	ns

AKYLA M20 1010/14 CL

Figure 10. Parallel Color Channel Mode, 20 MHz per Channel – Version: 1.0 – Date: 5/27/02 – PROM: B05

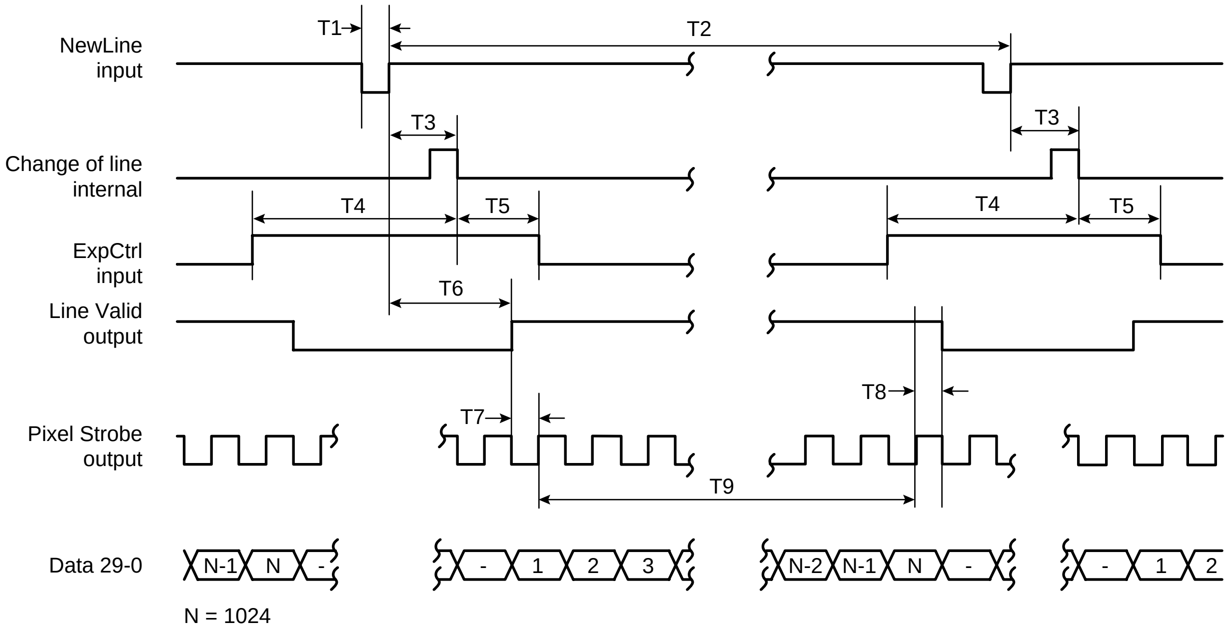


Figure 11. Timing Diagram

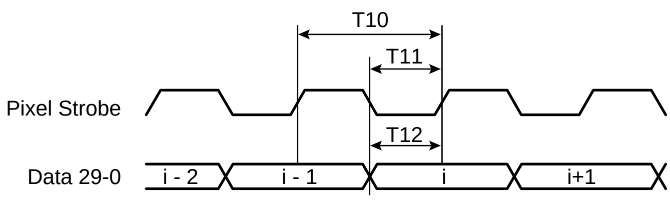


Table 4. AKYLA 1010/14 CL – 20 MHz

Symbol	Parameter	Min	Nom	Max	Unit
T1	NewLine low	0.05	10	–	µs
T2	Linescan period	56	–	–	µs
T3	Delay to Change of Line	–	0.76	–	µs
T4	Integration Time	2	–	–	µs
T5	Delay to ExpCtrl	2	–	–	µs
T6	Delay to Line Valid high	–	1.9	–	µs
T7	Line Valid high to first data	–	26	–	µs
T8	Last data to Line Valid low	–	24	–	µs
T9	Transfer Time	–	51	–	µs
T10	Pixel Strobe period	–	50	–	ns
T11	Pixel Strobe low	–	24	–	ns
T12	Data Setup Time	–	23	–	ns

Figure 12. Parallel Color Channel Mode, 20 MHz per Channel – Version: 1.0 – Date: 5/27/02 – PROM: B05

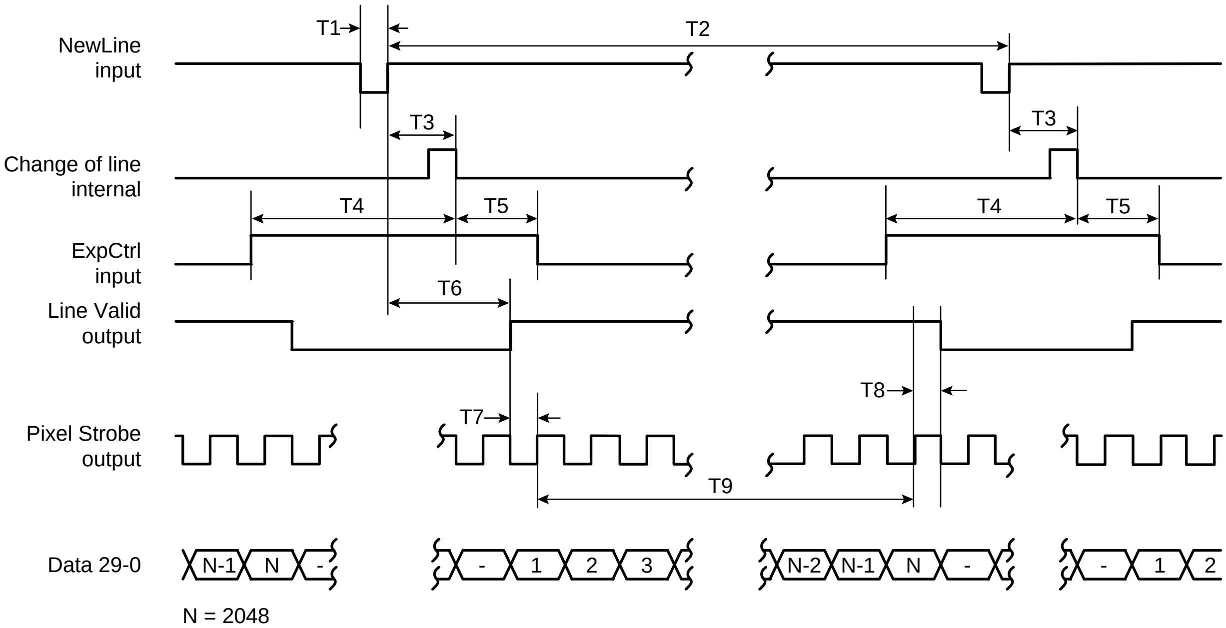


Figure 13. Timing Diagram

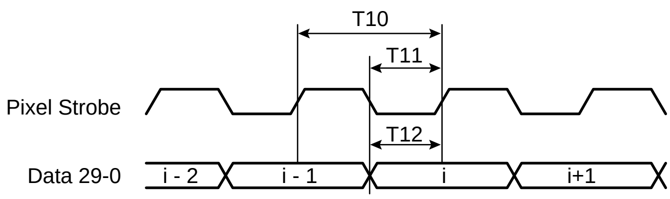


Table 5. AKYLA 2010 CL – 20 MHz

Symbol	Parameter	Min	Nom	Max	Unit
T1	NewLine low	0.05	10	–	µs
T2	Linescan period	107	–	–	µs
T3	Delay to Change of Line	–	0.76	–	µs
T4	Integration Time	2	–	–	µs
T5	Delay to ExpCtrl	2	–	–	µs
T6	Delay to Line Valid high	–	1.9	–	µs
T7	Line Valid high to first data	–	26	–	µs
T8	Last data to Line Valid low	–	24	–	µs
T9	Transfer Time	–	102	–	µs
T10	Pixel Strobe period	–	50	–	ns
T11	Pixel Strobe low	–	24	–	ns
T12	Data Setup Time	–	23	–	ns

Electrical Interface

All the electrical connections of the AKYLA color linescan camera are made via the rear panel. The two CameraLink connectors are used to interface to commercial CameraLink frame grabber boards or the users' own electronics.

All signals are available on the two CameraLink connectors. The interface is designed according to specifications outlined in the CameraLink standard (October 2000). Please refer to the standard on signal levels, cabling etc.

The standard RS-232 interface is used for modifying the parameters of the camera. For the details on the RS-232 SUBD9 cabling, refer to "Communication" on page 26.

Four indicator LEDs (on the left hand side) show the status of the camera.

Figure 14. Rear Panel Layout for CameraLink Models

LED Indicators

Table 6. LED Indicator Descriptions

LED Indicators	Color	Description
PWR	Green	On: Power input OK
RUN	Green	On: Normal operation Off: 1) The temperature limit (+55°C) has been exceeded and camera operation has been shut down. After the external temperature has fallen into the specified range, switch the power OFF once and then ON again. 2) The camera did not start up properly. Check the input power lines, the PWR LED and the position of the internal PROM (if you have just upgraded the camera).
PWR ERR	Red	On: At least one of the internal supply voltages has failed.
TMP ERR	Red	On: Warning that the internal temperature is too high. If the camera cools down, the LED will turn off, but if the temperature rises further the camera will be shutdown and remain so until the next power-up.

Power Input

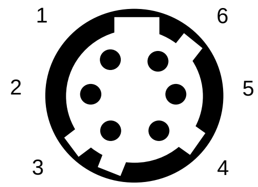
Camera connector type: Hirose HR10A-7R-6PB (male).

Cable connector type: Hirose HR10A-7P-6S (female).

Table 7. Power Supply Connector Pinout

Pin	Signal	Pin	Signal
1	PWR	4	GND
2	PWR	5	GND
3	PWR	6	GND

Figure 15. Receptacle Viewed from Behind the Camera



The AKYLA cameras operate from a single supply voltage of nominally 24 Vdc at typically 500 to 1000 mA, depending on the mode of operation and the external terminations of the output signals.

The maximum power consumption is 26W. For low frequency line ripples (less than 120 Hz) ±10% ripple is acceptable as long as the voltage level stays between 20 to 36 Vdc.

Supply Voltage

Nominal: 24 Vdc

Range: 20 to 36 Vdc

Supply Current

Typically: 500 to 1000 mA

Maximum: 1.1A (at 24 Vdc and at power-up)

Ripple

±10% (max 120 Hz): Voltage level (= nominal + ripple) must stay between 20 to 36V

RS-232 Serial Connector

The RS232 connector can be found on the rear panel of the camera. Use a standard socket type 9-pin D-connector (i.e. AMP 344643-1) for the camera side.

Table 8. RS-232 Serial Connector Pinout

Camera Side D9 Connector			PC Side D9 Connector	
Signal	Pin		Pin	Signal
TD (Transmit Data, output)	3	>	2	RD (Receive Data, input)
RD (Receive Data, input)	2	<	3	TD (Transmit Data, output)
RTS (Request To Send, output)	7	>	8	CTS (Clear To Send, input)
CTS (Clear To Send, input)	8	<	7	RTS (Request To Send, output)
SG (Signal Ground)	5	–	5	SG (Signal Ground)

Data Connector

Two MDR-26 connectors handle data communications as specified in the CameraLink specifications. The connectors are labelled CL1 and CL2. For 24-bit RGB images, only the first connector is required. The second connector is needed for all other selectable data output modes. On the camera side, cables can be secured with either screw-locks or latches.

For cabling, refer to the CameraLink specifications.

All the input signals are internally terminated by 100Ω resistors.

All the output signals should be terminated respectively (one 100Ω resistor connected between the positive and negative wire of each signal pair).

Table 9. Data Connector Pinout

		Parallel			
		Base		Dual Base	Medium
		24-bit	24-bit + LSB	30-bit	30-bit
A	0	2	2	0	0
	1	3	3	1	1
	2	4	4	2	2
	3	5	5	3	3
	4	6	6	4	4
	5	7	7	5	5
	6	8	8	6	6
	7	9	9	7	7
B	0	2	2	8	8
	1	3	3	9	9
	2	4	4	–	–
	3	5	5	–	–
	4	6	6	8	8
	5	7	7	9	9
	6	8	8	–	–
	7	9	9	–	–
C	0	2	2	0	0
	1	3	3	1	1
	2	4	4	2	2
	3	5	5	3	3
	4	6	6	4	4
	5	7	7	5	5
	6	8	8	6	6
	7	9	9	7	7

Table 9. Data Connector Pinout (Continued)

		Parallel			
		Base		Dual Base	Medium
		24-bit	24-bit + LSB	30-bit	30-bit
D	0	–	0	0	8
	1	–	1	1	9
	2	–	0	2	–
	3	–	1	3	–
	4	–	0	4	4
	5	–	1	5	5
	6	–	X	6	6
	7	–	X	7	7
E	0	–	–	8	0
	1	–	–	9	1
	2	–	–	2	2
	3	–	–	3	3
	4	–	0	4	4
	5	–	1	5	5
	6	–	X	6	6
	7	–	X	7	7
F	0	–	0	0	8
	1	–	1	1	9
	2	–	0	2	–
	3	–	1	3	–
	4	–	–	–	–
	5	–	–	–	–
	6	–	–	–	–
	7	–	–	–	–

Note: The grey boxes are bits that are not used, but which are present due to the hardware wiring of the camera (copies of output pins).

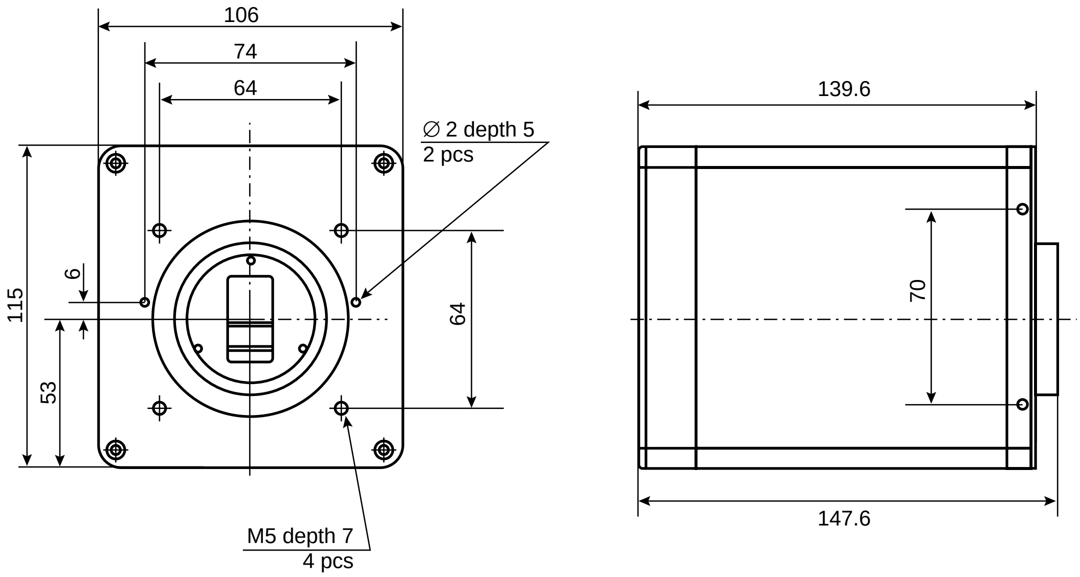
Mechanical Structure

Mechanical Dimensions and Mounting of the Camera

The mechanical structure of the camera provides a compact entity that meets the rigid demands of the industrial environment. The aluminium camera case provides an excellent electrical protection against external electromagnetic interference. When selecting the components, corrosion resistant properties were also considered.

The camera can be mounted from the front panel or from the side panel of the camera. The recommended way to mount the camera is to use the three M5 holes, which are situated around the optics on the front panel.

Figure 16. Mechanical Box Drawing and Dimensions



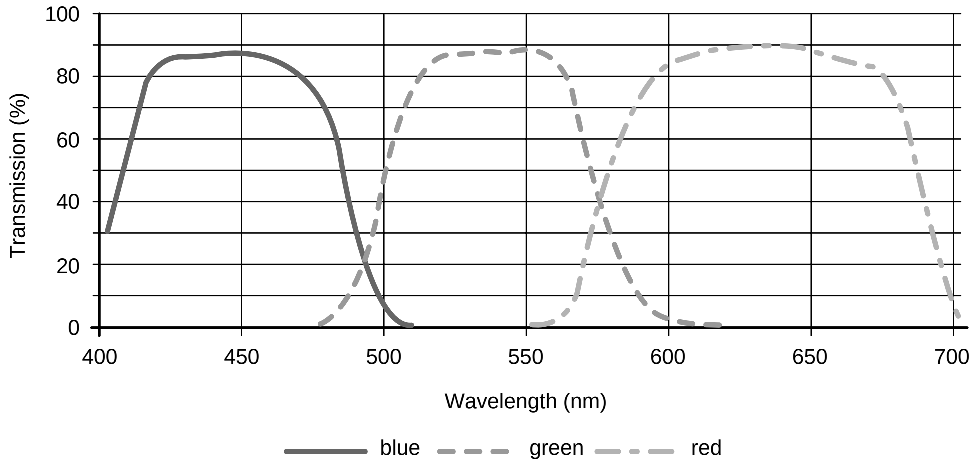
Attachment for Optics

There is a locking latch in the Nikon bayonet. The optics are attached by turning it (ca. 1/4 rev.) counter clockwise, seen from the front of the camera, until the latch rises into the upper position. When detaching the optics, first push the latch towards the front panel of the camera and then turn the optics clockwise, again seen from the front of the camera, until the optics are released from the bayonet. The optics may then be pulled away from the camera.

Optical Considerations

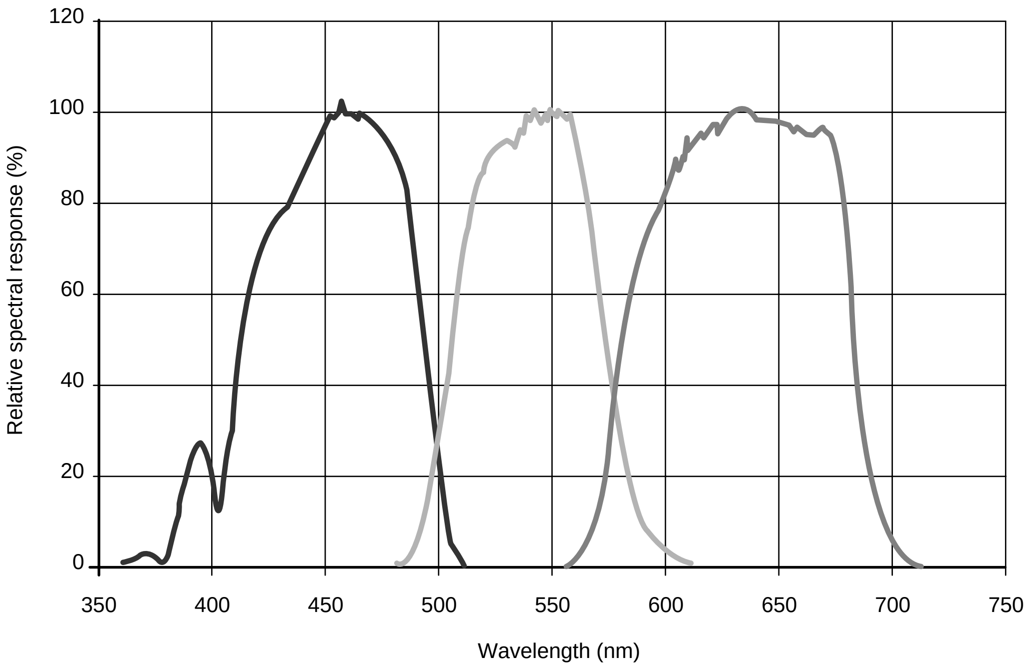
Spectral Response of the Beam Splitter PRISM

Figure 17. Spectral Distribution of the RGB Color Beam Splitter



The graph in Figure 17 shows the effect of the prism itself at each wavelength. Transmissivity is well balanced both in the sense of peak responses as well as total amount of light passed to the sensors at each wavelength (sum of the three separate curves). This all results in excellent color separation compared to trilinear CCD sensors.

Figure 18. Spectral Response of AKYLA Cameras



The graph in Figure 18 is based on spectral transmissivity measurements of the beam splitter prism and the spectral sensitivity of the CCDs.

Channels have been matched by selecting the gains of the channels. The range of the gains themselves are relatively large (typically 1x to 15x). In addition, digital gains (shifting of bits) are available for 1x, 2x, 4x and 8x gain coefficients.

For example, with equal gains on all the channels (at high gains, but not at maximum), the responses of the channels in terms of how many photons need to be received to cause one level higher 10-bit number to appear on the digital outputs for a camera with 10 µm sensors:

- Red: 13 photons/LSB
- Green: 20 photons/LSB
- Blue: 22 photons/LSB

Selection of Optics

The choice of optics affects the picture quality in terms of resolution, field of view, depth of field and amount of lighting needed, just to name a few factors. The selection of optics can have a dramatic effect on image quality. This is why a basic understanding of optics is required. In this section a few guidelines are presented. It is up to the user to make final decisions and evaluations as to what application specific requirements need to be fulfilled.

Modulation Transfer Function

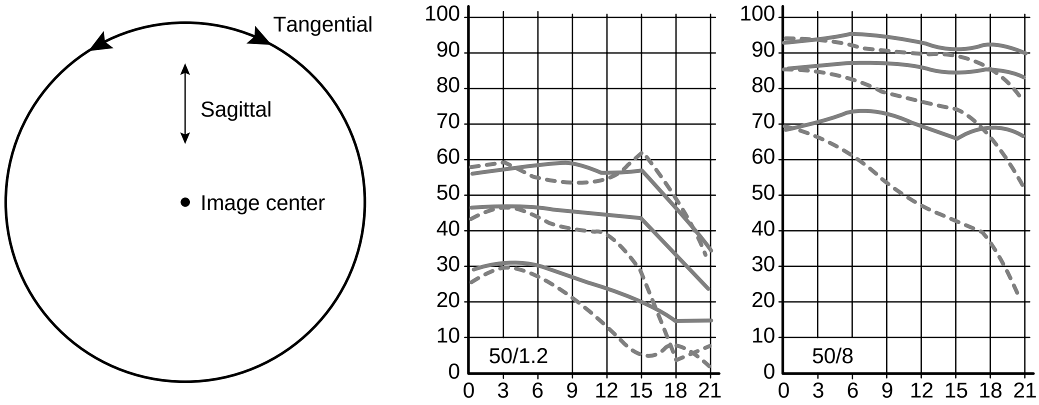
Lens systems can vary a lot in terms of image quality. Quality can be characterized in terms of Modulation Transfer Function (MTF). MTF gives a measurement of how much contrast is left between two details (usually black and white pairs of lines per mm) after they have been projected. In general it is defined as fidelity of the image in comparison to the object being imaged.

Maximum MTF is 1.0, but due to optical imperfections and diffraction, this is impossible to reach. MTF at large apertures (f1.0 - 2.8) is limited by optical imperfections that vary a lot from lens to lens and manufacturer. At small apertures (f11- f32+) lens performance is limited more by diffraction than optical quality, so in this case there are minor differences between lenses and manufacturers. Most lenses produce best results around aperture size f8.

Figure 19 shows two sample graphs of a typical, fair quality 50 mm lens at two different apertures. The graphs demonstrate various aspects discussed in this section. They represent MTF in percent (y-axis) for three different line frequencies of 10, 20 and 40 lp/mm from top to bottom (lp = line pairs). The solid lines represent sagittal (radial) MTF and the dashed lines tangential (circular) MTF. If the sagittal and tangential line pairs do not coincide, this indicates aberration, such as astigmatism. The x-axis represents the distance of from the centre of the image to the edge in millimeters.

The effect of MTF is application dependent. If very small details are to be examined or fine color separation to be performed by the image processing system, MTF might play an important role in the application.

Figure 19. MTF for a 50 mm Optic at Two Apertures and Different Spatial Line Frequencies (Graphs kindly provided by © Photodo AB, Sweden)



If the lens has field curvature, it will show up in the MTF plot as MTF dropping away from the centre of the image. Observing the plots, it is evident that this is true of wider apertures that have a small depth of field. This does not necessarily mean that sharpness is worse at the edges. It may just as well be that optimal focus for objects close to the edge is closer or further away from the lens. Normal camera lenses are usually used to photograph three-dimensional objects and do not exhibit a perfectly flat focal field. Enlarging or repro optics have a planar focal field and are used to reproduce flat objects.

Resolution and Field of View

Resolution is primarily affected by sensor dimensions and the quality of the optics. The optical system is responsible for the ability to produce finer details at a tolerable contrast. Normally, according to the Nyquist sampling theorem, it is required that a detail spans at least two pixels to be able to be identified with a reasonable accuracy by an image processing software.

Because of the CCD, the fastest transition from black to white can occur within one pixel. When using large apertures, large field of view, the 2k sensor and depending on the quality of the lens used, image quality can be reduced at the edges due to optical limitations. All AKYLA cameras have been designed and made to be used with standard commercial lenses at mid-range apertures.

The focal length of optics required for imaging can be calculated from the following formula:

$$F = \frac{d \times L}{FOV}$$, where:

- F = focal length of the lens (mm)
- d = distance to object (mm)
- L = length of the CCD:
- 10.24 mm for 1024 pixels (10 µm)
- 14.34 mm for 1024 pixels (14 µm)
- 20.48 mm for 2048 pixels
- FOV = field of view; object size (mm)

Example 1: The distance to the object to be imaged is 900 mm, the width of area to be imaged is 500 mm. When using 1024 pixel 10 µm sensor the focal length of the lens from the equation will be ~18.4, so a 20 mm optic would be acceptable, if the camera is moved backward to a distance of 977 mm.

Example 2: The size of an object within the image needs to be calculated in pixels. This can be accomplished by rearranging the equation to yield L = FOV x F/d. Thus a 10 mm object with a 50 mm lens at a distance of 900 mm will be projected as 0.56 mm, which equals ~56 pixels in the image (each pixel on the CCD is 0.01 mm by 0.01 mm).

Depth of Field and Working Aperture

Optimum sharpness of the image is achieved only when the object is in the focus plane. Behind and in front of this plane the sharpness is worse. Depth of field is defined by how unsharp a point is allowed to be. Depth of field is thus the distance from the plane of focus where the unsharpness stays tolerable. Therefore the depth of field depends on the smallest application dependent feature size to be recognized. Depth of field considerably increases with smaller aperture sizes.

Depth of field is also affected by the focal length used. A longer focal length with a given aperture will result in a shorter depth of field. Therefore, as a guideline, if the focal length is increased the aperture has to be stopped down by the same factor to retain the desired depth of field.

A lens improves optically when stopped down. At large apertures most of the area of the lens is used, this results in a slight blur caused by unavoidable imperfections in the lenses. When stopping down, only the central area of the lens is used. The optical picture is more correct and resolution improves. Considering this fact, the lens to be used should have a large maximum aperture and should be operated at a mid-range aperture.

In reality, stopping down does not improve optical quality indefinitely, since diffraction starts to affect image quality at small apertures. According to the law of diffraction, a sharp edge turns light slightly off. The aperture forms such a sharp edge and light closest to the edges causes fuzziness in the image. When using wider apertures the percentage of light passing along the edges decreases in relation to light passing through the centre. Therefore, at small apertures the ratio of light passing close to the edges increases and thus small apertures result in a lot of diffraction.

Sharpness is therefore limited not just by imperfections in the lens, but also by diffraction. Thus, the use of mid-range apertures (f5.6 - 11) results in optimum picture quality. Normally a lens is at its sharpest at aperture 8.

AKYLA cameras are very sensitive to light and have a wide range of user programmable gain factors, thus it is possible to use mid-range apertures without significantly increasing lighting costs.

Lighting

Lighting affects the quality of an imaging situation much more than the selection of proper optics. Proper lighting can increase accuracy, system reliability and response time. Furthermore, failure to implement correct object illumination will, in most cases, lead to loss of time and financial resources.

A good image for processing purposes is an image that has the greatest texture contrast in the areas of interest against the background. To be able to reliably process the image these conditions must prevail with certain accuracy over time.

Spectral Radiance and Color Temperature

The spectral radiance of the lighting used depends on the application, since certain wavelengths of light might produce either additional or the desired information in the application. Generally speaking the spectral distribution of the light sources should be as even as possible in the visible light spectrum (350 to 700 nm), where the AKYLA cameras are intended to be operated. Due to the technology used in the camera and the CCDs inherent increased sensitivity to the red end of the spectrum, the lighting should contain in it a considerable blue content.

The color temperature of a light source is a pretty accurate measure of the balance of spectral radiance. Reasonable results can be obtained when lighting color temperature is close to or over 4000k. High quality color images require a color temperature of around 6500k or more.

Lighting that generates a lot of IR or UV might affect the working of the CCD sensors and should be filtered out or the source of lighting must be chosen so that the content of undesired wavelengths is minimized.

Uniformity of Lighting

Uniformity of lighting means that there are negligible variations in light intensity over the used spectrum. Also, changes in ambient lighting should not affect the imaging situation. Such a light source is called a lambertian source or uniform diffused light. This light can be collimated to further improve stability and intensity.

A lambertian source will do for an imaging situation where shadows and reflections should be minimized. There are many other schemes of lighting which, of course, depend on the application. So it is up to the user to experiment with different lighting schemes to find which scheme best contrasts the desired image feature.

The way the light is driven also has a major impact on the evenness of lighting. Normally either high frequency ballasts (order of tens of kHz) are used to drive certain types of lighting or DC lighting is used. Some systems also use three different lamps each driven in a different phase with a square wave instead of a sinusoidal one. In any case, if DC lighting is not used, the frequency driving the lights should be considerably higher than the line frequency used for the application.

Aging of the light source should always be considered, since there might be changes in intensity and color temperature. If there is fine color based qualification to be performed, this aspect should be carefully considered.

The temperature dependency of the chosen light source should be verified. For example, fluorescent tubes have a relatively high relation between the operating temperature and both the intensity and the proportion of color output, while all AKYLA cameras have almost no changes in their performance.

Technical Specifications

Table 10. Technical Specifications: AKYLA M20 1010 CL and 2010 CL with 10 µm Sensors[1]

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Number of pixels	N N	–	1024 2048	–	–	–
Pixel size	–	–	10 x 10	–	µm	100% fill factor
Data rate per CCD	–	–	–	20	MHz	–
Linescan period	t_{exp}	56	–	–	µs	1024 pixels, max. line rate: ~18 kHz
Linescan period	t_{exp}	107	–	–	µs	2048 pixels, max. line rate: ~9.4 kHz
A/D conversions	–	–	10	–	bit	–
Typical gain control	G	x1	–	x24	–	–
Linearity	–	99.2	99.5	–	%	[2]
Photo response nonuniformity, p-to-p	PRNU	–	±2	±10	%	–
Saturation level	–	–	1023	1023	LSB	Least Significant Bit
Peak Response at Gmin	R G B	– – –	10 5.4 4.1	– – –	LSB/nJ/cm^2	G = x1
Signal to noise ration at Gmin	SNR	–	48	–	dB	G = x1
Supply voltage	V_{supp}	20	24	36	Vdc	ripple: ±10%, voltage + ripple must stay within 20 to 36V
Power consumption	–	–	12–17	26	W	–
Weight	m	–	2	–	kg	without lens
Operating temperature	T_{op}	5	–	35	°C	41 to 95F
Storage temperature	T_{st}	-10	–	55	°C	14 to 131F
Humidity, operation	–	5	–	85	%	relative, non condensing
Humidity, storage	–	5	–	95	%	relative, non condensing
Saturation equiv. exposure	SEE	–	102 8	–	nJ/cm^2	low gain high gain
Noise equiv. exposure	NEE	–	400 40	–	pJ/cm^2	low gain high gain

Notes: 1. Latest Update: March 7, 2002
2. Within 10 to 95% of the saturation exposure. Equals ±8 LSBs of 10-bit. Tested on all cameras both with the low and high gains (factory settings in memory banks 62 and 63).

Table 11. Technical Specifications: AKYLA M30 1010 CL and 2010 CL with 10 µm Sensors(1)

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Number of pixels	N N	–	1024 2048	–	–	–
Pixel size	–	–	10 x 10	–	µm	100% fill factor
Data rate per CCD	–	–	–	30	MHz	–
Linescan period	t_{exp}	37	–	–	µs	1024 pixels, max. line rate: ~18 kHz
Linescan period	t_{exp}	71	–	–	µs	2048 pixels, max. line rate: ~9.4 kHz
A/D conversions	–	–	10	–	bit	–
Typical gain control	G	x1	–	x24	–	–
Linearity	–	99.2	99.5	–	%	(2)
Photo response nonuniformity, p-to-p	PRNU	–	±2	±10	%	–
Saturation level	–	–	1023	1023	LSB	Least Significant Bit
Peak Response at Gmin	R G B	– – –	10 5.4 4.1	– – –	LSB/nJ/cm^2	G = x1
Signal to noise ration at Gmin	SNR	–	48	–	dB	G = x1
Supply voltage	V_{supp}	20	24	36	Vdc	ripple: ±10%, voltage + ripple must stay within 20 to 36V
Power consumption	–	–	12–17	26	W	–
Weight	m	–	2	–	kg	without lens
Operating temperature	T_{op}	5	–	35	°C	41 to 95F
Storage temperature	T_{st}	-10	–	55	°C	14 to 131F
Humidity, operation	–	5	–	85	%	relative, non condensing
Humidity, storage	–	5	–	95	%	relative, non condensing
Saturation equiv. exposure	SEE	–	102 8	–	nJ/cm^2	low gain high gain
Noise equiv. exposure	NEE	–	400 40	–	pJ/cm^2	low gain high gain

Notes: 1. Latest Update: March 7, 2002
2. Within 10 to 95% of the saturation exposure. Equals ±8 LSBs of 10-bit. Tested on all cameras both with the low and high gains (factory settings in memory banks 62 and 63).

Table 12. Technical Specifications: AKYLA M20 1014 CL with 14 µm Sensors(1)

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Number of pixels	N	–	1024	–	–	–
Pixel size	–	–	14 x 14	–	µm	100% fill factor
Data rate per CCD	–	–	–	20	MHz	–
Linescan period	t_{exp}	56	–	–	µs	1024 pixels, max. line rate: ~18 kHz
A/D conversions	–	–	10	–	bit	–
Typical gain control	G	x1	–	x24	–	–
Linearity	–	99.2	99.5	–	%	(2)
Photo response nonuniformity, p-to-p	PRNU	–	±2	±10	%	–
Saturation level	–	–	1023	1023	LSB	Least Significant Bit
Peak Response at Gmin	R G B	– – –	26 14 10.7	– – –	$LSB/nJ/cm^2$	G = x1
Signal to noise ration at Gmin	SNR	–	48	–	dB	G = x1
Supply voltage	V_{supp}	20	24	36	Vdc	ripple: ±10%, voltage + ripple must stay within 20 to 36V
Power consumption	–	–	12–17	26	W	–
Weight	m	–	2	–	kg	without lens
Operating temperature	T_{op}	5	–	35	°C	41 to 95F
Storage temperature	T_{st}	-10	–	55	°C	14 to 131F
Humidity, operation	–	5	–	85	%	relative, non condensing
Humidity, storage	–	5	–	95	%	relative, non condensing
Saturation equiv. exposure	SEE	–	40 3	–	nJ/cm^2	low gain high gain
Noise equiv. exposure	NEE	–	160 16	–	pJ/cm^2	low gain high gain

Notes: 1. Latest Update: March 7, 2002
2. Within 10 to 95% of the saturation exposure. Equals ±8 LSBs of 10-bit. Tested on all cameras both with the low and high gains (factory settings in memory banks 62 and 63).

Table 13. Technical Specifications: AKYLA M30 1014 CL with 14 µm Sensors[1]

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Number of pixels	N	–	1024	–	–	–
Pixel size	–	–	14 x 14	–	µm	100% fill factor
Data rate per CCD	–	–	–	30	MHz	–
Linescan period	t_{exp}	37	–	–	µs	1024 pixels, max. line rate: ~27 kHz
A/D conversions	–	–	10	–	bit	–
Typical gain control	G	x1	–	x24	–	–
Linearity	–	99.2	99.5	–	%	[2]
Photo response nonuniformity, p-to-p	PRNU	–	±2	±10	%	–
Saturation level	–	–	1023	1023	LSB	Least Significant Bit
Peak Response at Gmin	R G B	– – –	26 14 10.7	– – –	LSB/nJ/cm^2	G = x1
Signal to noise ration at Gmin	SNR	–	48	–	dB	G = x1
Supply voltage	V_{supp}	20	24	36	Vdc	ripple: ±10%, voltage + ripple must stay within 20 to 36V
Power consumption	–	–	12–17	26	W	–
Weight	m	–	2	–	kg	without lens
Operating temperature	T_{op}	5	–	35	°C	41 to 95F
Storage temperature	T_{st}	-10	–	55	°C	14 to 131F
Humidity, operation	–	5	–	85	%	relative, non condensing
Humidity, storage	–	5	–	95	%	relative, non condensing
Saturation equiv. exposure	SEE	–	40 3	–	nJ/cm^2	low gain high gain
Noise equiv. exposure	NEE	–	160 16	–	pJ/cm^2	low gain high gain

Notes: 1. Latest Update: March 7, 2002
2. Within 10 to 95% of the saturation exposure. Equals ±8 LSBs of 10-bit. Tested on all cameras both with the low and high gains (factory settings in memory banks 62 and 63).

Camera Configuration Using RS-232 Port

Version: 1.3

Date: July 28, 2002

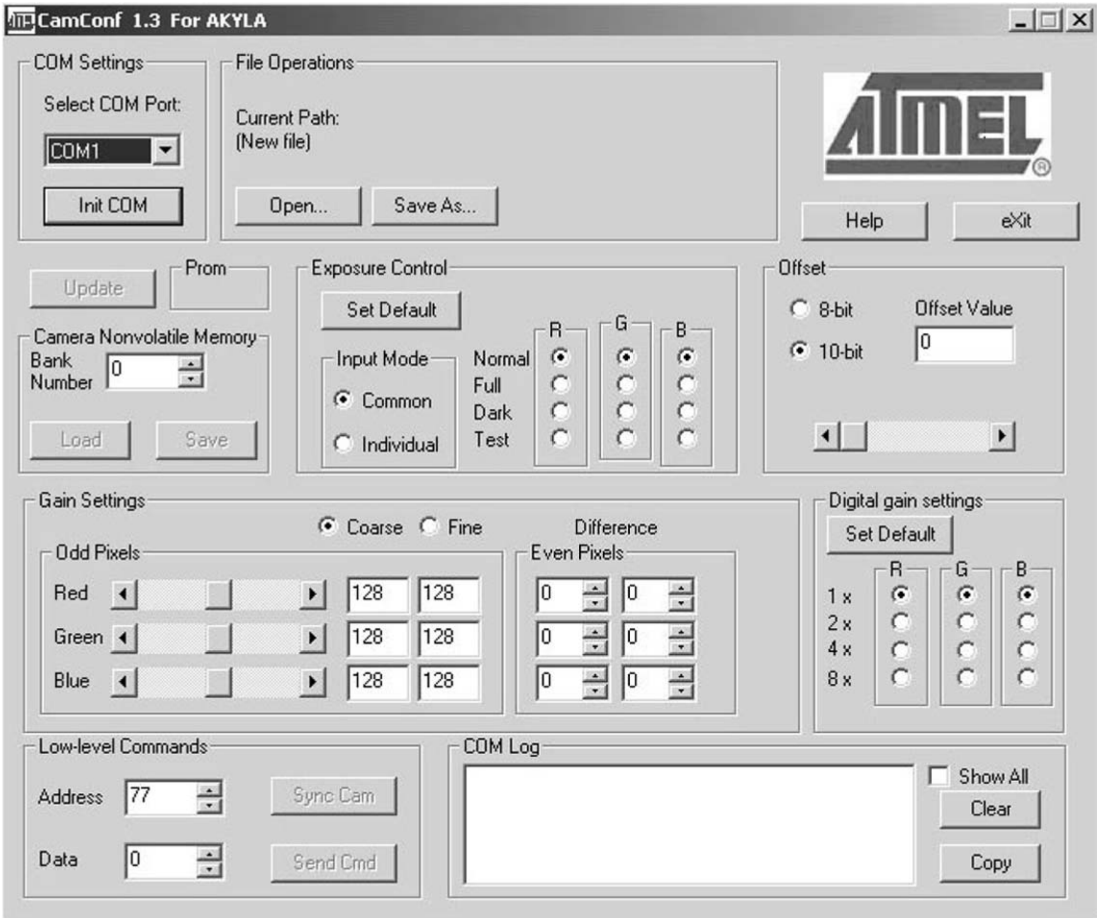
PROMs: B04, B05

Description

The AKYLA linescan cameras have user programmable features that are available by using the RS-232 port and a simple protocol.

The following section describes in general terms the communication and all the available functions for developing the users' own application software. Alternatively, Windows® software with source codes and documentation is available from Atmel. This is an application, written in VisualC++® 6.0 for Windows® 95/98/2000 and Windows NT® 4.0.

Figure 20. Camera Configuration



Communication

Programming of the camera is based on sixteen 8-bit registers that can be loaded with new values any time during the operation. New values are sent as sets of two bytes, where the first byte is the address of the register (command) and the second byte is the data (new value). A delay of 0.1 ms or more after sending each byte is recommended.

Table 14. Default Value

Address	Function	Default Value (Decimal)
64 to 75	Programmable gains	128
76	Exposure Control Mode	0
77	Programmable offset	0
78	Programmable digital gains	0
79	Output mode register	0

All the registers are automatically set to the values of memory bank 0 (see "Memory Functions (Addresses 80 and 81)" on page 32 for details) on power-up. The contents of this default memory bank can be altered with memory commands.

The values of these registers form a so called memory bank, which can be saved into one of the internal non-volatile memory banks for future reloading. Two commands are available for selecting the memory bank.

Table 15. Memory Bank

Address	Function	Memory Bank Addresses
80	Load from memory	64 to 127 (decimal)
81	Save to memory	64 to 127 (decimal)

The camera responds to each valid setting by sending the same values back (8-bit address and 8-bit data). Invalid commands are acknowledged with error codes.

There are three exceptions:

1. The Load Command does not return the address and data of the command itself. Instead, the camera sends out the contents of the selected memory bank (see "Output Mode Register (Address 79)" on page 31 for details).
2. The Escape code is the second exception. It can be used in situations, where the 2-byte sequence is, for some reason, lost. If the camera detects this value as the address, it will respond with the respective feedback and returns to the state, where it assumes that the next byte will be an address.

   Note 1: This value is accepted as data. This is why the Escape command should be sent twice to assure that it will be detected as a command also.

   Note 2: This command, of itself, does not change any register values; it is only meant for initializing the 2-byte sequence. All the registers should be reprogrammed afterwards to assure use of the intended values.

Table 16. Escape Command

Function	Decimal	Hexadecimal	Binary
ESCAPE	170	AA	1010 1010

3. The third exception is the Retrieve PROM Version – command, which takes only one data value and returns the address and number of the PROM version currently in use (see “Retrieve PROM Version (Address 82)” on page 32 for more details).

Table 17. Retrieve PROM Version

Address	Function	DATA (Decimal)
82	Retrieve PROM Version	82 (no other values accepted)

Communication Parameters

Set the RS-232 port (or the CameraLink serial port) to 9600 bits per second, 8 data bits, no parity and one stop bit (9600, 8, N, 1). Use RTS/CTS hardware handshaking for RS-232.

Error Codes

Table 18. Error Codes

Error	Decimal	Hexadecimal	Binary	ASCII
START and/or STOP bit error	101 followed by 49	65 followed by 31	0110 0101 followed by 0011 0001	e1
Illegal command	101 followed by 50	65 followed by 32	0110 0101 followed by 0011 0010	e2
Illegal data (255)	101 followed by 51	65 followed by 33	0110 0101 followed by 0011 0011	e3
Illegal data for the LOAD command	101 followed by 52	65 followed by 34	0110 0101 followed by 0011 0100	e4
Illegal data for the SAVE command	101 followed by 53	65 followed by 35	0110 0101 followed by 0011 0101	e5
Escape command	120	78	0111 1000	x

Programmable Functions

Programmable Gains (Addresses 64 to 75)

Each CCD has two output channels and each channel has both coarse and fine tuning gain controls. The range is from zero (minimum gain) to 254 (maximum gain).

Gains should be set by first using coarse tuning only to reach the closest possible response. All gain settings are relative and specific only to each camera and each register. The response is logarithmic, meaning that the steps at the upper end of the range are bigger than when using small values. The absolute values of these registers are not significant; the setting of the gains should be based on the feedback from the actual images.

Odd Channel: represents pixels 1, 3, 5, ...,1023 (up to 2047 with 2048-pixel cameras)

Even Channel: represents pixels 2, 4, 6, ...,1024 (up to 2048 with 2048-pixel cameras)

Table 19. Addresses for Coarse Gain Control

Channel	Odd/ Even	Decimal	Hexadecimal	Binary	ASCII
Red	odd	64	40	0100 0000	@
	even	65	41	0100 0001	A
Green	odd	68	44	0100 0100	D
	even	69	45	0100 0101	E
Blue	odd	72	48	0100 1000	H
	even	73	49	0100 1001	I

Table 20. Addresses for Fine Gain Control

Channel	Odd/ Even	Decimal	Hexadecimal	Binary	ASCII
Red	odd	66	42	0100 0010	B
	even	67	43	0100 0011	C
Green	odd	70	46	0100 0110	F
	even	71	47	0100 0111	G
Blue	odd	74	4A	0100 1010	J
	even	75	4B	0100 1011	K

Example: How to set the blue channel to maximum gain?

1. Set the selected COM port of the PC to 9600, 8, N, 1.
2. Set the analog gain of odd pixels of the blue channel to maximum value by first sending the respective address, which is 72. Afterwards, send the new setting value 254.
3. The even pixels of the blue channel are set to maximum by sending the following two decimal numbers: 73 and 254.

Refer to "Debugging" on page 33 for debugging this example.

Exposure Control Mode (Address 76)

The Exposure Control function can be applied individually to each CCD. As default, one common input signal (ExpCtrlR/CC2) drives all the three CCDs. Alternatively, each CCD can have its dedicated input signal for Exposure Control.

Table 21. Address for Modifying the Exposure Control Function

Function	Decimal	Hexadecimal	Binary	ASCII
Select ExpCtrl	76	4C	0100 1100	L

This function is used like the setting of the gains (see above). The data byte consists of eight bits, which are labelled as follows (MSB first):

- S – R1 – R0 – G1 – G0 – B1 – B0 – X

Bit S selects the source for the Exposure Control functions:

- 0 = common ExpCtrl signal (default)
- 1 = individual ExpCtrl signals

The next 6 bits are used as pairs for each color channel (Table 22):

- **Default mode**: the 6 bits are all zeros, and there is no need to change them. They can, though, be used for testing or debugging the system.
- **Normal State:** Exposure Controls are driven directly from the input pins of the camera (as set by bit S). The Exposure Control can be set to be always inactive (respective channel is never reset by the Exposure Control) or to be always active (pixels are reset all the time by the Exposure Control; this results in a dark output value for the selected channel).
- **Test Mode:** the pixels are reset until the end of the LineValid signal. This is a time constant. Thus the amount of exposure will depend on the line rate only (see Timing Diagrams for details).

Table 22. Exposure Control Function

R1	R2	Function
0	0	normal operation, default, the source is defined by bit 'S'
0	1	always inactive, full exposure, independent of bit 'S'
1	0	always active, dark, independent of bit 'S'
1	1	active (pixels reset) during line transfer, independent of bit 'S'

The same applies to pairs of G1 and G0 as well as for B1 and B0.

Bit X can be either 1 or 0 = don't care.

Examples:

Default value is 00. The ExpCtrlR input pins drive all the CCDs.
To return to this state send a 2-byte set 76 (decimal) and 0 (or 76 and 1).

Set all the channels to dark by sending 76 followed by 84.

Only red channel at full time exposure: 76 followed by 52.
Only green channel at full time exposure: 76 followed by 76.
Only blue channel at full time exposure: 76 followed by 82.

Exposure control function not in use: send 76 followed by 42.

Programmable Offset (Address 77)

The offset can be digitally removed by sending a value to the respective address. This value is subtracted from all the pixel values, before sending them out. The offset value is any number between 0 and 254. This is subtracted from the original 10-bit pixel values.

Table 23. Address for Modifying the Offset Function

Function	Decimal	Hexadecimal	Binary	ASCII
Offset value	77	4D	0100 1101	M

If you are using only the 8 upper bits (MSBs), please note that the offset value still affects the original 10-bit values (range 0 to 1023 in digital units).

The lowest output is limited to zero (negative numbers are rounded up to 0). The saturation level is lowered by the value of the offset.

Example:

To subtract 7 levels from the 8-bit output range, send (as decimal values) 76 followed by 28 (multiply the "8-bit offset value" by 4). The digital saturation level will be 248 instead of the original 255.

Programmable Digital Gain (Address 78)

The Digital Gain function can be applied individually to each color channel. Digital gains are implemented by shifting the original 10-bit data upwards (left) by 0, 1, 2 or 3 positions (corresponding to 1x, 2x, 4x and 8x respectively) and by limiting the overflow of the new, shifted value. The effect is that the response of the camera will be higher, but the effective noise levels will increase accordingly. Please note that after shifting, the lowest bits will be replaced by zeroes. For example, in 8-bit applications (using the topmost 8 bits) and with 8x gains, the LSB will always be zero.

Table 24. Address for Modifying the Digital Gain Function

Function	Decimal	Hexadecimal	Binary	ASCII
Select Digital gain	78	4E	0100 1110	N

This function is used like the setting of the gains (see above). The data byte consists of eight bits, which are labelled as follows (MSB first):

- X – R1 – R0 – G1 – G0 – B1 – B0 – X

The middle 6 bits are used as pairs for each color channel (see Table 25). As default, these are all zeros, and there is no need to change them due to the sensitivity of the camera. They can, though, be used in cases where lighting is insufficient or to compensate for reducing working aperture size to decrease blur in the image.

Table 25. Digital Gain Function

R1	R2	Function
0	0	1x digital gain (initial value)
0	1	2x digital gain
1	0	4x digital gain
1	1	8x digital gain

The same applies to pairs of G1 and G0 as well as for B1 and B0.

Bits marked X can be either 1 or 0.

Examples:

To remove the digital gains send a 2-byte set 78 (decimal) and 0.

Set all the channels to 4x digital gain by sending 78 followed by 84.

The lighting used has a small portion of blue, a little more green, and a lot of red. The normal gain setting does not produce enough signal (DU) to balance the camera to a reasonable signal level. The user sets the blue channel to 8x, green to 4x and red to 1x digital gain to compensate for poor lighting by sending 78 followed by 22.

Output Mode Register (Address 79)

The output mode register is used to change the configuration of data output in CameraLink models. The output mode register will define the pixel clock frequency, color order and which ports the data is routed to. All bits are *Don't Care* if camera is not with CameraLink output.

Table 26. Address for Modifying the Output Mode Registers

Function	Decimal	Hexadecimal	Binary	ASCII
Select Output Mode	79	4F	0100 1111	O

This function is used like the setting of the gains (see above). The data byte consists of eight bits, which are labelled as follows (MSB first):

- SP – CL – M2 – M1 – M0 – X – X – X

Bit SP selects the frequency of the pixel clock (STRB):

- 0 = Camera at faster output mode (default)
- 1 = Camera at slower output mode

Bit SP is defined as Don't Care (X) for 30 MHz parallel mode cameras, since there is no slower output mode.

Bit CL selects the color output order for multiplexed mode cameras:

- 0 = RGB color output (default)
- 1 = BGR color output

This bit is defined as Don't Care for parallel mode cameras.

The next three bits M2, M1 and M0 select which ports the data is output to. These bits are defined differently for multiplexed and parallel mode cameras.

Table 27. Output Mode Register

M2	M1	M0	Parallel Mode	Connectors /Ports	Multiplexed Mode	Connectors /Ports
0	0	0	24-bit Base (default)	1/ABC	8-bit Base (default)	1/A
0	0	1	24-bit Base + LSB byte	2/ABCD	10-bit Base	1/AB
0	1	0	30-bit Medium	2/ABCEF	Reserved	
0	1	1	30-bit Dual Base	2/ABCDE	Reserved	
1	0	0	Reserved		Reserved	
1	0	1	Reserved		Reserved	
1	1	0	Reserved		Reserved	
1	1	1	Reserved		Reserved	

Note: The "Low-level Commands" field of the CamConf can be used for setting this register.

Memory Functions (Addresses 80 and 81)

The internal non-volatile memory of the camera is divided into 64 so called memory banks. Each bank can save the status of all sixteen registers (addresses 64 to 79). Each register is made of 8 bits. Values can be loaded from memory as complete sets of sixteen registers (memory banks) only.

AKYLA cameras have a volatile memory buffer, which is updated after each new configuration setting to the camera (command and data pair). A copy of this buffer can be saved to any of the user accessible memory banks and any of the memory banks can be loaded into the buffer (overwrites the old values).

Memory bank 0 is automatically loaded, when the camera is powered up. The values are not sent out at this moment. LOAD Bank 0 to read-out the power-up values. To read the values that are currently in use (but not saved), use one of the memory banks to first SAVE and then to LOAD the same values. Bank number 59 is used as a temporary storage place for the AKYLA CamConf software. Banks 60 to 63 can not be written to, since they contain factory preset values.

Table 28. Memory Functions

Memory Bank	Save	Load	Notes
0	yes	yes	Power-up values
1 to 58	yes	yes	General purpose
59	yes	yes	Used by the AKYLA CamConf software as a temporary storage place
60	no	yes	Reserved for factory preset values
61	no	yes	Reserved for factory preset values
62	no	yes	High-gain version of bank 63
63	no	yes	Copy of the initial values in Bank 0

The actual data that must be used with LOAD or SAVE is Memory Bank number 64 (decimal). Thus, in order to save the settings of the camera to be its power up values send the SAVE command, 81, and then send the data, which now is 0 + 64. To reload the initial default settings from Bank 63, send 80 followed by 127 (decimal).

The camera responds to SAVE commands by sending back the address and the data.

LOAD commands are acknowledged by sending out the contents of the selected memory bank. Each of the 16 values is preceded by the address of the respective register. Thus, the response starts with (decimal) 64, coarse_gain_value_for_odd_pixels_of_red_channel, 65, coarse_gain_value_for_even_pixels_of_red_channel, 66 and so on until the total of 32 bytes has been sent out.

Please, note that a delay of at least 10 ms is required between any two consecutive SAVE commands. Data storage is guaranteed only up to 100 000 SAVE commands.

Retrieve PROM Version (Address 82)

Using this function, it is possible to retrieve the name of the PROM currently in use in the camera. If the PROM is an older version, which doesn't recognize the command, an error code will be sent back (e2). In this case the PROM label should be checked by opening the access cover of the rear panel.

Table 29. Address for Retrieving the PROM Number in Use

Function	Decimal	Hexadecimal	Binary	ASCII
Retrieve PROM version	82	52	0101 0010	R

The data byte for retrieving the PROM version is 82 (all other data values are reserved for future use). All other data bytes will return the error code of illegal data (code e3).

Table 30. Returned Data Value and PROM Version

Returned Data Value	PROM Letter	PROM Number
0–99	F	returned data minus 0
100–149	G	returned data minus 100
150–199	Z	returned data minus 150
200–254	B	returned data minus 200

Example:

To obtain the PROM version currently in use, send the 2-byte set 82 (decimal) and 82.

The camera returns 82 and 204, which means that B04 is currently in use.

Debugging

If the camera doesn't respond as expected go through the following check list:

1. Is the cable made correctly?
2. Are you using the correct serial connector on the PC?
3. Are the software settings for the selected COM port OK?
4. Is the COM port actually behaving as is set to? This is the most common problem encountered. Depending on the combination of software and operating system, the actual hardware may operate under incorrect settings. A possible solution is:

   Verify the operation of the actual hardware by measuring the waveform on the input data line of the camera (this may require disassembling the connector enclosure of the cable). The line is low, when no data transfer is in progress. The transfer always starts with one start bit, which is at high (1) level at the connector. The duration of each bit is about 104 µs. The polarity in the line is inverted compared to the bit values of the software.

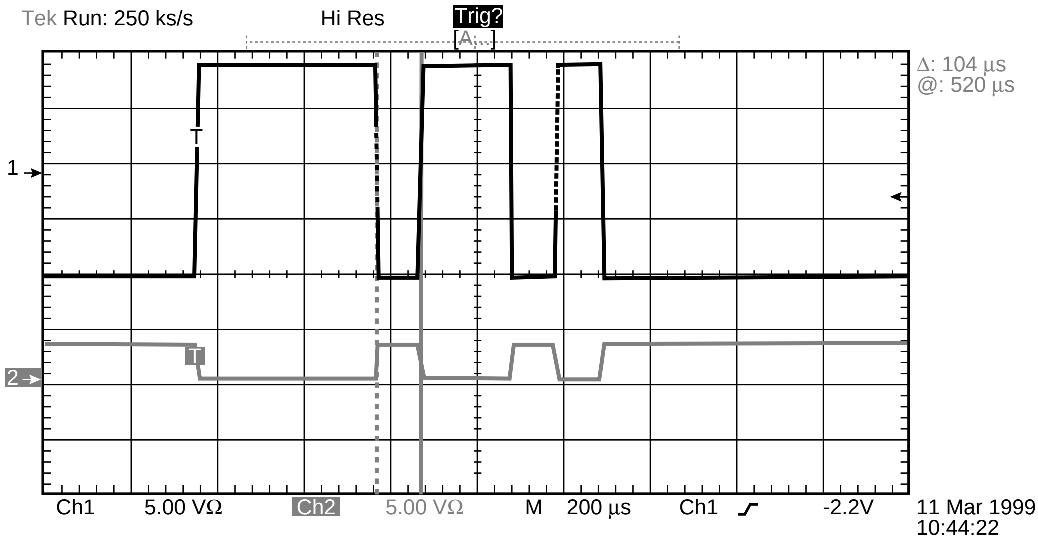
   After that the 8 data bits follow. The lowest bit (LSB) is sent out first. After these there will be one stop bit, which is at a low level. The line remains at this level until the start of the next transfer (byte).

Example: Odd pixels of the blue channel are set to maximum by sending out two bytes. First is the address for this channel, 72 as decimal value, and the second byte is the gain value, 254 (decimal).

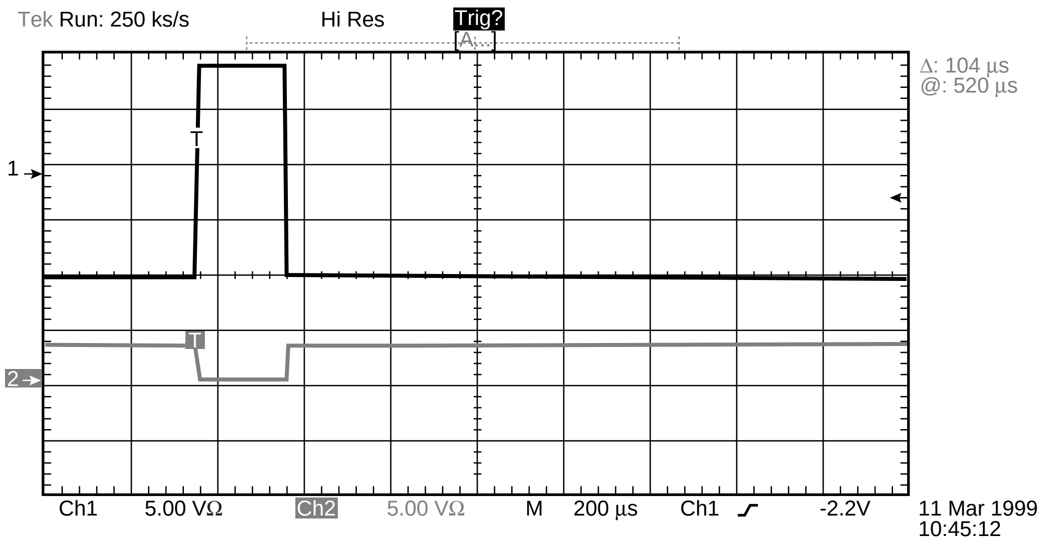
In the first part the actual waveform is as follows (L equals one bit at low level and H equals one bit at high level):

...LLLLLLLLLLLLLLLLLHHHHLHHLHLLLLLLLLLLLLLLLLLLLLLLLLLL...

Similarly, on the following oscilloscope plot, the upper waveform (nr. 1) represents the signal in the cable and the lower waveform is the same signal as TTL levels. The lower waveform corresponds also to the values of the software (sending starts with a 0 level start bit, followed by three zeroes, one 1, and two zeroes, one 1, one zero and a stop bit, which is always 1 (waveform two is not accessible for the users).



The gain value can be seen in the cable respectively:



Ordering Codes

Table 31. Model Numbers and Ordering Codes for AKYLA Camera

Product	Camera Designation	Part Number
AKYLA MD20 CL 1010	AKYLA MD20 CL 1010 F MOUNT	AT71-MD20CL1010
AKYLA MD20 CL 2010	AKYLA MD20 CL 2010 F MOUNT	AT71-MD20CL2010
AKYLA MD20 CL 1014	AKYLA MD20 CL 1014 F MOUNT	AT71-MD20CL1014
AKYLA MD20 LV 1010	AKYLA MD20 LV 1010 F MOUNT	AT71-MD20LV1010
AKYLA MD20 LV 2010	AKYLA MD20 LV 2010 F MOUNT	AT71-MD20LV2010
AKYLA MD20 LV 1014	AKYLA MD20 LV 1014 F MOUNT	AT71-MD20LV1014
AKYLA MD30 CL 1010	AKYLA MD30 CL 1010 F MOUNT	AT71-MD30CL1010
AKYLA MD30 CL 2010	AKYLA MD30 CL 2010 F MOUNT	AT71-MD30CL2010
AKYLA MD30 CL 1014	AKYLA MD30 CL 1014 F MOUNT	AT71-MD30CL1014
AKYLA MD30 LV 1010	AKYLA MD30 LV 1010 F MOUNT	AT71-MD30LV1010
AKYLA MD30 LV 2010	AKYLA MD30 LV 2010 F MOUNT	AT71-MD30LV2010
AKYLA MD30 LV 1014	AKYLA MD30 LV 1014 F MOUNT	AT71-MD30LV1014

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