Peripheral Imaging Corporation

PI409MC-A4
400DPI CIS Module
Engineering Data Sheet

Key Features

- Light source, lens, and sensor are integrated into a single module

- Ultra-High-Speed

- Four parallel analog video outputs clocked at 5.0MHz.

- 180 µsec/line scanning speed @ 5.0 MHz clock speed

- 15.8 dpm resolution, 216 mm scanning length

- Wide dynamic range

- Red light source 660nm

- Standard A4 size $\cong$ 14mm x 19 mm x 232 mm

- Low power

- Light weight

General Description

The PI409MC-A4 is a CIS module. It is a long contact image sensor modules, using MOS image sensor technology for high-speed performance and high sensitivity. Its four parallel video outputs gives the PI409MC-A6 its high speed performance. The PI409MC-A4 is suitable for scanning A4 size (216 mm) documents with 15.8 dots per millimeter resolution. Applications include document scanning, mark readers, gaming and office automation equipment.

Functional Description
The PI409MC-A4 imaging module consists 27 imaging chips, PI3022, produced by Peripheral Imaging Corporation. The sensor chips are monolithic devices with 128 photo

sensing elements. Twenty seven of these imaging chips are cascaded to provide 3456 photo-elements module. The PI3022 chips are integrated with the photo sensors' associated multiplex switches, a digital shift register and chip selection switch. The shift register sequentially clocks out the integrated image charges from each sensing elements and passes them through the chip-select switch and out onto the video line. The chip-select switch are sequentially switched as each of the predecessor chip completes its scan. These 27 sensors bonded on a PCB are grouped into 4 sub-cascaded sections. Each contiguously cascaded chips section are connected on separate video lines, accordingly providing four video outputs VOUT1, VOUT2, VOUT3 and VOUT4. Before the signal charges from the four video lines appear at their respective outputs they are converted to signal voltages by four on-board buffer amplifiers, one for each of its corresponding video section. The first three sections VOUT1, VOUT2, and VOUT3 have 7 sensor chips, while the VOUT4 has 6 sensor chips. Since each sensor chip have 128 pixels, there are total of 3456 pixels. See Figure 1. PI409MC-A4 Module Block Diagram.
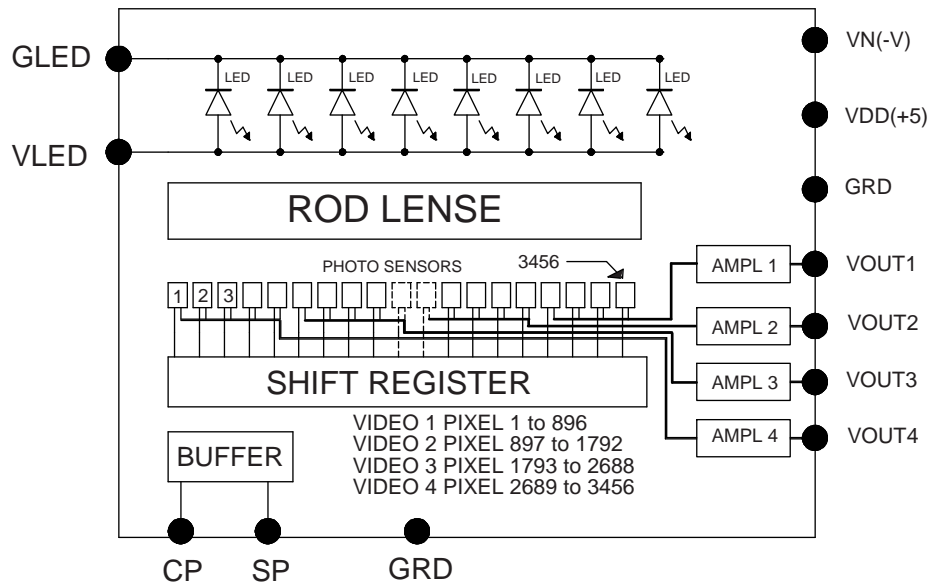

Figure 1. PI409MC-A4 Module Block Diagram
(See Table 1 for pin-out designation)

Mounted in the module housing, along with the PCB, is a one-to-one graded indexed micro lens array that focuses the scanned documents' image onto the sensing line of the sensor chips. The third major component mounted in the module is the LED light source. See Figure 2. PI409MC-A4 Cross Sectional View. The pictorial cross section shows the LED Bar light source and its Illumination path as it reflects the image from the document and focuses through the ROD lens on to its image sensing line of the sensing chips. All components are housed in a small plastic housing that has a cover glass. This cover glass is, also, the window. It serves as the focal point for the object being scanned, as well as to protect all of the critical components with the housing from dust. I/O to the module is

a 12-pin connector located on one end of the module. See Figure 5. Module's Mechanical Overview.
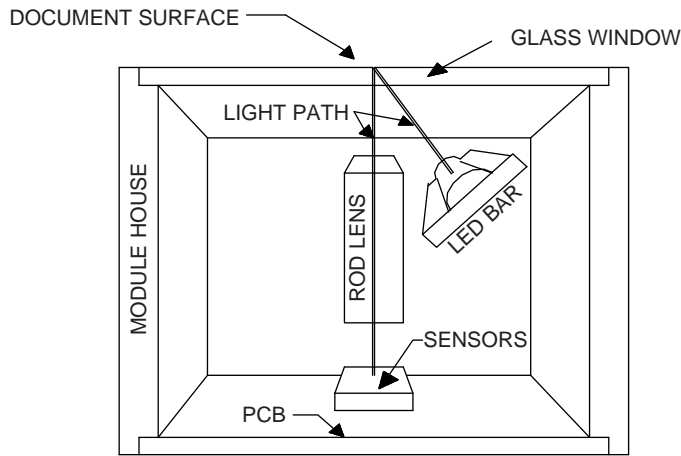
INSIDE PICTORIAL OF MODULE

Figure 2. PI409MC-A4 Cross Section

I/O Designation

Table 1 lists the pin numbers and their designations for the I/O connector. It is JAE IL-Z-12P-S125L3-E connector.

Pin Number	Symbol	Names and Functions
1	VOUT1	Analog Video Output 1
2	VOUT2	Analog Video Output 2
3	GND	Ground; 0V
4	VOUT3	Analog Video Output 3
5	VOUT4	Analog Video Output 4
6	Vdd	Positive power supply
7	SP(START)	Shift register start pulse
8	GND	Ground; 0V
9	CP(CLOCK)	Sampling clock pulse
10	Vn	Negative power supply
11	GLED	Ground for the light source; 0V
12	VLED	Supply for the light source

Table 1. Pin configuration

Absolute Maximum Rating:

Parameter	Symbols	Maximum Rating	Units
Power supply voltage	Vdd	7	V
	Idd	100	ma
	Vn	-15	V
	In	35	ma
	VLED	6	V
	ILED	600	ma
Input clock pulse (high level)	Vih	Vdd – 0.5V	V
Input clock pulse (low level)	Vil	-0.5	V

Note: These parameters are absolute maximums do not operate under these conditions.
Table 2. Absolute Maximum Rating

Environmental Specifications

Operating temperature[1]	Top	0 to 50	^{0}C
Operating humidity[1]	Hop	10 to 90	%
Storage temperature[1]	Tstg	-20 to+75	^{0}C
Storage humidity[1]	Hstg	10 to 90	%

Table 3. Operating and Storage Environment
Note (1) These are standard specifications for the CIS modules.

Electro-Optical Characteristics (25℃)

Parameter	Symbol	Parameter	Units	Note
Total number of photo detectors		3456	Elements	
Section 1, 2, & 3 number of photo detectors		896	Elements	
Section 4 number of detectors		768	Elements	
Pixel-to-pixel spacing		63.5	μm	
Line scanning rate	Tint[1]	180	μsec	@ 5.0MHz clock frequency
Clock frequency[2]	f	5.0	MHz	
Bright output voltage[3]	Video Output	500	mVolt	

Bright output nonuniformity[4]	Up	+/-30	%	
Dark nonuniformity[5]	Ud	<140	mV	
Dark output voltage[6]	Dark Level (DL)	<600	mV	
Modulation transfer function[7]	MTF	>50	%	

Table 4. Electro-optical characteristics at 25° C.

Definition:

(1) Tint: line scanning rate or integration time. Tint is determined by the interval between two start pulses (SP).

(2) f: main clock frequency also equals the video sampling frequency.

(3) Video output level is controlled with an adjustment as well as Integration time

(4) Up = {[Vp(max) –Vp(min)]/Vp(max)}x100%

   Where Vp(max) = maximum peak pixel and Vp(min) = minimum pixel.

(5) Ud = Vdmax – Vdmin

Vdmin is the minimum output voltage with LED off.

Vdmax is maximum output voltage with LED on.

(6) This level is measured from the reset level that is located between the pixels, during the pixel reset duration. The reset level is at or near ground, 0V. Note the gain is adjustable on each output. However, it is recommended that the gain should not be increased above the level where the reset ground level starts to increase above zero.

(7) A graph of the typical is shown under discussion of MTF in Figure 3.
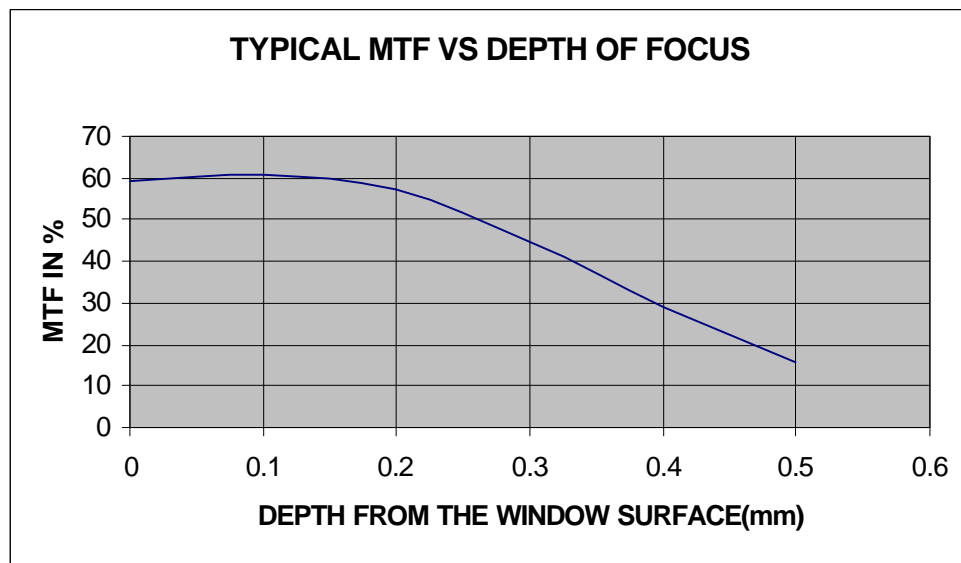
MTF Graph and Its Discussion

Figure 3. MTF versus Distance

See Figure 3 MTF versus Distance. This graph essentially shows the working depth of focus. Since this module is a 400DPI module, a pixel density of 400 pixel per inch, the

MTF was measured with a 200 DPI or a 100 line-pair per inch optical bar pattern. The test was conducted with pixel rate set to 2.5MHz.

The effective algorithm used in the measurements is as described by the following equation:
$$MTF=\{[Vp(n)+Vp(n+1)]/2-[Vp(n+2)+Vp(n+3)]/2\}/\{[Vp(n)+Vp(n+1)]/2+[Vp(n+2)+Vp(n+3)]/2\}$$
Where n is 1, 2, ...3456th, Vp(n) is the signal amplitude of the nth pixel.

## Recommended Operating Conditions (25℃)

Item	Symbol	Min	Typical	Max	Units
Power Supply	Vdd	4.5	5.0	5.5	V
	Vn.	-13	-5	-4.0	V
	Idd		87	95	ma
	In		25	30	ma
	ILED		450	550	ma
	VLED		5	5.5	V
Input voltage at digital high	Vih	Vdd-1.0	Vdd-.5	Vdd	V
Input voltage at digital low	Vil	0		0.6	V
Clock frequency	f	0.	5.0	6.0	MHz
Clock pulse high duty cycle			25		%
Clock pulse high duration			50		ns
Integration time	Tint		180		µs
Operating temperature[1]	Top		25	50	℃

Table 5. Recommended Operating Condition (25 ℃)
Note (1) see the note under the Table for Operating and Storage Environment.

Switching Characteristics (25℃)

The Switching Characteristics (25℃) for the I/O clocks are shown in the diagram Figure 4, on the following page. For the timing symbol definitions see Table 6 below the timing diagram. Note: Only one video output is shown because all four videos have identical electrical characteristic. The only physical difference is in section 4 output,VOUT4. Section 4 has only 6 sensor chips, hence, its active scan is shorter by 128 pixels.
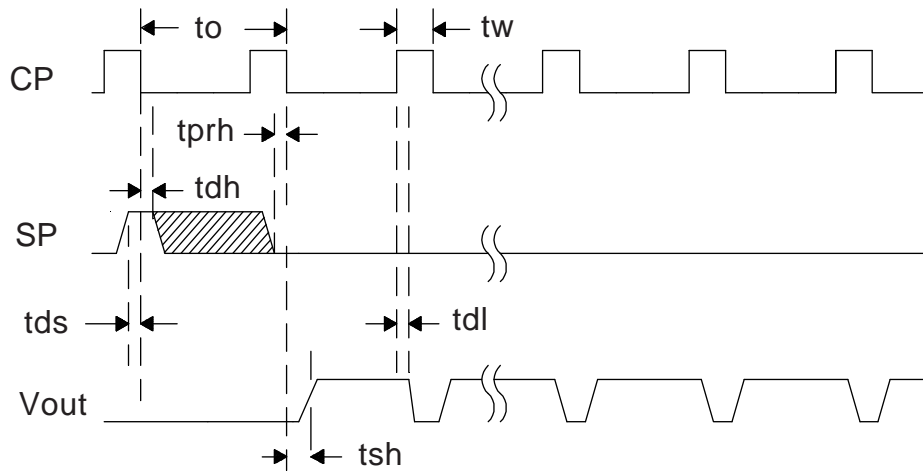
MODULE TIMING DIAGRAM
FIGURE 4

Item	Symbol	Min.	Typical	Max.	Units
Clock cycle time	to	0.20		4.0	μs
Clock pulse width	tw	50			ns
Clock duty cycle		25		75	%
Prohibit crossing time of Start Pulse[1]	tprh	0			ns
Data setup time	tds	20			ns
Data hold time	tdh	0			ns
Signal delay time	tdl	20			ns
Signal settling time	tsh	100			ns

Table 6. Timing Symbol's Definition and Timing Values.

Note1:
"Prohibit crossing of start pulse" is to indicate that the start pulse should not be active high between any two consecutive high going clock pulse or two consecutive low going clock pulses. See the timing diagram. Only one high going clock under the active high start pulse initiates the internal shift register, and it must not be active over two high going clocks. All low going clock pulses will not initiate the shift register. To ensure that the start pulse will not be actively high during two consecutive high going clocks, the circuit should be design to keep the start pulse active only for one high going clock cycle.

Mechanical Structure of the Module

The isometric sketch, Figure 5, of the housing is shown to demonstrate the connector location, the approximate overall dimensions and its general geometric layout of the module. It is not intended for use as a design reference. The detailed drawing for the PI409MC-A4 Module Housing is available upon request.
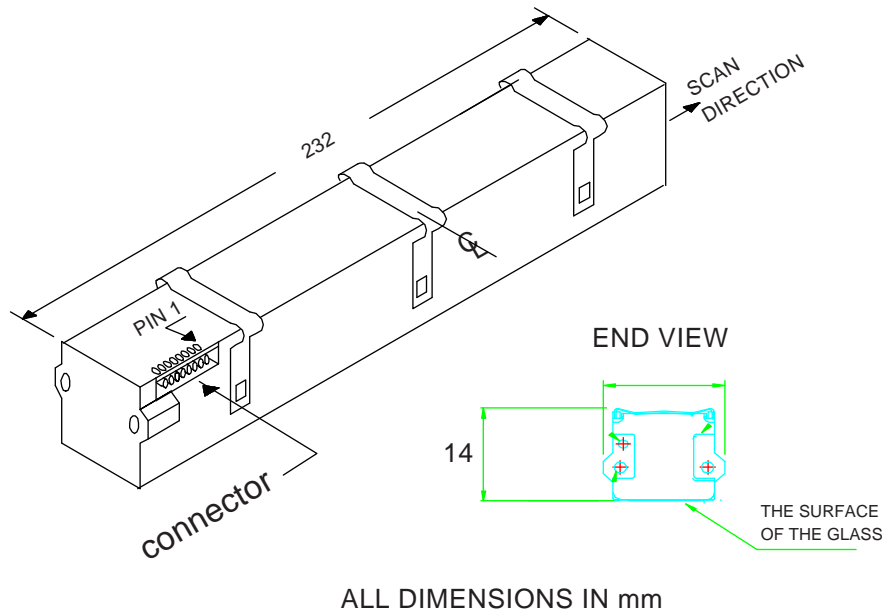

Figure 5. PI409MC-A4 Module Housing Sketch