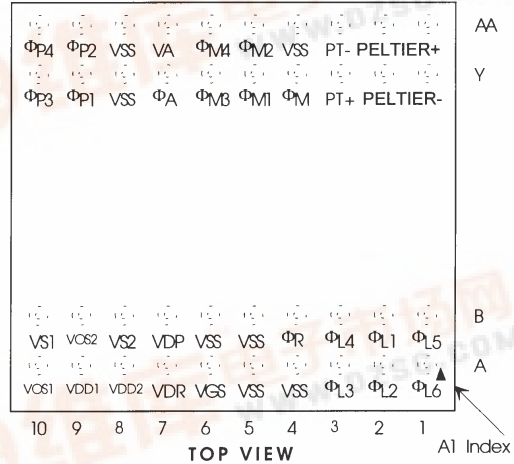


AREA ARRAY CCD IMAGE SENSOR
1024 x 1024 PIXELS WITH ANTIBLOOMING

- 1024 x 1024 pixels with memory zone
- Up to 30 images / second
- Built-in antiblooming device providing an electronic shutter function.
- Pixel : 14 μm x 14 μm
- Image zone : 14,34 x 14,34 mm²
- 2 outputs at 20 MHz each
- Readout through 1 or 2 outputs
- Possible binning 2 x 2
- Optical shield against parasitic reflexions and stray light
- A/R window in 400 - 700 nm bandwidth
- Optional integrated Peltier cooler



PIN IDENTIFICATION

Pin N°	Symbol	Designation
Y9	ΦP1	Image zone clocks
AA9	ΦP2	
Y10	ΦP3	
AA10	ΦP4	
Y5	ΦM1	Memory zone clocks
AA5	ΦM2	
Y6	ΦM3	
AA6	ΦM4	Memory to register clock
Y4	ΦM	
B2	ΦL1	Readout register clocks
A2	ΦL2	
A3	ΦL3	
B3	ΦL4	
B1	ΦL5	
A1	ΦL6	
A9	VDD1	Output amplifier drain supply
A8	VDD2	
B10	VS1	Output amplifier source supply
B8	VS2	
B7	VDP	Protection drain bias
A6	VGS	Register output gate bias
A10	VOS1	Video outputs
B9	VOS2	
B4	ΦR	Reset clock
Y7	ΦA	Antiblooming gate clock
A7	VDR	Reset bias
AA7	VA	Antiblooming diode bias
A4, A5, B5, B6	VSS	Substrate bias
Y8, AA4, AA8	VSS	
AA1, AA2	PELTIER+	OPTIONAL Peltier cooler power supply NC otherwise
Y1, Y2	PELTIER -	OPTIONAL Temperature sensor Pt 100Ω DIN43760 NC otherwise
AA3	PT-	

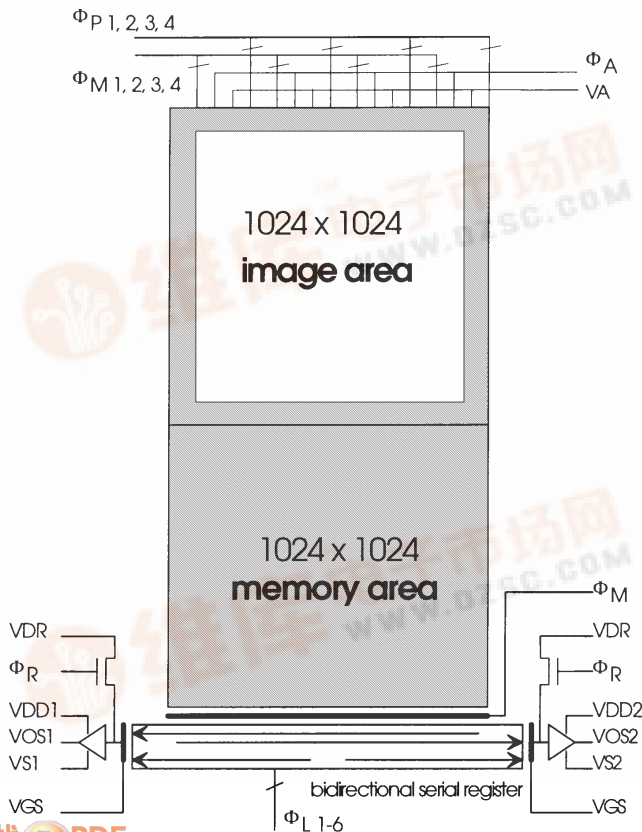


Figure 1 : TH7888A organization



TH7888A

DESCRIPTION

TH7888A is especially designed for high data rate applications (up to 30 pict /s in 1024x1024 format progressive scan) in medical and industrial fields.

This area array image sensor consists of a 1024 x 1024 pixels (14 μm x 14 μm) image zone associated to a memory zone (masked with optical shield).

In order to increase data rate, it is provided 2 separate outputs that can be used for parallel readout. (readout frequency up to 20 MHz / output leading to a total readout frequency of 40 MHz). These two outputs allow 3 readout modes (single or dual port readout).

TH7888A is designed with antiblooming structure providing electronic shutter capability.

Moreover the 2 x 2 binning mode is available on this sensor. In that case, the image size is 512 x 512 with 28 μm x 28 μm pixels.

TH7888A package is sealed with a specific anti-reflective window optimized in 400-700 nm spectrum bandwidth.

OPTIONS : the device can be delivered with integrated low power Peltier cooler in order to improve sensor performances in high temperature environments (typically + 50°C).

FUNCTIONAL DIAGRAM

Figure 1 gives the general sensor organization.

Extra dark lines are provided for use as dark references or for smearing digital correction.

Extra dark pixels are provided for line dark reference clamping.

Each frame is made of **1056** video lines :

- 1 dummy line
- 12 useful dark reference lines (with optical shield)
- 3 isolation lines
- **1024** useful lines
- 3 isolation lines
- 12 dark reference lines (with optical shield)
- 1 dummy line

Each video line is made of **546** or **1058** elements, depending on readout mode (single or dual port modes):

- 12 inactive prescan elements
- 1 isolation element
- 16 useful dark references (with optical shield)
- 5 isolation elements
- **512** or **1024** useful video pixels

GEOMETRICAL CHARACTERISTICS

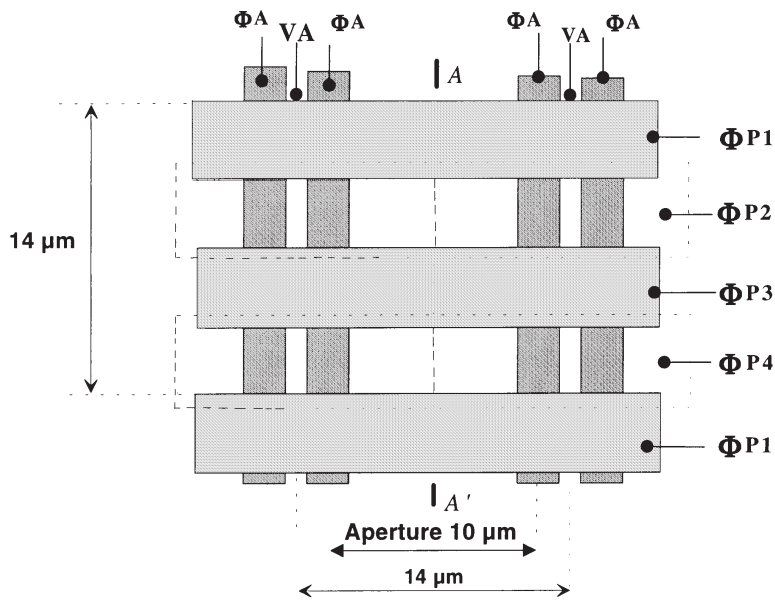


Figure 2b : Pixel layout

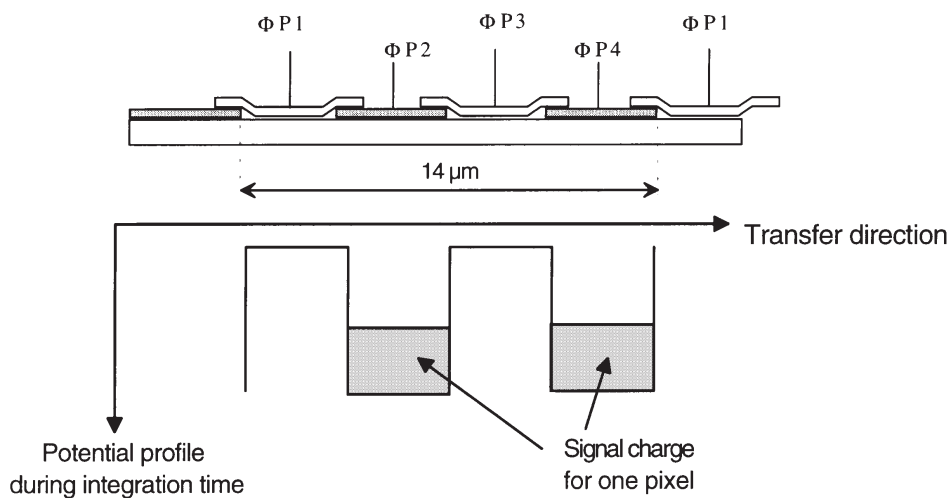


Figure 2c : Cross-section AA'

ABSOLUTE MAXIMUM RATINGS

Storage temperature	-55°C to +150°C
Operating temperature.....	-40°C to +85°C
Thermal cycling.....	15°C / mn

Maximum applied voltages :

Y9, AA9, Y10, AA10, Y5, AA5, Y6, AA6, Y4, B2, A2, A3, B3, B1, A1, B4, A6.....	-0.3 to 15 V
A9, A8, B10, B8, B7, A7, AA7	-0.3 V to 15.5 V
Y7.....	-0.3 V to 12 V
A4, A5, B5, B6, Y8, AA4, AA8	0V (ground)

PELTIER OPTION

Storage temperature-55°C to +85°C
 Operating temperature.....-40°C to +70°C
 Thermal cycling.....10°C / mn

Maximum applied voltages :

PIN	MAX VOLTAGE RANGE	MAX CURRENT RANGE
AA1, AA2 with respect to Y1, Y2	5 V	1.8 A

Stresses above those listed under absolute maximum ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

Operating range defines the limits within which the functionality is guaranteed.

Electrical limits of applied signals are given in operating conditions section

OPERATING PRECAUTIONS

Shorting the video outputs to any other pin, even temporarily, can permanently damage the on-chip output amplifier.

OPERATING CONDITIONS

TABLE 1 - DC CHARACTERISTICS

PARAMETER	SYMBOL	VALUE			UNIT
		Min.	Typ.	Max.	
Output amplifier drain supply	VDD1, VDD2	14.5	15	15.5	V
Protection drain bias	VDP	14.5	15	15.5	V
Reset bias	VDR	14.5	15	15.5	V
Antiblooming diode bias	VA	14.5	15	15.5	V
Register output gate bias	VGS	2.2	2.5	2.8	V
Output amplifier source supply	VS1,2		0		V
Ground *	VSS		0		V
OPTIONAL					
Peltier power supply **	IPELTIER		1.1		A
Voltage accross Peltier	VPELTIER		3		V

* Ground : note that the package metal back is internally grounded.

** Peltier power supply : conditions for 10°C sensor temperature with 50°C external temperature.

TIMING DIAGRAMS

Readout Mode

The serial readout register is operated in a two phase transfer mode. However, there are provided 6 separated command electrodes that shall be connected differently depending on the required readout mode. The following table gives the connections to be made for each mode:

Readout modes ↻	1 output, VOS1	1 output, VOS2 (mirror effect)	2 outputs (parallel)
Drive clocks (signals) ⚡			
ΦL1	pins B2, B3, B1	pins B2, A3, A1	pins B2, B3, A1
ΦL2	pins A2, A3, A1	pins A2, B3, B1	pins A2, A3, B1

The following diagrams are given for 20 MHz readout frequency, 1.25 MHz vertical transfer frequency

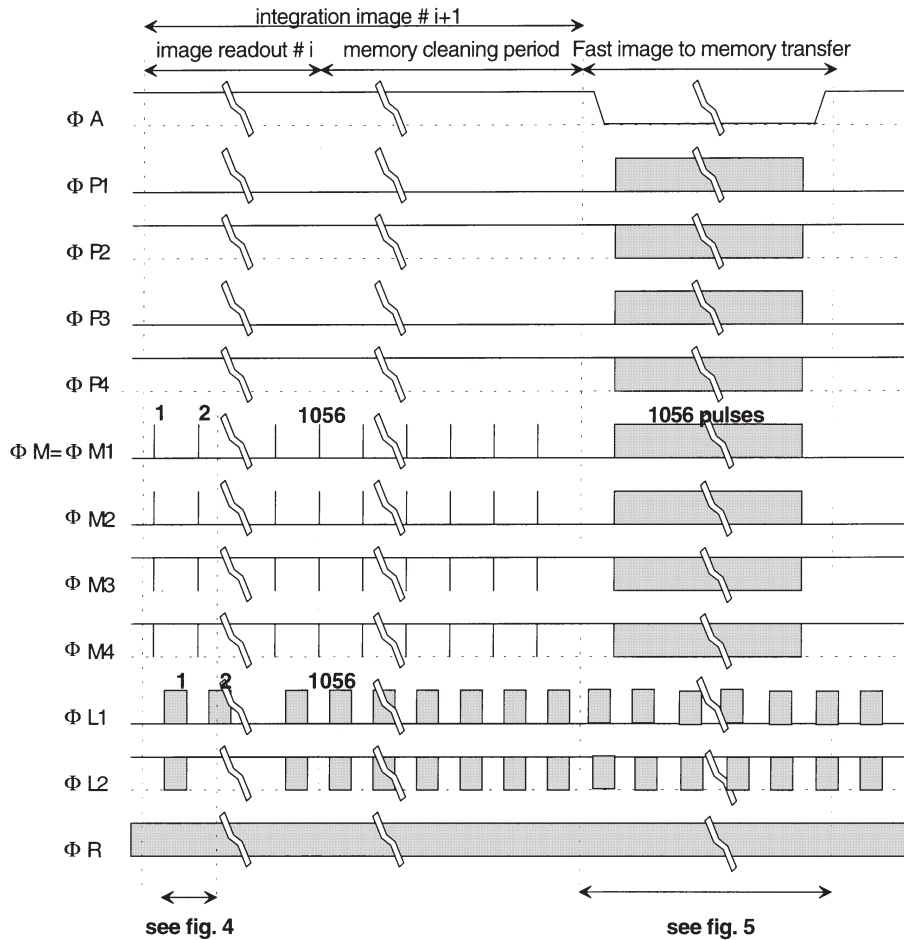


Figure 3 : Frame timing diagram

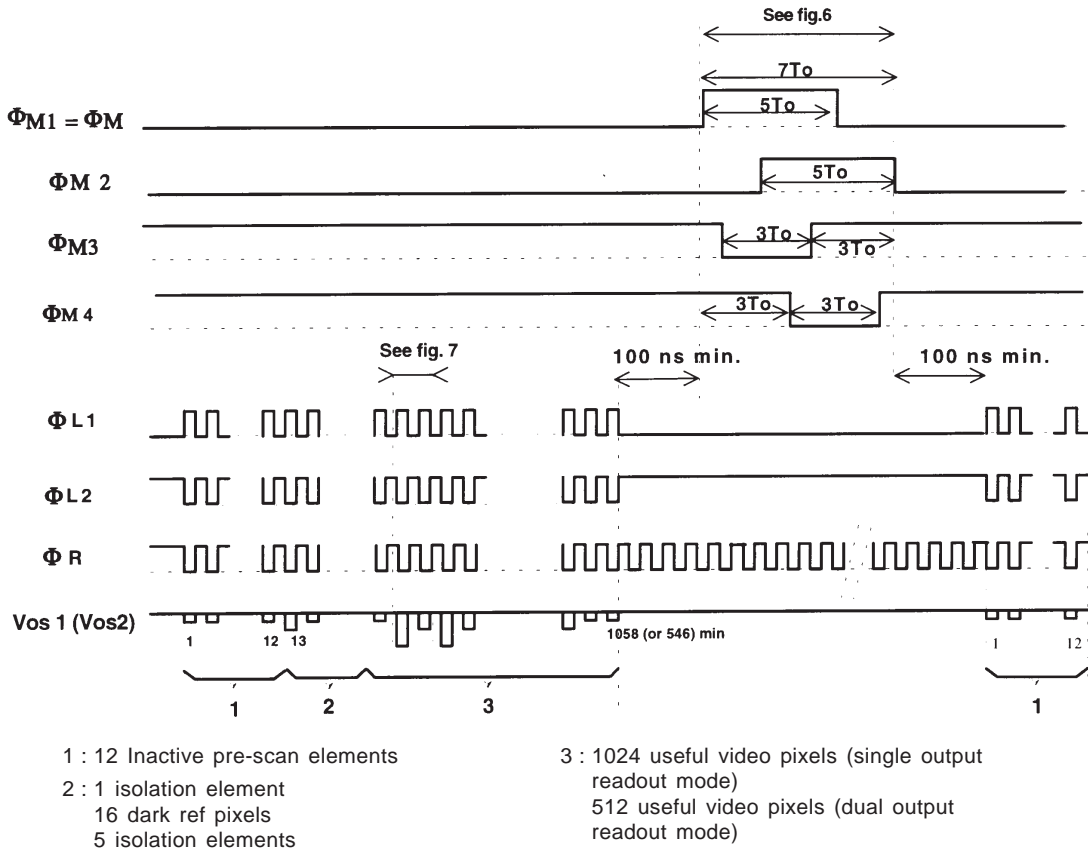


Figure 4 : Line timing diagram

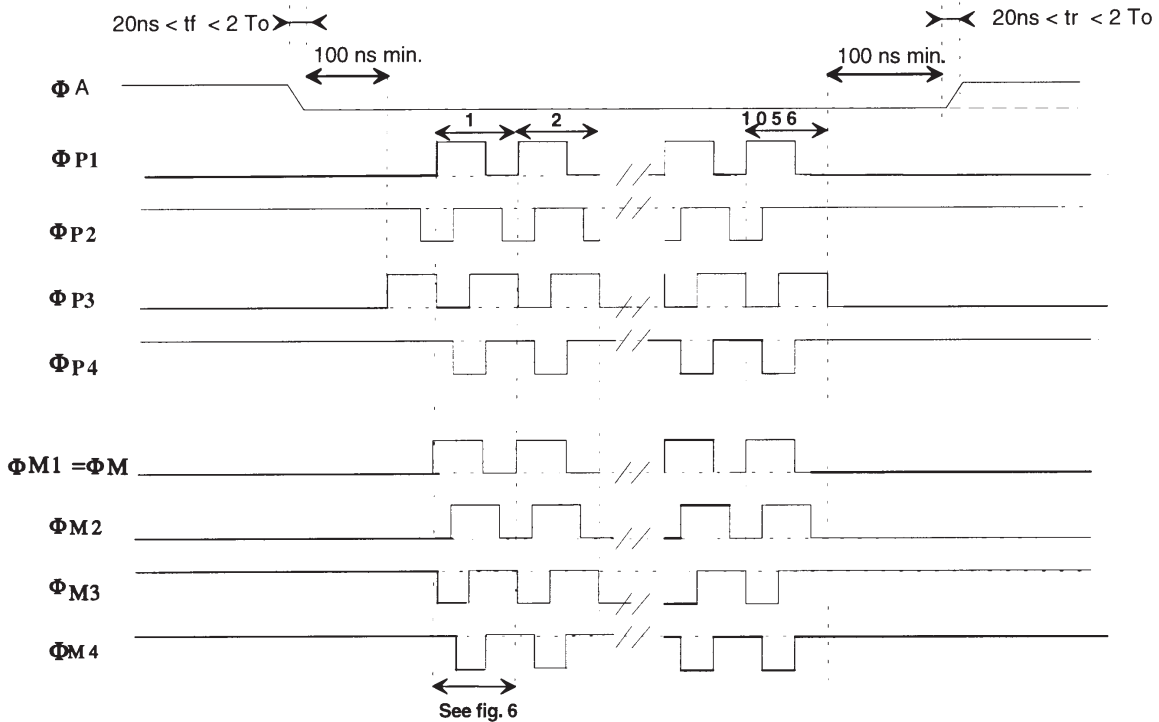


Figure 5 : Vertical transfer during Image to memory zone transfer

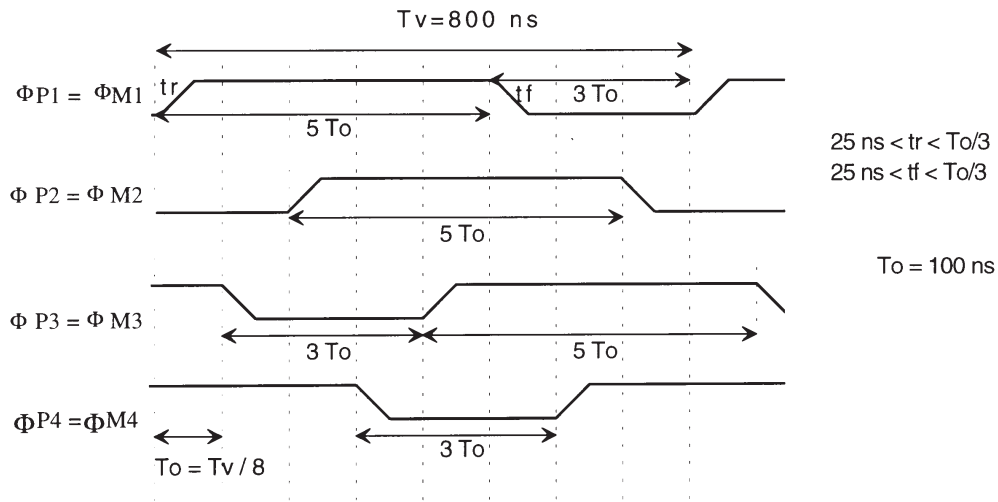


Figure 6 : Transfer period from image zone to memory zone (Φ_P and Φ_M) for 1.25 MHz vertical transfer frequency ($F_v = 1 / T_v$).

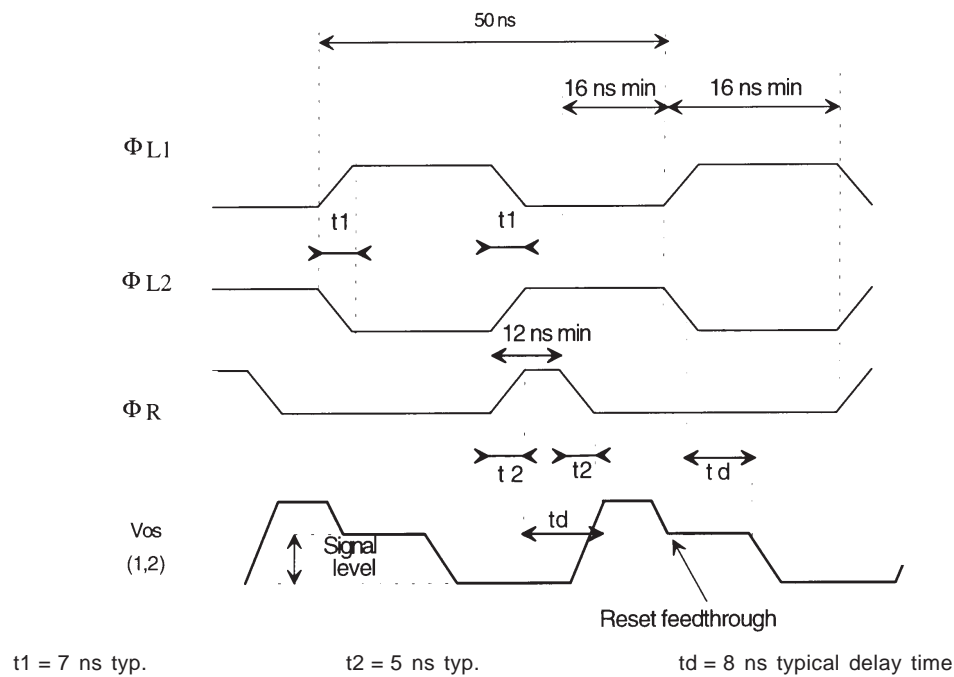


Figure 7 : Output diagram for readout register and reset clock 20 MHz applications. Cross over of complementary clocks (Φ_{L1} , Φ_{L2}) between 30% and 70% of max. amplitude.

BINNING MODE OPERATION

In this mode, the image is composed of 512 x 512 pixels (28 μm x 28 μm each).

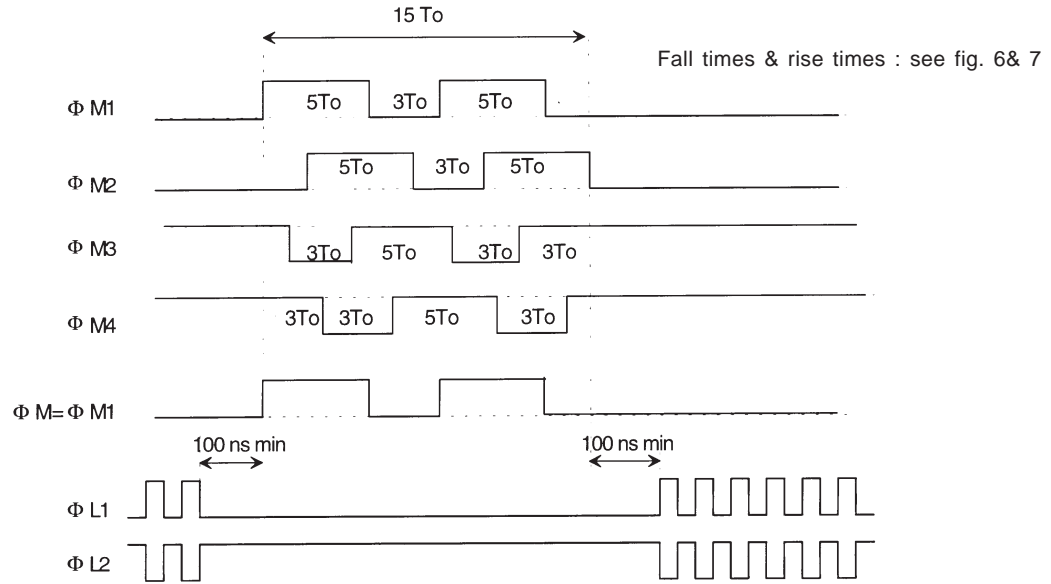


Figure 8 : Summation in the readout register of 2 adjacent lines.

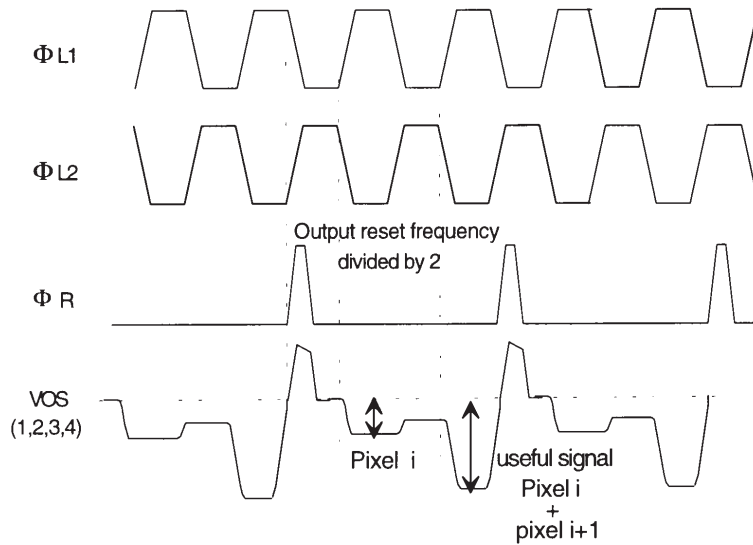


Figure 9 : Summation of 2 adjacent pixels

In binning mode operation, maximum level of elementary pixel (14 x 14 μm) is reduced to $V_{sat} / 4$.

EXPOSURE TIME REDUCTION

TH7888A allows exposure time control (electronic shutter function).

The exposure time reduction is achieved by pulsing all the ΦP_i gates to 0 volt so as to remove continuously all the photo-generated electrons through antiblooming drain VA.

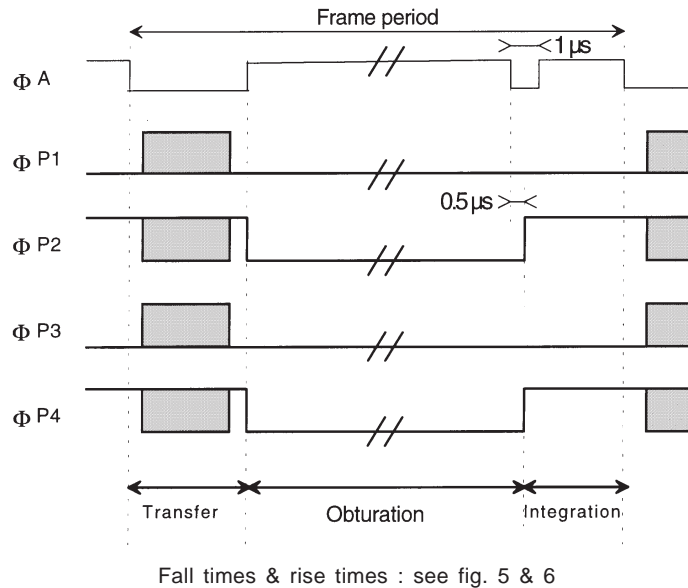


Figure 10 : Timing diagram for electronic shutter

TABLE 2 - DRIVE CLOCK CHARACTERISTICS

Parameter	Symbol	Value			Unit	Remarks	
		Min	Typ	Max			
Image zone clocks	$\Phi P_{1,2, 3,4}$	High level	7.5	8	8.5	V	Typical input capacitance 15 nF See figure 11
		Low level	0	0.5	0.8	V	
Memory zone clocks	$\Phi M_{1,2,3,4}$	High level	7.5	8	8.5	V	Typical input capacitance 15.5 nF See figure 11
		Low level	0	0.5	0.8	V	
Memory to register clocks	ΦM	High level	8.5	9	9.5	V	Typical input capacitance 10 pF
		Low level	0	0.5	0.8	V	
Antiblooming gate	ΦA	High level (integration)	3	4	7	V	Typical input capacitance 14 nF See figures 11 & 13
		Low level (transfer)	0	0.5	0.8	V	
Reset gate	ΦR	High level	10	12	13	V	Typical input capacitance 10 pF
		Low level	0	2	3	V	
Readout register clocks	$\Phi L_{1,2}$	High level	8.5	9	9.5	V	
		Low level	0	0.5	0.8	V	
Maximum readout register frequency	F_H		20	23	MHz	See figure 7	
Image zone to memory zone transfer frequency	F_V		1.25	1.7	MHz	See figure 12	

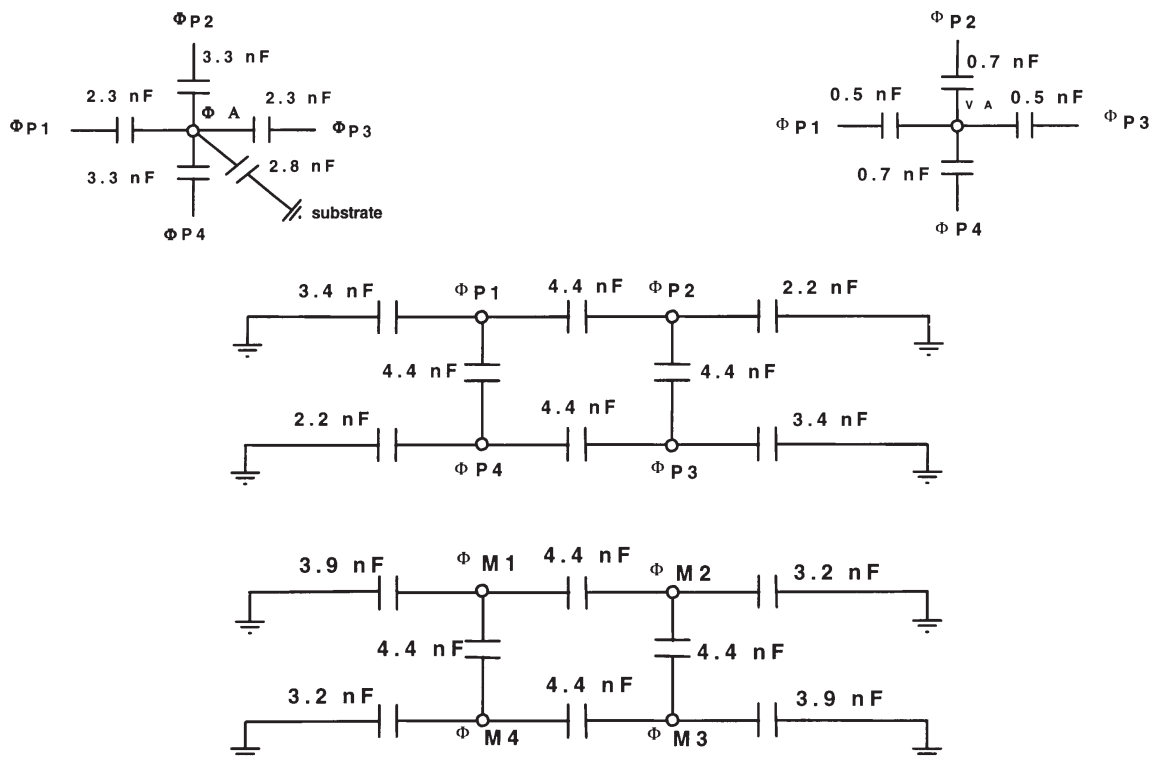


Figure 11 : Drive clocks capacitance network

TABLE 3 - STATIC AND DYNAMIC ELECTRICAL CHARACTERISTICS

PARAMETER	SYMBOL	VALUE			UNIT	REMARKS
		Min.	TYP.	Max.		
Output amplifier supply current	I _{DD}		10		mA	per amplifier
Output impedance	Z _S	200	225	250	Ω	
DC output level	V _{REF}		11		V	
Output conversion factor	CVF	5.5	6	6.5	μV/ e-	

ELECTROOPTICAL PERFORMANCE

• General conditions :

Temp = 25°C (package back temperature)

Light source : 2854K with 2 mm BG38 filter (unless specified) + F/3.5 optical aperture .

30 images per second mode (unless specified)

Typical operating conditions.

• Readout mode : 2 outputs

• Values exclude dummy elements and blemishes.

PARAMETER	SYMBOL	VALUE			UNIT	REMARKS
		Min.	TYP.	Max.		
Output register saturation level	VSAT reg	2.3	2.6		V	
Pixel saturation level	VSAT	1.6	1.9	2.2	V	Note 1
Pixel saturation charge (electron per pixel)	QSAT	270	320	370	ke-	
Responsivity at 640 nm Responsivity with BG38 filter	R		6.5 11		V/ μ J/cm ² mV/lux	
Quantum efficiency at 640 nm	QE		15		%	see fig.15
Photo response non uniformity (1σ)	PRNU		1.3	1.7	% VOS	
Dark signal non uniformity (1σ)	DSNU		0.28	0.4	mV	Note 2
Average dark signal	V _{DS}		2	3	mV	Note 3
			4	5.6	mV	Note 4
Temporal RMS noise in darkness (Last line)	V _N		200		μ V	Note 5
Dynamic range	D		80		dB	Note 6
Horizontal modulation transfer function at 500 nm	MTF		70		%	Note 7
Vertical charge transfer inefficiency	VCTI			2.10 ⁻⁵		Note 8
Horizontal charge transfer inefficiency	HCTI			7.10 ⁻⁵		Note 9
<p>Note 1 : Pixel saturation (full well) as a function of vertical transfer frequency (see figure 12) and antiblooming adjustment (see figure13).</p> <p>Note 2 : After subtraction of dark signal slope due to memory readout time</p> <p>Note 3 : First line level referenced from inactive prescan elements (12 samples)</p> <p>Note 4 : Last line level referenced from inactive prescan elements (12 samples)</p> <p>Note 5 : Measured with Correlated Double Sampling (CDS) including 160 μV readout noise and dark current noise in the general test conditions.</p> <p>Note 6 : Saturation to RMS noise in darkness ratio.</p> <p>Note 7 : At Nyquist frequency.</p> <p>Note 8 : VSAT / 2 measurement and 1.25 MHz vertical transfer frequency.</p> <p>Note 9 : VSAT / 2 measurement and 20 MHz horizontal transfer frequency.</p>						

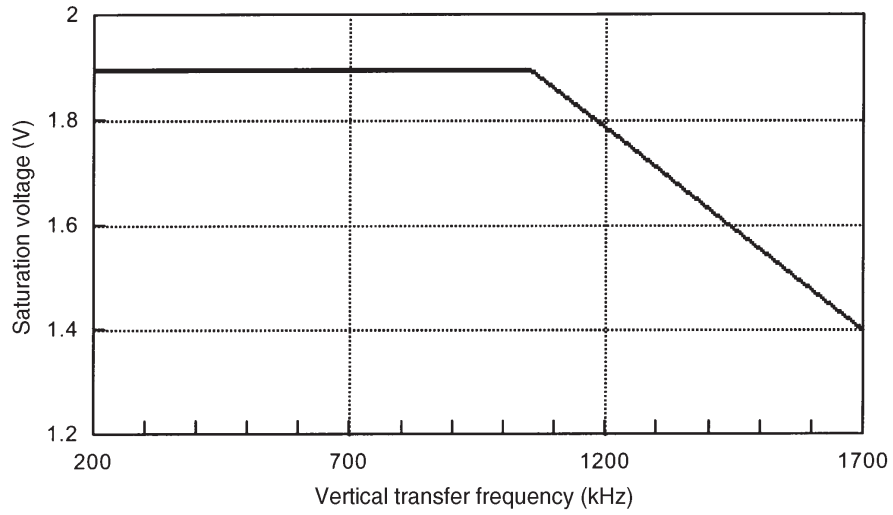


Figure 12 : Saturation level by full well with antiblooming out (Φ_A high = 0 volt) vs the vertical transfer frequency.

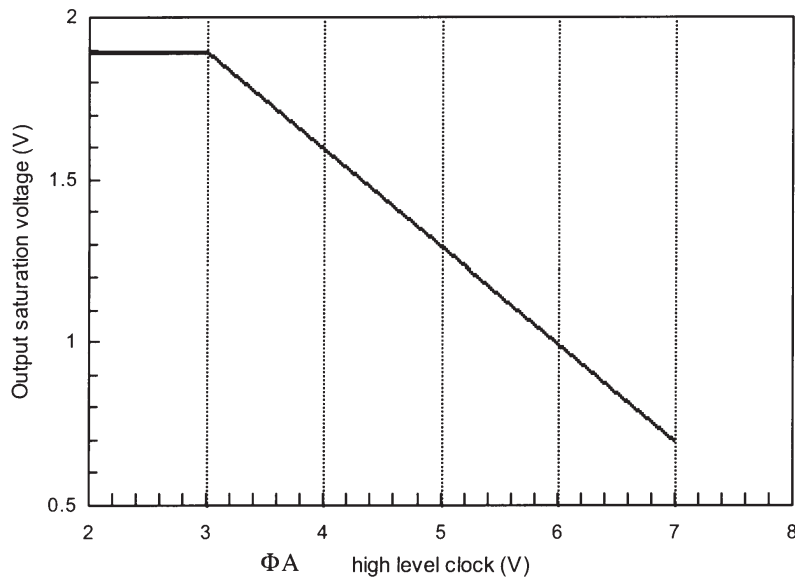
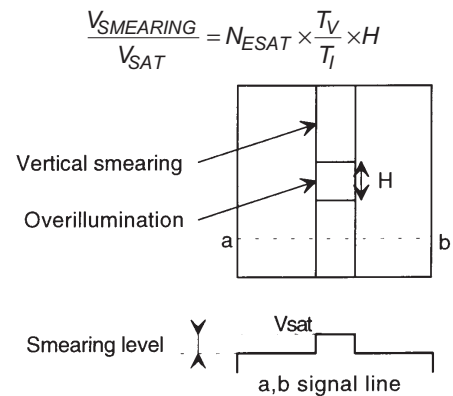
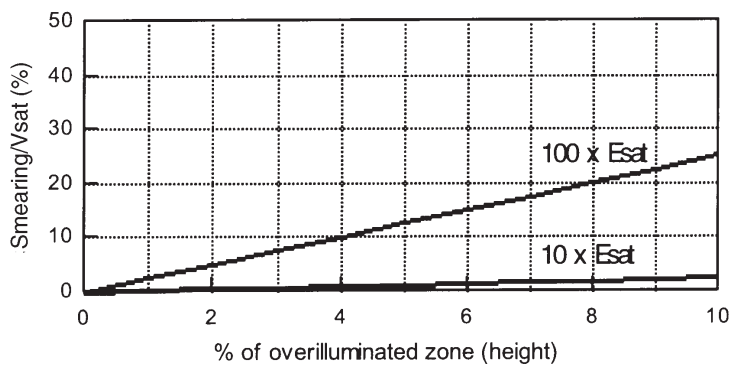


Figure 13 : Saturation level limitation by the antiblooming effect on the pixel (Typical operating conditions)



N_{ESAT} = number of times $ESAT$

T_I = integration time

with $ESAT = V_{SAT} / \text{Responsivity}$ (typical illumination conditions)

T_V = image to memory transfer time

Figure 14 : Smearing effect

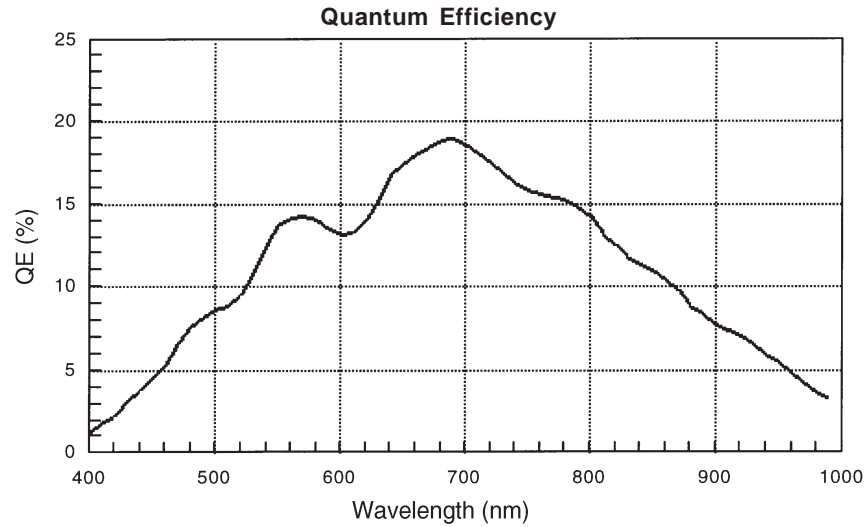


Figure 15 : Spectral response.

IMAGE QUALITY GRADE

Blemish

Max area of 2 x 2 defective pixels

Clusters

Less than 7 contiguous defects in a column

Columns

More than 7 contiguous defects in a column

General conditions

Room temperature.....25°C
 Frequency.....30 images/s
typical operating conditions
 Considered image zone1024 x 1024
 Light source2854 K with BG38 filter + F/3.5 optical aperture

At Vos = 0.7 Vsat.

TYPE	WHITE	BLACK
Blemishes / clusters	$\alpha > 20 \% \overline{Vos}$	$ \alpha > 30 \% \overline{Vos}$
Columns	$\alpha > 10 \% \overline{Vos}$	$ \alpha > 10 \% \overline{Vos}$

In darkness

Blemishes / clusters	$\alpha > 10 \text{ mV (*)}$
Columns	$\alpha > 5 \text{ mV (*)}$
(*) reference is Vo : average darkness signal	

Number of defects

Total pixel number affected by blemishes and clusters:.....100
 Maximum number of clusters:.....10
 Maximum number of columns:.....5

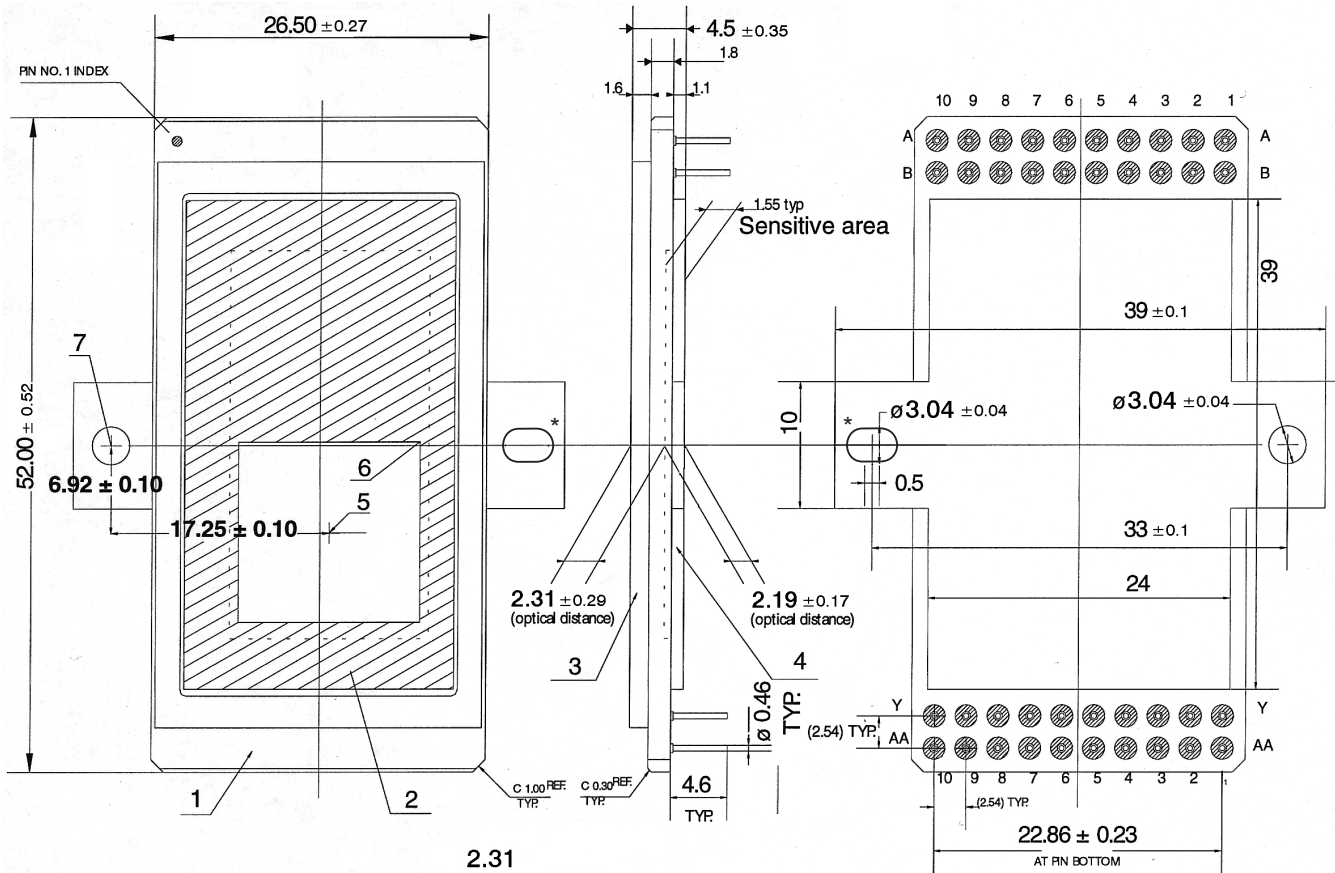
α : amplitude of video signal of defect with respect to mean output voltage \overline{Vos}

Ordering code :

TH7888AVRHRB

TH7888ACBHRB (OPTIONAL: with integrated Peltier cooler)

PACKAGE OUTLINE DRAWING (standard)



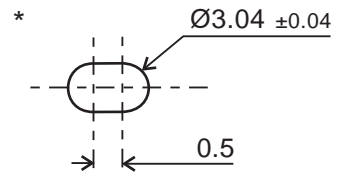
TOP VIEW

BOTTOM VIEW

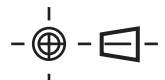
Legend

All values are in mm.

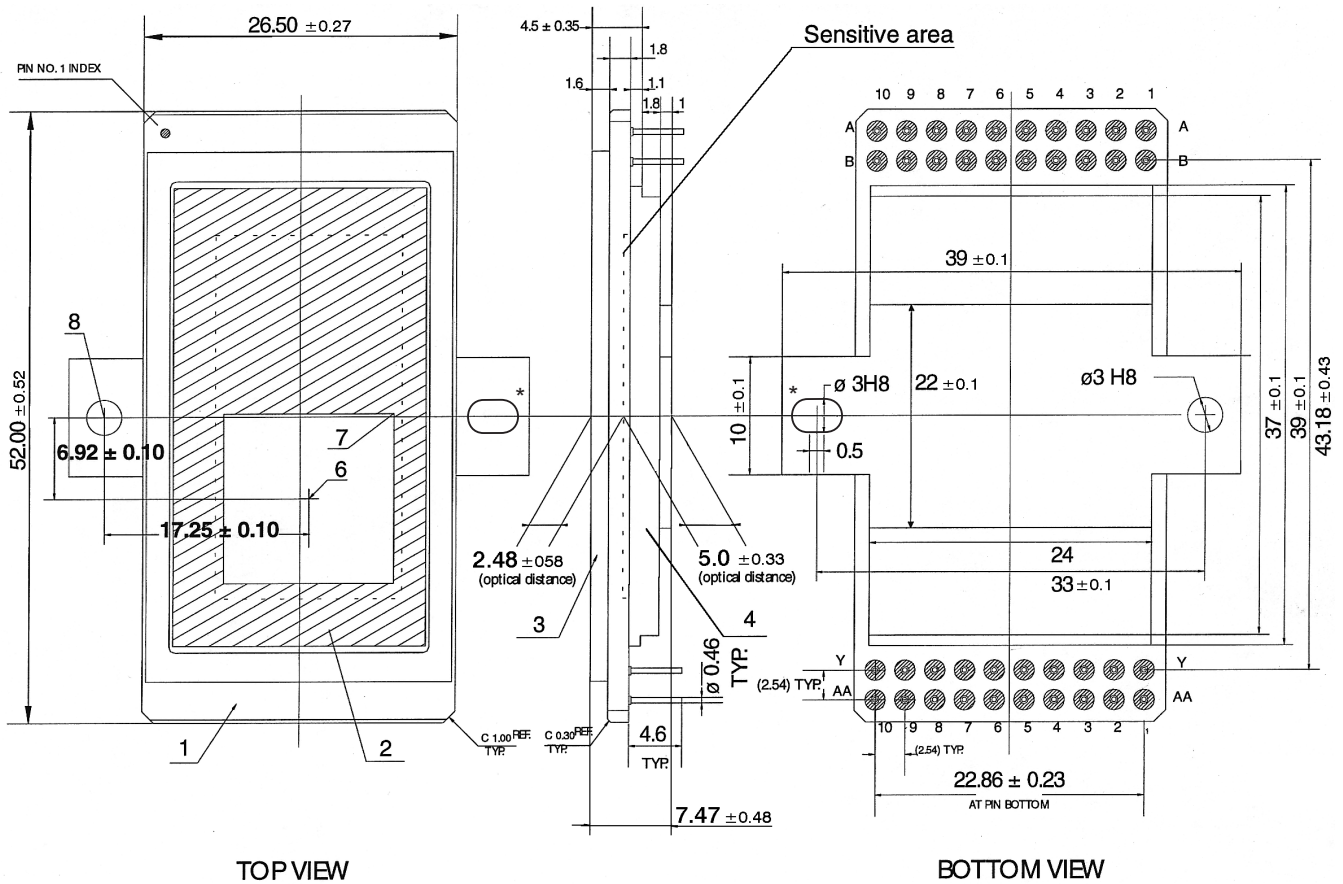
- 1 : black alumina 40 pins PGA package
- 2 : black optical mask
- 3 : 400nm - 700 nm AR coated window (R<1 % per side)
- 4 : Metal back, (CuW - copper tungsten) gold plated. Electrically grounded (VSS).
- 5 : Optical center.
- 6 : first useful pixel (readout through VOS1)
- 7 : mechanical reference



	Mechanical distance	Optical distance
Z _{top}	2.82 ± 0.31	2.31 ± 0.29
Z _{bottom}	1.68 ± 0.15	2.19 ± 0.17



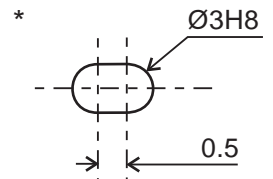
PACKAGE OUTLINE DRAWING (Peltier option)



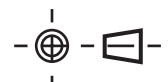
Legend

All values are in mm.

- 1 : black alumina 40 pins PGA package
- 2 : black optical mask
- 3 : 400nm - 700 nm AR coated window (R<1 % per side)
- 4 : Metal part with integrated Peltier element.
- 5 : Metal back, (CuW - copper tungsten) gold plated. Electrically grounded (VSS).
- 6 : Optical center.
- 7 : first useful pixel (readout through VOS1)
- 8 : mechanical reference



	Mechanical distance	Optical distance
Z _{top}	2.98 ± 0.68	2.48 ± 0.58
Z _{bottom}	4.50 ± 0.32	5.00 ± 0.33



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