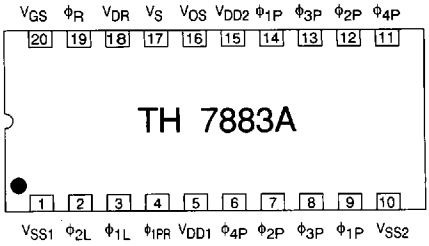
TH 7883A

FULL FIELD CCD IMAGE SENSOR 576 x 384 PIXELS

- **Image zone : 13.25 x 8.83 mm.**
- **Dark reference for each line.**
- **Square pixels (23 μm x 23 μm) with 100 % aperture.**
- **Optimized resolution and responsivity in the 400-1100 nm spectrum (visible + near infrared) :**
  30 db S/N at 30 milli-lux,
  60 % modulation at nyquist frequency.
- **4-phase operation (dynamic range : 13000/1).**
- **Minimum readout time : 17 ms (for entire field).**



OPTIONS

- **Fiber optic window 1:1.**
- **UV coating for improved sensitivity in UV and blue.**
- **Non sealed window.**

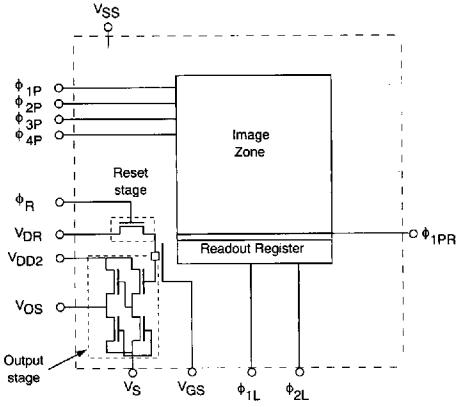


Figure 1 : TH 7883A organization.

PIN IDENTIFICATION

Pin n°	Symbol	Designation
14, 12, 13, 11 9, 7, 8, 6	$\Phi_{1P} \rightarrow \Phi_{4P}$	Image zone clocks
4	Φ_{1PR}	Image-to-register gate clock
3, 2	Φ_{L1}, Φ_{2L}	Readout register clocks
19	Φ_R	Reset clock
5, 15	V_{DD1}, V_{DD2}	Output amplifier drain supply
18	V_{DR}	Reset bias
1, 10	V_{SS1}, V_{SS2}	Substrate bias
20	V_{GS}	Register output gate bias
16	V_{OS}	Video output signal
17	V_S	Output amplifier source bias

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GEOMETRICAL CHARACTERISTICS

Photoelement pitch (see Figure 2) : 23 μm x 23 μm.

Elementary photosensitive area : 23 μm x 23 μm.

Image zone dimensions : 13.248 mm (V) x 8.832 mm (H).

The image is made up of a single field of 576 lines plus 4 extra lines. The video line is composed of 384 useful pixels, and 407 elements in total (see timing diagram, Figure 5).

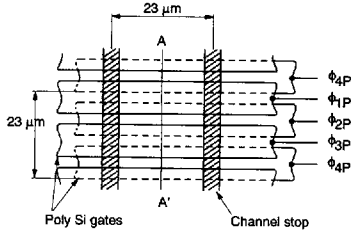

Figure 2a : Front view of a photoelement.

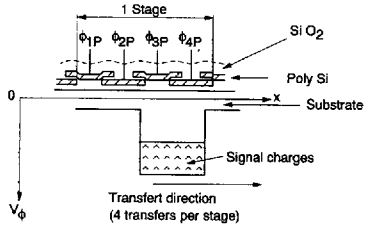

Figure 2b : Cross-sectional view (AA') of a photoelement and potential profile during transfer.

ABSOLUTE MAXIMUM RATINGS

Storage temperature	– 55°C to + 150°C
Operating temperature	– 40°C to + 85°C
Maximum applied voltages :	
– pins : 1, 10, 17	0 V (ground)
– pins : 5, 15, 18	– 0.3 V to + 18 V
– pins : 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 19, 20	– 0.3 V to + 16 V
Thermal cycling	15°C/mn

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

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

Electrical limits of applied signals are given in operating conditions section.

Thermal limits are given in each image grade specification.

OPERATING PRECAUTIONS

Shorting the video output to V_{SS} or V_{DD}, even temporarily, can permanently damage the output amplifier.

OPERATING CONDITIONS (T = 25°C)

Table 1 - DC characteristics

Parameter	Symbol	Value			Unit
		Min	• Typ	Max	
Output amplifier drain supply	$V_{DD1} \cdot V_{DD2}$	14.5	15.0	15.5	V
Reset bias	V_{DR}	V_{DD} – 2.4	V_{DD} – 2.2	V_{DD} – 2	V
Substrate bias (Note 1)	$V_{SS1} - V_{SS2}$		0.0		V
Output amplifier source bias (Note 2)	V_S		0.0		V
Register output gate bias	V_{GS}	1.3	1.5	1.7	V

Note 1 : V_{SS} = 0 V requires that the drive clocks, loaded by the device, do not contain spurious negative spikes (less than – 0.1 V).

Note 2 : A separate bias on V_S pin provides a better output signal regarding spurious spikes.

TIMING DIAGRAM

The principle of interlacing shown in Figure 7, can be applied to this device. It consists in shifting the potential wells by half a pixel in alternate fields. Thus two successive fields contain different information, giving a 1152-line image with reduced aliasing.

Device operation generally begins with a «cleaning» period, which consists in transferring and eliminating all charges created by thermal generation. Once emptied, each pixel can accumulate charges in proportion to incident light during the integration (exposure) period.

After that time, no luminous event must reach the image zone, in order to prevent smearing effects during the image readout period. This condition can be achieved by using a shutter, gated intensifier or strobe (as an example) to ensure that no light is collected during the readout period. The 580 lines are then transferred, line by line, into the output register. The total number of transfer periods is at least 580.

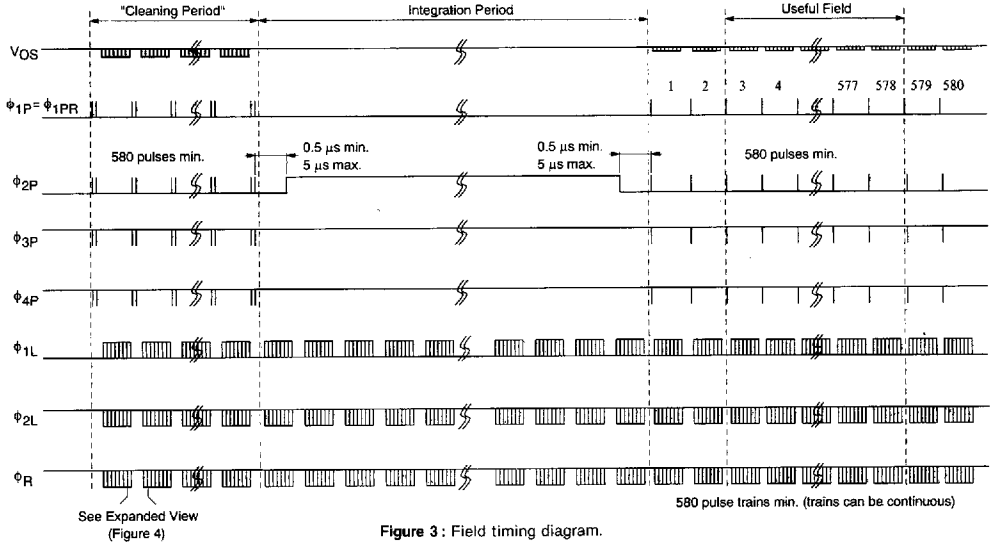

Figure 3 : Field timing diagram.

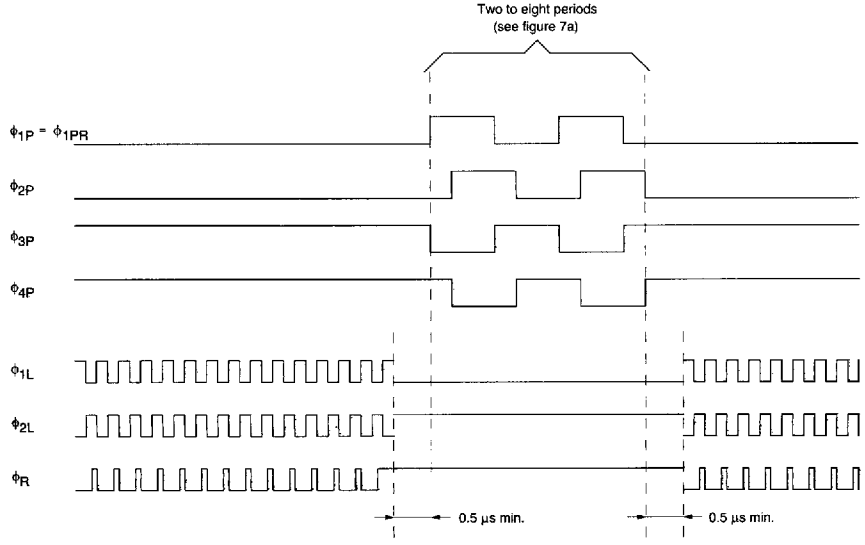

Figure 4 : Expanded view.

After parallel transfer into the readout register, the video line is transferred sequentially to a single output circuit. The minimum number of drive clock pulses (407) corresponds to the number of register stages.

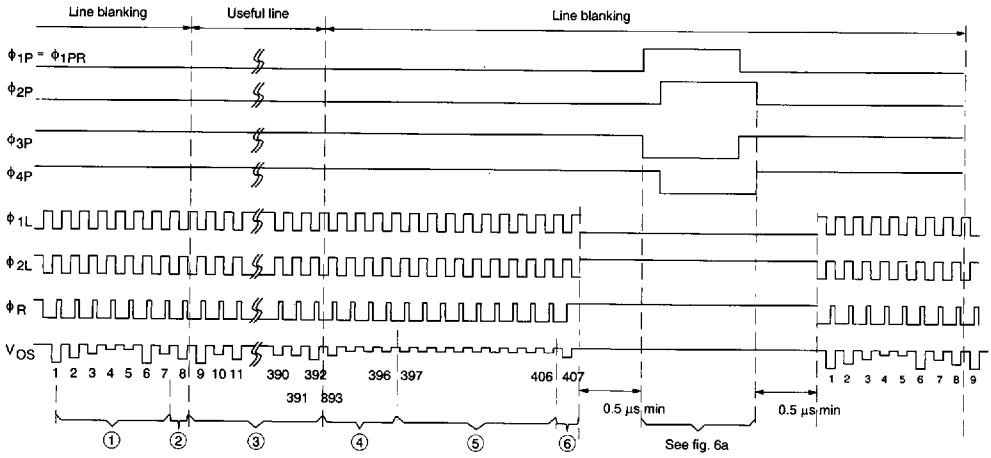

Figure 5 : Line timing diagram.

The video line comprises:
1 - 7 inactive "pre-scan" elements = zero reference level
2 - 1 isolation element;
3 - 384 useful video pixels;
4 - 4 isolation elements;
5 - 10 dark reference elements (element 397 to 406);
6 - 1 isolation element;

All 23 dummy elements are read during the line blanking period

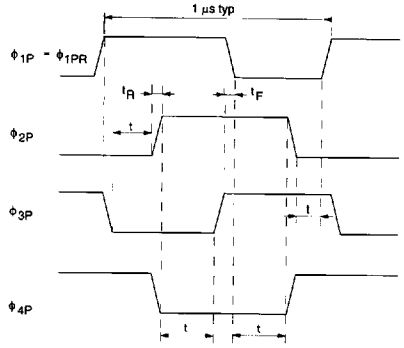

Figure 6a : Ouput timing diagram for Φ_p clocks during transfer.

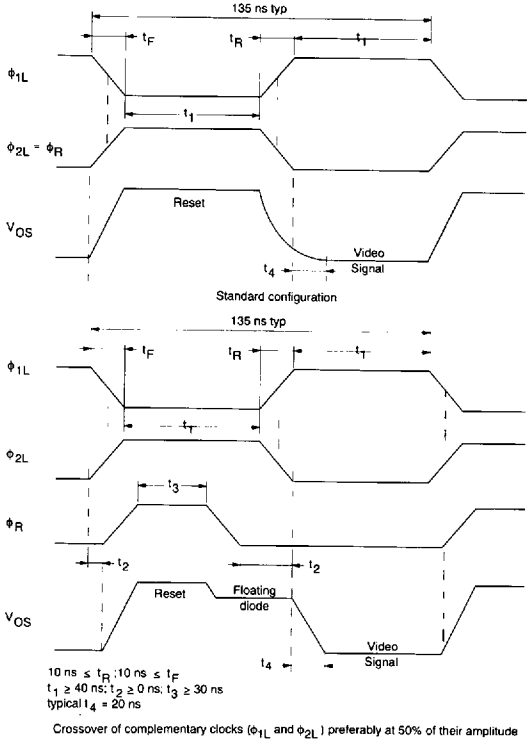

Figure 6b : Output timing diagram for readout register and reset clocks.

Table 2 · Drive clock characteristics

Parameter	Symbol	Value			Unit	Remarks
		Min	Typ	Max		
Image zone clocks during integration period	Φ_{1P}, Φ_{1PR}, Φ_{2P}	9	10	11	V	see Note
	Φ_{3P}	0.0	0.3	0.5	V	
	Φ_{4P}	1.5	1.8	2.0	V	
OR						$C\Phi_{1P} = C\Phi_{2P} = C\Phi_{3P} = C\Phi_{4P}$ = 4 000 pF max
	Φ_{1P}, Φ_{1PR}	0.0	0.3	0.5	V	
	Φ_{2P}	1.5	1.8	2.0	V	
	Φ_{3P}, Φ_{4P}	9	10	11	V	$C\Phi_{1PR}$ = 20 pF max
Image zone clocks during transfer period	(Φ_P) Low	0.0	0.3	0.5	V	
	(Φ_P) High	9	10	11	V	
Output register and reset clocks : Low (L)	(Φ_L, Φ_R) L	0.0	0.3	0.5	V	$C\Phi_{1L} = C\Phi_{2L}$ = 120 pF max
High (H)	(Φ_L, Φ_R) H	9	10	11	V	$C\Phi_R$<5 pF

Note : Transients under 0.0 V in the clock pulses will lead to charge injection, causing a localized increase in the dark signal. If such spurious negative transients are present, they can be suppressed by inserting a serial resistor of appropriate value (typically 20 to 100 Ω) in the corresponding driver output.

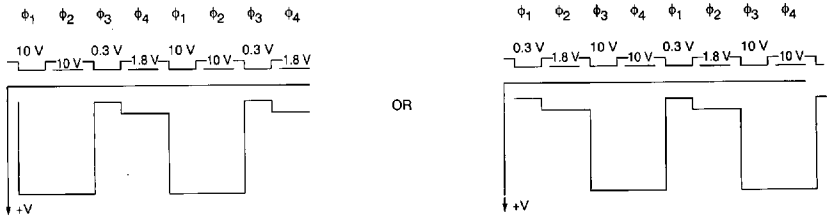

Figure 7 : Image zone potential wells during integration period.

Table 3 · Static and dynamic electrical characteristics

Parameter	Symbol	Value			Unit	Conditions
		Min	Typ	Max		
DC output level	V_{ref}		12		V	
Output impedance	Z_S		250		Ω	
Maximum image to output register frequency	F_I max	0.9	1.8		MHz	see Note
Maximum output register and reset frequency	F_L max	7.38	12		MHz	see Note
Output amplifier supply current	I_{DD}		6	10	mA	$V_{DD} = \Phi_R = V_{DR}$ = 15 V, V_{SS} = 0 V
Input current on an active pin (except for V_{DR} and V_{DD})	I_e			2	μA	V_e = 15 V, V_{SS} = 0 V
Peak current on one clock (Φ_P)	I_{pp} Φ_P		600		mA	Under typical operating conditions t_{rise} = 50 ns
Peak current on one clock (Φ_L)	I_{pp} Φ_L		120		mA	Under typical operating conditions t_{rise} = 10 ns

Note : The minimum clock frequency is limited by the increase in dark signal.

ELECTROOPTICAL PERFORMANCE

- General measurement conditions : T_C = 25°C
  - Integration time : 20 ms,
  - Output frequency : 7.38 MHz.
- Illumination conditions
  - 2854 K tungsten filament lamp + 2 mm BG 38 filter + F/3.5 aperture. The filter limits the spectrum to 700 nm ; in these conditions, 1 μJ/cm² corresponds to 3.5 lux.s.
- Typical operating conditions (see Tables 1 and 2).
- Measurement excludes :
  - first and last pixels of useful video line (n° 9 and 392),
  - first and last lines of useful field (n° 3 and 578),
  - dummy elements,
  - blemishes.

Table 4 - Performance characteristics

Parameter	Symbol	Value			Unit	Remarks
		Min	Typ	Max		
Saturation output voltage	V_{SAT}	0.9	2.0		V	Note 1
Saturation exposure	E_{SAT}		0.18		μJ/cm²	
Responsivity	R	7	11		V/μJ/cm²	See Figure 8
Photo-response non-uniformity, σ	PRNU		± 1	± 3	% V_{OS}	Notes 2 and 3
Noise in darkness (rms)	V_N		0.15		mV	Note 4
Dynamic range (relative to rms noise)	D_R		13000			
Average dark signal	V_{DS}		2	8	mV	Note 5
Dark signal non-uniformity, σ	DSNU		0.2	0.7	mV	Notes 3 and 6

Note 1 : 1 mV = 470 electrons or 0.45 nA, V_{SAT} min is a guaranteed voltage level above which local saturation or non linearity can occur.
Note 2 : From low level (limited by DSNU) up to 90 % V_{SAT} min.
Note 3 : Number of blemishes allowed ; see image grade specification.
Note 4 : Measured with Correlated Double Sampling (CDS).
Note 5 : Measured with respect to zero reference level.
Note 6 : Measured with line clamping on dark reference.

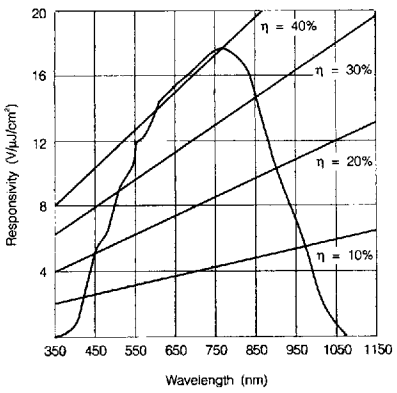

Figure 8: Typical spectral response.

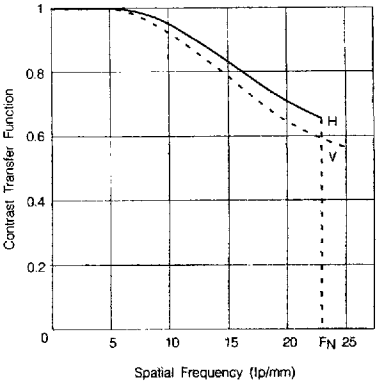

Figure 9: Typical CTF curves ($\overline{V_{OS}}$ = 400 mV).

ELECTROOPTICAL PERFORMANCE WITHOUT INFRARED CUTOFF FILTER

The TH 7883A's special semiconductor process enables it to exploit the silicon's high near infrared sensitivity while maintaining good imaging performance in terms of response uniformity and resolution. Changes in performance with and without IR filtering are summarized below.

Table 5 - Electrooptical performance comparison

	With IR cutoff filter	No IR cutoff filter
Average video signal due to a given scene illumination	V_{OS}	V_{OS} × 8
Photo response non-uniformity	±1 %	±1 %
CTF at nyquist frequency	60 %	40 %

IMAGE QUALITY GRADE

GRADE H : ordering code TH78883AVCH.

This image quality grade is guaranteed at +25°C and +85°C for applications with a wide operating range (−40°C to +85°C).

BLEMISH DEFINITION

Column
It is a one-pixel wide defect whose height is constant with light level.

Blemish
A blemish is a white or black spot. There are usually three types of blemish :

- white defect, dependent on temperature, as dark signal : its amplitude doubles for every 8 to 10°C temperature rise.
- black defect, not dependent on temperature, but whose amplitude is proportional to the mean output voltage.
- trap, a trap appears as a partial back column, which fills in with a constant amount of charge. Thus a trap affects a number of pixels which varies with the mean level of the output signal. The length of the partial column will increase with a reduction in temperature or light level.

White defects are specified in darkness, at +25°C and +85°C for H grade.
Black defects are specified under illumination, as a percentage of mean illumination up to 90 %. V_{SAT} min independently of temperature.
Traps are specified as defects in darkness, at 25°C.

First and last useful line and first and last useful column are excluded from the image grade.

IMAGE GRADE SPECIFICATION

Note : α is the amplitude of video signal of blemishes.

Eg : 20 % < α < 40 %.

For amplitude < 20 %, pixel is not a blemish.

For amplitude > 40 %, the device is rejected.

Depending on temperature and light level, the amplitude α is the highest value expressed either in % of V_{OS} or in mV in darkness at operating temperature.

$V_{OS} \leqslant 90\ \%\ V_{SAT}$ min
T_C = −40°C to +85°C

Type (white or black)	W	B
Maximum number of blemishes Amplitude α (%) Area, max (pixels)	0 $\alpha > 15$	20 $20 < \alpha < 40$ 1
Maximum number of columns Amplitude α (%)	0 $\alpha > 3$	

In darkness T_C = +25°C

Maximum number of blemishes Amplitude α	0 $\alpha > 2$ mV
Maximum number of columns Amplitude α	0 $\alpha > 0.8$ mV

In darkness T_C = +85°C

Maximum number of blemishes Amplitude α	0 $\alpha > 70$ mV
Maximum number of columns Amplitude α	0 $\alpha > 35$ mV
Average dark signal, max Dark signal non uniformity, max	220 mV 45 mV

NON SEALED WINDOW PACKAGE

DESCRIPTION

The sensor chips are assembled in a standard ceramic DIL package, but the window sealing operation is omitted.
The window is simply held in place by adhesive tape or clips to provide mechanical protection of the chip during handling and shipping.

SHIPPING

The devices are enclosed in a sealed anti-static bag with a dessicant.

STORAGE

The pieces must be stored in a dry, inert atmosphere such as nitrogen or dry air.

ORDERING CODE

Open-package sensors are designated by the letter N (5th letter of the reference) :
TH7883AVCHN (image quality grade H).

TH 7883A WITH FIBER OPTIC WINDOW

DESCRIPTION

TH 7883A area array CCD image sensor is also available in a special fiber-optic (FO) configuration, in which an FO window is glued to the sensor chip. The FO window is formed of low absorption elementary fibers separated by EMA (extra-mural absorption) cement to minimize crosstalk.

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FO window sensors are comprised of the following elements :

- a high image quality grade sensor chip,
- a DIL ceramic package,
- an FO window of geometry adapted to sensor,
- a mechanical support (with grounding wire) to ensure the assembly's rigidity.

TH 7883A is available with a 1:1 optical fiber.

ORDERING CODE : TH7883AVCBF.

ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings are the same as for standard TH 7883A, except for :

Storage temperature	– 55°C to + 85°C
Thermal cycling	10°C/mn
Maximum allowed pressure	2 bars

OPERATING RANGE

Operating range defines the limits between which the functionality is guaranted.

Electrical operating range : same as standard TH 7883A.

Thermal limits are given in image grade specification.

OPERATING PRECAUTIONS

Shorting the video output to V_{SS} or V_{DD}, even temporarily, can permanently damage the output amplifier.

Connect the ground lead before operating the CCD. In case of coupling to a device containing high voltages, such as light image intensifier, the ground connection must be made both before device operation and after the device supply has returned to 0 V.

OPERATING CONDITIONS

Same values as standard TH 7883A.

Table 6 - TH7883AVCBF performance characteristics
General measurement conditions : same as standard TH 7883A

Parameter	Symbol	Value			Unit	Conditions
		Min	Typ	Max		
Saturation output voltage	V_{SAT}	0.9	2.0		V	Notes 1 and 2
Saturation exposure	E_{SAT}		0.22		$\mu J/cm^2$	
Responsivity	R	5	9		$V/\mu J/cm^2$	Note 3
Photo-response non-uniformity	PRNU		±5		% V_{OS}	Note 4
Noise in darkness (rms)	V_N		0.15		mV	Notes 1 and 2
Dynamic range (relative to rms noise)	DR		13000			Note 1
Average dark signal	V_{DS}		2	8	mV	Notes 1 and 5
Dark signal non-uniformity ; σ	DSNU		0.2	0.7	mV	Notes 1 and 6
Numerical aperture			1			
Contrast transfert function	CTF		50		%	At Nyquist frequency

Note 1 : Performance is the same as the standard TH 7883A one.
Note 2 : 1 mV = 470 electrons or 0.45 nA.
Note 3 : Typically, 80 % of the responsivity of the TH 7883A without Fiber Optic.
Note 4 : PRNU of the CCD + FO is not a gaussian curve : the fiber adds a certain amont of black blemishes, but no white blemishes.
Typically, there is 2 ‰ pixels whose amplitude is $\leqslant V_{OS} - 10$ %.
Number of allowed blemishes : see image grade specification.
Note 5 : Measured with respect to zero reference level.
Note 6 : Measured with line clamping on dark reference.

IMAGE GRADE SPECIFICATION - TH78883AVCBF
Temperature range : −40°C to +85°C.

In darkness T_C = +25°C

Maximum number of blemishes Amplitude α	1 $\alpha > 2$ mV
Maximum number of columns Amplitude α	0 $\alpha > 0.8$ mV

$V_{OS} \leqslant 90$ % V_{SAT} min

	White	Black
Maximum number of spots Amplitude α (%) Area, max (pixels) Note 1	0 $\alpha > 15$	30 $\alpha > 20$ 3×3
Maximum number of dashes Amplitude α (%) Length, max (pixels) Note 2	0	10 $10 < \alpha < 20$ 10
Maximum number of columns Amplitude α (%)	0 $\alpha > 3$	

Note 1 : Less of 1 ‰ of one pixel size black spots.
Note 2 : Less than five pixel long dashes are not taken in account. If $\alpha > 20$ %, the dash is considered as a «Spot» blemish.

TH 7883A WITH UV COATING

DESCRIPTION

UV coating is a proprietary organic phosphor developed in order to improve sensitivity of charge-coupled devices (CCDs) in blue-visible and ultraviolet wavelengths. A 0.4 to 0.6 μm thick UV coating applied to frontside-illuminated CCD dramatically improves the quantum efficiency of the device in the 120 nm to 450 nm range.

Optical properties : UV coating emits light at approximately 540 to 580 nm when excited with light of wavelengths shorter than 450 nm. The conversion efficiency of the coating is nearly unity which makes it an ideal ultraviolet downconverter for use on silicon detectors. At wavelengths longer than 460 nm, UV coating is transparent and, thus, has no detrimental effect on the quantum efficiency of a CCD in the visible and near-infrared portions of the spectrum.

The window of the CCD with UV coating is transparent down to 180 nm (quartz window).

ORDERING CODES

TH7883AGCCNQA (non sealed quartz window),
TH7883AGCCQ-A (sealed quartz window).

ABSOLUTE MAXIMUM RATINGS

Same values as standard device, except for :

Storage temperature	−55°C to +50°C
Operating temperature	−40°C to +50°C

OPERATING RANGE

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

Electrical operating range : same as standard TH7883A.

Thermal limits are given in image grade specification.

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STORAGE

The pieces must be stored in darkness. UV coated CCDs with non sealed window must be stored in a dry inert atmosphere, such as nitrogen, to prevent a UV sensitivity decrease.

OPERATING CONDITIONS

Same values as standard device.

ELECTROOPTICAL PERFORMANCE

Performance in visible spectrum

General measurement conditions, performance characteristics and image grade specification are the same as TH7883A H grade, except for PRNU whose maximum value at 3 σ is ±13 % (typically ±8 %).

Image grade in UV spectrum

Temperature range : −40°C to +50°C

The wavelength of measurement is 253 nm for an output level of 300 mV.

Blemish number	Size (pixel number)	Amplitude
20	1	$\lvert\alpha\rvert > 25\%$
10	2 to 10	$13\% < \lvert\alpha\rvert < 25\%$
4	11 to 20	$13\% < \lvert\alpha\rvert < 25\%$

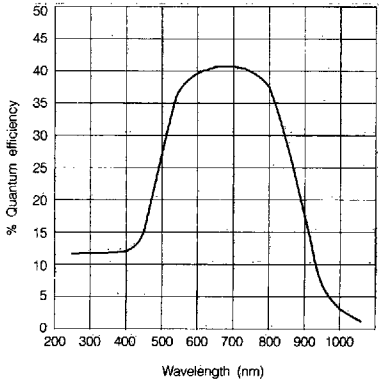
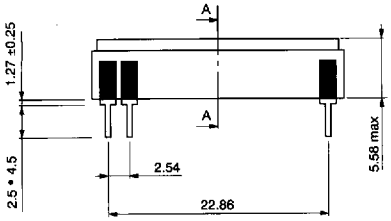
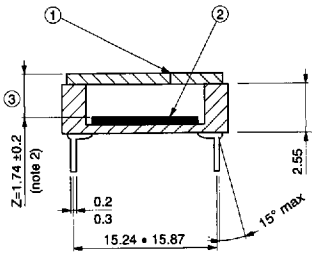


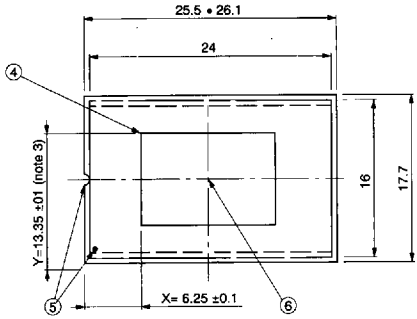
Figure 10 : Typical quantum efficiency with UV coating.

OUTLINE DRAWING : TH 7883A STANDARD AND UV COATED DEVICES

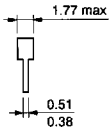


AA CROSS SECTION

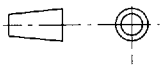




PIN DETAIL



dimensions in mm



① Window

② Photosensitive area

③ Z = Optical distance between external face of window and photosensitive area (note 1 and 2)

④ First pixel of first line (X, Y, Z coordinates)

⑤ Index (notch or dot)

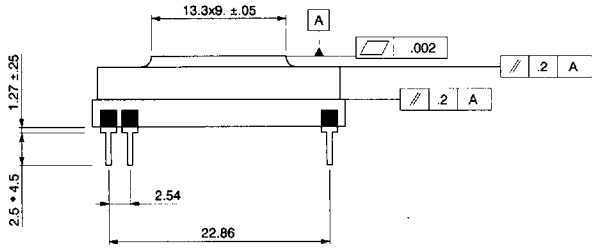
⑥ Optical center (identical to package center)

Note 1 : The mechanical reference plane is the window faceplate.

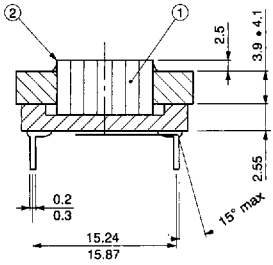
Note 2 : Variation of Z on the photosensitive area of a device (azimuth) is $\leqslant \pm 0.1$ mm. The optical distance Z is not specified when the window is not sealed.

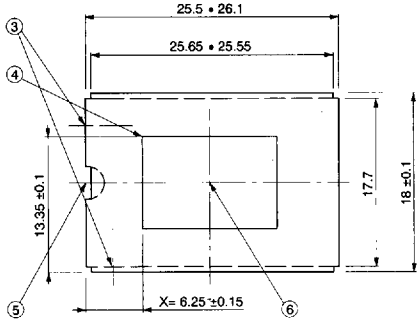
Note 3 : Variation of Y between the first pixel of the first line and the first pixel of the last line (tilt) is $\leqslant \pm 0.05$ mm.

OUTLINE DRAWING : TH 7883A WITH FIBER OPTIC WINDOW

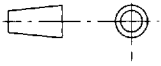


AA SECTION

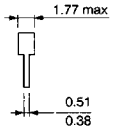




dimensions in mm



PIN DETAIL



① Fiber optic face plate

② Focal plane

③ Ground lead: ∅ **M2 one of these points have to be grounded**

④ First pixel of first line (X, Y coordinates)

⑤ Index (notch)

⑥ Optical center referred to the first pixel : 0 | 6.6 / 4.4

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ORDERING INFORMATION

TH7883AVCH	image grade H.
TH7883AVCHN	image grade H non sealed window.
TH7883AVCBF	FO window 1:1.
TH7883AGCCQ-A	UV coated CCD, sealed quartz window.
TH7883AGCCNQA	UV coated CCD, non sealed quartz window