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- to destroy the old edition
- to take notice that this present document is the latest edition

UL 02 05 1

160×120 LWIR UNCOOLED MICROBOLOMETER DETECTOR

TECHNICAL SPECIFICATION

PREVIOUS SOFRADIR REFERENCE: IDML 087

Specific care must be taken for the handling of the IDA, mainly regarding electrostatic discharge (ESD) protection, limitation for maximum voltages and currents to be applied

ULIS reserves the right to modify this specification at any time

Table of Contents

1 GENERAL

The purpose of this document is to describe the main features, performances and specifications of the 160 x 120 LW IRCMOS uncooled integrated microbolometer detector referenced as UL 02 05 1.

The UL 02 05 1 is an advanced, high reliability, small and lightweight, low input power Infrared Detector Assembly (IDA) adapted to uncooled thermal imaging, for commercial applications (surveillance, non destructive test, process control, hazard warning for vehicle,…) and military applications (weapon and vehicle sights, low cost goggles,…).

2 PRODUCT DESCRIPTION

2.1 General

The UL 02 05 1 is an infrared opto-electronic device sensitive to radiation in the long wavelength (8 to 14 micrometers) spectral region.

It includes a microbolometer infrared focal plane array (IRFPA) comprised of a 160 x 120 element two dimensional detector array made from amorphous silicon resistive microbolometers connected to a silicon readout integrated circuit (ROIC) by the mean of micro-bridges, and a thermoelectric cooler integrated into a miniaturized package.

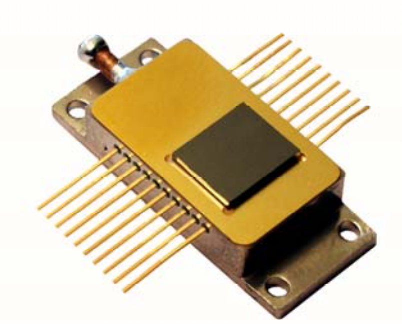


Figure 1
IR detector assembly

2.2 Focal plane description

2.2.1 Focal plane array characteristics

The focal plane array is composed of 160 columns × 120 rows of pixels. The sensitive area is 5.6 mm × 4.2 mm. The pixel pitch is 35 µm in both directions. The fill factor is greater than 80 %. The typical thermal time constant is about 10 ms and the TCR of the bolometer material is about 2.3 %/K.

2.2.2 Readout integrated circuit description

2.2.2.1 Readout integrated circuit architecture

The CMOS readout circuit enables to extract a low signal from an important background current.

The organization of the readout integrated circuit permits to integrate the information from the microbolometer, to subtract the background current, to multiplex this information per row, to sample and hold and to pre-amplify.

2.2.2.2 Operating mode

The detector readout is based on a ripple operation mode (electronically scanned array). The microbolometers are pulse-voltage biased and the information is read thanks to the current variation due to the microbolometer temperature shift generated by the IR scene flux absorption.

2.2.2.3 Signal voltage conversion

The pixel current is sequentially integrated in a current-voltage conversion stage at the end of each column. Capacitance Trans-Impedance Amplifiers (CTIA) performs the current-voltage conversion. The signal voltage conversion stage is controlled by internally generated biases.

2.2.2.4 Sample and Hold

A unity gain sample and hold amplifier fixes the output of the CTIA for a row period. During this period, the CTIA can integrate a new row of pixels that is serialized by the multiplexer.

2.2.2.5 Skimming

One blind bolometer per column allows skimming the pixel current with common mode current before integration. The input VSKIMMING drives this general skimming per column.

2.2.2.6 Analog output stage

There is one analog output for the video signal, named VIDEO. After the signal voltage conversion, a multiplexer (160 to 1) allows the transfer of the signals from the amplifiers to the output.

The master clock frequency of the readout circuit is adjusted with respect to the desired frame rate. Typical frame rates are 30 Hz or 60 Hz for US standard, or 25 Hz or 50 Hz for European standard.

For optimum output rate (6.75 MHz, 60 Hz), the stability range is about 50 ns.

OUTPUT /
C1R1 C2R1 .... C160R1 C1R2 C2R2 .... C160R2 C1R3 C2R3 .... C160 R120

C = column, R = Row

Table I
Output sequence

2.2.2.7 Sequencer

The sequencer generates all internal necessary signals for the readout integrated circuit operation from the different external clocks and bias voltages. The readout integrated circuit operation is totally asynchronous.

The clocks necessary to operate the sequencer are SYT, SYL and SYP, see table V.

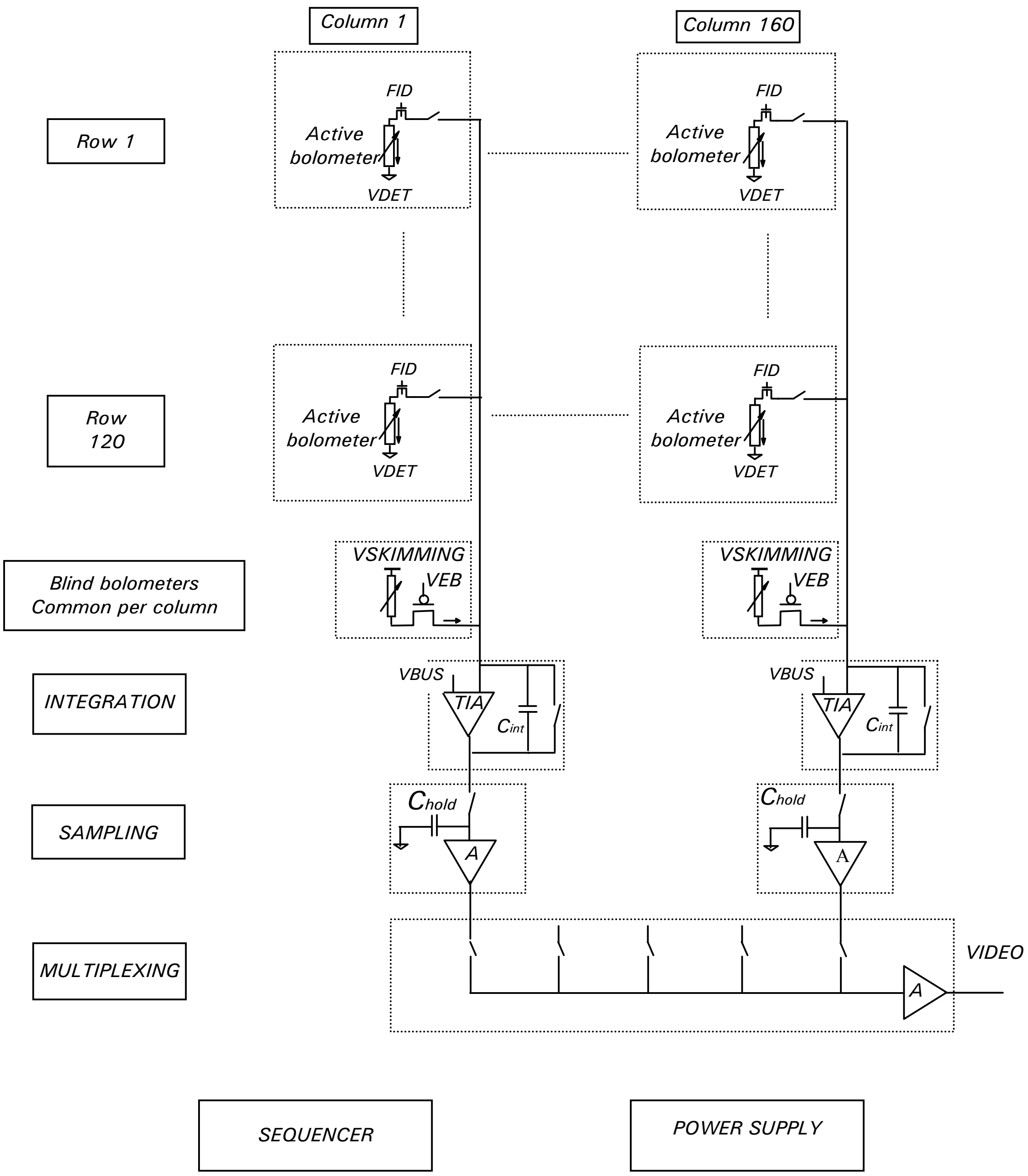


Figure 2
Readout circuit architecture

2.3 IR Detector Assembly description

2.3.1 General

The uncooled microbolometer detector packaging design is based on the miniaturization of the assembly linked to the small size of the thermoelectric cooler.

2.3.2 Packaging description

The packaging is based on the following features : vacuum sealed miniaturized metallic package, use of getter for long vacuum life, on-chip temperature sensors, thermoelectric cooler, mechanical references located on the front side of the package base plate and electrical connections located along each side of the package. Pins material is: Kovar, Nickel (around 2 µm) and gold (around 1.25 µm). See technical data drawing in §10.

2.3.3 Getter description

The getter is an autonomous (no power supply) device that continuously absorbs outgasing molecules from the component materials. Therefore it ensures over a long period of time (depending on the component operational life profile) a sufficient vacuum quality inside the packaging.

If vacuum happened to be insufficient (end of the lifetime period), getter may be fired for regeneration of their gas absorbency, with the following maximum current on the two getter's pads :

Function	Pin number	Maximum current
Getter +	1	4 Amperes
Getter -	11	

Table II
Getter pin-out

This getter activation may be performed either at the detector manufacturer facility, or at user location with a specific procedure described in the Technical Data Package (ref. TBD).

3 MECHANICAL INTERFACES

The general mechanical description and the outline dimensions of the IDA are given in § 10.

4 THERMAL INTERFACE

One temperature sensor device (VTEMP) is included on the FPA. It indicates the focal plane temperature (see paragraph 6.2.2 for VTEMP description). Thermoelectric coolers (TEC) are low power miniature heat pumps or heat generators (depending on the necessity to cool down or to heat up the microbolometer detector) that are small enough to be easily integrated into compact systems. VTEMP is available to drive an external thermoelectric driving unit (not supplied) that can efficiently control the focal plane temperature with less than 10 mK stability, ensuring stable detector performance. For the thermoelectric cooler, two pins provide the electrical interface.

Function	Pin number	Nominal current
TEC+	2	≤ 250 mA (4 V)
TEC -	12	

Table III
Thermo-electric cooler pin-out

Depending on the operating conditions requirements, these nominal values can be optimised.

5 OPTICAL INTERFACES

5.1 General

The optical interfaces consist of an antireflective-coated infrared window and the infrared focal plane array. The field of view is defined by the window clear aperture and is compatible with f/1 optics for the whole array (see optical interface §10) .

5.2 Infrared window

The infrared window has a refractive index of 4 and a thickness of 1 mm. It is antireflective coated in order to optimise the 8 to 14 µm incident radiation on the focal plane array and wavelength below 7.7 µm are blocked by an optical thin film coating.

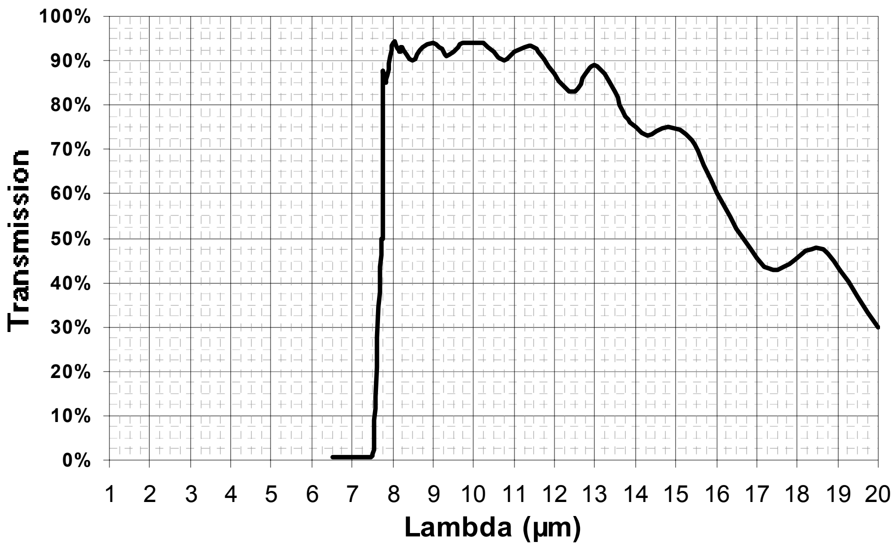


Figure 3
Infrared window transmission

6 IRFPA ELECTRICAL INTERFACES

All the inputs and outputs are described in this section and in the different tables IV to VI.

6.1 Input interfaces

The adjustments of all bias voltages are defined by their values, the maximum current and the maximum rms noise. Their default levels and values define the pulsed digital voltages.

6.1.1 Bias voltages (table IV)

The bias voltages necessary to operate the CMOS processor are :

- *VDDA : Analog power supply.*
- *VDDL : Digital power supply.*
- *VSSA : Analog ground.*
- *VSSL : Digital ground.*
- *VDET : This voltage biases the bolometers.*
- *VSKIMMING: This voltage biases the blind bolometers.*

The other bias voltages are :

- *FID : This voltage biases the bolometers.*
- *VEB : This voltage biases the blind bolometers.*
- *VBUS : This voltage is the reference voltage of the integrated circuit. Decoupling capacitor, typically 1 µF, should be placed as closely as possible to VBUS pin.*

VDET and VSKIMMING have to be adjusted to bias the bolometers and to obtain the video signal in the electrical dynamic range.

VEB and FID can be adjusted to optimise the detector operation. If FID and VEB pins are not connected, FID is internally set at 1.8 V and VEB at 2.2V ("nominal value"). In this case, FID and VEB pins should be decoupled as closely as possible with 1µF capacitances.

All these adjustable biases can be tuned for operating the IRFPA at temperature ranging between 0°C and 60°C in case the camera ambient operating temperature is far from +30°C. Thus, this enables lower power consumption for extreme ambient temperatures.

6.1.2 Pulsed digital voltages (table V)

Three pulsed voltages (SYP, SYL and SYT) are necessary to operate the sequencer of the CMOS processor (see 2.2.2.7).

The rise and fall times of these voltages shall be less than 10 ns.

Integration time is equal to the time duration of the low level of SYL. The integration of the first row is triggered by the second SYL falling edge that follows a SYT falling edge.

$T1 > T_{SYL}$; $T2 \geq 0$; $T3 \geq 1.5$ µs; $T4 \geq 1.5$ µs; $T5 = 4.7$ µs +/- 30 % and $T6 \geq 1.5$ µs, see figures 6 and 7.

6.2 Output signals (table VI)

Two types of outputs are available : one analog output (VIDEO) and one temperature data (VTEMP).

6.2.1 Analog output

The analog output is defined by its value, the maximum current and the maximum rms noise.

These analog output VIDEO swings between 0.4 V and 3.2 V. A signal increase corresponds to an output voltage increase. VIDEO can be loaded by a resistance $R \geq 10$ kΩ in parallel with a capacitance $C \leq 25$ pF external to the packaging.

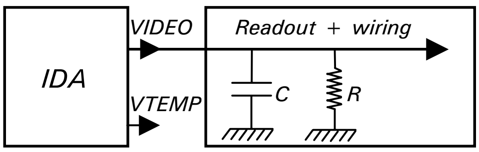


Figure 4
VIDEO output

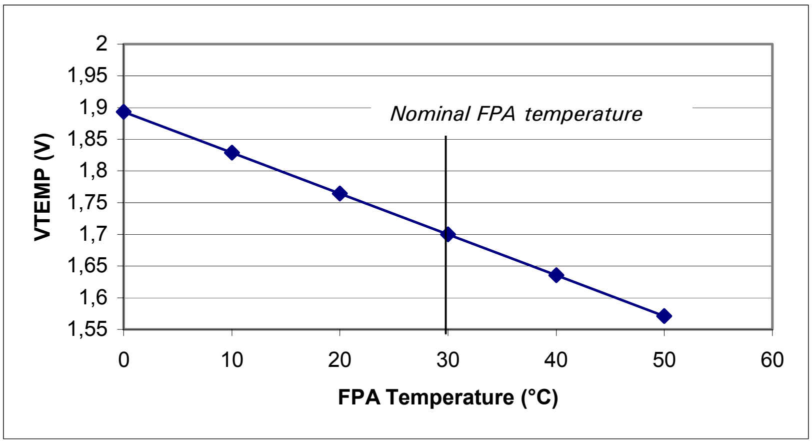
6.2.2 Temperature data

VTEMP is an analog output voltage that corresponds to the FPA temperature information.

The FPA temperature has to be stabilized around 30°C and the FPA temperature regulation has to be done thanks to this output voltage VTEMP.

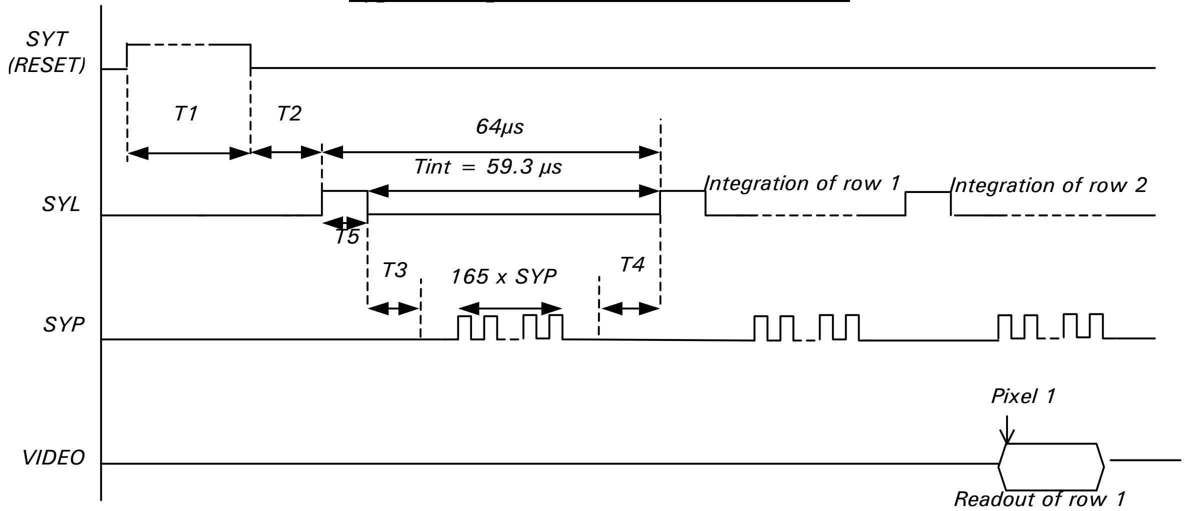
VTEMP output is provided on one pin of the detector and its sensitivity is – 6.45 mV/K.

VTEMP is around 1.70 V (exact voltage is given in acceptance test report) at 30°C (temperature of the FPA). The relation between VTEMP and the FPA temperature is defined on figure 5.

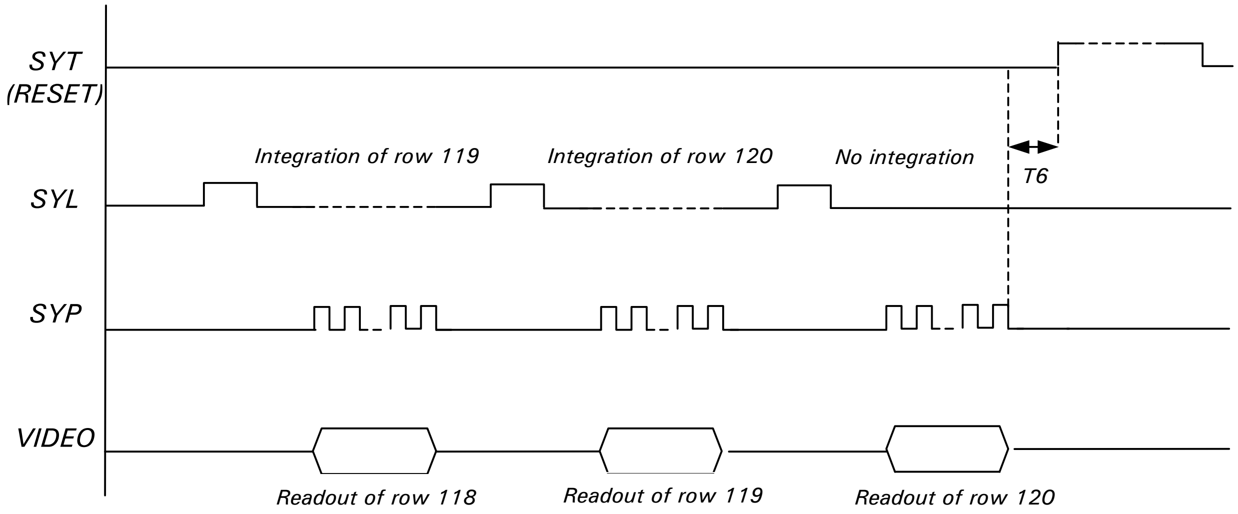


<u>Figure 5</u>

<u>Typical temperature sensor characteristic</u>



<u>Figure 6 : Clock-diagram (1/2)</u>



<u>Figure 7 : Clock diagram (2/2)</u>

Pin number	Name	Electrical function	Value	Maximum current	Maximum RMS noise
3	VDDA	Analog power supply	5 V + 10 %	30	< 1mV
17	VDDL	Digital power supply	5 V +/- 10 %	5	< 100mV
6	VSSA	Analog ground	0 V	-	-
18	VSSL	Digital ground	0 V	-	-
9	FID	Microbolometer biasing	1.8 V if not connected Tunable [1.5-5V](*)	1 mA	< 100µV
10	VSKIMMING	Microbolometer biasing	Tunable [3-5.5V](*)	1 mA	< 100µV
7	VEB	Microbolometer biasing	2.2 V if not connected Tunable [0-4V](*)	1 mA	< 100µV
4	VBUS	Microbolometer biasing	3.2 V if not connected Tunable [1.5-4V](*)	1 mA	< 100µV
20	VDET	Microbolometer biasing	Tunable [0-2V](*)	1 mA	< 100µV

(*) *These values are given for information only*

Table IV
Bias voltages

Pin number	Name	Electrical function	Low level	High level
13	SYP	Pixel Synchronisation	< 0.5 V	> 4.5 V
14	SYL	Line Synchronisation	< 0.5 V	> 4.5 V
15	SYT	Frame Synchronisation	< 0.5 V	>4.5 V

Table V
Pulsed digital voltages

Pin number	Name	Electrical function	Value	Maximum current
5	VIDEO	Analog output	0.4 V to 3.2 V	-
8	VTEMP	Temperature data	≅1.7 V @ 30°C	-

Table VI
Analog output and temperature sensor

7 DELIVERY

7.1 Delivery description

The hardware delivery consists of the IR Detector Assembly including the IRFPA integrated in its miniaturized packaging. The IR Detector Assembly is delivered with its acceptance test report.

The Command and Control Electronics for both the IRFPA and the temperature stabilizer are not part of the delivery. They may be ordered as an option but without ULIS full guaranty since it is offered as development support equipment.

7.2 Marking

The IR Detector Assembly is clearly marked with the manufacturer's serial number.

7.3 Packaging

During transportation, the IDA is sealed in a plastic bag.

7.4 Operation of the IDA

As the IRFPA Command and Control Electronics and TE stabilizer are not part of the delivery, the equipment user needs to supply all biases and pulsed voltages necessary to operate the complete IDA.

7.5 General recommendations

Specific care must be taken for the handling of the IDA, mainly regarding electrostatic discharge (ESD) protection, limitation for maximum voltages and currents to be applied and handling of optical parts.

The microbolometer pixels being heated up by radiation, the detector in its camera can not face sun directly, otherwise the bloomed pixels will be depolarised and semi-permanently shifted out of the dynamic range.

ULIS will establish documents named "General Handling Procedure" or "Technical Data Package" (ref. TBD) in which the following issues are also addressed: assembly and disassembly of a Command and Control Electronic, and getter activation procedure.

8 MINIMUM PERFORMANCE SPECIFICATION

8.1 General

Except as otherwise specified, the following paragraphs detail the minimum objective performance specification for the IR Detector Assembly.

8.2 Electro-optical performance

8.2.1 Operating conditions

The IDA is set for operation at a typical focal plane temperature of 30°C. The FPA temperature stability shall be controlled with a more precise accuracy of ± 10 mK. The optimum output rate depends on the application taking into account the detector thermal time constant.

The nominal field of view defined by the window aperture is compatible with f/1 optics for the whole array. In these conditions, the useful scene temperature dynamic range at the detector window level is typically 60°C depending on the tuning of the detector.

8.2.2 Temporal NETD

For 60 Hz frame rate, and for an optical aperture of f/1, the 300 K average temporal pixel NETD of all non-defective elements of the array is ≤ 100mK.

8.2.3 Responsivity

The average 300 K responsivity of all non-defective elements of the array is at least greater than 5 mV/K. This value will be given for information only in the ATR for each detector.

8.2.4 Cross-talk

The cross-talk signal level between adjacent elements is TBD.

8.2.5 Dynamic range

The minimum useful scene temperature dynamic range at the detector window level is typically settled for at least 60°C. The output dc level can be shifted up or down when changing VSKIMMING bias value, (according to table IV). The dynamic range can be increased when lowering FID bias value (according to table IV) from the recommended value, but potentially to the detriment of the NETD performance.

8.2.6 Spectral response

The IR Detector Assembly is sensitive in the 8 µm to 14 µm spectral bandwidth.

8.2.7 Operability

An element is considered as non defective if pixel NETD < 1.5 × Average NETD defined in 8.2.2, and if the requirements of 8.2.3 are fulfilled in the operating conditions defined in 8.2.1. The IR Detector operability is better than 99 %.

8.3 Mechanical and thermal performance

8.3.1 Weight

The IDA weight is less than 10 g.

8.3.2 Total power consumption

The IR Detector Assembly stabilized power consumption is < 200 mW for 30°C ambient temperature.

8.3.3 Vacuum integrity

The vacuum integrity of the package is ensured thanks to a reusable electrically activated getter device. The period duration between getter activation is defined in function of the customer-furnished detector life profile. The getter activation procedure is described in the Technical Data Package delivered along with detectors.

8.4 Environmental conditions

8.4.1 Temperature

8.4.1.1 Storage temperature

The IDA shall be stored in ambient temperatures comprised between - 40°C and + 70°C. The storage duration is TBD.

8.4.1.2 Operating temperature

The IDA operates for an ambient temperature range from - 40°C to + 60°C, providing an adapted heat sink is applied for high ambient temperatures.

8.4.2 Vibration

8.4.2.1 Random vibration

The IDA behaviour after exposure to random vibration in the three mutually perpendicular axes during one hour per axis is TBD.

The random profile is :

- *Between 5 Hz and 28 Hz : + 6 dB/octave (linear from 0.0026 g²/Hz to 0.1 g²/Hz);*
- *Between 28 Hz and 350 Hz : constant 0.1 g²/Hz;*
- *Between 350 Hz and 2000 Hz : - 6 dB/octave (linear from 0.1 g²/Hz to 0.0013 g²/Hz).*

8.4.2.2 Sinusoidal vibration

The IDA behaviour after exposure to sinusoidal vibration in the three mutually perpendicular axes at a rate of 1 octave/minute is TBD.

The vibration spectrum is :

- *Between 5 Hz to 20 Hz : 1.25 mm peak*
- *Between 20 Hz to 2000 Hz : 2 g peak.*

8.4.2.3 Shocks

The IDA behaviour after exposure to shocks with the following level (3 shocks per axis per direction) is TBD.

The shocks spectrum is ½ sine 50 g 16 ms.

9 QUALITY ASSURANCE

9.1 Manufacturing process

Main subassemblies are manufactured in house except packaging sub-parts, TEC coolers and Silicon wafers, and all critical manufacturing steps are performed in house.

Environmental Stress Screening (ESS) is performed on each unit before ULIS quality acceptance test.

9.2 Acceptance test

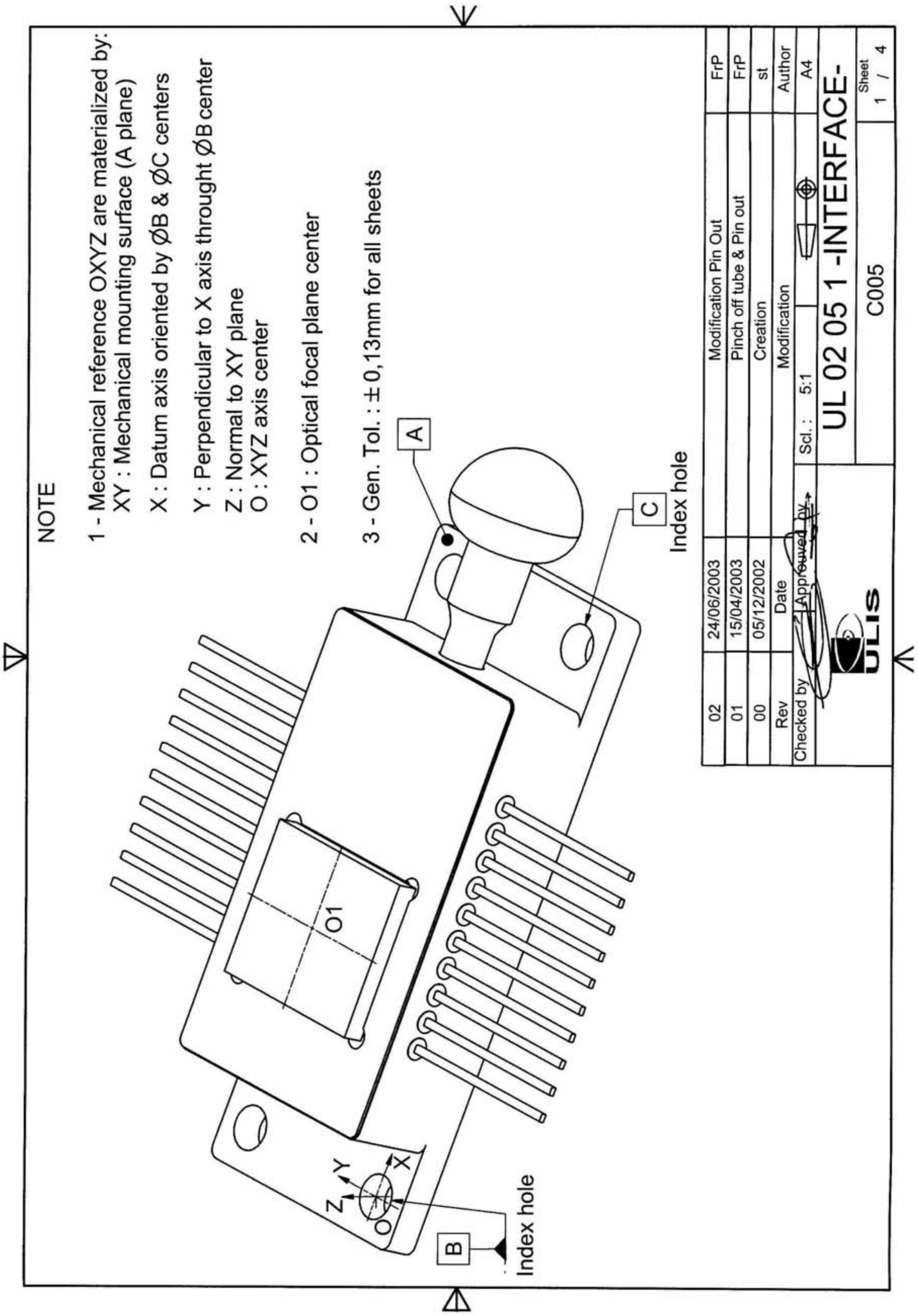
Each delivery unit undergoes an acceptance test consisting in :

- *NETD at 60 Hz (8.2.2) and responsivity (8.2.3) measurements in the operating conditions described in 8.2.1,*
- *Operability statement (8.2.7).*

All other performances are guaranteed and some parameters are verified either by batch or during process. Each unit is delivered with its corresponding acceptance test report indicating the reference to the contract, the reference of the specification paragraph concerned (number and title), the reference of the measurement procedure to be used, specific measurement conditions if necessary, the specified value, and the measurement results.

10 MECHANICAL, OPTICAL AND ELECTRICAL INTERFACES

(See next pages).


NOTE
1 - Mechanical reference OXYZ are materialized by:
XY : Mechanical mounting surface (A plane)
X : Datum axis oriented by ØB & ØC centers
Y : Perpendicular to X axis throught ØB center
Z : Normal to XY plane
O : XYZ axis center
2 - O1 : Optical focal plane center
3 - Gen. Tol. : ± 0,13mm for all sheets
A
C
Index hole
O1
B
Index hole
Z
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O
02 | 24/06/2003 | Modification Pin Out | FrP
01 | 15/04/2003 | Pinch off tube & Pin out | FrP
00 | 05/12/2002 | Creation | st
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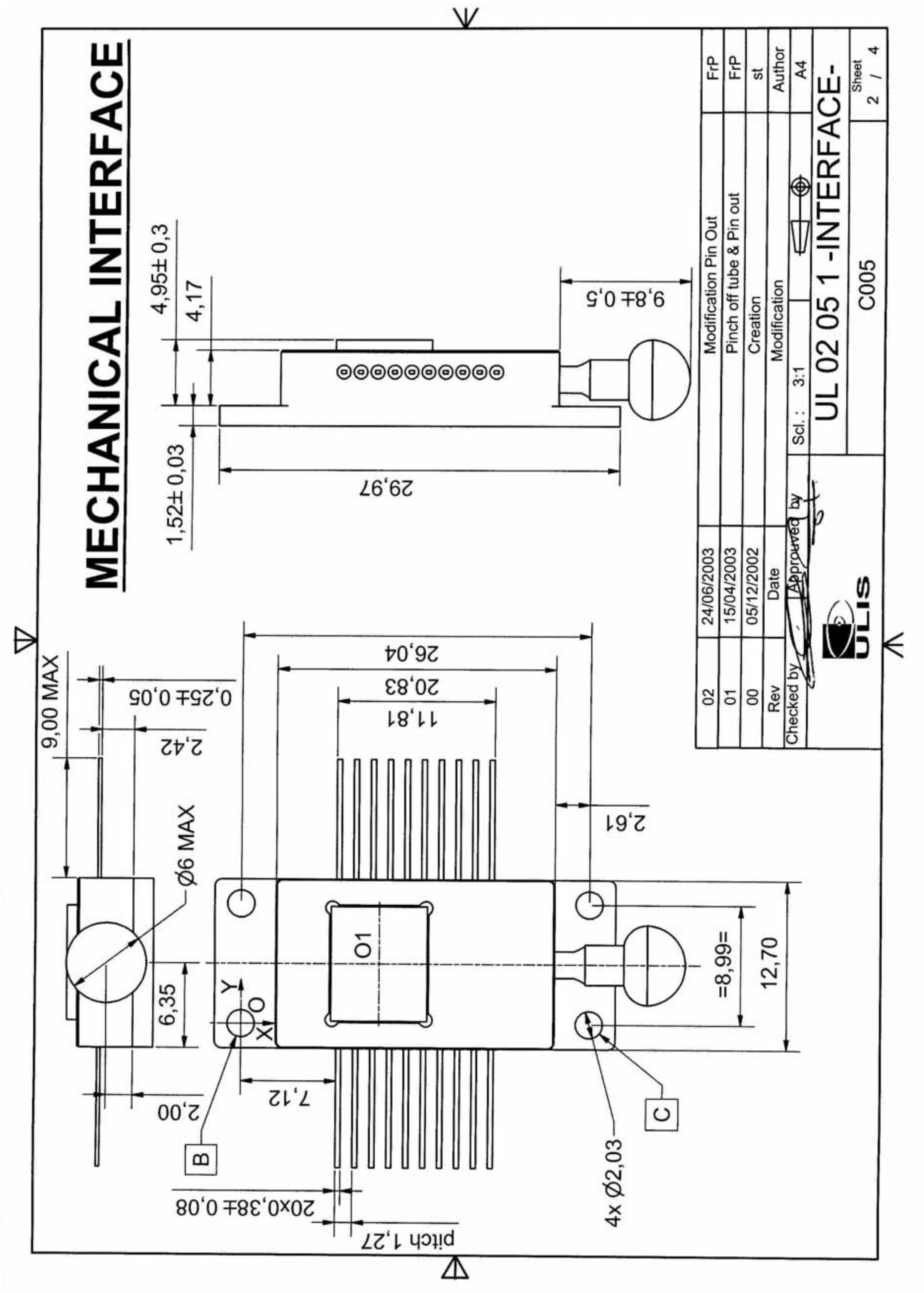
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X
Y
O
B
C
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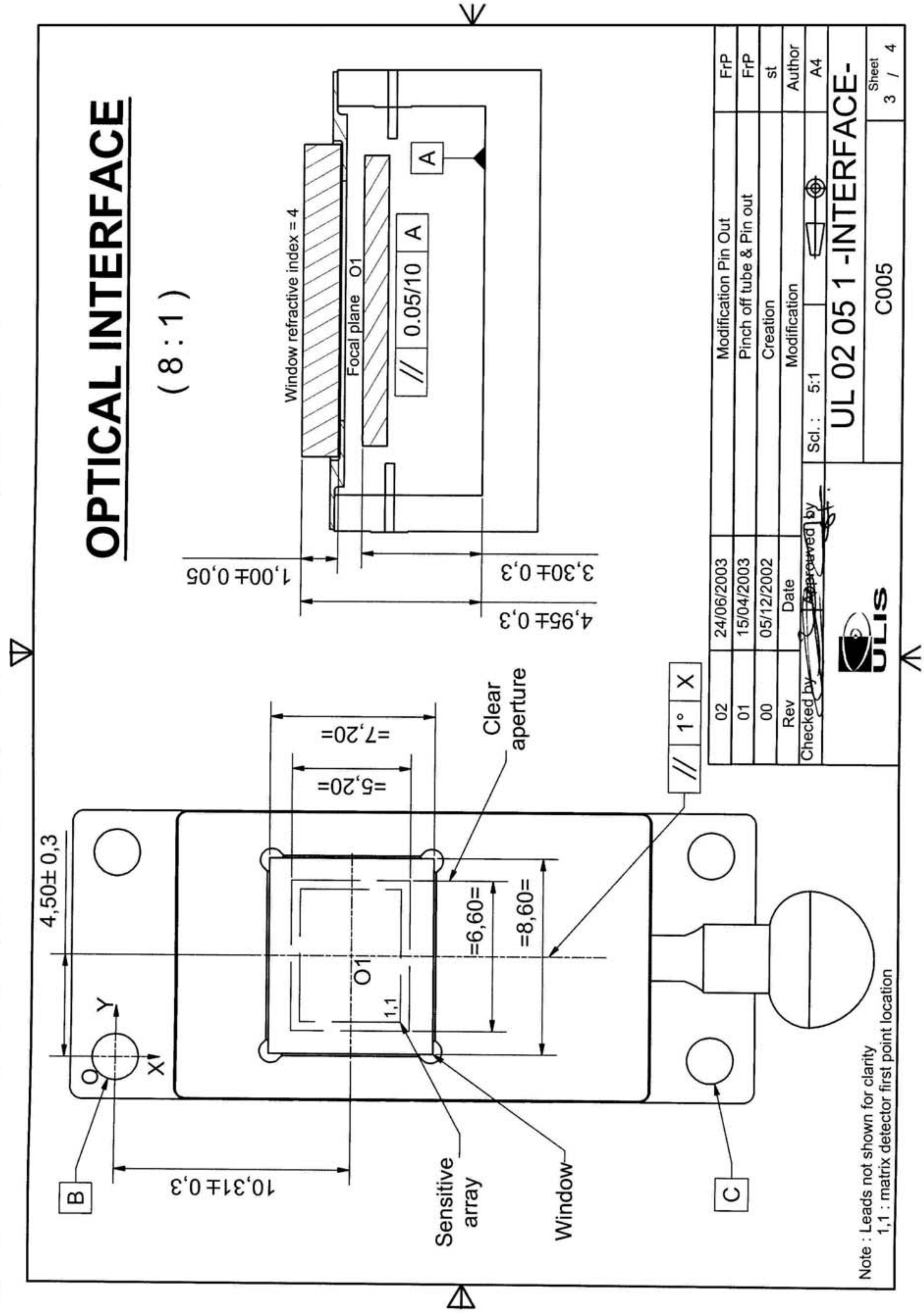
OPTICAL INTERFACE
(8 : 1)
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A
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3,30± 0,3
4,95± 0,3
4,50± 0,3
=7,20=
=5,20=
Clear aperture
// 1° X
=6,60=
=8,60=
O1
1,1
O
Y
X
B
10,31± 0,3
Sensitive array
Window
C
Note : Leads not shown for clarity
1,1 : matrix detector first point location
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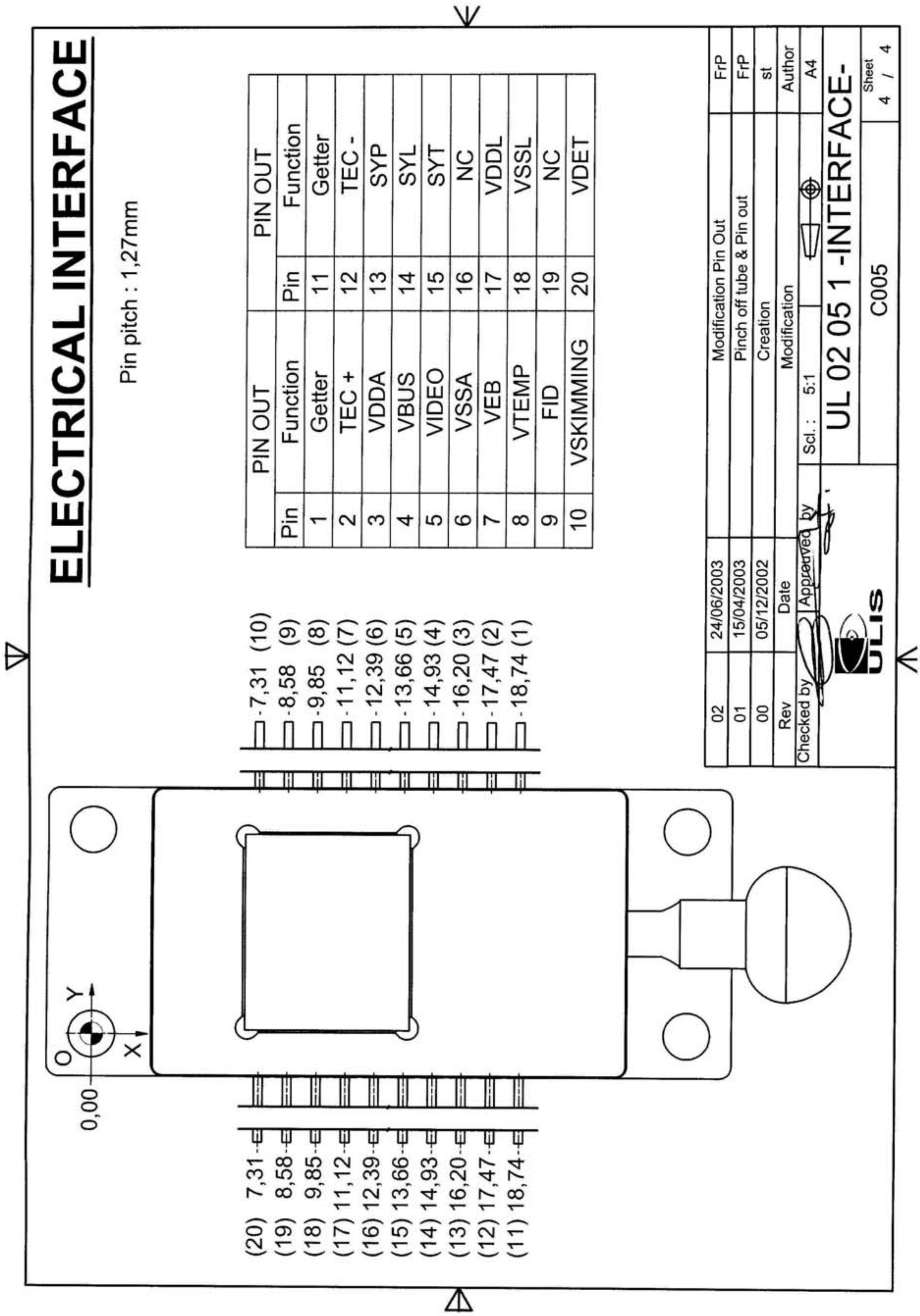

PIN OUT		PIN OUT	
Pin	Function	Pin	Function
1	Getter	11	Getter
2	TEC +	12	TEC -
3	VDDA	13	SYP
4	VBUS	14	SYL
5	VIDEO	15	SYT
6	VSSA	16	NC
7	VEB	17	VDDL
8	VTEMP	18	VSSL
9	FID	19	NC
10	VSKIMMING	20	VDET

11 GLOSSARY

ATR	:	*Acceptance Test Report*
FID	:	*Microbolometer biasing*
FPA	:	*Focal Plane Array*
IDA	:	*Integrated Detector Assembly*
IRFPA	:	*Infrared focal plane array*
LW IRCMOS	:	*Long Wave Infrared CMOS*
NETD	:	*Noise Equivalent Temperature Difference*
ROIC	:	*Readout Integrated Circuit*
SYL	:	*Line Synchronization*
SYP	:	*Pixel Synchronization*
SYT	:	*Frame Synchronization*
TCR	:	*Thermal Coefficient Resistance*
TEC	:	*Thermo Electric Cooler*
TIA	:	*Trans-impedance amplifier*
VDDA	:	*Analog supply fixed*
VDDL	:	*Digital supply fixed*
VEB	:	*Blind microbolometer biasing*
VSKIMMING	:	*Blind microbolometer biasing*
VIDEO	:	*Analog output*
VREF	:	*REFerence Voltage*
VSSA	:	*Analog electrical ground*
VSSL	:	*Digital electrical ground*