Specification for
“DUAL and QUAD TDI CCD”

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Time Delay Integration (TDI) Charge Coupled Device (CCD) requirements

Table 1: Electro-optical requirements of DUAL TDI sensor

Unless and otherwise specified all parameters to be measured at 25°C

Sr.No.	Parameter Description	Requirements
1.	Number of TDI arrays in one package	2
2.	Array to array (centre to centre) separation	≤2002um
3.	Element size	8.8µmx8.8µm
4.	Antiblooming	Required at pixel level
5.	Photosensitive elements	2680 x 132
6.	Externally selectable stage options	15, 45, 132
7.	Spectral response	440nm - 900nm
8.	Pixel readout rate per output port	≥14.5MHz
9.	Readout mode	a) 8 output b) 4 output c) 2 x 2 binning
10.	Number of outputs per array	8, feasibility of cascading of two ports
11.	Array to array and port to port coupling/crosstalk	to be measured on one device and provide information
12.	Conversion Factor	≥5.2µV/e-
13.	Saturation charge	≥138ke-
14.	Average Responsivity	to be provided by manufacturer at three different wavelengths 450nm, 650nm, 850nm
15.	Read Noise	≤60e-
16.	Average Dark signal	≤15e/ms
17.	Output Signal Non-Linearity (10% to 80% of saturation)	≤2%
18.	Dark current density	to be provided by manufacturer
19.	RMS Photoresponse Non Uniformity in: 450-520nm 520-580nm 620-690nmF 770-860nm For 132 stage	≤ ±4% for all 4 bands
20.	Charge Transfer Inefficiency vertical (80% of saturation)	≤2%
21.	Charge Transfer Inefficiency horizontal (80% of saturation)	≤1%
22.	CTF in TDI direction TDI at Nyquist	≥50% at 500 nm ≥60% at 850 nm
23.	CTF in horizontal direction at Nyquist	≥50% at 500 nm ≥60% at 850 nm

Table 2: Geometrical Parameter **of DUAL TDI sensor**

Parameter	**Specified values/tolerance**	**Definition/description**
ΔX_i	± 0.5 µm	The tolerance on the distance between first element and i^{th} element of any one stage with respect to (Lox (i-1) / (N-1))
ΔY_j	± 0.5 µm	The tolerance on the distance between first element and j^{th} element of any one pixel with respect to (Loy (j-1) / (Ns-1))
N	2680	The number of active pixels along X-axis.
Ns	15, 45, 132	Number of TDI stages along Y-axis shall be selectable.
Pcx, Pcy	8.8 µm X 8.8 µm	Pixel pitch in x and y direction
ΔZ	≤± 10 µm	Deviation of $z_{i,j}$ co-ordinates from the best fit plane
Δtx, Δty	≤ ± 100 µm	Die position tolerance in X, Y direction w.r.t package
ΦD (in X, Y direction)	≤ ±0.4 degree	Die orientation w.r.t package

Note: Location of pixel 1 with respect to mounting hole is desired.

Table 3: Package and storage Requirements of DUAL TDI sensor

Sr.No.	**Parameter Description**	**Requirements**
1	Operating temperature	0°C to +70°C
2	Storage temperature (non-operating)	-55°C to +150°C
3	Package (ceramic package hermitically sealed with glass window)	AlN PGA, 78 pins

Table 4: Electro-optical requirements of QUAD TDI sensor

Unless and otherwise specified all parameters to be measured at 25°C

Sr.No.	Parameter Description	Requirements
1	Number of TDI arrays in one package	4
2	Array to array (centre to centre) separation	≤2002um
3	Element size	17.6μmx17.6μm
4	Antiblooming	Required at pixel level
5	Photosensitive elements	1340 x 45
6	Externally selectable stage options	5, 15, 45
7	Spectral response	440nm - 900nm
8	Pixel readout rate per output port	≥14.5MHz
9	Readout mode	a) Four port/array b) Two port /array c) 2 x 2 binning
10	Number of outputs per array	4, feasibility of cascading of two ports
11	Array to array and port to port coupling/crosstalk	to be measured on one device and provide information
12	Conversion Factor	≥5.5μV/e-
13	Saturation charge	≥450ke-
14	Average Responsivity	to be provided by manufacturer at three different wavelengths 450nm, 650nm, 850nm
15	Read Noise	≤60e-
16	Average Dark signal	≤15e/ms
17	Output Signal Non-Linearity (10% to 80% of saturation)	≤2%
18	Dark current density	to be provided by manufacturer
19	RMS Photoresponse Non Uniformity in: 450-520nm 520-580nm 620-690nm 770-860nm For 45 stages	≤ ±4% for all 4 bands
20	Charge Transfer Inefficiency vertical (80% of saturation)	≤1%
21	Charge Transfer Inefficiency horizontal(80% of saturation)	≤2%
22	CTF in TDI direction TDI at Nyquist	≥65% at 500 nm ≥70% at 850 nm
23	CTF in horizontal direction at Nyquist	≥65% at 500 nm ≥70% at 850 nm

Table 5: Geometrical Parameter **of QUAD TDI sensor**

Parameter	**Specified values/tolerance**	**Definition/description**
ΔX_i	± 0.5 µm	The tolerance on the distance between first element and i^{th} element of any one stage with respect to (Lox (i-1) / (N-1))
ΔY_j	± 0.5 µm	The tolerance on the distance between first element and j^{th} element of any one pixel with respect to (Loy (j-1) / (Ns-1))
N	1340	The number of active pixels along X-axis.
Ns	5, 15, 45	Number of TDI stages along Y-axis shall be selectable.
Pcx, Pcy	17.6 µm X 17.6 µm	Pixel pitch in x and y direction
ΔZ	≤± 10 µm	Deviation of $z_{i,j}$ co-ordinates from the best fit plane
Δtx, Δty	≤ ± 100 µm	Die position tolerance in X, Y direction w.r.t package
ΦD (in X, Y direction)	≤ ±0.4 degree	Die orientation w.r.t package

Note: Location of pixel 1 with respect to mounting hole is desired.

Table 6: Package and storage Requirements of QUAD TDI sensor

Sr.No.	**Parameter Description**	**Requirements**
1	Operating temperature	0°C to +70°C
2	Storage temperature (non-operating)	-55°C to +150°C
3	Package (ceramic package hermitically sealed with glass window)	AlN PGA, 78 pins

R & QA Requirements

1. Introduction:

Devices with dies from same mask sets as used in Dual & Quad TDI devices developed by M/s e2V, France for Cartosat-Series satellites shall be assembled, tested, screened, qualified and delivered. This section provides the R&QA requirements for development and testing of Dual & Quad TDI detectors.

2. Quality Control Plan

Vendor shall follow the same quality control plan as followed during development of previously delivered devices. If there is any change in quality control plan including materials control and process control, same shall be provided to ISRO for approval. This shall contain.

a) List of materials
b) List of Vendors
c) Process flow chart indicating process monitoring stages.
d) Internal quality control plan
e) Contamination control plan

All the devices delivered to ISRO shall be accompanied by a certificate of compliance to the quality control plan.

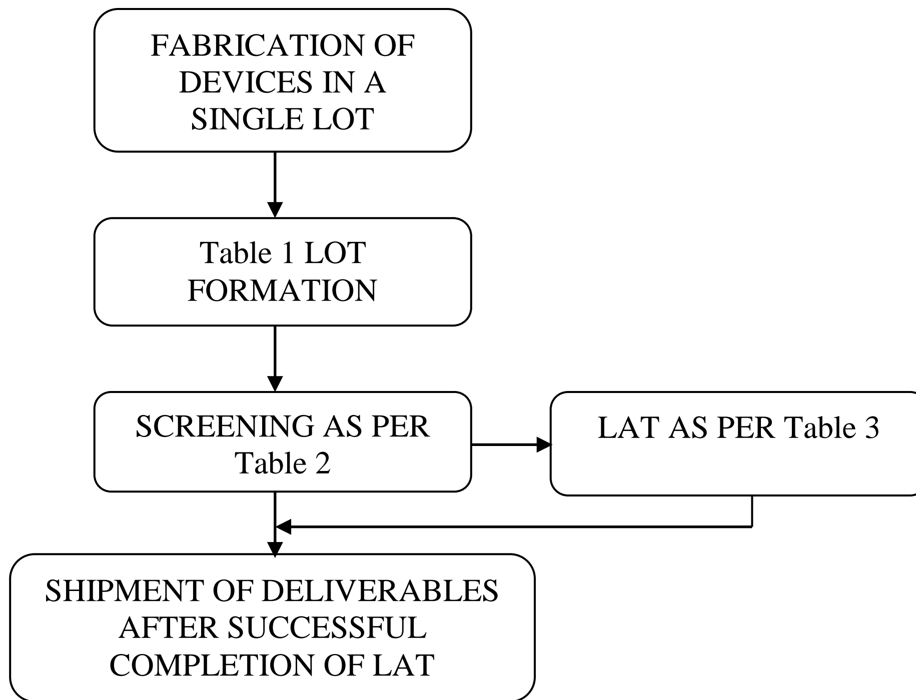
3. Shelf Life

The devices shall be capable of meeting the functional requirements after the assembly and storage for a minimum storage period of 3 years and an in-orbit operation period of 7 years subsequently. The manufacturer shall specify the exact method of storage and retest criteria in case of longer storage.

4. Qualification & Screening Tests

All devices shall be inspected and tested as per the flow chart given in Flowchart-1. The term 'LOT' as mentioned in the flow chart is defined to be consisting of devices manufactured from same batch of raw materials on the same - production and assembly lines over a period of six weeks maximum. During assembly level devices shall be subjected to tests as per Table-7. After successful assembly, devices shall be subjected to screening test as per Table-8. Any device failing in any of the screening tests shall be removed from the lot. In addition, the whole lot shall be rejected if it fails to meet the Percentage Defective Allowed (PDA) requirement for burn-in test. In case of lot rejection, the manufacturer shall reprocess a new lot according to specifications.

Considering that the devices shall be fabricated using the dies from same mask sets as used in previous project, the qualification plan is formulated addressing the new assembly lot and long term storage effects on the wafer lot. Devices randomly selected from screened lot shall be subjected to Lot Acceptance Tests as per Table-9.



FLOWCHART-1: FLOWCHART FOR TESTS

Table-7: Assembly Level Tests

S/N.	Test	Method/Condition MIL-STD-883	Accept/Reject Criteria
1.	Destructive bond pull test	Method 2011	On-line destructive test on samples in each lot
2.	Pre-cap. inspection	ESA/SCC20400 MIL-STD-883, Method 2010, Condition A	All devices to be inspected
3.	Geometrical measurement	Lo on 1 TDI array/device, flatness and die positioning as per Table-2	All devices to be tested
4.	Sealing, marking and serialization	ESA/SCC21700	All devices to be marked

Table-8: Screening Tests

S/N.	Test	Method/Condition MIL-STD-883
1.	Stabilization bake	Method 1008, 150°C,48 hrs
2.	Thermal cycling	Method 1010, Condition B, 10 cycles.
3.	Constant Acceleration	Method 2001, Condition A (5000g), Y1 orientation only

4.	External visual inspection	Method 2009 or ESA 20500
5.	Fine Seal Leak Test	Method 1014, Condition A
6.	Particle impact noise detection (PIND)	Method 2020 Condition-A
7.	Pre Burn-in Electrical Test	Leakage and dark current measurement
8.	Dynamic Burn-in	Method 1015, 540 hrs. at 125 °C
9.	Post Burn-in Electrical	Same as Step 7 Delta criteria as per Table-5, PDA in a lot = 10% max.
10.	Fine Seal Leak Test	Method 1014, Condition A
11.	Geometrical test	Lo on 1 TDI array/device, flatness and die positioning as per Table-2
12.	Final electrical and electro-optical tests	All tests as per Table-1
13.	External visual inspection	Same as step 4

Table-9: Lot Acceptance Tests

SN	**Step**	**Method/Condition MIL-STD-883**	**Sample Size (Accept No)**	
			Dual TDI	**Quad TDI**
0	**All Subgroups – Electro-optical Measurements[Note-1]**			
1.	E-O test at 25°C	As per Table-12	8(0)	15(0)
I	**Subgroup I - Mechanical**			
1.	Mechanical Shock	Method 2002, Condition B	3/3(0)	3/3(0)
2.	Vibration variable frequency	Method 2007, Condition A	3/3(0)	3/3(0)
3.	Constant Acceleration	Method 2001, Condition A (5000g), Y1 orientation only	3/3(0)	3/3(0)
4.	Fine Seal Leak Test	Method 1014	3/3(0)	3/3(0)
5.	E-O test at 25°C	As per Table-9	3/3(0)	3/3(0)
6.	Visual examination	As per criteria described in Method 1010	3/3(0)	3/3(0)
II	**Subgroup II - Environmental**			
1.	Temperature cycling	Method 1010, Condition C, 100 cycles	3/3(0)	3/3(0)
2.	Moisture Resistance	Method 1004	3/3(0)	3/3(0)
3.	Fine Seal Leak Test	Method 1014	3/3(0)	3/3(0)
4.	E-O test at 25ºC	As per Table-9	3/3(0)	3/3(0)
5.	Visual examination	As per criteria described in Method 1010	3/3(0)	3/3(0)
III	**Subgroup III – Assembly / Capability[Note-2]**			
1.	Physical dimensions	Method 2016	2/2 (0)	2/2 (0)
2.	Lead integrity	Method 2004	2/2 (0)	2/2 (0)
3.	Solderability	Method 1004	2/2 (0)	2/2 (0)

4.	Decap and internal Visual examination	As per criteria described in Method 2010	2/2 (0)	2/2 (0)
5.	Bond strength	Method 2011 Condition D (All Bonds)	2/2 (0)	2/2 (0)
6.	Die shear/Stud Pull test	Method 2019/Method 2027	2/2 (0)	2/2 (0)
IV	**Subgroup IV – Endurance (operating Life test)**			
1.	Steady state life test	125°C, 1000 hrs[Note-3]	-	7 (0)
2.	E-O test at 25 ºC	As per Table-9, Drift Criteria as per Table-8	-	7 (0)
3.	Fine Seal Leak Test	Method 1014	-	7 (0)
4.	Visual examination	As per criteria described in Method 1010	-	7 (0)

1. Recorded data during the screening tests described in Table-8 may be used here.
2. Electrical rejects may be used for these tests
3. The measurements are to be carried out after 240, 500 and 1000 hours of Burn-In.

Table - 10: Parameter drift value (for Burn-in)

N°	Characteristics	Drift
1	Leakage Current on Input gates	±100% of initial value
2	Average Dark Signal	±50% of initial value
3	Total power current	±10% of initial value

Before and after Burn-in health parameter in table 10 will be checked.

Table - 11: Parameter drift value (for Life Test)

N°	Characteristics	Drift
1.	Leakage Current on Input gates	The absolute change value less than 500 pA
2.	Total power supply current	±10% of initial value
3.	Dark current mean	25% max
4.	Dark current peak	100% max
5.	Responsivity/sensitivity	10% max.
6.	Contrast Transfer Function	0.05 max. (the absolute difference)
7.	Charge transfer Inefficiency	0.02 max. (the absolute difference)
8.	Saturation Voltage	20% max.

Before and after Life Test health parameter in table 11 will be checked.

Table 12: E-O Tests for LAT

N°	Characteristics	Symbol
1	Leakage Current on Input gates	IL

2	Total Power Supply Current	IDD
3	Average Dark Signal	V_{DS}
4	Average Responsivity BG38 filter	Rbg38
5	Charge transfer inefficiency	VCTI

Table-13

Deliverables and Delivery schedule

S. No.	Item	Qty.	Schedule
1	Interface control document	1	T0+3 months or earlier
2	Generic radiation test results	1	T0+6 months or earlier
3	QUAD TDI CCD FM detector (batch 1)	30	T0+10 months or earlier
4	QUAD TDI CCD FM detector (batch 2)	40	T0+24 months
5	DUAL TDI CCD FM detector	40	T0+24 months
6	QUAD TDI CCD FM Test report (batch 1)	1	T0+24 months
7	QUAD TDI CCD FM Test report (batch 2)	1	T0+24 months
8	DUAL TDI CCD FM Test report	1	T0+24 months
9	Data package report for QUAD TDI CCD	1	T0+24 months
10	Data package report for DUAL TDI CCD	1	T0+24 months
11	LAT devices (QUAD TDI CCD)	1 lot	T0+24 months
12	LAT devices (DUAL TDI CCD)	1 lot	T0+24 months
13	Lot acceptance test report for QUAD TDI CCD	1	T0+24 months
14	Lot acceptance test report for DUAL TDI CCD	1	T0+24 months

Warranty: one year

T0: Date of Purchase Order