Low Temperature (30 K) TID Test Results of a Radiation Hardened 128 Channel Serial-to-Parallel Converter.

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To be presented by Stephen Meyer and Stephen Buchner at Radiation and Its Effects on Components and Systems (RADECS) 2006, Athens Greece, September 27-29, 2006.

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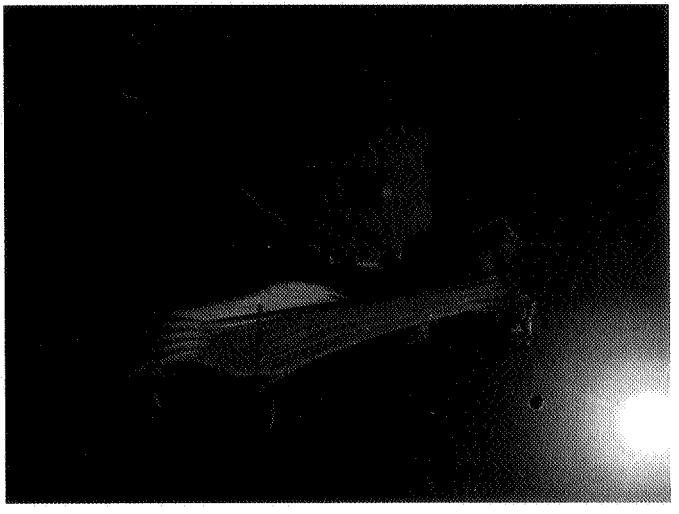
James Webb Space Telescope



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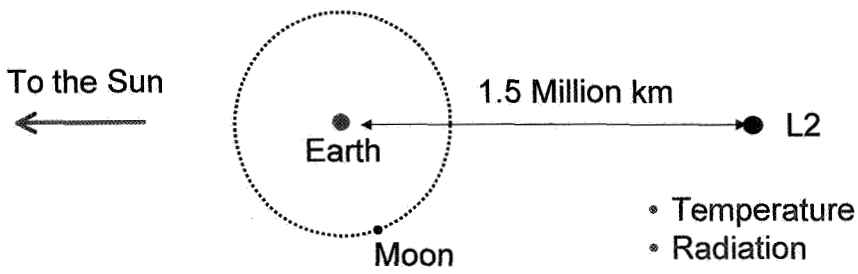
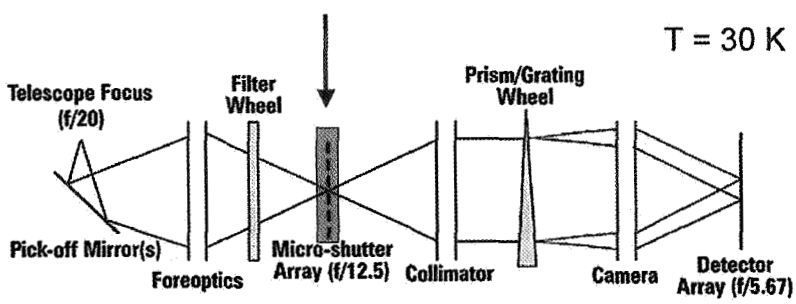
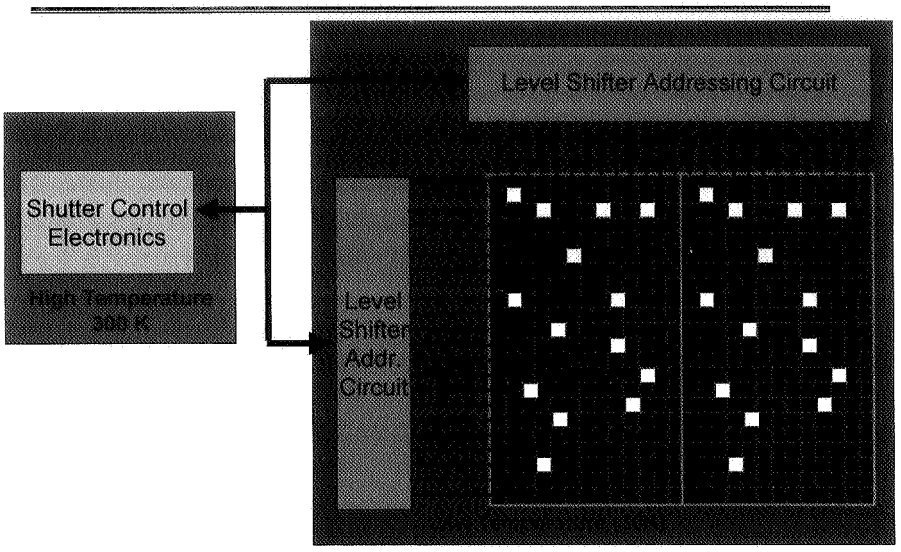
JWST Orbit



NIRSPEC Optics

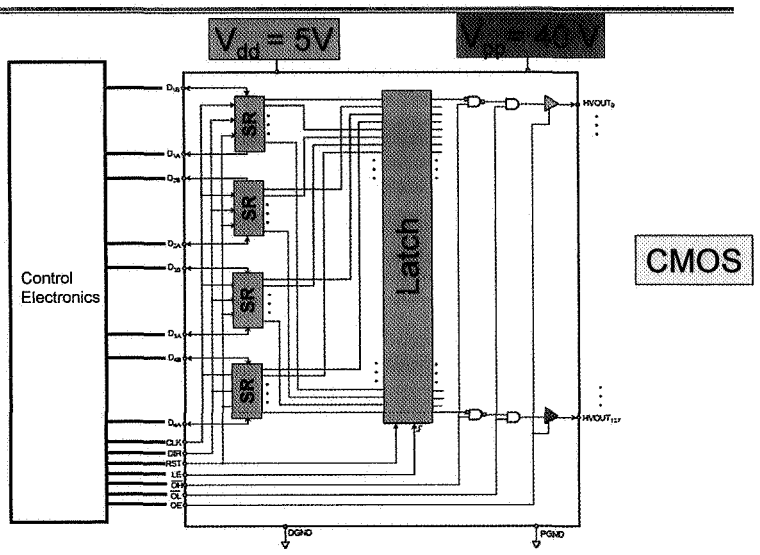


Electronic Circuit



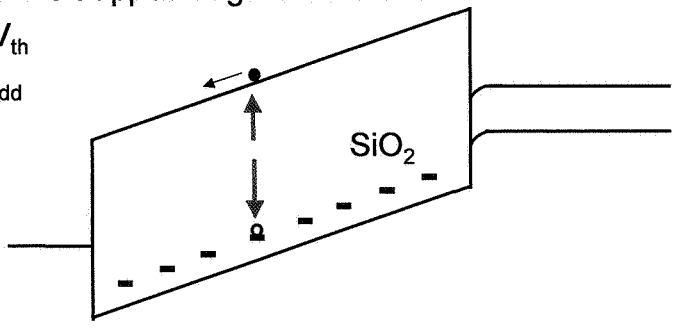
HV583 COTS

HV583 – COTS Part



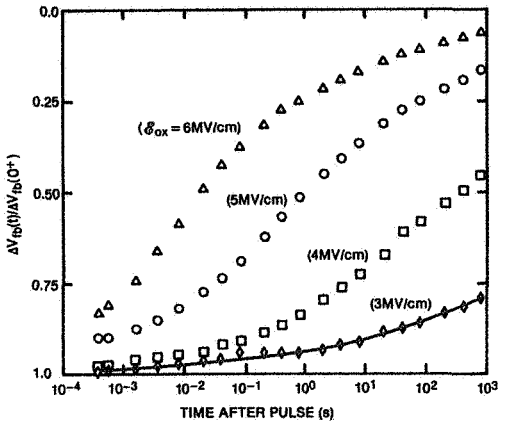
TID at 30 K

- TID Effects (1 μm process) in gate and field oxides.
  - Electrons exit oxide
  - Holes are trapped at generation site
    - o ΔV_{th}
    - o ΔI_{dd}



TID at 80 K

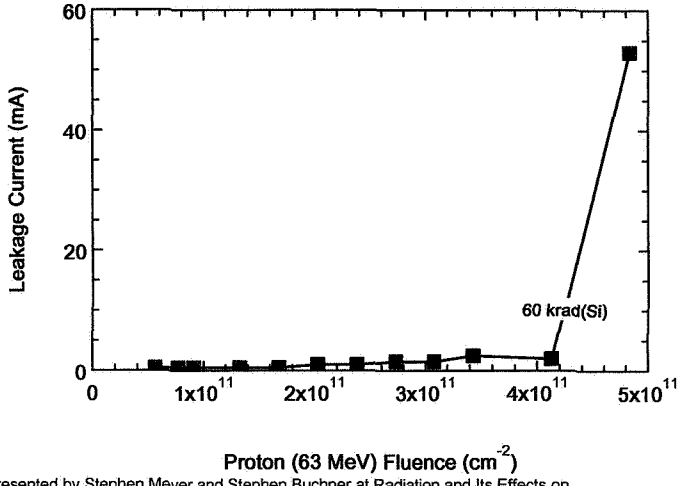
- Above approximately $3x10^6$ Volts/cm, the holes and protons are mobile.



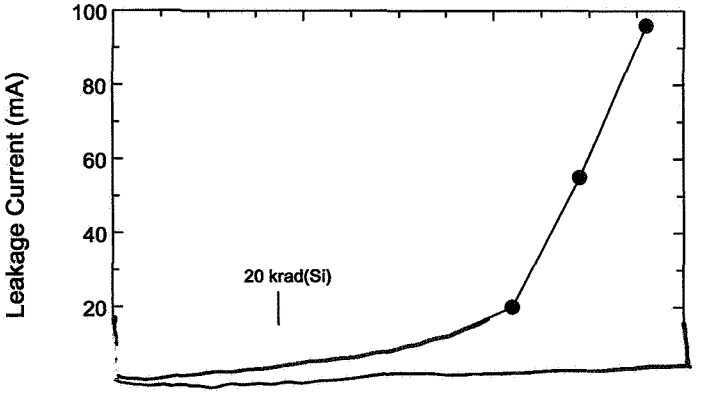
Proton (63 MeV) Testing

- Both TID and SEE at the same time
- Devices at 30 K during irradiation
- Heavy ion needed for Single Event Dielectric Breakdown (SEDB) test

Proton Test Results (40V)



Proton Test Results (5V)

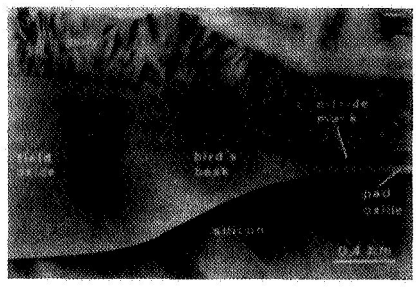


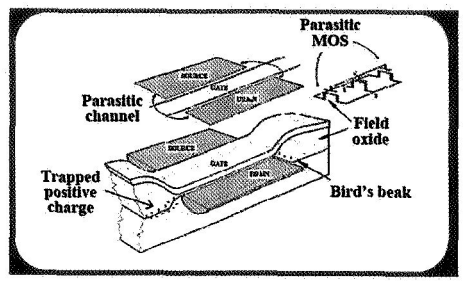
HV584
Redesigned Part

HV584 – Rad-Hard by Design

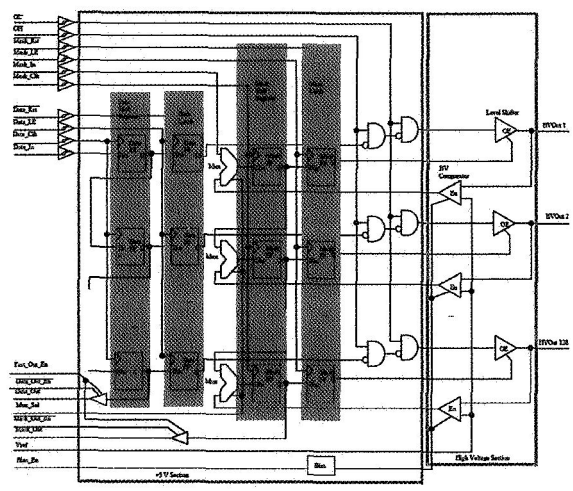
- Features
  - 1.0 μm, Single Poly/Double Metal, HV CMOS
  - Closed transistors via ion implantation to suppress leakage currents in "bird's beak" region of NMOSFETs
  - Gate oxide thickness reduced by 50%
    - 1100 Å for HV transistor (SEGR)
    - 200 Å for LV transistor
- Added Functions
  - Mask to isolate faulty outputs
  - Comparator to measure V_{out}

Leakage Current via Bird's Beak





HV584



TID Test

- Performed at 30 K in a dewar
  - Eight devices
- Co^{60} (gamma ray source)
  - Up to 200 krad(Si)
- Dose rate was ~7 krad(Si)/hr

I_{dd}(nA) – 5 V Supply

Total Current Through Eight Devices

Test #	0 krad	5 krad	10 krad	20 krad	50 krad	100 krad	200 krad
1	0	75	72	0	79	83	0
2	1	68	72	2	79	78	0
3	1	68	75	1	78	82	0
4	0	75	71	1	80	83	0
5	0	66	78	1	81	83	0
6	0	67	74	1	79	81	0
7	1	72	71	1	77	81	0
8	392	392	391	392	392	391	392
9	196	196	196	196	196	196	196
10	196	196	196	196	196	196	196
11	3	64	69	4	6	6	0

Tested While Irradiated with Gamma Rays

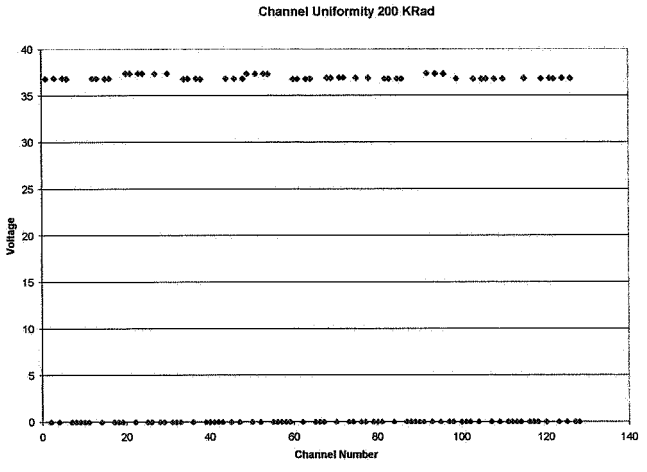
I_{pp}(nA) – 40 V Supply

Total Current Through Eight Devices

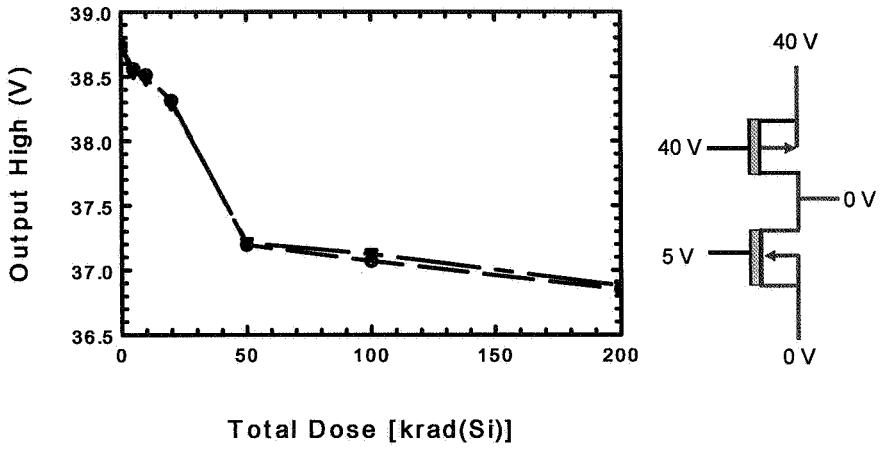
Test #	0 krad	5 krad	10 krad	20 krad	50 krad	100 krad	200 krad
1	0	63	64	1	80	67	6
2	0	67	64	0	57	67	11
3	0	92	80	12	80	86	4
4	0	74	66	5	70	77	3
5	0	67	64	0	68	70	2
6	0	68	64	0	68	63	2
7	1	67	63	2	69	75	2
8	0	64	75	1	68	73	2
9	0	67	68	2	68	72	3
10	0	65	67	1	68	72	2
11	0	62	66	1	68	71	2

Tested While Irradiated with Gamma Rays

Output Voltage after 200 krad(Si)



Output Low During Irradiation



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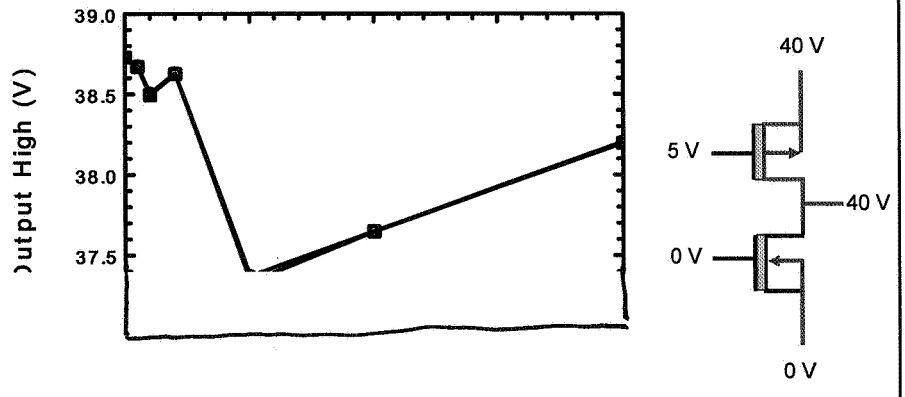
Output High During Irradiation



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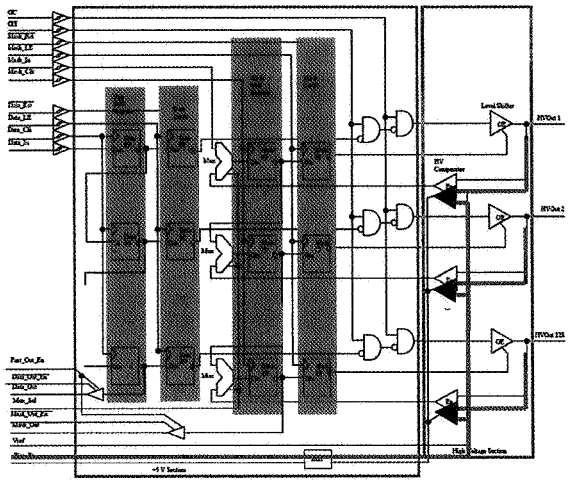
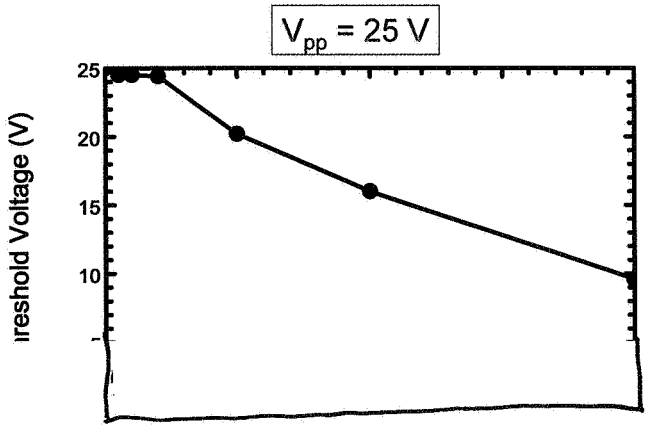
Output Voltage Measurement



V_{out} Measured by Comparator



Summary and Conclusions

- The original HV583 level shifter – a COTS part - was not suitable for JWST because the supply currents exceeded specs after 20 krad(Si)
- The HV584 – functionally similar to the HV583 – was designed using RHBD approach that reduced the leakage currents to within acceptable levels and had only a small effect on the level-shifted output voltage.