SELECTION AND ANALYSIS OF COTS POWER MANAGEMENT DEVICES UNDER RADIATION

DATE: NOVEMBER 2019
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COTS USE IN SMALL SATELLITE MISSIONS

- COTS components are being increasingly selected for small satellite missions
- Cost reductions are driving companies to make these selections
- In many cases, this can help reduce the cost of satellite production, while still maintaining high reliability
  - Automotive COTS products seem to be a good option here
- COTS devices, even automotive have no radiation assurance
- Power management applications are especially sensitive to radiation effects, specifically SEE
  - SEL/SEB can render a power management device un-usable and building in redundant power can be challenging
  - SET can potentially damage downstream devices and mitigation techniques can be limited
- Radiation testing and selection can be expensive and take a significant amount of time…and in many cases, the COTS devices still do not perform

COTS COMPONENTS TESTED FOR RADIATION

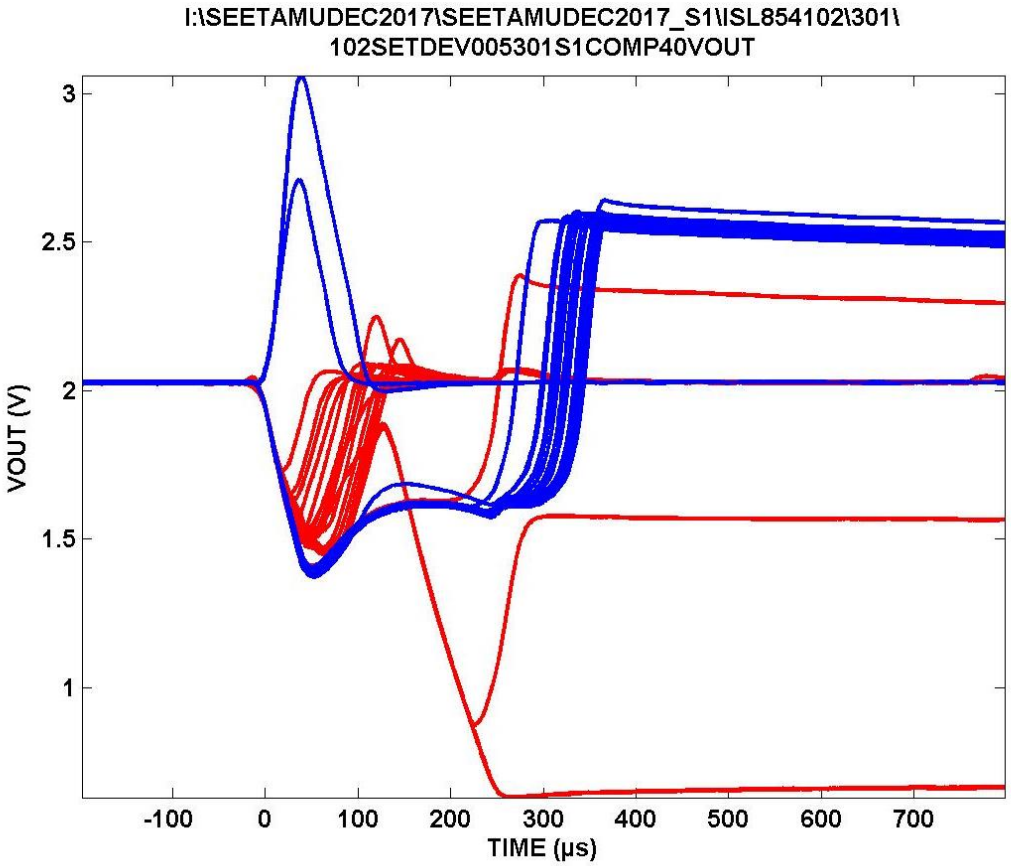
- List of parts tested for radiation
- Total Dose testing and SEE testing (performed at Texas A&M University)
- These products were selected based on fab process or radiation performance of similar parts
- Even with Intersil's background knowledge of the process and part design and experience with radiation effects , it can still be challenging to find COTS parts that have good radiation performance

Focus of the talk today

Part Number	Description	Issues Encountered
ISL85003	3A Synchronous Buck Regulator	SEB at 20MeV @ 3A load, V_{in} = 5V, V_{out} = 1.0V
ISL85033	24V point of load	4.3% V_{ref} shift by 30krad, 76% V_{in} derating at LET 43, 400mV deviations on the output
ISL85410	40V point of load	>80% derating on input at LET 43, continuous SEFI in latch state starting at LET 2.7V
ISL71123	Single Supply, SPDT Analog Switch	Non-functional < 20krad, switch stays open
ISL78600	Multi-Cell Li-Ion Battery Manager for 12 series stack cells	Catastrophic damage at LET 20V, derating below targeted battery stacks > 30V.

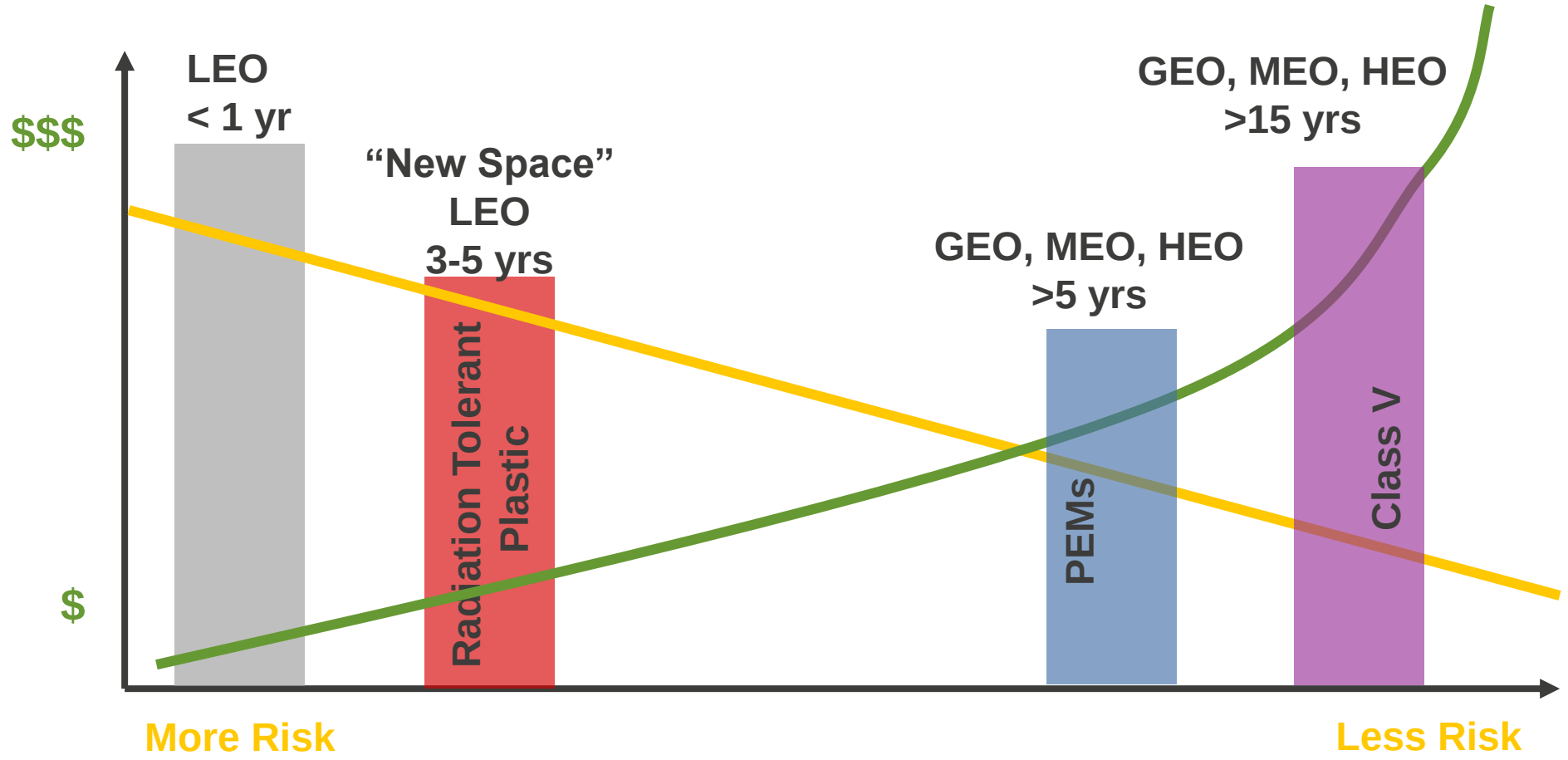
ISL85410

- Serves as a cautionary tale for cots devices in space for power management
- Initial radiation testing showed that the part could withstand up to 43MeV without SEL/SEB
  - Vin had to be de-rated from 40V (ISL85410) to 7V abs max, with an operating max of 5.5V
- Further SET testing showed significant transients at LET as low as 2.7MeV
- In light of this, we had no choice but to cancel the project
- In some cases, VOUT was supposed to be 2V but recovered after an ion strike where VOUT = 2.5V
  - This is destructive to downstream devices



RENESAS SPACE PLASTIC PRODUCTS

SUPPORTING THE BROAD SPECTRUM OF SPACE



MISSION PROFILES

Rad Tolerant Plastic

- Expected Life Cycle ≤ 5 years
  - Satellites will be replaced with system upgrades
- Low Earth Orbit (LEO)
  - Less Total Radiation exposure and less susceptible to heavy ion strikes
    - TID Target = 30krad(Si)
    - SEE Target = LET of 43MeV·cm^2/mg
- Cost Sensitive (Cost can be ~10%-20% of Class V in high volume)
  - Cost reduction areas
    - Plastic package vs. hermetic
    - Radiation characterized one time up front
    - No ongoing in-line quality monitors, i.e. burn in
    - Single temperature production testing (25C)

PEMs Plastic

- Expected Life Cycle > 10 years
  - Satellites will be more traditional, with new weight and size requirements
- Medium/Geosynchronous Earth Orbit (MEO/GEO)
  - High total radiation exposure
    - TID Target = 75-100krad(Si)
    - SEE Target = LET of 86MeV·cm^2/mg
- Not as cost sensitive
  - Cost reductions are nice, but not a primary driver
  - Board area savings are the driving factor
  - Ongoing RLAT, SEE up front characterization
  - 100% Burn-In and Temperature Cycle Testing
  - Lot level quality monitors
  - Tri-temp testing

RADIATION AND ELECTRICAL CHARACTERIZATION

- TID testing done at low rate, <10mrad/sec at facility in Palm Bay, FL
- Single event testing done at Texas A&M University
  - SEL/SEB up to 43MeV·cm^2/mg
  - SEU/SET potentially at lower LET levels
- 2 wafer lots electrical characterization done to full military temp range (-55C to +125C) target
  - Data analysis and statistics are used to set data sheet and final test limits, final test at 25C only

- For PEMs up-screened parts, the characterization process is the same as above
  - Radiation performance for TID is up to 75krad
  - SEL/SEB up to 86MeV cm^2/mg
  - Production tri-temp testing is included for higher reliability
  - Production flow follows AS6294/1 standard for plastic parts in space

RT PLASTIC QUALIFICATION TESTS

Test	Test Conditions	Lots	Samples/Lot
External Visual, Serialization	JSED22-B101	3	77
Preconditioning	JEDEC J-STD-020/JESD22 – A113	3	77
TCT	JESD22-A014, -65C to +150C for 500 cycles	3	77
HAST	JESD A101 +135C, 85% RH 96 hrs	3	77
HTSL	JESD22 A103 +150C, 1000 hrs	3	77
HTOL	JESD22 A108, +125C, 2000 hrs	3	77
MSL	JEDEC J-STD-033C	3	77
WBS	AEC-Q100-001 Wire Bond Shear	3	77
WBP	MIL-STD-883 Method 2011, Wire Bond Pull	3	77
Outgas	ASTM E595, 1.5 NASA Plastic Outgas	1	15
HBM/MM	AEC-Q100-002, AEC-Q100-003	1	3
CDM	AEC-Q100-011	1	3
LU	Latch Up JESD 78E	1	6

RT PLASTIC PRODUCT MANUFACTURING FLOW

Manufacturing

- Electrical acceptance testing based on WAT data
- No radiation wafer assurance testing
- Offshore assembly & test (non-China)
  - Plastic package and enhanced lead frame
- 25C electrical screening (w/ -55C to +125C guard banded limits)

Change control & single manufacturing site for both assembly & test

- Same as Enhanced Product (EP) flow in this regard

RENESAS SPACE PLASTIC ADVANTAGES

- High Reliability Materials
  - Lead frame: NiPdAg or NiPdAg-Au plated lead frame to mitigate tin whiskers
  - Bond wires: Gold only, not copper
  - Mold compound: High glass transition temperature
  - Assembly site: Automotive assembly lines in Southeast Asia
  - Passes NASA outgas testing
  - Full military temperature range, -55ºC to +125ºC
- Support
  - Renesas has many years of supporting customers in space applications
  - Can assist with electrical, quality, reliability and radiation related questions
  - Support is obtained through Hi Rel channels such as direct support or via rep firms
  - MOQ is 25 pieces
- Radiation Performance
  - Radiation testing done for SEB/SEL/SEU/SET and TID – leads to known rad tolerant devices

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