Radiation Tested Extended Common Mode LVDS Components

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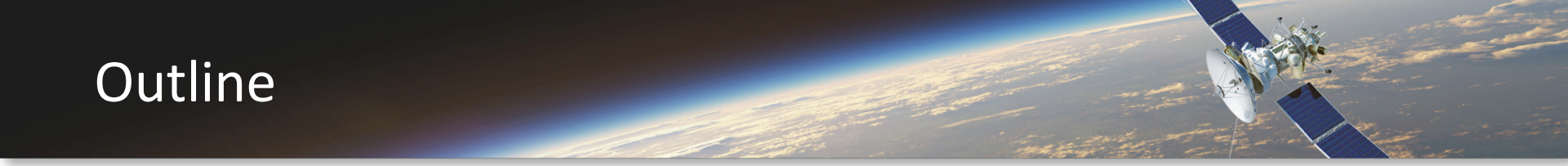
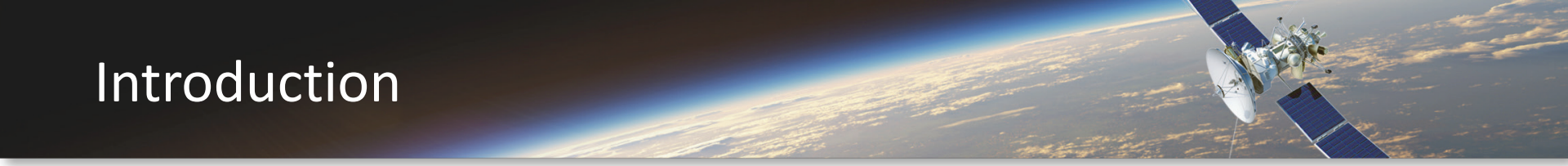
Outline



- Introduction
- Advantages of SOI
- Tested Components
- TID Test Results
- SEE Test Results
- Conclusion & Outlook

Introduction



Until 2013 | **From 2014**

TELEFUNKEN *Semiconductors*

Wafer Manufacturing

IC Products STOP

- Closure of IC product business

SPACE IC **rad-hard IC products**

- SPACE IC takes over development and manufacturing of rad-hard IC products (exclusive license)

Introduction

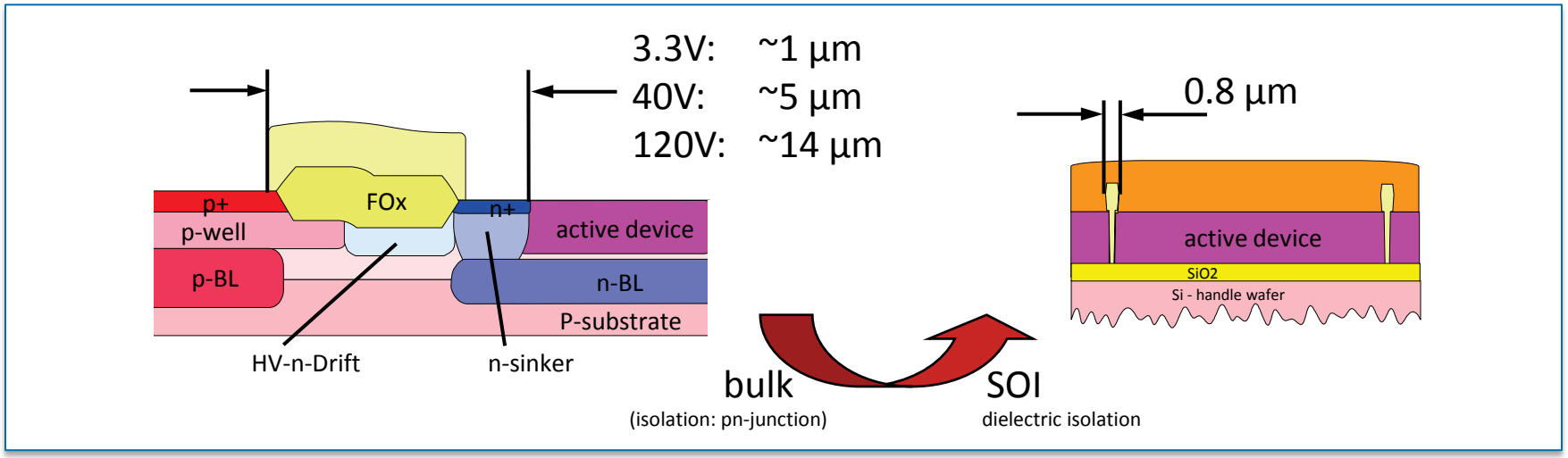
TELEFUNKEN Semiconductors

- SOI technologies: 0.35µm, 0.8µm
- Robustness: ≤ 200V, no latch-up
- Efficiency: LV & HV on die, isolation ≤ 100V
- Low power: low leakage, precise currents

SPACE IC

- ITAR free, high quality, radiation hard integrated circuits from Germany
- Power management and distribution
- Robust interfaces

Advantages of SOI



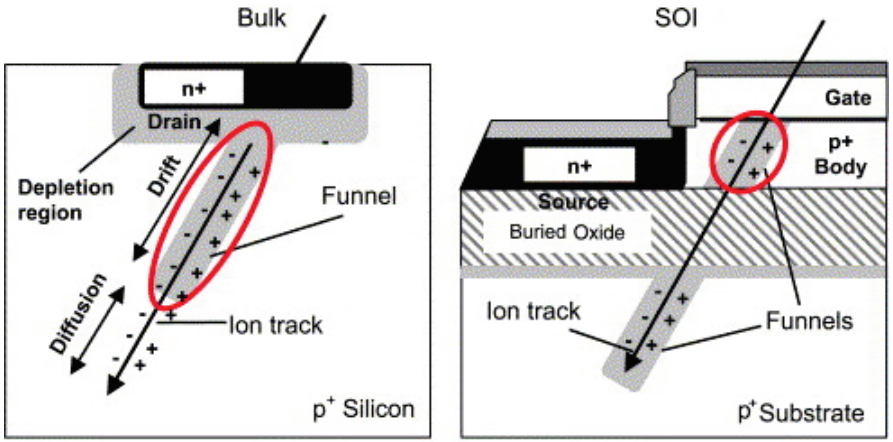
Full dielectric isolation with deep trench

- Enhanced integration density i.e. smaller chip size (more than 50% is possible)
- Superior leakage control
- Inherent prevention of latch-up

Reduced substrate coupling

- Enhanced device performance due to reduced parasitic coupling
- High voltage capability, device stacking and even negative well voltages

Radiation Effects on SOI

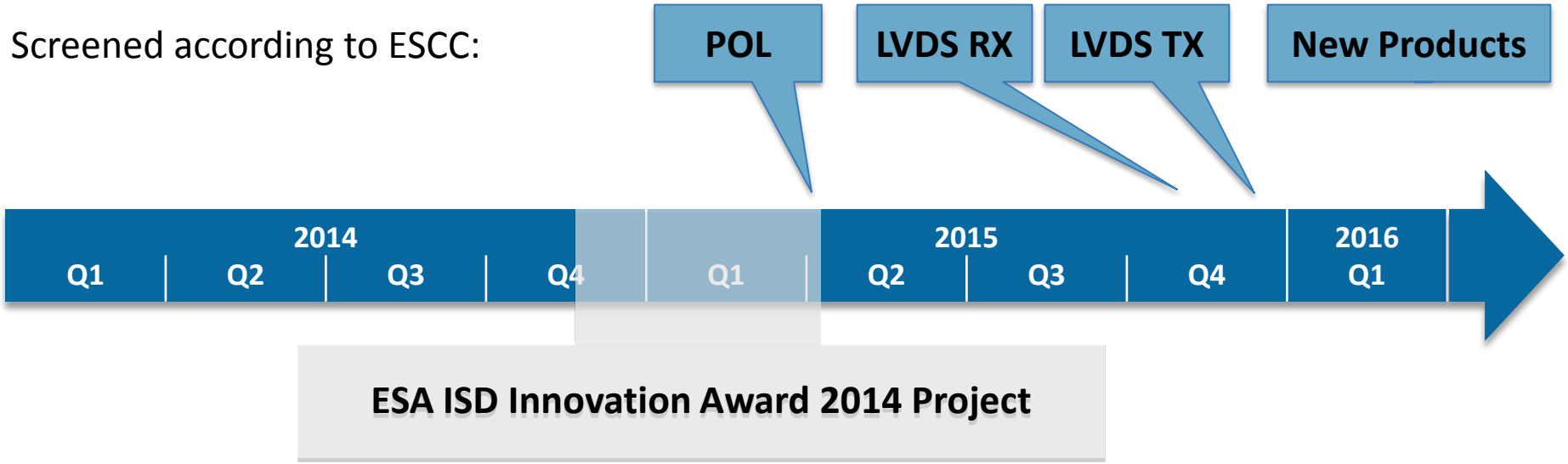


- SOI devices are known to be immune to SEL, which is a typical latch-up event triggered by prompt ionizing particles (ions, protons) entering into silicon.
- Other like SEB, SEGR, SET and others can also be mitigated by the use of SOI due to much smaller charge collection volume compared to bulk devices.
- The body tie improves the single event immunity of SOI by providing the possibility to divert generated charges to the device ground.
- TID effects are mainly relevant to the insulator properties.

Products & Availability

- Point-of-Load (POL) Converter **SPPL12420RH**
- Extended Common Mode LVDS Receiver **SPLVDS032RH**
- Extended Common Mode LVDS Transmitter **SPLVDS031RH**

Screened according to ESCC:



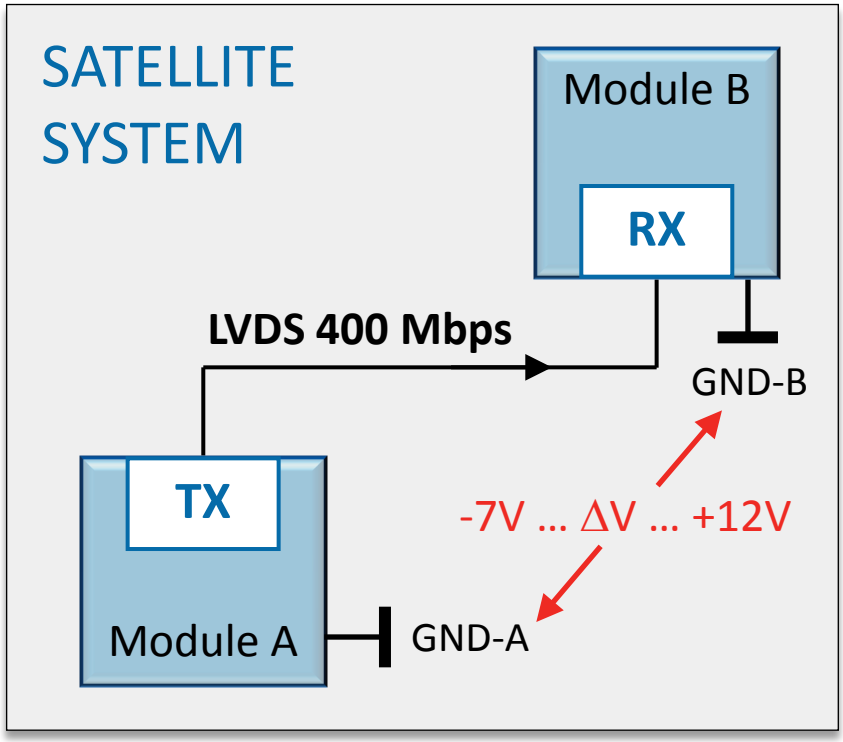
LVDS

Box-to-box communication

- Fast point-to-point data transfer with exceptional ground noise immunity

Advantages

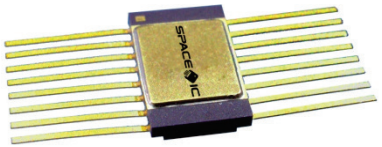
- Compliant to TIA/EIA-644-A
- Extended Common-Mode
- 400Mbps over single wire pair
- High voltage robustness
- Latch-up immunity

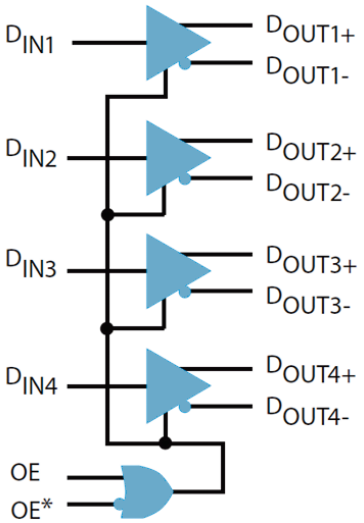


LVDS Driver SPLVDS031

Features:

- Ceramic hermetic flatpack package
- SOI technology
- 400Mbps quad LVDS line driver
- Low skew
- 23mA max supply current (loaded)
- ESD HBM >8kV
- -55°C to +125°C extended temperature range (target)

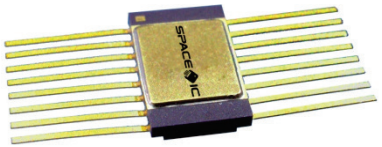


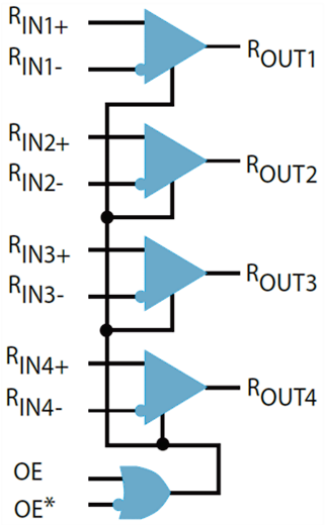


LVDS Receiver SPLVDS032

Features:

- Ceramic hermetic flatpack package
- SOI technology
- 400Mbps quad LVDS line receiver
- -7V to +12V extended common mode
- Low skew
- 7mA max supply current
- ESD HBM >8kV
- -55°C to +125°C extended temperature range (target)

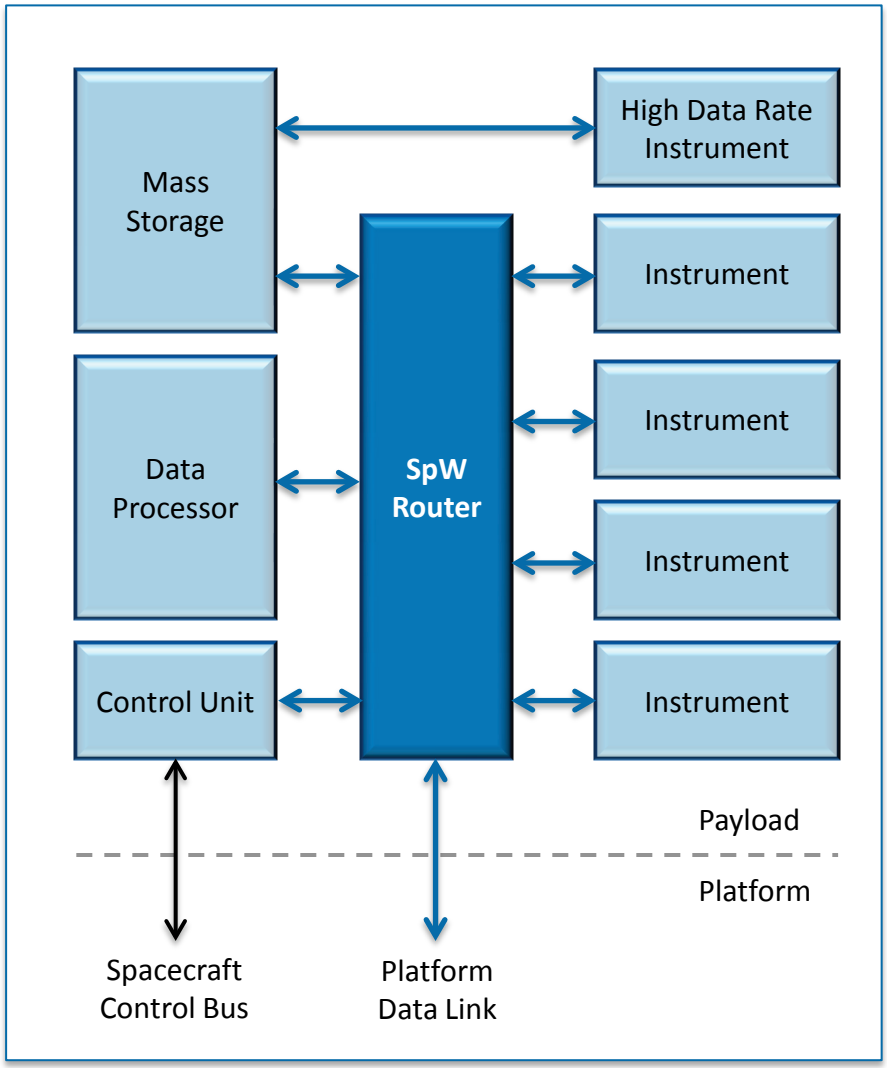




SPLVDS031 & SPLVDS032 Application

SpaceWire Networks:

- First application in space is for SpaceWire networks
- Initially with single point-to-point links between high-data-rate instruments and mass storage
- Rapid growing of SpaceWire usage on board a satellite in the unique type of bus / network present on the payload part of spacecraft
- Transfer of scientific data but also of housekeeping and command and control messages issued by the on-board computer (OBC)



SPLVDS031 & SPLVDS032
TID Tests

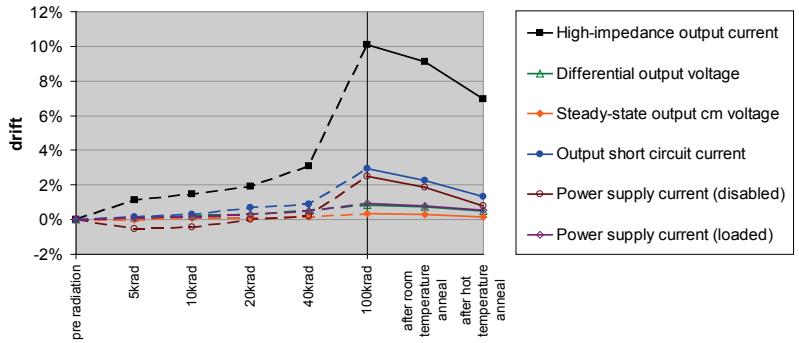
SPLVDS031

Conditions:

- TID without applied bias
- Dose rate: 75rad/min (^{60}Co source)
- Room temperature annealing
- Hot temperature annealing 100°C for 5h

Results:

- Minor shifts in key data sheet parameters after TID irradiation up to 100krad
- None of the specifications are violated
- All tested parts keep full functionality



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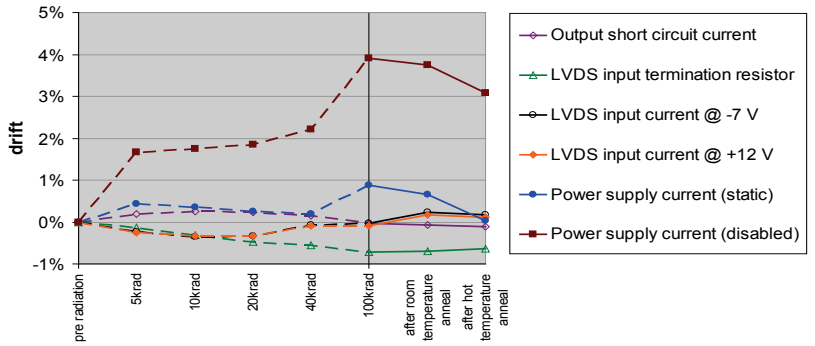
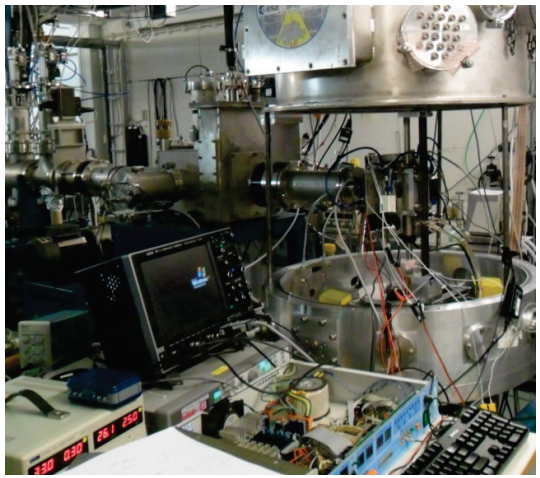
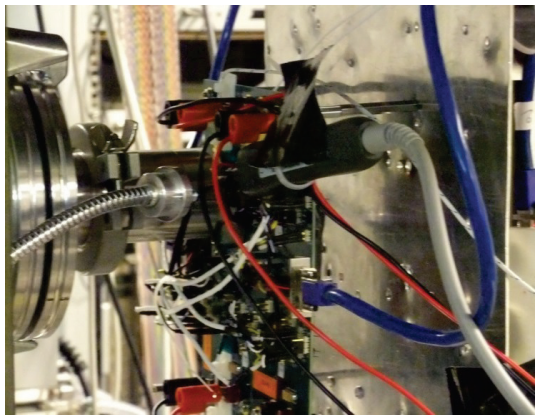


SPLVDS031 & SPLVDS032
Heavy Ions Test (I)

Test facility

- At RADEF located in the Accelerator Laboratory of the University of Jyväskylä (FIN) in June 2013
- Cyclotron used at JYFL is a versatile, sector-focused accelerator for producing beams from Hydrogen to Xenon
- Heavy ions exposure of an LVDS chain based on SPLVDS031 (driver) and SPLVDS032 (receiver) composing a SpaceWire transmission channel
- Driver and receiver have been irradiated separately

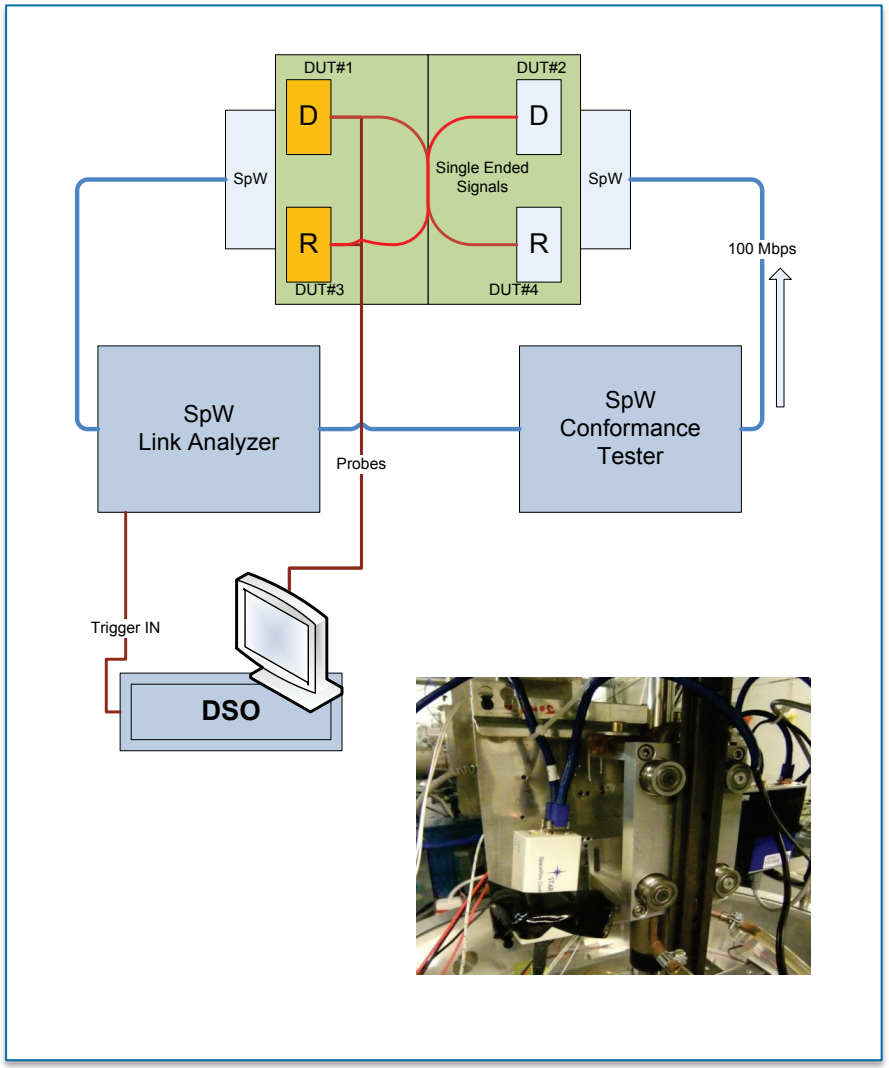




SPLVDS031 & SPLVDS032
Heavy Ions Test (II)

Test setups for 4 device ports

- Static test mode #0:
  " 1" and "0" set at one driver input and differential output monitored for SET. One receiver input unconnected and output monitored for SET
- Dynamic test mode #0:
  One driver and one receiver fed with clock and outputs monitored for duty cycle variation > 10-20%
- Dynamic test mode #1:
  2 ports used for SpW transmission (data & strobe) at 100 Mbit/s link speed fed and monitored by Star Dundee Conformance Tester and Link Analyzer



SPLVDS031 & SPLVDS032
Heavy Ions Test (III)

Irradiation

- Xenon, Krypton, Iron, Argon ions
- In air at normal direction (normal incidence)

Ion	Kinetic Energy in vacuum (MeV)	Kinetic Energy at DUT surf (MeV)	Air distance (mm)	Angle (degree)	Range (µm)	LET (MeV/mg/cm^2)
$^{40}Ar^{+12}$	372	295	20	0°	70	12.7
$^{56}Fe^{+15}$	523	408	10	0°	73	20.8
$^{82}Kr^{+22}$	768	570	10	0°	70	35.1
$^{131}Xe^{+35}$	1217	856	10	0°	65	65.2

- For each irradiation run a fluence of 5x10^6 ions/cm2 has been reached

Observations

- **No SELs** for both parts (up to 65.2 MeV/mg/cm^2, 75°C, 3.6V, 1x10^7 ions/cm^2)
- **Few SET** events during Xenon irradiation of **SPLVDS031** with LET of 65.2 MeV/mg/cm^2 (no effects on duty cycle, no disconnections, no parity errors)
- **SETs** at **SPLVDS032** receivers irradiated with Xe, Kr, Fe - not observed with Ar with LET of 12.7 MeV/mg/cm^2
  (disconnection / parity errors on the ports used for SpW link, but the communication with SpW protocol was still working)

SPLVDS031 & SPLVDS032
Heavy Ions Test (IV)

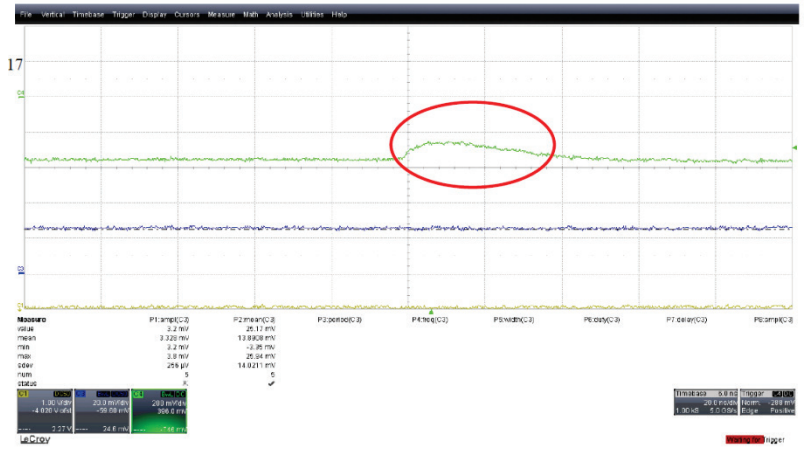
SPLVDS031

Conditions:

- Static test mode #0
- LET 65.2MeV/(mg/cm^2)

Results:

- No fails (SEL, SEGR, SEB)
- SET Event - small variation of output magnitude (<100mV, 25ns)



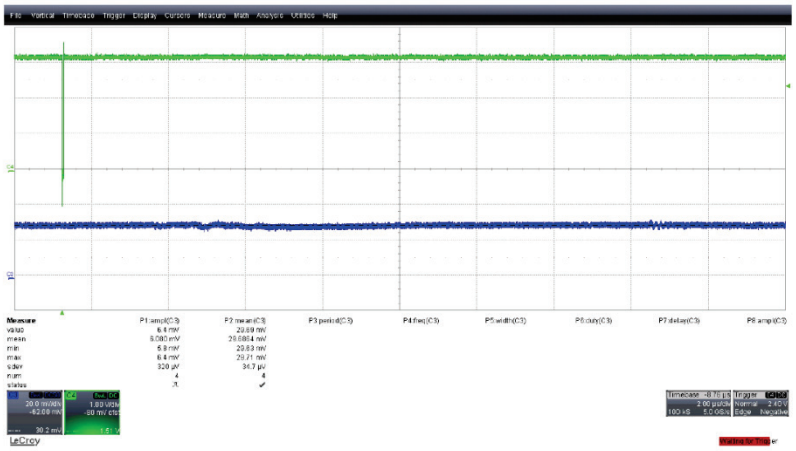
SPLVDS032

Conditions:

- Static test mode #0 (external fail-safe NW)
- LET 65.2MeV/(mg/cm^2)

Results:

- No fails (SEL, SEGR, SEB)
- SET event - single bit error



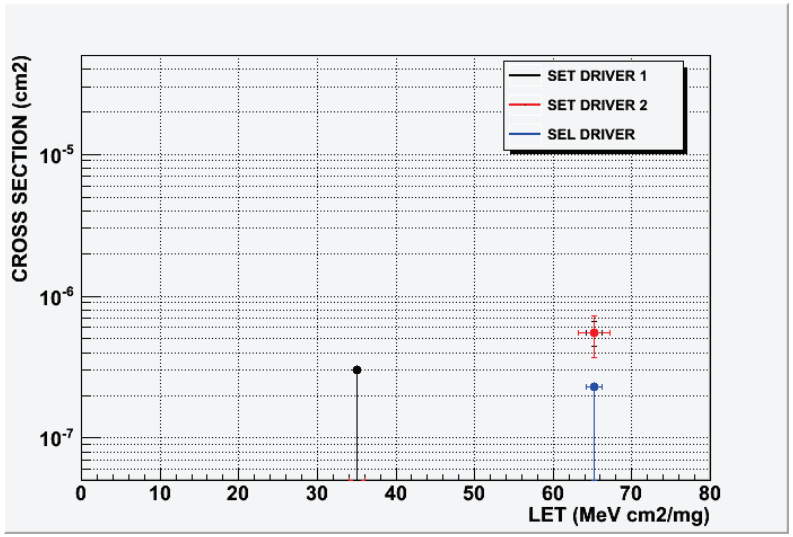
SPLVDS031 & SPLVDS032
Heavy Ions Test (V)

SPLVDS031

Conditions:

- Static test mode #0
- T = 75°C

SET cross section:



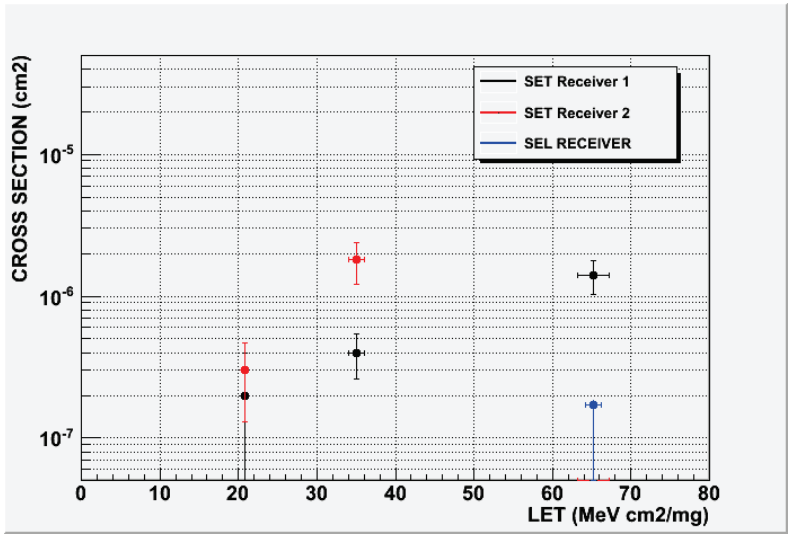
(The upper limit for SEL is represented by blue points.)

SPLVDS032

Conditions:

- Static test mode #0 (external fail-safe NW)
- T = 75°C

SET cross section:



(The upper limit for SEL is represented by blue points.)

SPLVDS031 & SPLVDS032
Heavy Ions Test (VI)

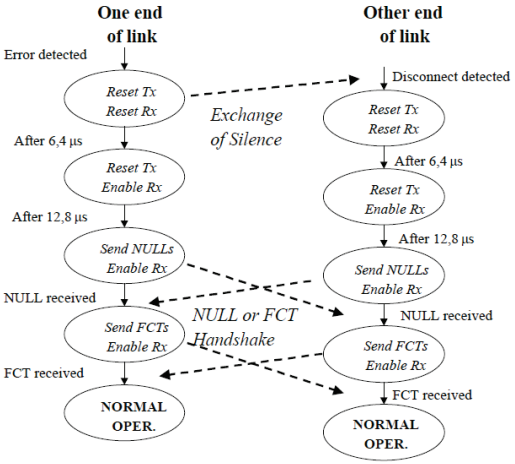
SpaceWire Link

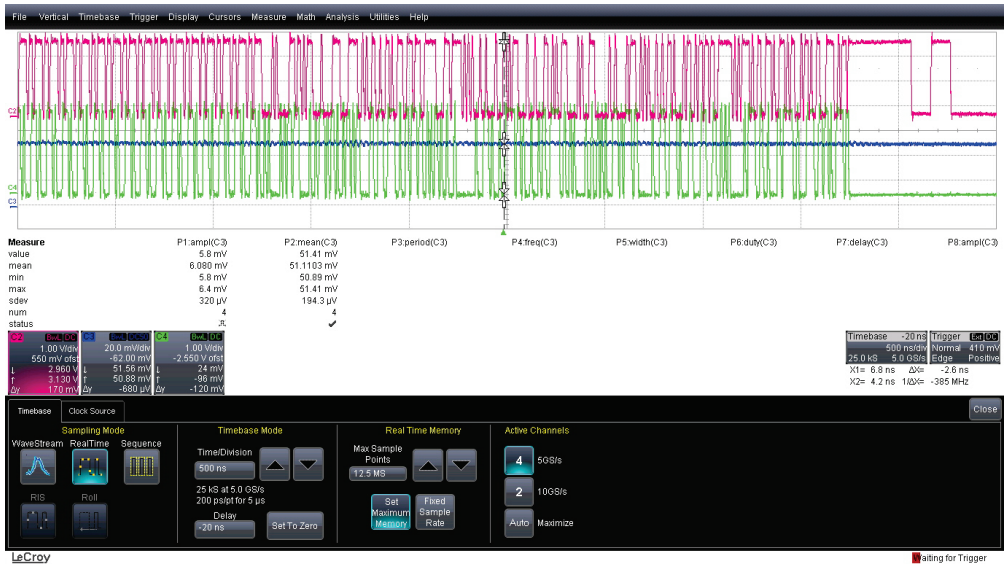
Conditions:

- Dynamic test mode #1: SpaceWire data and strobe signals (RX external failsafe NW)
- T = 25 °C

Results:

- SET disconnection on SpW RX
- Autonomous reset and return to normal operation mode





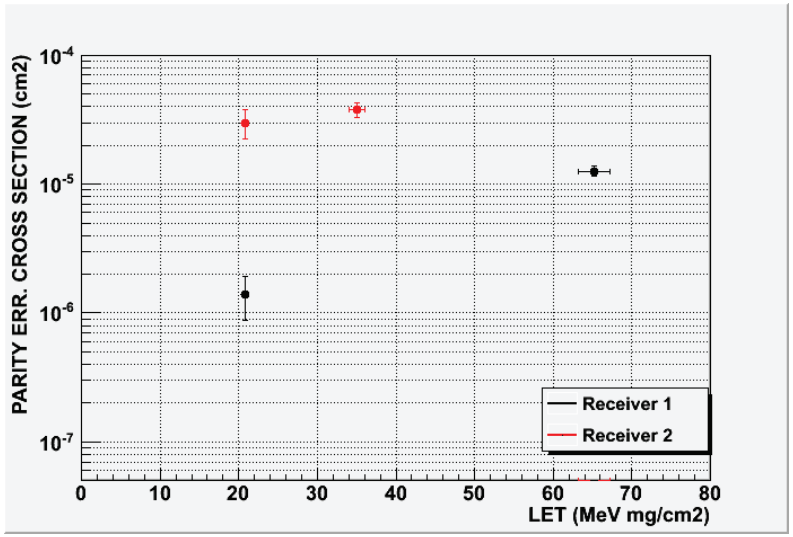
SPLVDS031 & SPLVDS032
Heavy Ions Test (VII)

SpaceWire Link

Conditions:

- Dynamic test mode #1:
  SpaceWire data and strobe signals
- T = 75 °C

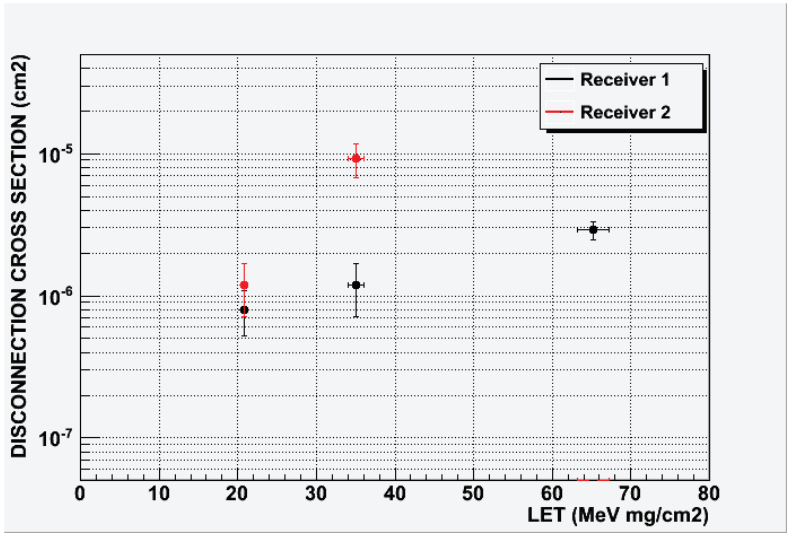
RX DISCONNECTION EVENT cross section:



Conditions:

- Dynamic test mode #1:
  SpaceWire data and strobe signals
- T = 75°C

RX PARITY ERROR cross section:

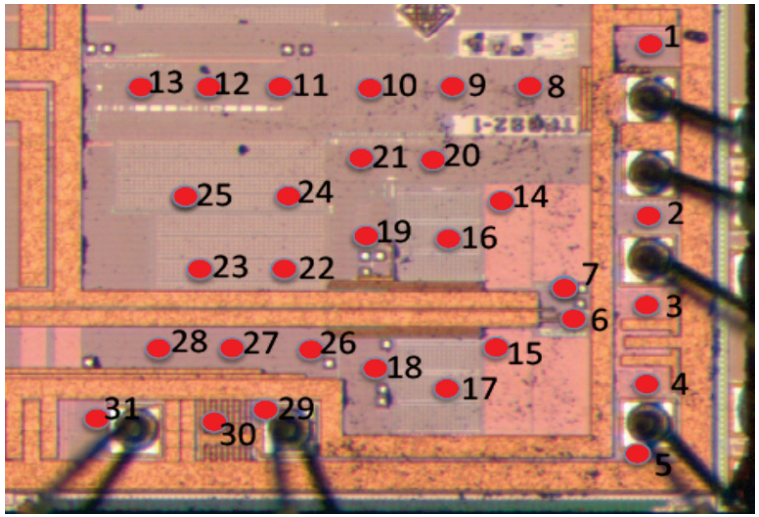


SPLVDS032
Laser Test

SPLVDS032 and prototype of improved LVDS RX

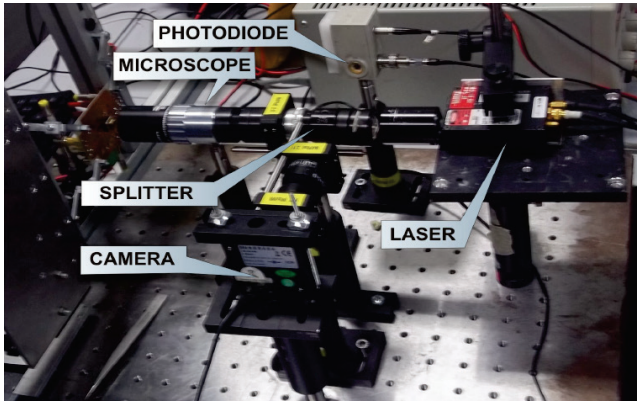
Conditions:

- Steady-state “1” (external fail-safe NW)
- Solid-state laser with 915nm wavelength
- Laser spot 5-10um
- Working distance of about 12mm
- Pulses length of 1us



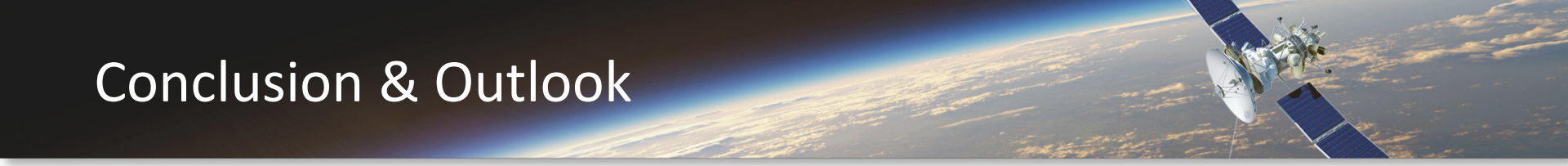
Results:

- No effects induced by the laser beam
- Supposed reason:
  The suspected sensitive areas (SETs) are the two capacitance areas at the differential inputs that are covered by a thin metallic layer



MAPRad

Conclusion & Outlook



- **Components show good SEE behavior**
  - SETs on SPLVDS031 don't influence SpaceWire communication
  - SETs on SPLVDS032 create data errors which are corrected by the SpaceWire protocol (link BER figures to be considered)
- **Further investigations on Extended Common Mode LVDS Rx**
  - Laser beam test didn't show any sensitivity – improved test intended
  - **The new design of the LVDS Rx by SPACE IC is subject to a new heavy ion test campaign in fall 2014**
- **Low dose rate TID test with applied bias will follow**

Thank you for your attention!

www.space-ic.com
www.esa.int