ISL7202XXSEH, ISL71026M

OVERVIEW OF INTERSIL CAN BUS TRANSCEIVERS
SET PERFORMANCE OF INTERSIL CAN TRANSCEIVERS IN A TWO NODE CAN BUS SYSTEM

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INTERSIL SPACE AND HI-RELIABILTY
RENESAS ELECTRONICS CORPORATION

PRESENTATION OUTLINE

CAN Bus Transceivers (QML Class V (space))

- ISL7202xSEH
- ISL7202xASEH (version "A")
  - Medium Speed Optimized for 500kbps Data Rates
  - Slow Speed Optimized for 250kbps Data Rates
  - Improved Driver Skew Performance

ISL71026M Radiation Tolerant Plastic CAN Bus Transceiver for Low Cost, Low Orbit, Short Duration Satellite/Space Applications

- Radiation Tolerant to 30krad(Si) & SEE Characterized
- 14Ld TSSOP Plastic Package
  - Tin (Sn) free lead finish with Ni/Pd/Au-Ag lead finish
  - Passes NASA Low Outgassing Specifications

SET Performance of Intersil CAN Transceivers in a Two Node CAN Bus System

ISL7202XSEH AND ISL7202XASEH QML CLASS V (SPACE) CAN TRANSCEIVERS

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INTERSIL RH QML CLASS V 3.3V CAN BUS TRANSCEIVER PRODUCT FAMILIES

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Released the First Class V Rad Hard CAN Bus 3.3V Transceiver Family in March 2016

Intersil worked closely with ESA and Airbus during development to define the parts

Six Transceiver Parts (LDR: 75krad (Si) and SEL/SEB:LET 86MeV at VCC≤5.5V and bus voltages of ± 20V)

- ISL72026SEH, ISL72027SEH, ISL72028SEH — Data Rates: 1Mbps, 250kbps, 125kbps
- ISL72026**A**SEH, ISL72027**A**SEH, ISL72028**A**SEH — Data Rates: 1Mbps, 500kbps, 250kbps

All Six CAN Bus Transceiver Parts are on the same SMD #5962-15228

Standards:

- ISO11898-2
- ECSS–E-ST-50-15C (May 1, 2015)

SMD, Evaluation Board, PSPICE Model, TID Report, SEE Report, and White Paper are Available

BIG IDEAS FOR EVERY SPACE

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INTERSIL 3.3V CAN BUS TRANSCEIVER FAMILY

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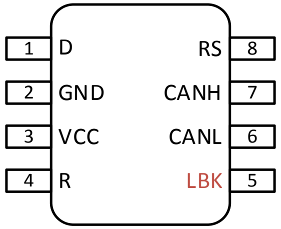
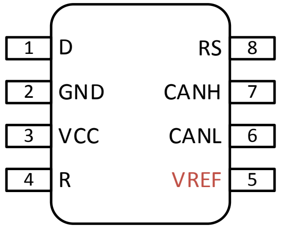
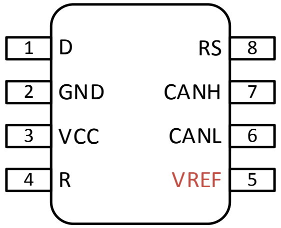
ISL72026SEH / 26ASEH
Listen Mode & Loopback



ISL72027SEH / 27ASEH
Listen Mode & Split Termination



ISL72028SEH / 28ASEH
Low Power Mode & Split Termination



Features

Operating Supply Range 3V to 3.6V

Bus Fault Protection up to ±20V

120 Nodes over Common Mode Range = -7V to +12V

Cold Spare Capable to Support Redundant Systems

Current Fold Back OC Protection

Programmable Driver Rise/Fall Times

Radiation Tolerance

- 75krad(Si) LDR (ISL7202xSEH, ISL7202xASEH)
- No SEB up to 60MeV·cm^2/mg with ±20V Bus Pins & 5.5V VCC
- SEL Immune – BiCMOS SOI Process

Package = 8 ld. CDFP

ESD Safe
4kV HBM

<50µA
Low Power

ISO
ISO 11898-2 Compatible

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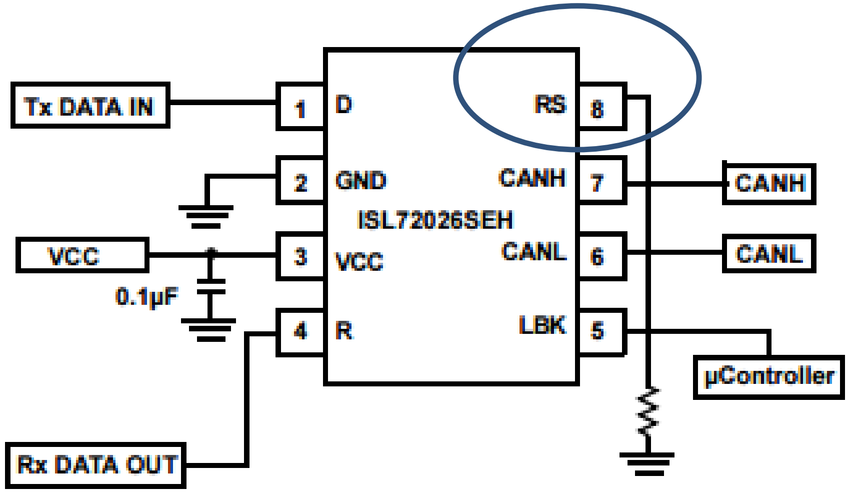
INTERSIL: RH 3.3V CAN BUS TRANSCEIVER FAMILY

Three Discrete Programmable Driver Speed Selection



Resistor to Ground on the RS pin determines Speed Grade

- RS = 0V (High Speed Mode – 1Mbps) Typical Driver Rise / Fall Times: 55ns / 25ns
- RS = 10kΩ (Medium Speed – 250kbps) Typical Driver Rise / Fall Times: 400ns / 300ns
- RS = 10kΩ (Medium Speed – 500kbps) Typical Driver Rise / Fall Times: 250ns / 250ns
- RS = 50kΩ (Slow Speed - 125kbps) Typical Driver Rise / Fall Times: 700ns / 650ns
- RS = 50kΩ (Slow Speed - 250kbps) Typical Driver Rise / Fall Times: 360ns / 390ns

Version A

Drive RS pin HIGH

- ISL72026SEH Listen Mode: TX Powered Down Supply Current: 2mA max
- ISL72027SEH Listen Mode: TX Powered Down Supply Current: 2mA max
- ISL72028SEH Shutdown Mode: TX and RX Powered Down Supply Current: 50µA max

ISL7202XASEH VS ISL7202XSEH

Parameters	ISL7202xSEH		ISL7202xASEH	
	Medium Speed	Slow Speed	Medium Speed	Slow Speed
Data Rate	250kbps	125kbps	500kbps	250kbps
Prop Delay L->H (ns)	520	850	350	475
Prop Delay H->L (ns)	460	725	410	550
Skew (ns)	60	110	60	75
Rise Time (ns)	400	700	250	360
Fall Time (ns)	300	650	250	390
Total Loop Delay (ns) Dom to Rec	500	750	450	575
Total Loop Delay (ns) Rec to Dom	550	850	380	500
Max Cable Length (m) - 85% SP, 5ns/m cable	165	400	50	150

ISL71026M RADIATION TOLERANT PLASTIC CAN BUS TRANSCEIVER

POWERING THE NEXT GENERATION OF SATELLITE CONSTELLATIONS

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PROGRAM PROFILE FOR NEXT GENERATION SATELLITE CONSTELLATIONS

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Program Profile

- Expected Life Cycle ≤ 5 years
  - Satellites will be replaced with system upgrades

- Total radiation exposure = 10 - 30krad(Si)
  - Margin may be needed, devices may need to meet as high as 60krad(Si)

- SEE expectations = LET of 30 – 43MeV·cm^2/mg
  - Non-destructive SEE can be typically handled with redundancy, EDAC, filtering, etc.
    – Adds system level design complexity and cost
    – May not even be fully effective
  - Destructive SEE causes early termination of satellite life cycle

ISL71026M | RADIATION TOLERANT CAN BUS TRANSCEIVER

Key Specifications

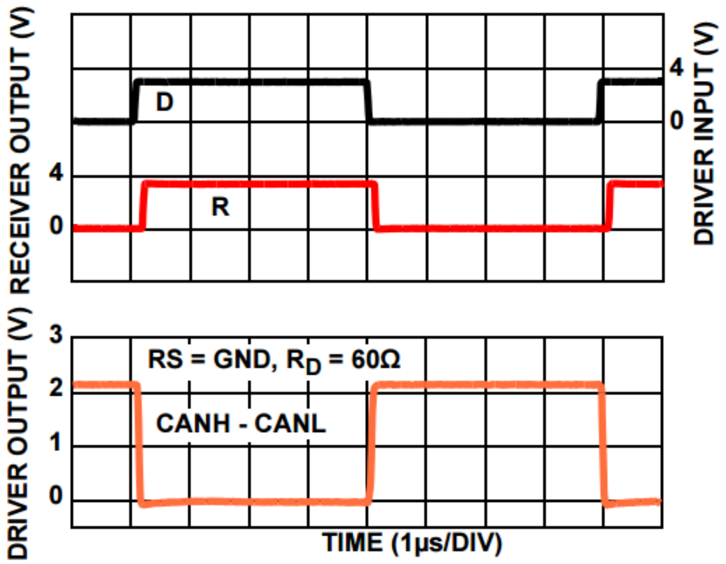
- Operating Supply Range: 3V to 3.6V
- Low Operating current: 7mA
- Compatible to ISO 11898-2
- Bus fault protection up to ±20V
- Loopback and listen mode

Package

- 5mm x 4.4mm , 14-lead TSSOP

Benefits

- Radiation tolerant to 30krad(Si) & SEE characterized
- Ideal for N+1 applications with cold spare capability
- Selectable rise/fall times for optimal bus performance
- Wide common mode range to allow for ground shifts



FAST DRIVER AND RECEIVER WAVEFORMS

RADIATION TOLERANT PLASTIC PRODUCT LINE QUALIFICATION CRITERIA

One time characterization to 30krad(Si) at a dose rate of ≤10mrad/sec.

SEE characterization for destructive and transient events

2 lot temperature characterization to -55C and +125C

- To set datasheet limits

Automotive “like” qualification

- 2000 hours of life test
- Moisture resistance test (MRT)
- 500 Temperature Cycles (-55C to +125C)
- Unbiased HAST
- Biased HAST
- 1000 hour Storage life
- +125C latch-up and ESD
- Surface mount leaded packages with NiPdAu finish

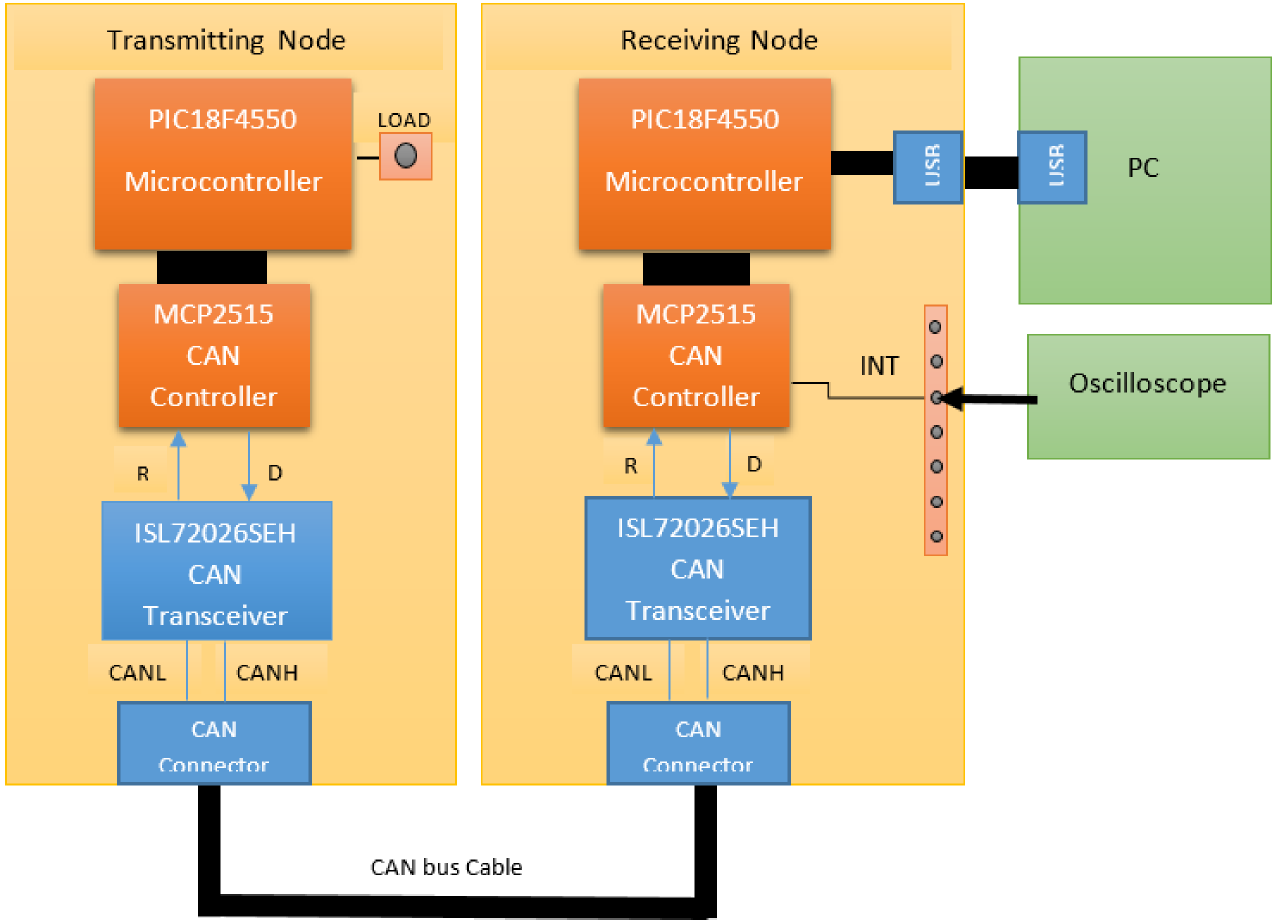
INTERSIL RADIATION TOLERANT (RL) PLASTIC PRODUCTS INITIATIVE

RL Plastic Parts Current Released:

- **ISL71026MVZ 3.3V CAN Bus Transceiver – 14Ld TSSOP Package**
- ISL71001MNZ 6A Buck Regulator with Intergrated MOSFETs – 64Ld TQFP Package
- ISL71444MVZ Quad Op-Amp – 14Ld TSSOP Package
- ISL71010BMB25Z 2.5V Precision Voltage Reference – Package: 8Ld SOIC
- ISL71010BMB50Z 5.0V Precision Voltage Reference – Package: 8Ld SOIC
- ISL71218MBZ Dual Op-Amp – Package: 8Ld SOIC
- ISL71003M High Efficient 3A Buck Regulator – Package: 12Ld DFN
- ISL71915M Nano Power RRIO Comparator – Package: 6Ld SOT23
- ISL71710M and ISL71610M Digital Isolators – Package: 8Ld SOIC
- ISL71123M Single Supply SPDT Switch – Package: TBD

SEE PERFORMANCE OF CAN TRANSCEIVERS IN A TWO NODE CAN BUS SYSTEM

SEE TESTING OF A TWO NODE CAN BUS SYSTEM



SEE Two Node CAN bus System Block Diagram

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

SET Test Description

- The two-node CAN bus system consisted of a transmitting node and a receiving node that were connected together over a 10ft 120Ω cable.
- System under test was powered with VCC = 3.0V and 4.5V at an ambient temperature of approximately 25°C.
- The transmitting node CAN controller was programmed with a specific standard CAN data packet message. A timer in the PIC microcontroller was programmed to have the CAN controller output a CAN data packet every 200µs.
- Every CAN data packet message sent out on the bus was identical and was transmitted at a data rate of 1Mbps.
- The receiving node was programmed to receive/process the CAN data packet message and to send the packet contents over a USB connection to a GUI running on a PC. In addition, the receiving node CAN controller was programed to set an interrupt whenever an erroneous packet was identified by the controller.
- Testing was done at various LET levels while irradiating the Transmitting Node Transceiver and the Receiving Node CAN Transceiver separately. For each LET level applied the total number of packets were counted along with the number of packets that were received with errors. The counts were done over the time that the transceiver was exposed to the ion beam.
- Over all the irradiations the average packet rate was 5016 packets per second which resulted in ~ one million packets (mega-packet) per irradiation. Each irradiation was done with normal incidence to a fluence of 1×10^7ion/cm^2 at a flux of approximately 5×10^4ion/(s·cm^2).

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

SET Testing Procedure:
The transmitting node CAN transceiver and the receiving node CAN transceiver of the two-node CAN bus link are irradiated separately. A transceiver is exposed to the ion beam while the system is running (Load pin = High).

CAN Transceiver Testing at the Transmitting Node:
Testing is done at various LET levels while irradiating the Transmitting Node Transceiver. For each LET level applied the total number of packets are counted along with the number of packets that were received with errors. The counts are done over the time that the transceiver is exposed to the ion beam.

CAN Transceiver Testing at the Receiving Node:
Testing is done at various LET levels while irradiating the Receiving Node Transceiver. For each LET level applied the total number of packets are counted along with the number of packets that were received with errors. The counts are done over the time that the transceiver is exposed to the ion beam.

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

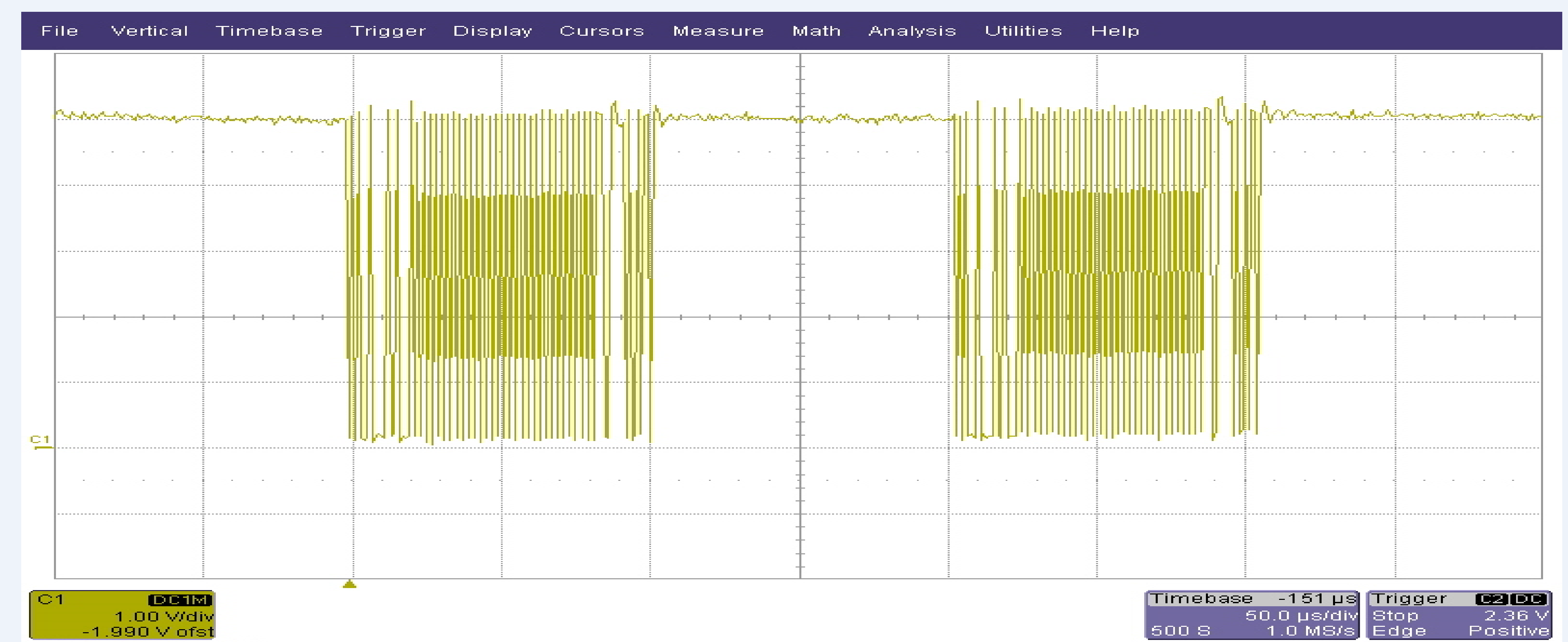


Figure 2: Scope plot of two data packets

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

Figure 3: Scope plots of the system CAN data packet at the transmitting node (yellow trace) and the receiving node (blue trace)

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

Packet Bits 0 -19																			
SOF	11 bit Identifier											RTR	Stuff Bit	IDE	RO	DLC			
0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0
Packet Bits 20 - 39																			
Data Byte 1								Data Byte 2								Data Byte 3			
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Packet Bits 40 - 59																			
Data Byte 3				Data Byte 4								Data Byte 5							
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Packet Bits 60 - 79																			
Data Byte 6								Data Byte 7								Data Byte 8			
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Packet Bits 80 - 99																			
Data Byte 8				CRC									Stuff Bit	CRC					
0	1	0	1	1	1	0	0	1	1	1	1	1	0	1	0	0	1	0	1
Packet Bits 100 - 117																			
CRC DEL	ACK	ACK DEL	EOF							IFS									
1	*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
*Note: The receiving node overwrites the transmitting node recessive bit (1) with a dominant bit (0) to indicate to the transmitting node that an error-free message has been received.																			

Table 1: CAN data packet bit values and packet frame definitions

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

Irradiated DUT	Species & LET ($MeV \cdot cm^2/mg$)	VCC (V)	Packet Errors	Ion Beam Time (s)	Mega Packets	Errors per Mega Packet	Cross Section (cm^{-2})
DUT1	Au 86	3	6	241	1.23	4.87	6E-07
		4.5	1	277	1.40	0.71	1E-07
DUT3		3	4	204	1.03	3.90	4E-07
		4.5	0	231	1.15	0.00	0
DUT5		3	5	213	1.07	4.68	5E-07
		4.5	0	202	1.01	0.00	0
DUT7		3	6	220	1.10	5.45	6E-07
		4.5	0	226	1.12	0.00	0
DUT9	Ag 43	3	6	200	1.01	5.95	6E-07
DUT11			2	198	0.99	2.02	2E-07
DUT13			6	211	1.07	5.61	6E-07
DUT15			5	210	1.05	4.77	5E-07
DUT17	Cu 20		0	185	0.96	0.00	0
DUT19			0	206	1.02	0.00	0
DUT21			0	197	1.00	0.00	0

Table 2: Packet error results from irradiating the transmitter of the CAN transceiver pair while sending a continuous stream of packets.

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

Irradiated DUT	Species & LET (MeV·cm²/mg)	VCC (V)	Packet Errors	Ion Beam Time (s)	Mega Packets	Errors per Mega Packet	Error Cross Section (cm^{-2})
DUT2	Au 86	3	4	239	1.20	3.34	4E-07
		4.5	0	240	1.20	0.00	0
DUT4		3	4	232	1.16	3.45	4E-07
		4.5	0	189	0.94	0.00	0
DUT6		3	4	199	1.00	4.00	4E-07
		4.5	0	201	1.01	0.00	0
DUT8		3	3	202	1.01	2.96	3E-07
		4.5	0	193	0.97	0.00	0
DUT10	Ag 43	3	5	200	1.01	4.94	5E-07
DUT12			2	203	1.03	1.95	2E-07
DUT14			4	205	1.02	3.92	4E-07
DUT16			2	202	1.01	1.98	2E-07
DUT18	Cu 20		0	199	1.02	0.00	0
DUT20			0	213	1.02	0.00	0
DUT22			0	203	1.00	0.00	0

Table 3: Packet error results from irradiating the receiver of the CAN transceiver pair while sending a continuous stream of packets.

SEE TESTING OF A TWO NODE CAN BUS SYSTEM

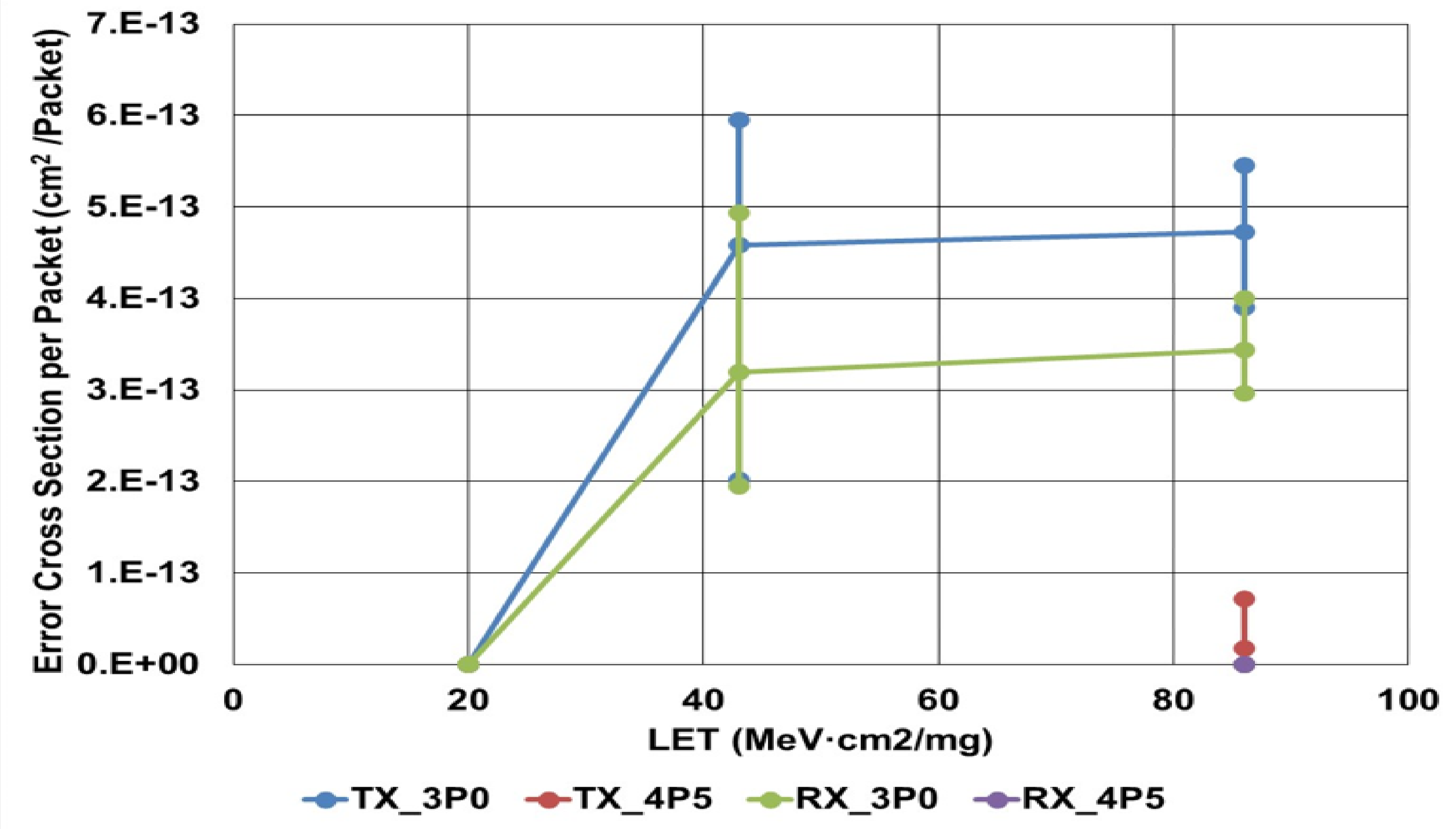


Figure 4: Chart of the error cross section per packet. The means at each LET are connected while the minimum and maximum at each LET are also plotted vertically.

SINGLE EVENT EFFECTS (SEE) PERFORMANCE

Destructive SEE test summary

- No SEL (single event latch-up) or SEB (single event burnout) for ions with 86MeV•cm^2/mg while operating at or below the voltages of VCC = 5.5V and bus common-mode voltages of ±20V.

Single Event Transients (SET) summary

- Transmitter more prone to inducing a packet error than the receiver.
- No transmitter or receiver SET packet errors detected for LET = 20MeV•cm^2/mg out of 1 million packets transmitted.
- Transmitter (VCC = 3V) SET packet errors detected for LET = 43MeV•cm^2/mg and 86MeV•cm^2/mg out of 1 million packets send per irradiation resulted in a worse case error cross section of 6x10^{-13} cm^2/packet with a mean cross section of 4.7x10^{-13}cm^2/packet.
- Receiver (VCC = 3V) SET packet errors detected for LET = 43MeV•cm^2/mg and 86MeV•cm^2/mg out of 1 million packets send per irradiation resulted in a worse case error cross section of 5x10^{-13} cm^2/packet with a mean cross section of 3.14x10^{-13}cm^2/packet.
- Testing with Au at 86MeV-cm^2/mg and V_{CC} = 4.5V did not yield any packet errors on 3 of the 4 parts tested and only 1 error on the 4th part, so testing with Ag (43MeV-cm^2/mg) and Cu (20MeV-cm^2/mg) was only done at V_{CC} = 3V. Accordingly, the 3V data was chosen to analyze.

SINGLE EVENT EFFECTS (SEE) PERFORMANCE

Single Event Transients (SET) summary continue

- CRÈME96 LET spectrum files were generated for a satellite in a geosynchronous orbit and a low earth orbit of 1100km at a 45 degree inclination, using all species of heavy ion particles (atomic numbers 2 – 92) with a minimum energy value of 0.1MeV/nuc and solar minimum conditions (worst case for long-term cosmic rays). 100 mils of Aluminum shielding was assumed for both cases.
- Based on the 3V SET test results, Weibull parameters were estimated. These parameters, along with the appropriate LET Spectrum file, were used to obtain the heavy ion error rates per mega-packet for the transmitter and receiver operating at 1Mbps, as shown in Table 1, for the 2-node CAN system. Of course in a complete multi-node bus system (e.g., nine receivers and one transmitter) all nodes are subject to irradiation at the same time, so the error rates per packet would have to be summed accordingly to give a complete bus error cross section per packet.

Table 1. Two-Node System Error Rates per Mega-packet for GEO and LEO Missions

	Low Earth Orbit		Geosynchronous Orbit	
	Transmitter	Receiver	Transmitter	Receiver
Errors/device/day	1.29519E-09	1.05560E-09	1.63688E-07	1.35818E-07
Errors/device/year	4.73068E-07	3.85558E-07	5.97870E-05	4.96075E-05

For a LEO mission a system with 25 nodes would experience a transmit error to heavy ion exposure no more than once every 9,889 years.

For a GEO mission a system with 25 nodes would experience a transmit error to heavy ion exposure no more than once every 769 years.

THANK YOU

BACK UP SLIDES

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FAQ: CALCULATING MAX CABLE LENGTH?

Length of cable that can be driven in actual CAN System Depends ON

- Data Rate, Cable Delay (5ns/m to 6ns/m) , Transceiver: Driver Prop Delay + Receiver Prop Delay or Total Loop Delay, Bit Sampling Point (75% to 85% of the bit width)

Formula:

- 2(Tpcable + Tpdriver + Tpdreceiver) = (Tpcable + TLD) ≤ SP
  - Where:
    - Tpcable = cable propagation delay, in nsec
    - Tpdriver = driver propagation delay, in nsec
    - Tpreceiver = receiver propagation delay, in nsec
    - TLD = transceiver total loop delay, in nsec
    - SP = bit width sample point, in nsec
- Tpcable = [(SP/2) – (Tpdriver – tpreceiver)] = [(SP/2) – (TLD)]

Max Cable Length (m) = Tpcable x V where v = speed of the signal in m/nsec

FAQ: CALCULATING MAX CABLE LENGTH?

intersil

Example Calculation:

- Given: 1Mbps, 5ns/m cable, Sample Point: 80%
- Step One: Calculate the sample point:
  - SP = 1us x 0.80 = 800ns
- Step Two: Find Total Loop Delay in Transceiver Data Sheet

Total Loop Delay, Driver Input to	$t_{(LOOP2)}$	RS = 0V, Figure 17	Full	-	130	270	ns

- Step Three: To calculate max cable length - Put SP (ns), TLD (ns), and 1m/5ns into formula.
  - Max Length Cable (m) = [(800ns/2) – (270ns)] x (1m/5ns) = 26m

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ISO 11898–2 COMPATIBLE VS COMPLIANT

The Intersil rad hard CAN transceivers are not fully compliant with ISO11898-2 standard. They are compatible with the standard and meet the key electrical specifications of the standard.

The Intersil parts are essentially compliant to Table 1, Table 2, Table 4, Table 5 and Table 6

- Exceptions
  - Table 5: The output bus voltage minimum for CAN_H is 2.25V vs. the ISO Spec of 2.75V and CAN_L is 0.1V vs. the ISO spec of 0.5V
  - Table 6: Typical Cin is 35pF and Cdiff = 15pF vs. ISO typical values of 20pF and 10pF

We are not compliant with Table 3 where it states for a battery voltage of 24V, the voltage at CANH and CANL must tolerate 32V.

- Our parts can handle ±20V on the bus lines with ±18V under beam (this is acceptable with ESA spec.).

For Table 12 “Bus failure detection”, Intersil worked with the ESA to identify the requirements for Table 12 for space applications

- See ECSS-E-ST-50-15C (May 1, 2015) Section 5.3.3 on pages 33 - 38.

COLD SPARE CAPABILITY

Reliability is an essential requirement in space applications and single point failures must be avoided

To achieve a high reliable communication system a node will use two CAN transceivers in parallel

One transceiver will be active while the other transceiver will be a cold spare (in a powered down condition)

The cold spare transceiver gets used if the active transceiver malfunctions

Intersil CAN transceivers when in the powered off state does not affect the communication on the bus and present a high impedance between the bus and the system supply rail > 2MΩ (typical)

REFERENCE DOCUMENTATION

ECSS-E-ST-50-15C (May 1, 2015) created by European Space Agency (ESA) to standardize the CAN communication protocol for space applications. It does not modify the basic CAN network specification and complies with IS0 11898-1/-2:2003. It does define protocol extensions needed to meet spacecraft specific requirements. http://ecss.nl/

http://www.intersil.com/content/dam/Intersil/whitepapers/rad-hard/using-can-bus-in-space-flight-applications.pdf

Intersil CAN Transceiver Data Sheets:
http://www.intersil.com/content/dam/intersil/documents/isl7/isl72026seh.pdf
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http://www.intersil.com/content/dam/intersil/documents/isl7/isl72028seh.pdf

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