Application Brief

Space-Grade, 30-krad, Isolated CAN Serial Transceiver Circuit

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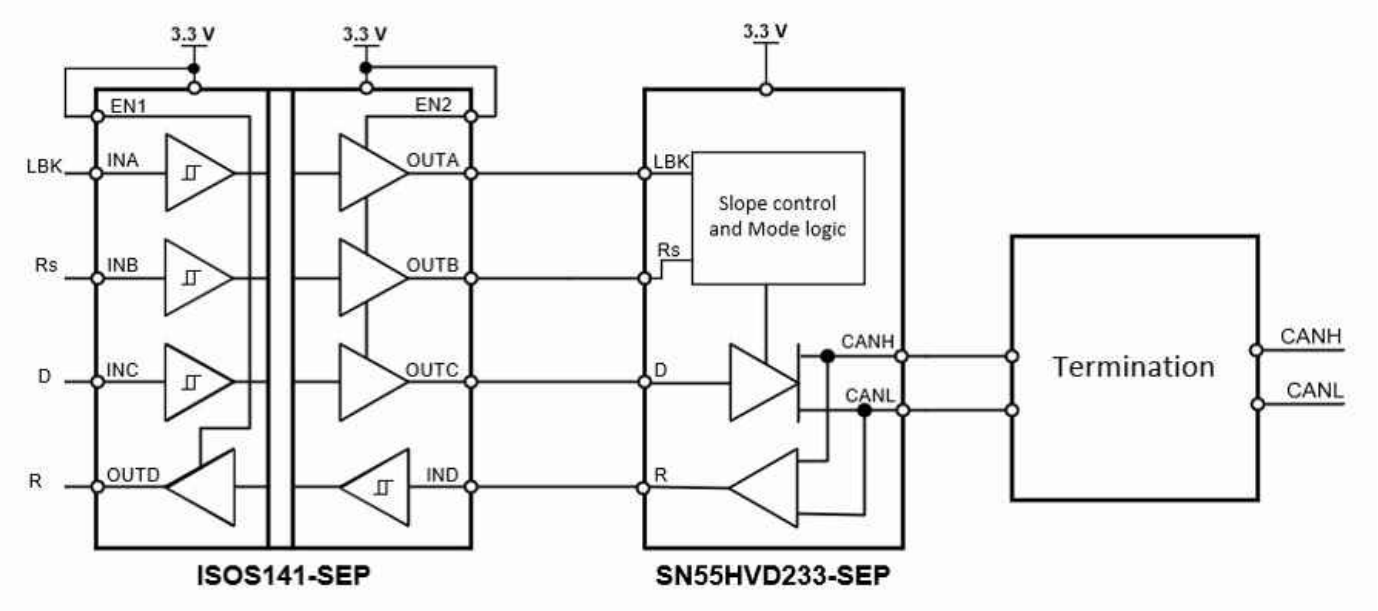
Design Goals

Parameter	Design Requirement
Bit rate	1 Mbps
Bus length	40m
Maximum Total Ionizing Dose	30krad(Si)
Maximum SEL to LET	43MeV × cm^2/mg
Isolation voltage	3000 V_{RMS} per UL1577

Design Description

The controller area network (CAN) protocol is a proven, highly-reliable communication system for harsh environments. The CAN two-wire bus multi-master, multi-drop topology is robust, low-cost, has low power consumption, and helps reduce the number of wires in wire-intensive point-to-point topologies. These advantages make CAN a good data bus for spacecraft applications.

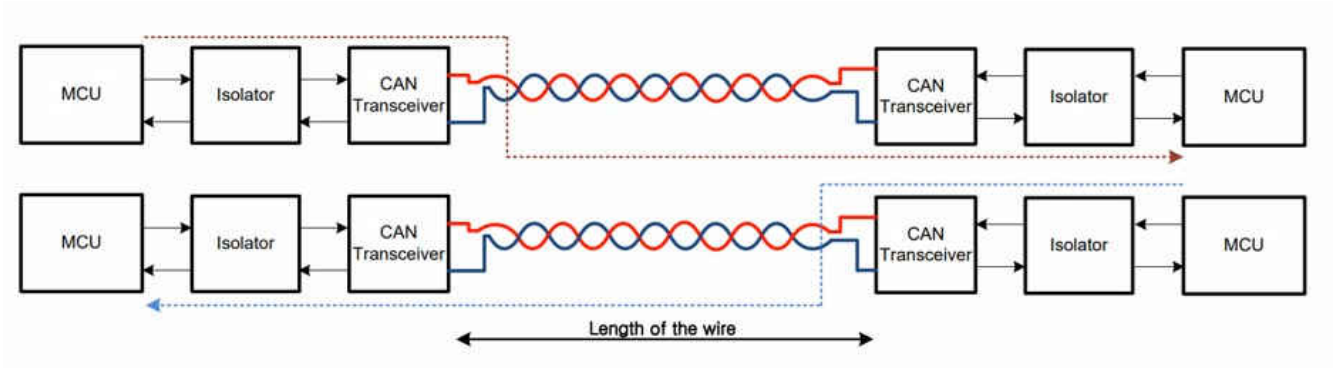
The following circuit uses the ISOS141-SEP digital isolator and SN55HVD233-SEP CAN transceiver devices to achieve an isolated CAN serial transceiver.



Design Notes

The ECSS-E-ST-50-15C is a standard dedicated to spacecraft projects that opt to use the CAN Network for spacecraft onboard communications and control. It defines the protocol extensions needed to meet spacecraft-specific requirements and adopts the ISO11898-1/-2:2003 standard without modification. Therefore, CAN transceivers used in space applications must meet the key electrical specifications of the ISO 11898-2 standard. In addition, the system must have a good Single-Event Latch-Up (SEL) immunity to Linear Energy transfer (LET) and be able to survive the harsh radiation environment encountered in space. ISOS141-SEP and SN55HVD233-SEP are picked for this circuit for their good SEL immunity to LET as described in the *Single-Event Latch-Up Test Report of the SN55HVD233-SEP CAN Bus Transceiver* radiation report.

According to the ISO11898-1/-2:2003, the maximum bit-rate is 1Mbps and the maximum bus length is 40m. A round-trip delay must be calculated based on the components to ensure that a signal has enough time to be made back from the most distant CAN controller on the bus while the bit is still being written by the sender to meet the bit rate.



Round-trip delay = 2 × (Propagation delay of digital isolator 1 + Propagation of CAN1 TX to bus + Propagation delay of wire + Propagation delay of CAN2 bus to RX + Propagation delay of digital isolator 2+ propagation delay of MCU)

Design Steps

- Collect the propagation delays for all components

Propagation Delays in Components

Parameter	Conditions	Typ (ns)	Max (ns)
Propagation delay of ISOS-141-SEP	With RL = 50Ω, CL=15pF	10.7	16
Propagation delay of Tx to CAN bus	With RL = 60Ω, CL=50pF	70	130
Propagation delay of 40m wire	Approximate delay is 5nsm-1 (Typ), 5.3nsm-1 (Max)	200	212
Propagation delay of CAN bus to Rx	With RL = 60Ω, CL=50pF	35	105
MCU propagation delay	(This value may differ from your MCU)	20	20

- Calculate the round trip delay

  Round-trip delay (TYP) = 2 × (10.7ns + 70ns + 200ns + 35ns + 10.7ns + 20ns) = 692.8ns

  Round-trip delay (MAX) = 2 × (16ns + 125ns + 212ns + 105ns + 16ns + 20ns) = 998ns

- Calculate bit time

$$\text{Bit time} = \frac{1}{Bit\ rate} = \frac{1}{1Mbps} = 1000ns$$

- Check round-trip delay < bit time

This design meets the timing requirement as the approximate worst-case round-trip delay is 9898ns which is less than 1000ns.

Note: If round-trip delay is greater than bit time, use the following options:

1. Pick components with shorter propagation delays
2. Shorten the wire length
3. Lower the maximum bit rate

- 120-Ω termination resistors are recommended to be placed at the extreme ends of the CAN bus to mitigate reflection to achieve good signal integrity.

Reference

Design Featured ISOS141-SEP Digital Isolator

ISOS141-SEP	
VCC1, Vcc2	2.25 V to 5.5 V
Data-rate	100MHz
Propagation delay	10.7ns to 16ns
TID Characterized (ELDRS-Free)	30 krad(Si)
TID RLAT, RHA	30 krad(Si)
CMTI	±100kV/µs
VISO	3000 V_{RMS}
https://www.ti.com/product/ISOS141-SEP	

Design Featured SN55HVD233-SEP CAN Transceiver

SN55HVD233-SEP	
VCC1	3 V to 3.6 V
Data-rate	1Mbps
TID Characterized (ELDRS-Free)	30 krad(Si)
TID RLAT, RHA	20 krad(Si)
Common Mode Range	–7 V to 12 V
Bus Pins ESD (HBM)	±14kV
https://www.ti.com/product/SN55HVD233-SEP	

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