

Application Note

LVDS Designs for SpaceWire



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Abstract

Low-voltage differential signaling (LVDS) has been used in a wide variety of applications due to the low power consumption, fast data rates, and EMC robustness. While the TIA/EIA-644 standard defines the LVDS physical layer, many modern communication networks are built on top of the LVDS physical layer. For space-grade systems, one of the main communication networks used is SpaceWire. While TI does not produce any devices specifically designed for SpaceWire, TI does produce space-grade LVDS devices that can be used to implement SpaceWire networks in different ways.

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1 Introduction

SpaceWire is high-speed serial communication network used in spacecraft to connect instruments throughout the spacecraft. SpaceWire is defined by Star Dundee to use the LVDS physical layer and data strobe encoding differential signaling to enable asynchronous communication. With this structure, SpaceWire utilizes the fast data rates and EMC robustness of LVDS to enable data rates up to 200Mbps for cables up to 10m in length. A SpaceWire node consists of four differential I/O ports: Data In (D_In), Data Out (D_Out), Strobe In (S_In), Strobe Out (S_Out) (see [Figure 1-1](#)). This allows for the transmission clock to be encoded with the data into Data and Strobe so that the clock can be recovered by XORing the data and strobe line together. The data being transmitted on these lines are typically generated by an FPGA or MPU. However, due to the limitations of these space-grade FPGAs/MPUs, implementing SpaceWire can be challenging unless other LVDS devices are used. The following sections highlight some key use cases where TI LVDS devices enable and/or improve SpaceWire functionality in a spacecraft.

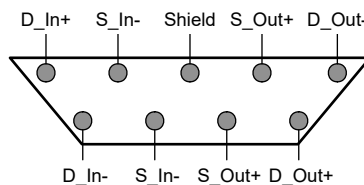


Figure 1-1. Pinout

2 Use Cases

2.1 Use Case 1: FPGA/MPU Without LVDS Pins

FPGAs can be programmed to accomplish many different tasks including handling SpaceWire data. However, if there are no pins that can directly transmit or receive LVDS signals, an LVDS driver and receiver is needed to convert single-ended signals to LVDS. Since each SpaceWire node requires two inputs and two outputs, two driver channels and two receiver channels are needed to achieve full functionality. Figure 2-1 shows how the SN55LVTA4-SEP LVDS driver and SN55LVRA4-SEP LVDS receiver can enable SpaceWire in a system that uses FPGAs without any LVDS pins since the driver converts single-ended GPIO signals to LVDS and the receiver performs the opposite.

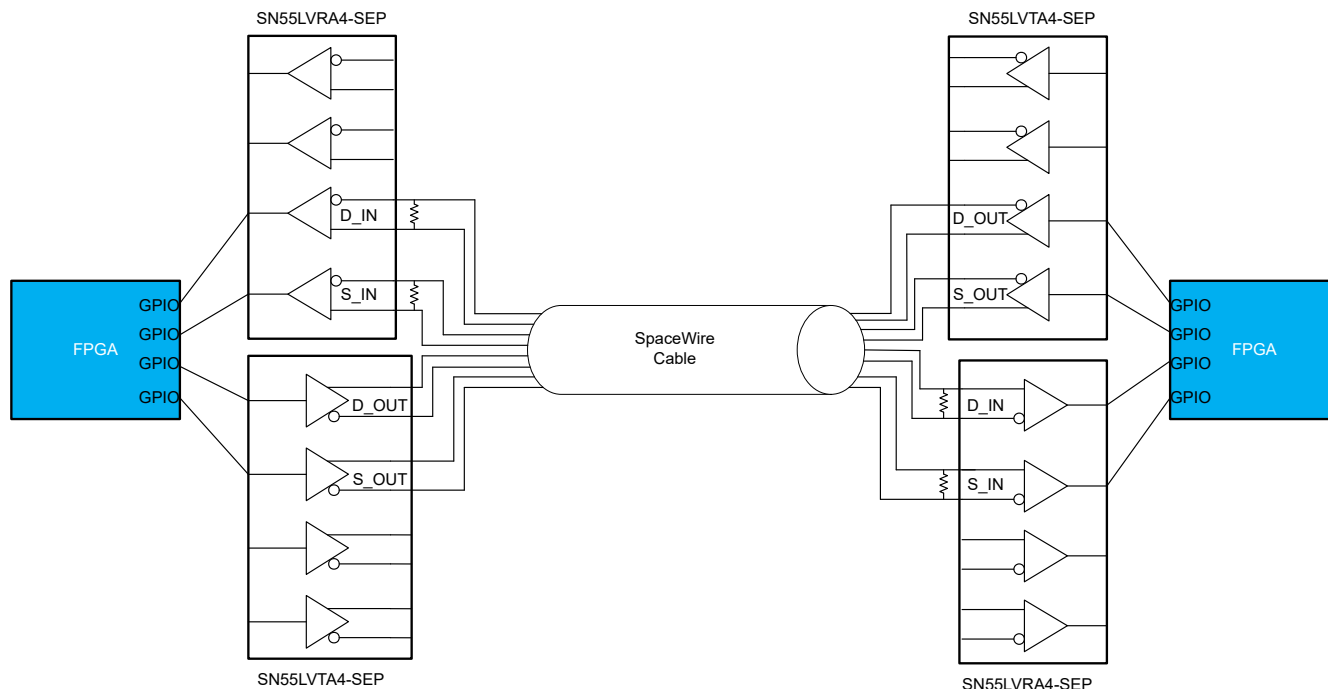


Figure 2-1. Schematic

2.2 Use Case 2: FPGA/MPU With LVDS Pins

If using an FPGA or MPU that does provide LVDS I/O pins, then an LVDS driver/receiver pair is not needed. However, that does not necessarily mean SpaceWire can be implemented effectively. Depending on the location of the FPGA on the board, the LVDS signals might need to be re-driven by a buffer to improve signal integrity. An LVDS transmission medium needs to be impedance-matched and terminated at the receiver with 100Ω. Star Dundee also recommends that differential PCB traces be less than 5mm in length due to edge rates going up to 1GHz. This means that if the FPGA has a trace length of more than 5mm from the board connector, a buffer can be used to re-drive the received LVDS signals to maintain proper signal integrity.

One way to implement this with TI LVDS products is by using SN55LVCP22A-SP. While this is technically a crosspoint LVDS switch, SN55LVCP22A-SP can be configured to act as a dual channel buffer as Figure 2-2 shows. Additionally, while this device is marketed as an LVDS product, it also accepts LVPECL and CML signals as inputs and convert them into LVDS. Since LVPECL and CML signals have higher voltage swings that can damage sensitive LVDS pins on an FPGA, SN55LVCP22A-SP can be used to convert these signals to LVDS to protect the receiving FPGA pins.

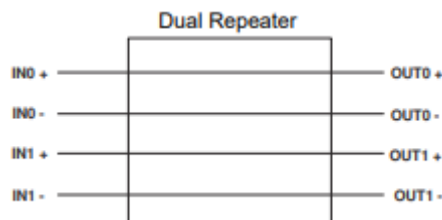


Figure 2-2. Dual Channel Buffer

2.3 Use Case 3: Redundancies

Many space applications require protection switching where a redundant backup data stream can be switched to replace a faulty data stream. For example, if a control unit that is talking to other parts of the system over SpaceWire fails, a backup control unit needs to be switched over to continue system operation. This can be achieved by using the SN55LVCP22A-SP device, this time, as a switch. Figure 2-3 below shows how eight units of SN55LVCP22A-SP can achieve a redundant SpaceWire interface with primary and backup controllers and cables by utilizing all channels of each crosspoint switch.

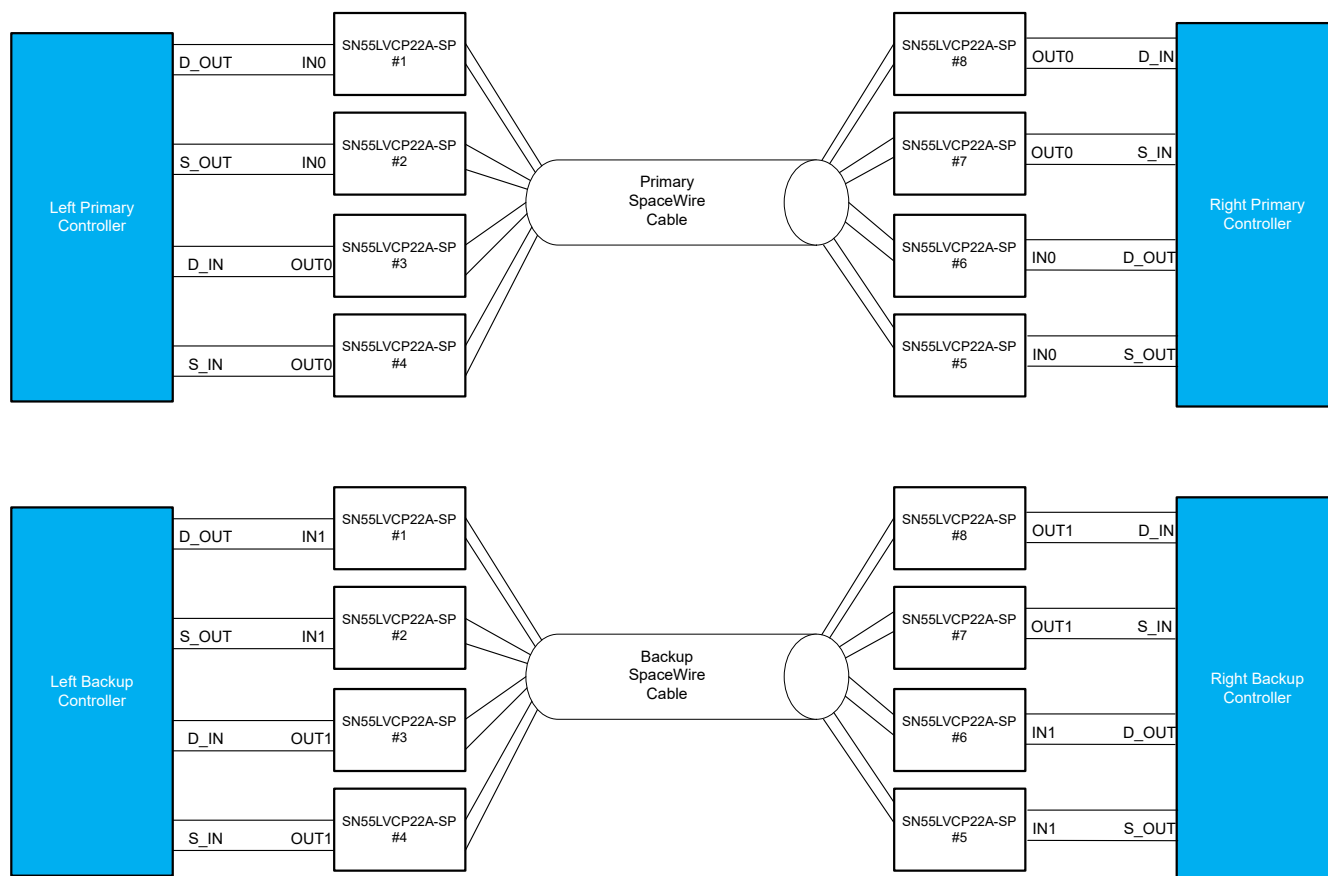


Figure 2-3. Redundant SpaceWire Interface

3 Summary

In summary, SpaceWire is a very useful interface for any type of space-grade application that can be implemented in a variety of ways. TI makes it easy for customers to address these use cases with their space-grade, radiation tolerant LVDS devices. See [Table 3-1](#) for suitable TI devices.

Table 3-1. TI Devices

Function	Device	# of Channels	Signaling Rate	SEL Rating
LVDS Driver	SN55LVTA4-SEP	4	400Mbps	50MeV-cm ²
	SN55LVDS31-SP	4	400Mbps	110MeV-cm ²
LVDS Receiver	SN55LVDS33-SP	4	400Mbps	90MeV-cm ²
	SN55LVRA4-SEP	4	400Mbps	50MeV-cm ²
LVDS Buffered Crosspoint Switch	SN55LVCP22A-SP	2	1000Mbps	75MeV-cm ²

4 References

1. STAR-Dundee, [SpaceWire User's Guide](#)
2. Texas Instruments, [LVDS Application and Data Handbook](#)
3. Texas Instruments, [Termination Guidelines for Differential and Single-Ended Signals](#)

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