Technical White Paper

Multiplexing FPD-Link Serializer Deserializer (SerDes)

Rhea Kadakia *Systems Engineering and Marketing*

ABSTRACT

With the growing focus on technological advancement and autonomy in the automotive industry, high-resolution, uncompressed data channels are increasingly in demand for cameras, radar, LIDAR, ultrasound, and display applications. FPD-Link SerDes supports delivery of high-resolution signals and streamlines designs within advanced driver assistance systems (ADAS) or infotainment displays. For certain applications, multiplexing FPD-Link SerDes can facilitate the addition of sensor modules. Multiplexing provides a simple solution to switch between different sensor modules without degrading the signal integrity of FPD-Link SerDes.

Table of Contents

List of Figures

1 Market Need

The automotive industry is seeing a trend towards more advanced systems that assist drivers, reduce vehicular accidents, and improve passengers' overall experience. The implementation of these remarkable designs demand an increase in the number of camera modules and communication channels. In particular, automotive systems are incorporating environmental sensing (front view camera, rearview camera, blind-spot detection) as well as driver and in-car monitoring.

FPD-Link SerDes provides a method of high resolution, uncompressed data transfer enabling high-speed, high-performance video and sensor interfaces. Quad- and dual-channel FPD-Link SerDes modules are available for multi-camera applications. In some cases, an odd number of cameras is not easily supported by these multichannel deserializers. The addition of a fifth or third undedicated camera module to a quad or dual camera system respectively can be simply implemented using multiplexing. Multiplexing FPD-Link can be used specifically for multi-camera systems where using two or more cameras in the application are mutually exclusive as illustrated by Figure 1-1. Multiplexing also reduces the number of CSI-2 ports needed on the central processor. This configuration can contribute to a reduction in the cost and size of the processor and overall space efficiency.

Figure 1-1. Automotive Application of Multiplexing FPD-Link SerDes

2 Multiplexing FPD-Link Scheme

For high-speed, high-resolution multiplexing applications, considering the impact to channel scattering parameters and link margin between the SER and DES is important. This characterization was done using the setup shown in Figure 2-1. A DS90UB960-Q1 EVM was modified with multiplexing capabilities on two out of four channels using a high-speed, bidirectional multiplexer, HD3SS3212-Q1. DS90UB960-Q1 is a quad 2MP camera hub FPD-Link III deserializer device with dual CSI-2 output ports. HD3SS3212-Q1 is a two-channel differential 2:1 and 1:2 multiplexing and demultiplexing device.

Implement the multiplexer to intercept FPD-Link SerDes, specifically on the deserializer side of the power over coax (PoC) and the PoC filter. This allows for the DC component of the PoC to be removed prior to being feed into the multiplexer. Additionally, switch the multiplexer according to the protocol described in Section 3, Implementation of Switching Protocol.

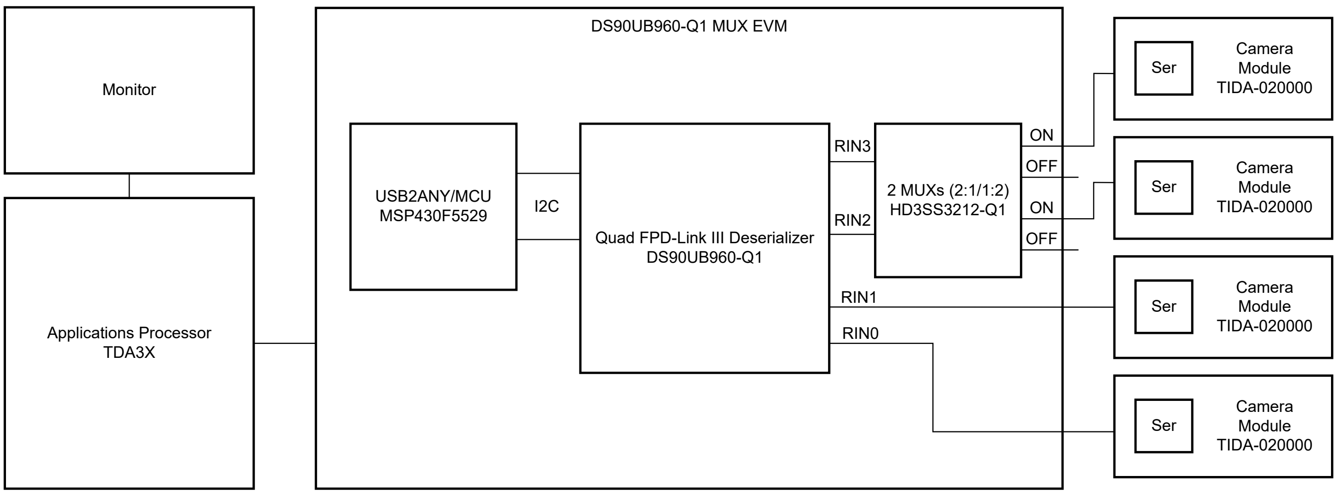

Figure 2-1. Multiplexing Testing Scheme

3 Implementation of Switching Protocol

Prior to switching, the deserializer output can be disabled to prevent the system from entering an error handling or fail-safe mode. Switching between cameras while data is actively being transmitted is not possible. Implement the following protocol when multiplexing between channels.

```
Analog LaunchPad Program
# Digital reset at initialization
        board.WriteI2C(desAddr,0x01,0x01)

# Enable CSI-2 output and forwarding (steps below)
        board.WriteI2C(desAddr,0x32,0x01) # Select CSI-2 port 0
        board.WriteI2C(desAddr,0x33,0x03) # Enable CSI-2 output with continuous clock mode
        board.WriteI2C(desAddr,0x20,0x00) # Forward all CSI-2 to port 0

# Before switching the MUX, disable the associated port and forwarding
        board.WriteI2C(desAddr,0x20,0xF;0) # Disable forwarding
        board.WriteI2C(desAddr,0x0C,0x00) # Disable the RX port receiver

# After switching the MUX, restart the forwarding and the port receiver
        board.WriteI2C(desAddr,0x0C,0x0F) # Enable the RX port receiver
        time.sleep(0.1) # Allow time for the port to re-lock
        board.WriteI2C(desAddr,0x20,0x00) # Enable forwarding
```

4 Assessing Impact on Signal Integrity

Because introducing an additional component, that is, the multiplexer, into the signal path can have an impact on the signal integrity and performance, the impact needs to be measured and quantified.

Scattering-parameters or S-parameters provide a framework for describing networks based on the ratio of incident and reflected microwaves. These S-parameters are useful for characterizing linear, high-frequency circuits. S-parameter analysis provides information about return loss and insertion loss specifically to compare the signal integrity of FPD-Link SerDes with and without a multiplexer.

Return loss is the ratio of the reflected signal to the launched signal. Insertion loss is a measure of the transmitted signal attenuation. Higher return loss and lower insertion loss translates to higher signal integrity.

Figure 4-1 indicates the reconfiguration of the DS90UB960-Q1 MUX EVM for non-multiplexed and multiplexed S-parameter analysis.

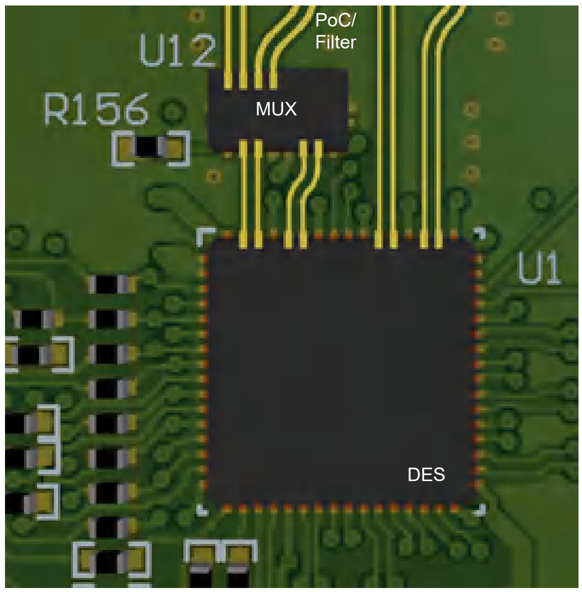

Figure 4-1. Multiplexer and Deserializer Configuration

4.1 Return Loss

The return loss for both the non-multiplexed (channels 1, 2) and the multiplexed (channels 3, 4) are within the required limits for stable operation as defined by Texas Instruments FPD-Link SerDes shown in red on Figure 4-2.

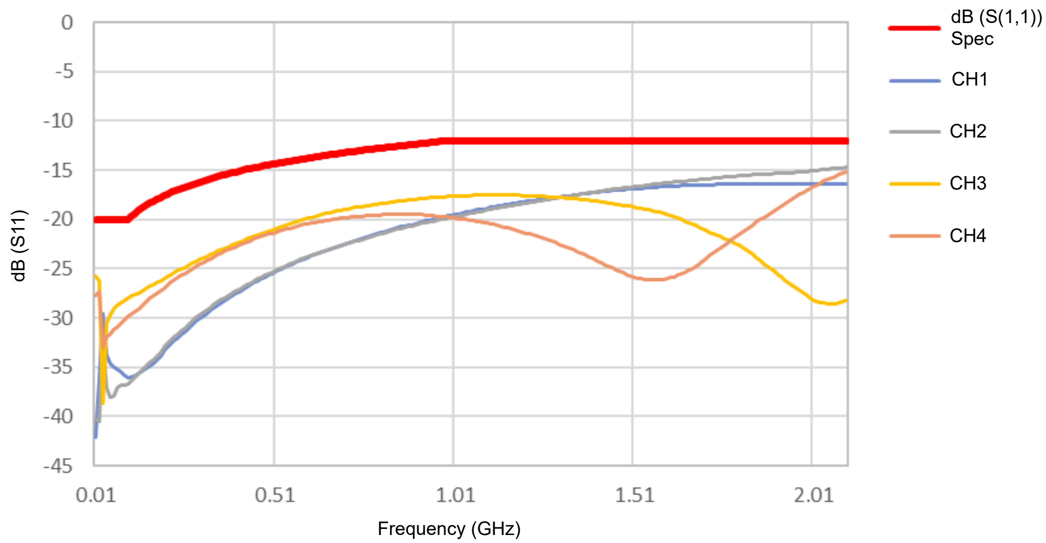

Figure 4-2. Channel Return Loss

4.2 Insertion Loss

The non-multiplexed configuration meets the requirements outlined by TI shown in red on Figure 4-3. However, the addition of the multiplexer increases the insertion loss by 0.4 dB, so the recommended PCB insertion loss is no longer met. The total channel insertion loss requirements between the serializer and deserializer are dependent on both the PCB and the cable assembly budget. As the insertion loss penalty for using a multiplexer is relatively small with regards to the overall cable budget guidance, the required insertion loss minimum value for the total channel can still be met by offsetting the cable loss budget by 0.4 dB.

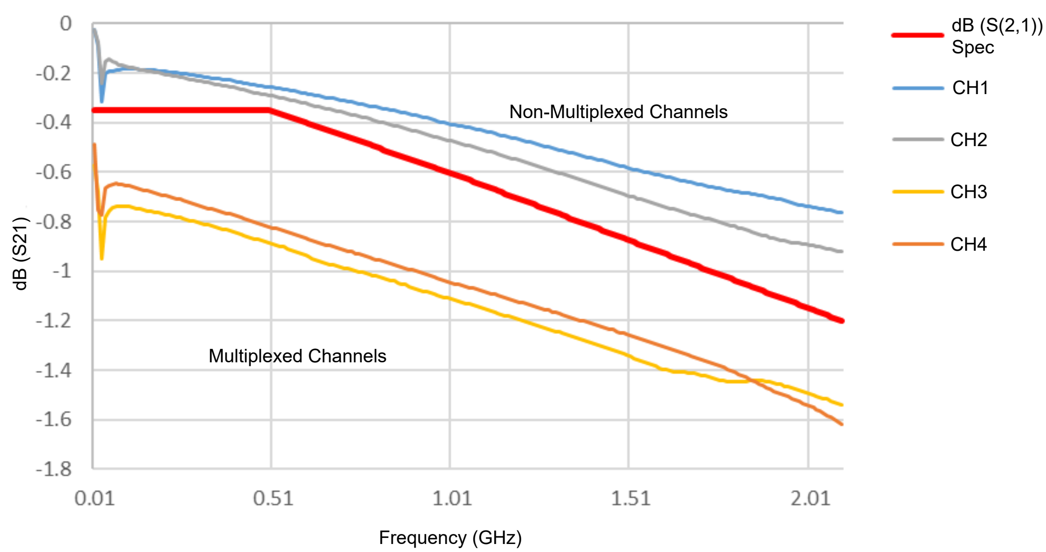

Figure 4-3. Channel Insertion Loss

5 Margin Analysis

The TI DS90UB960-Q1 deserializer includes multiple forms of automatic adaptations to improve link reliability. One such method is the use of automatically adjusted strobe positions, which controls where data is sampled in the signal eye. Different strobe positions can be the most effective in different circumstances depending on factors such as cable length, cable quality, and temperature. The Margin Analysis Program (MAP) checks for errors and lock at combinations of the strobe positions and EQ levels to analyze the margin in the system.

Manual strobe control is a useful tool for system evaluation, because the tool can be used to evaluate the condition of the eye with only an I2C connection. In general, this is done by creating a margin analysis plot where the status of the deserializer is monitored for each combination of EQ and strobe settings. These diagrams track lock status, parity errors, forward channel CRC errors, forward channel sequencing errors, and forward channel encoding errors over all EQ settings and strobe positions using the smaller base delay. The green squares indicate passing settings, in which the deserializer and serializer are locked with zero errors. EQ levels with at least four passing strobe positions are considered recommended EQ levels. In general, TI recommends having a margin of at least three EQ levels with four passing strobe positions, including a contiguous rectangle of passing states that measures two EQ levels by four strobe positions.

Both the non-multiplexed (Figure 5-1, Figure 5-2) and multiplexed (Figure 5-3, Figure 5-4) channels on the DS90UB960-Q1 MUX EVM have a passing margin analysis report as shown with the black rectangles. This demonstrates that the addition of the multiplexer does not significantly impact the overall channel signal integrity.

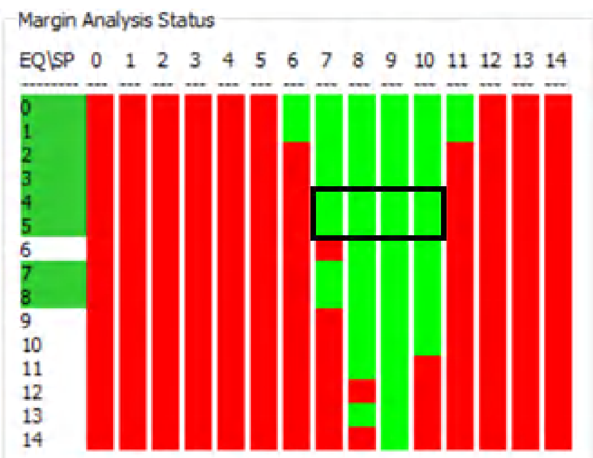

Figure 5-1. Margin Analysis Plot - RX PORT0 (CH1)

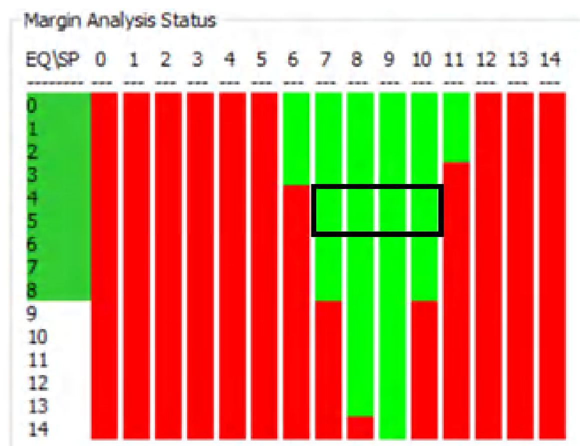

Figure 5-2. Margin Analysis Plot - RX PORT1 (CH2)

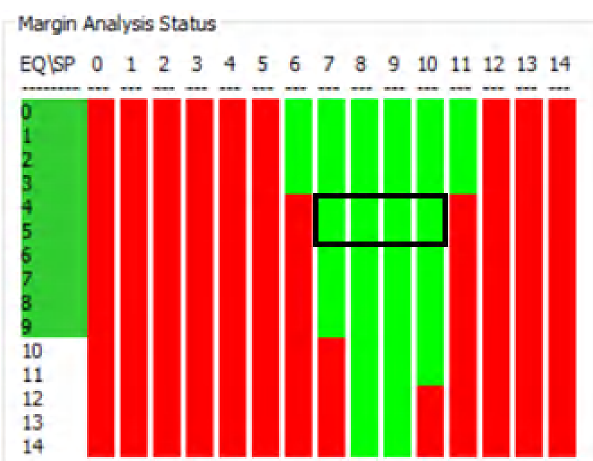

Figure 5-3. Margin Analysis Plot - MUX RX PORT2 (CH3)

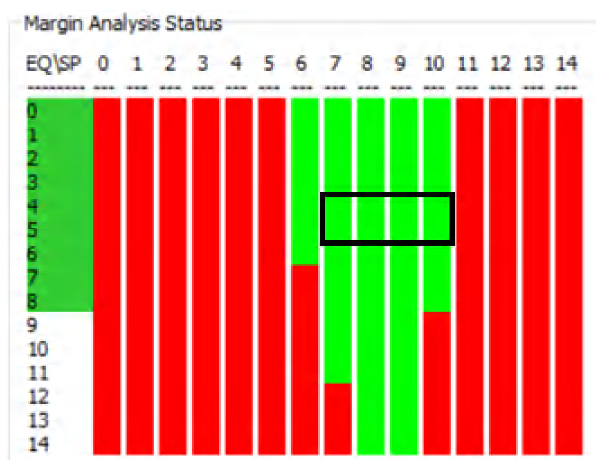

Figure 5-4. Margin Analysis Plot - MUX RX PORT3 (CH4)

6 Conclusion

Multiplexing FPD-Link is a viable answer for increasing the number of peripherals without necessarily increasing the number of deserializers. This method can provide a more space-efficient and simple implementation for systems with an odd number of mutually exclusive sensors. Additionally, multiplexing reduces the need for CSI-2 ports on the processor, a common limitation.

The multiplexing scheme does increase the insertion loss which can be offset according to user implementation with cabling choices. In terms of link margin and return loss, the multiplexed FPD-Link SerDes scheme is comparable to the non-multiplexed counterpart.

7 References

1. Texas Instruments, *DS90UB960-Q1 Quad 4.16-Gbps FPD-Link III Deserializer Hub With Dual MIPI CSI-2 Ports* data sheet
2. Texas Instruments, *HD3SS3212-Q1 Two-Channel Differential 2:1/1:2 USB3.2 Mux/Demux* data sheet
3. Texas Instruments, *Automotive 2.6-MP camera module reference design with POL PMIC, FPD-Link III, supervisor and POC* data sheet
4. Texas Instruments, *Automotive 2.6-MP Camera Module Reference Design With POL PMIC, FPD-Link III, Supervisor, and POC* design guide
5. Texas Instruments, *Margin Analysis Program (MAP) and strobe positions for DS90UB954-Q1 and DS90UB960-Q1* application note