Application Note

TI FPD-LINK and TI SoC in Automotive Multi-Camera and Multi-Display Applications

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ABSTRACT

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With the rapid advancement of intelligent vehicles, the demands placed on automotive camera and display systems have become increasingly complex. High-resolution cameras, multi-sensor fusion, low-latency video transmission, and multi-screen interaction have emerged as critical technologies for enabling Advanced Driver Assistance Systems (ADAS) and autonomous driving functions. Texas Instruments (TI) offers a highly effective solution portfolio combining its SoC processors and FPD-Link high-speed interface technology, providing a robust hardware and communication foundation for automotive camera data acquisition, processing, and multi-display output.

TI's FPD-Link is a mature high-speed signal interface solution widely adopted in automotive ADAS and In-Vehicle Infotainment (IVI) systems globally. Leveraging serializer/deserializer (SerDes) technology, it converts multiple parallel data streams into a single or dual serial data stream for transmission. This approach enhances the immunity to interference and system robustness of high-speed signals over long distances, supports bidirectional communication between the host and remote devices, and reduces the number of cables required, thereby lowering overall system weight.

TI's SoC processor family, including the TDA4VM, TDA4VH, and AM62x, is built on the Keystone III architecture and integrates Arm® Cortex®-A72 cores, C7x DSP, and deep learning and vision accelerators. These devices are capable of simultaneously processing multiple high-resolution video streams, executing complex vision and AI tasks, and supporting a wide range of display output interfaces (such as DPI/RGB, MIPI DSI, and OLDI/LVDS), along with multiple MIPI CSI camera inputs. With functional safety support up to ASIL-B, they are ideally suited for automotive applications.

The combination of TI's SoC processors and FPD-Link technology delivers a high-performance, highly integrated solution for automotive multi-camera and multi-display systems, including digital cockpits and ADAS. The following sections provide a detailed overview of the primary applications, key advantages, and relevant technical considerations in this domain.

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1 Technical Advantages of TI SoC and FPD-LINK

1.1 Core Capabilities of TI SoC Processors

Taking the TDA4VH system shown in Figure 1-1 as an example, we examine the processor's compute architecture, display subsystem, and camera system:

Heterogeneous Multi-Core Compute Architecture: The TDA4x family integrates Arm Cortex-A72 cores (for general-purpose computing), C7x DSP (for high-performance signal processing), GPU (for graphics processing), dedicated vision accelerators (VPAC), and a deep learning engine (MMA). This enables parallel processing of data from multiple cameras, radar, and other sensors.

Display Subsystem (DSS): The TDA4x/AM6x series employs the Keystone 3 architecture-based display system, supporting multi-screen output at up to 4K resolution. It is compatible with LVDS, MIPI DSI, and other display interfaces, enabling simultaneous driving of instrument clusters, center information displays, HUDs, and rear-seat entertainment screens. It also supports real-time graphics and video overlay (e.g., ADAS warning indicators).

Camera System: The TDA4x family integrates multiple MIPI CSI interfaces, responsible for delivering visual information captured by image sensors ("eyes") to the domain controller ("brain") with high speed, high reliability, and low latency.

Automotive-Grade Reliability: Compliant with ISO 26262 functional safety standards, featuring fault detection and redundancy mechanisms to ensure stable operation under extreme temperatures and electromagnetic interference.

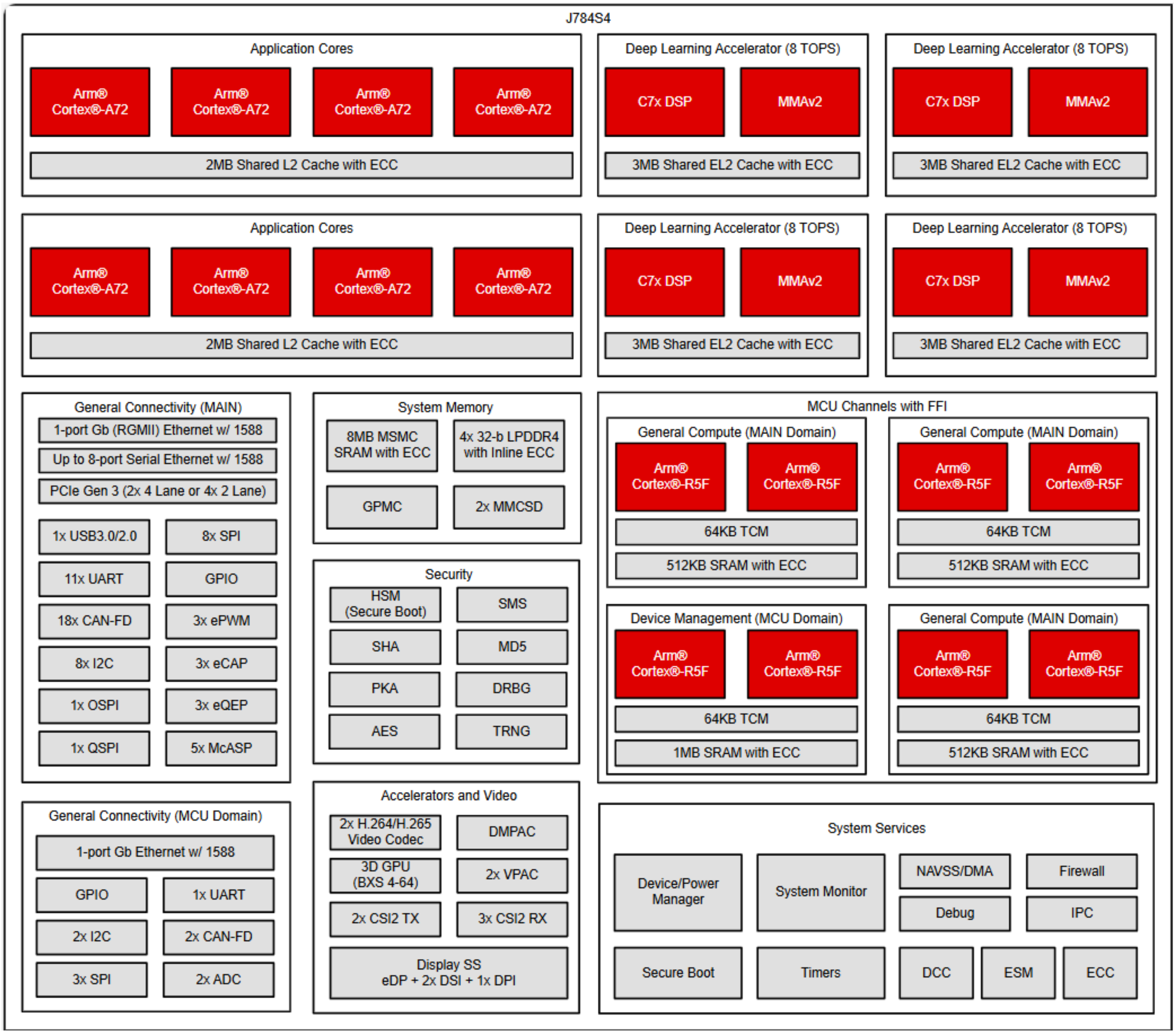

Figure 1-1. TDA4VH System Block Diagram

1.2 Features of the FPD-LINK Interface

FPD-Link (Flat Panel Display Link) is TI's high-speed serializer/deserializer (SerDes) technology, which transmits high-resolution video, audio, control data, and power over a single coaxial cable or twisted-pair wire. Its core value lies in:

- Simplified Wiring: Reduces the number of cables, harness weight, and connector complexity.
- Strong Immunity to Interference: Leverages a proprietary protocol to stably transmit audio/video signals and control signals, making it well-suited for the automotive electronic environment.
- Long-Distance Transmission Support: Reliable transmission over distances of up to 10–15 meters.
- Flexible Architecture: Enables a "screen-display separation" design, allowing displays and hosts to be physically decoupled.

High-Speed, Low-Latency Transmission: FPD-Link III/IV supports serial data rates of up to 30Gbps, seamlessly transmitting 4K/60fps video data to meet the high bandwidth requirements of ADAS cameras. T

Robust Immunity to Interference: Differential signal transmission and adaptive equalization provide video signal integrity in complex automotive electromagnetic environments, reducing the impact of cable length on image quality.

Simplified Wiring Design: Integrates video, control signals, and power delivery over a single wire (e.g., FPD-Link IV supports power-over-coax), reducing the number and weight of cables and lowering overall vehicle cost.

Functional Capabilities: FPD-Link III and above support video and audio data transmission as well as full-duplex control (e.g., I2C, GPIO) over a single differential link, enabling bidirectional communication. This means that touch inputs, status information, and other data from the display side can be sent back to the host system through the same cable. **Functional Safety and EMI:** Many FPD-Link SerDes chips are AEC-Q100 certified, with the ability to withstand automotive temperature variations and electromagnetic interference (EMI). They often include adaptive equalization to dynamically compensate for signal degradation caused by cable aging and temperature fluctuations.

Application diagrams of FPD-Link in automotive display and ADAS systems are shown in Figure 1-2 and Figure 1-3.

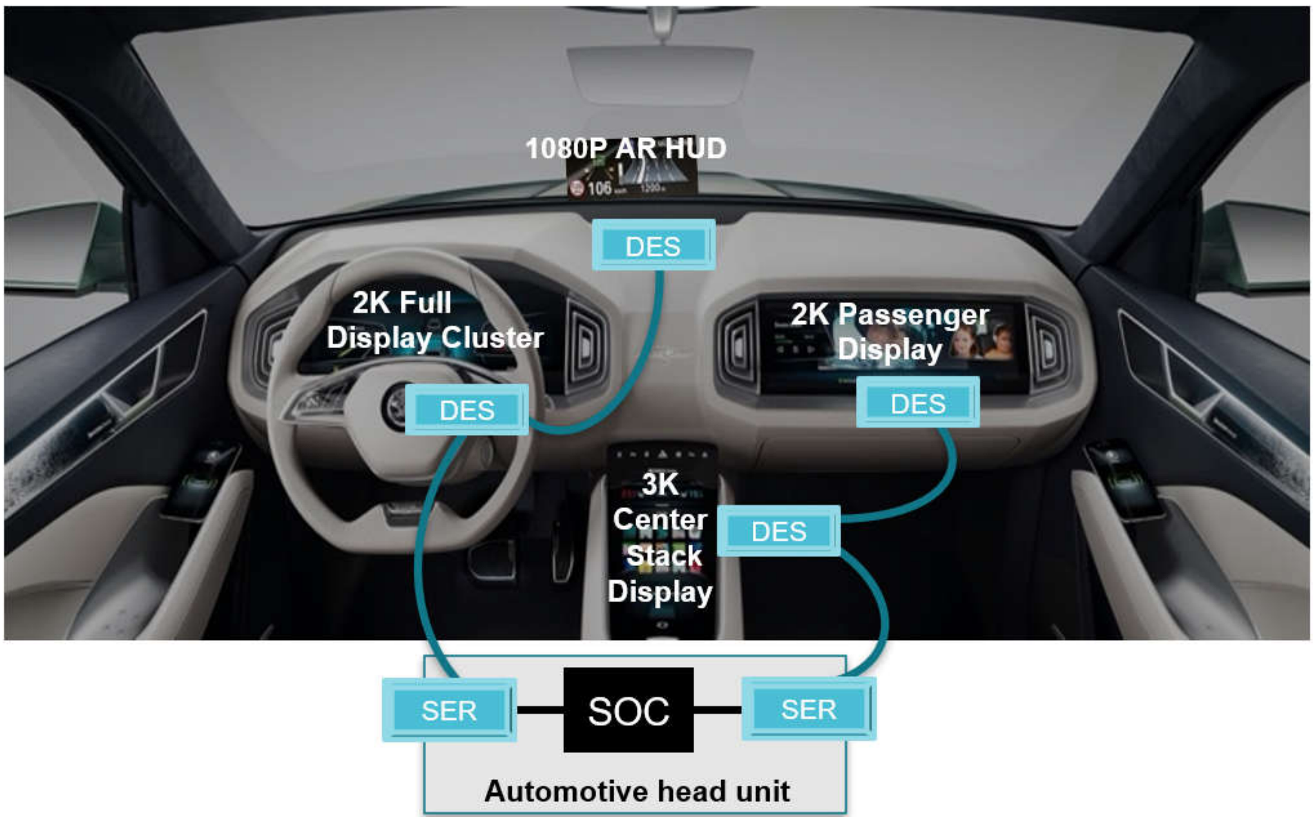

Figure 1-2. SerDes in Cockpit Application Diagram

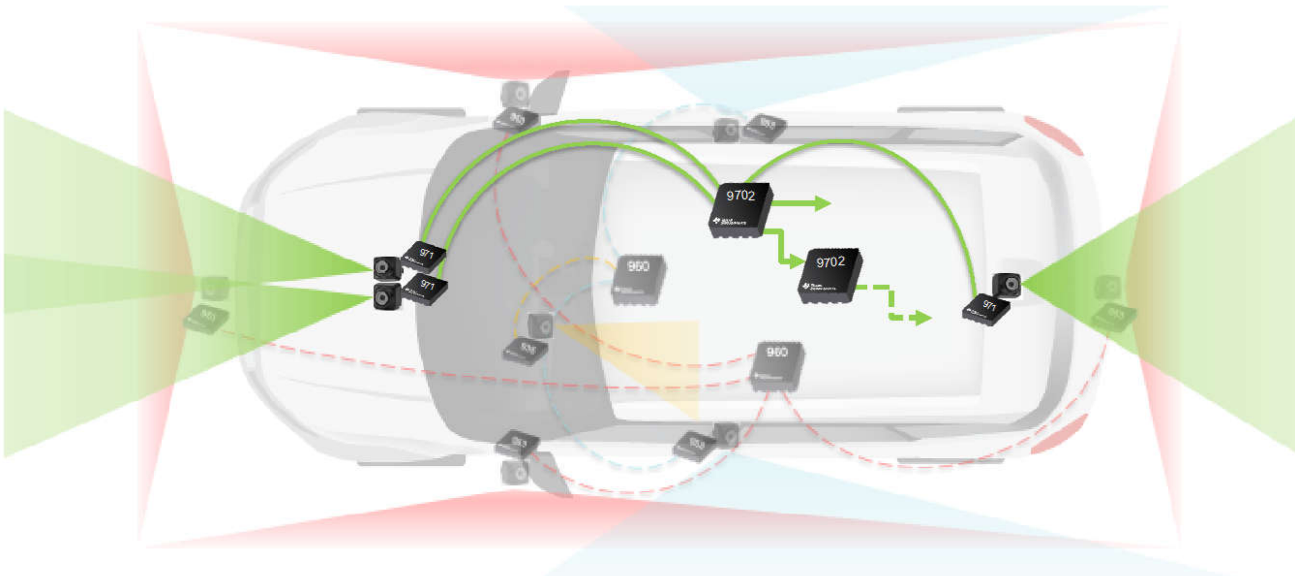

Figure 1-3. SerDes in Camera Application Diagram

1.3 Introduction to K3 DSS and MIPI

The K3 Display Subsystem (DSS) is a unified, scalable display controller designed by TI for its K3 architecture processors (including the TDA4x and AM62x families). Its core design objectives are to provide flexible display output capabilities, support multiple interfaces and formats, and optimize power consumption. The DSS is a hardware module that can be divided into two major components, as illustrated in Figure 1-4:

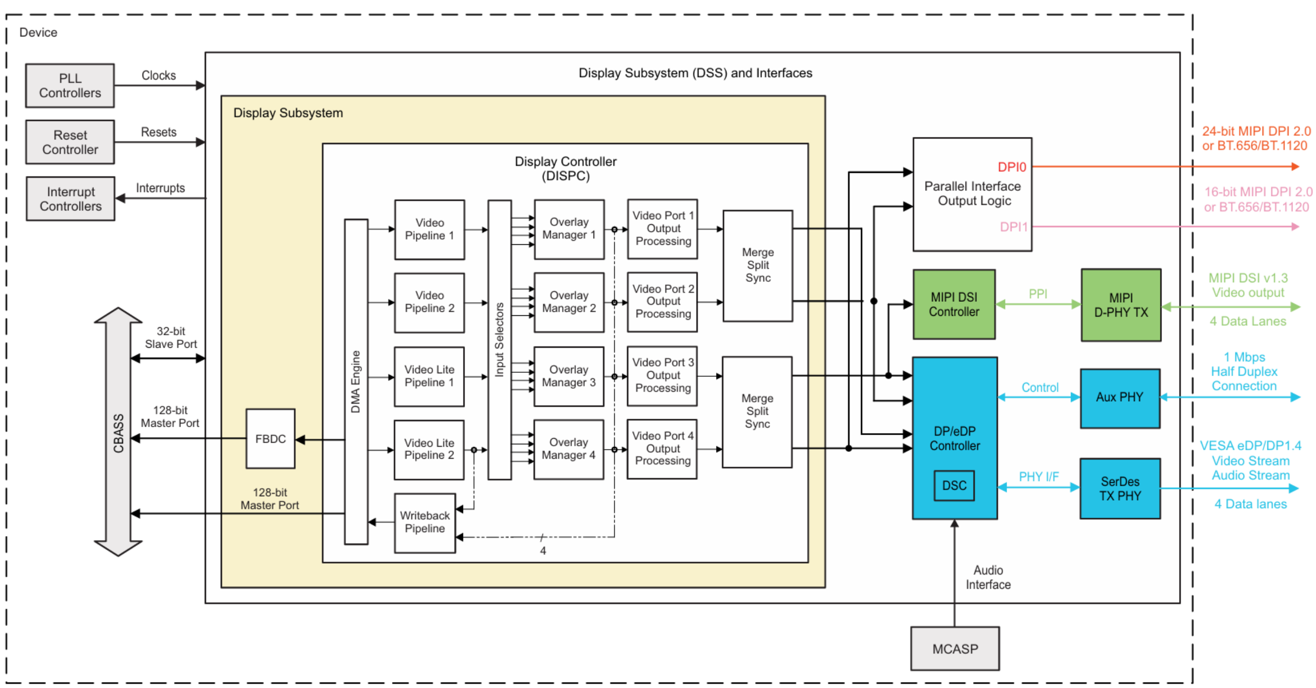

Figure 1-4. K3 DSS Block Diagram

- Display Controller (DISPC): Responsible for fetching pixel data, performing color conversion, composition, and other pixel operations.
- Peripherals: Responsible for encoding raw pixel data into standard display signals, such as DPI, DP, or DSI. Supported display interfaces include (see Table 1 and 2 for details):
  - DPI (Parallel RGB Interface): Used to drive traditional LCD screens.

- DSI (Display Serial Interface): Used to connect MIPI DSI panels, commonly found in more modern, compact displays.
- DP (DisplayPort Interface): Used for higher-resolution screens.

Table 1-1. Technical Specifications Overview

Display Interface	Pins Used	Bandwidth	Application	Remarks
DPI	RGB 24 8 bits/color 4x clock	24 bits x 165MHz = 3.96GB/Sec	Low-resolution display applications	DPI (24-bit parallel RGB): Up to 1920 × 1080 at 60fps (165MHz pixel clock)
DSI	Data pairs and 1 clock pair	4 × 1.5Gb/s = 6Gb/s	Mid-resolution display applications	MIPI® DSI: 4-lane MIPI® D-PHY, supporting up to 3840 × 1080 at 60fps (300MHz pixel clock)
eDP	Up to 4 data pairs	Up to 4 × 8.1Gbps = 32.4Gbps	High-resolution display applications	1 eDP/DP interface with Multi-Stream Transport (MST) support.

Table 1-2. Supported Display Interfaces

Device	DPI	DSI	OLDI/LVDS	EDP
AM62Lx	✓	✓	x	x
AM62x	✓	x	✓	x
AM62Ax	✓	x	x	x
AM62Px	✓	✓	✓	x
AM64x	x		x	x
AM67x/TDA4VEN	✓	✓	✓	x
AM68x/TDA4VE	✓	✓	x	✓
AM68Ax/TDA4VM	✓	✓	x	✓
AM69x/TDAVPE	✓	✓	x	✓
AM69Ax/TDA4VH	✓	✓	x	✓

2 System Application: A Complete Pipeline from Cameras to Multi-Display Output

The display subsystem (DSS) integrated in the TDA4 processor typically includes multiple display controllers (DCs), each of which can be independently configured to output video streams to different display interfaces (such as parallel RGB or MIPI DSI). To enable multi-display output, the TDA4's display output interfaces (e.g., DPI/RGB, MIPI DSI) can be connected to multiple FPD-Link serializers. The serializer converts parallel video data into high-speed serial signals for transmission over a single cable. At the display end, the FPD-Link deserializer receives the serial signal and recovers it back to parallel video data (e.g., OpenLDI/LVDS, RGB) to drive the display panel.

The powerful processing capability of the TDA4 processor allows it to simultaneously generate multiple independent video streams and output them through different interfaces, which are then transmitted to physically distributed displays via FPD-Link serializers.

2.1 Multi-Camera Data Acquisition and Transmission

As vehicles become increasingly intelligent, the number of cameras installed in cars continues to grow. Based on the camera applications found in mainstream vehicle models currently on the market, the types and functions of automotive cameras are summarized in the table below:

Table 2-1. Types and Applications of Automotive Cameras

Camera Type	Mounting Position	Primary Function	Field-of-View Characteristics	Typical Use Cases
Forward Camera	Inside front windshield, near rearview mirror	Perceiving forward road environment, enabling active safety functions	Monocular/stereo: narrow FOV (for distant object recognition), wide FOV (for traffic signs, lane lines)	Adaptive Cruise Control (ACC), Automatic Emergency Braking (AEB), Lane Keep Assist (LKA), Traffic Sign Recognition (TSR), Pedestrian/Vehicle Collision Warning
Surround View Camera	Around the vehicle: typically front grille, under side mirrors, rear trunk handle	Providing 360° bird's-eye view, eliminating blind spots	Ultra-wide-angle fisheye lens with significant distortion; requires algorithm-based correction and stitching	360° Panoramic View, Parking Assistance, Transparent Chassis (synthesized via algorithms)
Rear Camera	Near rear trunk handle or license plate	Assisting reverse maneuvers, monitoring rear blind spots	Wide-angle, some with dynamic trajectory lines	Reverse Camera, Rear Cross-Traffic Alert (RCTA)
Side Camera	Under side mirrors or on front fenders	Monitoring side/rear blind spots, assisting lane changes and turns	Wide-angle	Blind Spot Detection (BSD), Lane Change Assist (LCA), Side-view display when turn signal is active (replacing traditional mirrors)
In-Cabin Camera	Inside cabin: A-pillar, behind steering wheel, rearview mirror, etc.	Monitoring driver and passengers	Infrared or standard RGB lens	Driver State Monitoring (DSM): fatigue warning, distraction alert; passenger monitoring; object left behind reminder; gesture recognition; video calls

For various scenarios and camera types, camera data requires long-distance transmission. TI FPD-Link provides solutions for camera data transmission, with recommended solutions for different data requirements as follows:

Table 2-2. Recommended SerDes Solutions for Automotive ADAS Systems

Camera Resolution	Interface Type	Recommended Serializer	Recommended Deserializer	Max. Cameras Supported per Deserializer
1M	DPI	DS90UB933-Q1	DS90UB934-Q1	1
	CSI-2	DS90UB935-Q1	DS90UB936-Q1	2
	CSI-2	DS90UB935-Q1	DS90UB962-Q1	4
2M	CSI-2	DS90UB935-Q1	DS90UB936-Q1	2
	CSI-2	DS90UB935-Q1	DS90UB962-Q1	4
3M	CSI-2	DS90UB953-Q1	DS90UB954-Q1	2
	CSI-2	DS90UB953-Q1	DS90UB960-Q1	4

Table 2-2. Recommended SerDes Solutions for Automotive ADAS Systems (continued)

Camera Resolution	Interface Type	Recommended Serializer	Recommended Deserializer	Max. Cameras Supported per Deserializer
8M	CSI-2	DS90UB971-Q1	DS90UB9722-Q1	2
	CSI-2	DS90UB971-Q1	DS90UB9702-Q1	4

2.2 Data Processing and Sensor Fusion

Camera data is processed and fused with data from other sensors before being sent to displays. Taking the TDA4 processor as an example: camera data passes through the VPAC module of the TDA4x, which performs lens distortion correction on raw video, and through the MMA to accelerate deep learning models (e.g., object classification), generating environmental perception results. In addition to camera data, information from ultrasonic sensors and LiDAR can be integrated to construct a 3D environmental model around the vehicle, providing decision-making support for automated parking or L3 autonomous driving. Figure 2-1 illustrates the data processing modules of the SoC TDA4.

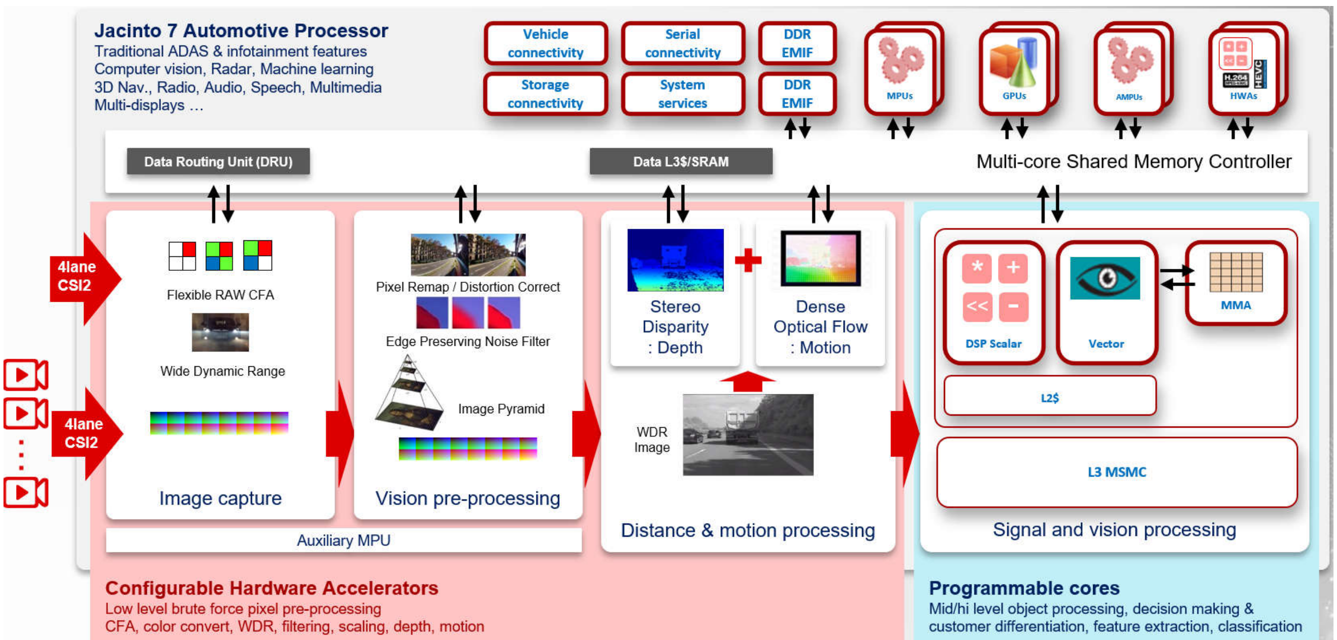

Figure 2-1. TDA4 Data Processing Modules

2.3 Multi-Display Output and Interaction

Vehicle cabins are increasingly equipped with multiple displays, facilitating operation for different occupants and enhancing the overall riding experience. For example, next-generation instrument clusters, HUDs, center information displays, rear-seat entertainment screens, etc. Instrument Cluster and HUD: The DSS subsystem renders the fused environmental model (e.g., vehicle trajectories, obstacle annotations) within the driver's field of view, ensuring low-latency presentation of critical information. Center Display and Rear-Seat Entertainment: GPU acceleration enables 3D rendering of navigation interfaces and video content, supporting either independent display on multiple screens or synchronized content (e.g., rear passengers controlling the center console menu). In the event of a camera or display failure, the system automatically switches to a redundant signal source or a simplified interface to ensure that basic driving functions remain unaffected.

In automotive processing, display interfaces such as DPI, DP, OLDI, or DSI are widely used. These different interface technologies effectively enable a variety of display solutions. Table 4 lists commonly used SerDes solutions for automotive display applications.

- **DPI**: Supports RGB interfaces as well as YUV image formats such as BT565/BT601. As a relatively basic interface, it has limited transmission distance and weaker immunity to interference, making it more suitable for small-sized screens. Recommended FPD-Link solution: Serializer DS90UB925-Q1, Deserializer DS90UB926-Q1.

- **OLDI/LVDS**: Encodes high-speed signals into differential signals for transmission, significantly improving immunity to interference and supporting larger screen sizes and higher resolutions. Recommended FPD-Link solution: Serializer DS90UB947-Q1, Deserializer DS90UB948-Q1.
- **DSI**: Developed by the MIPI Alliance, it also uses low-voltage differential signaling at the physical layer, similar to LVDS, but with a more complex protocol. DSI can switch between high-speed and low-power modes during video transmission to reduce power consumption. Both SoCs and FPD-Link devices support DSI single-link and dual-link configurations. Recommended FPD-Link solutions: Serializer DS90UB941AS-Q1 with Deserializer DS90UB948-Q1; or Serializer DS90UB981 with Deserializer DS90UB988-Q1 (supports superframe).
- **DP:** Developed by the VESA association, this interface is currently the mainstream choice and future direction for high-resolution automotive displays. DP supports higher bandwidth, enabling 4K or even 8K resolution with high refresh rates. Additionally, DP supports MST technology, facilitating multi-video transmission. Recommended FPD-Link solution: Serializer DS90UB983AS-Q1, Deserializer DS90UB984-Q1.

Table 2-3. Recommended SerDes Solutions for Common Automotive Display Applications

Screen Resolution	SoC Interface Type	TOCN Interface Type	Recommended Serializer	Recommended Deserializer	Port Count (Serializer/ Deserializer)
720P/1080P	OLDI	OLDI	DS90UB947N-Q1	DS90UB948-Q1	1 (720p), 2 (1080p)
	DSI	OLDI	DS90UB941AS-Q1	DS90UB948-Q1	1 (720p), 2 (1080p)
2K	DSI	OLDI	DS90UB681-Q1	DS90UB688-Q1	1
	DP	DP	DS90UB943A-Q1	DS90UB944-Q1	1
3K	DSI	OLDI	DS90UB981-Q1	DS90UB688-Q1	1
	DP	DP	DS90UB943A-Q1	DS90UB944-Q1	2
	DP	DP	DS90UB983-Q1	DS90UB984-Q1	1
4K	DP	DP	DS90UB983-Q1	DS90UB984-Q1	2

In SerDes-based display applications, several technologies (Superframe, Daisy-Chain, MST, etc.) are employed. By combining these technologies, a wide variety of multi-display solutions can be conveniently implemented.

- Daisy-Chain: Modern vehicles, particularly new energy and premium models, are typically equipped with multiple screens. In such multi-display systems, daisy-chaining plays a critical role. Daisy-chain topology allows a single SoC interface to drive multiple displays or audio processing modules. It also resolves the issue of complex, heavy, and expensive wiring that would otherwise result from connecting each display to the host with independent cables. The topology is illustrated in Figure 2-2.

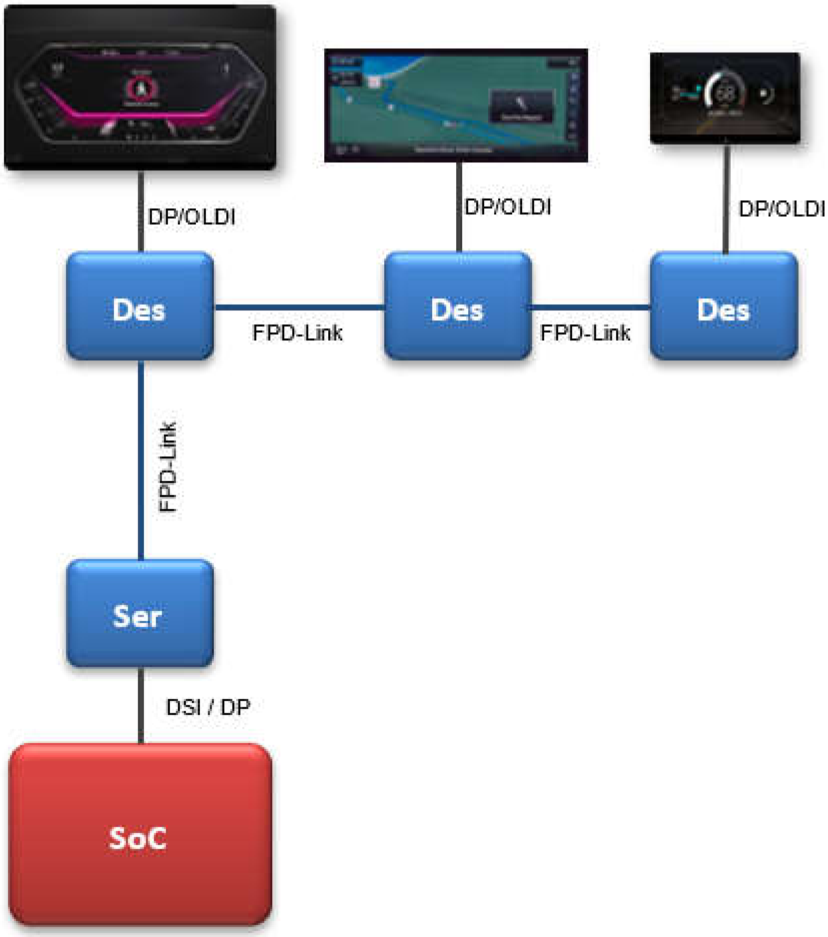

Figure 2-2. Daisy-Chain Topology

- MST: Supported in DP 1.2 and higher interface protocols, MST enables simultaneous transmission of video streams with different resolutions, color depths, and frame rates. It offers high transmission efficiency and stability, and can be used in conjunction with daisy-chaining.
- Superframe: Apart from the MST functionality of the DP interface, Superframe is another common method for multi-video transmission. By leveraging the SoC's video processing capabilities, video streams of different resolutions are combined into a standard rectangular video stream by inserting vertical blanking intervals between them. The combined stream is then transmitted, and the internal video processor within the serializer restores the individual video streams for output to each display. This approach enables the transmission of a greater number of video streams using fewer SoC video interfaces.

Figure 2-3. Superframe Video Processing

3 Typical Use-Case Scenarios

In this section, we use typical application scenarios to illustrate our SerDes solutions and the technologies employed.

3.1 Surround-View Parking Assistance System

As shown in Figure 3-1, four surround-view camera inputs are received via FPD-Link. The GPU performs image stitching and perspective transformation to generate a bird's-eye view, which is displayed in real time on the center display. Simultaneously, ultrasonic sensor data is integrated to overlay distance guidelines and obstacle warnings, assisting the driver in safe parking maneuvers.

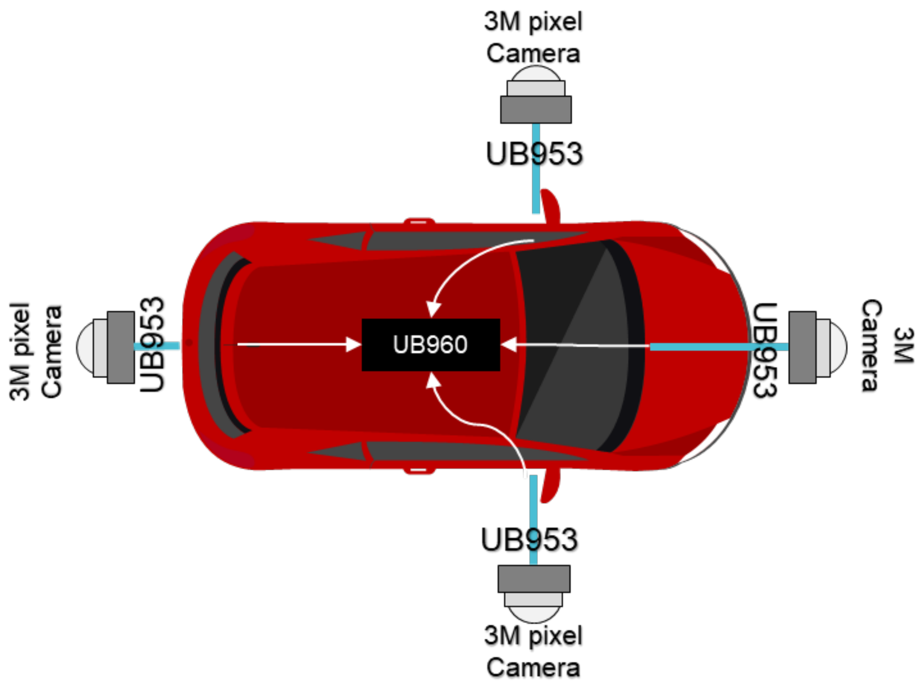

Figure 3-1. Typical Surround-View Camera FPD-Link Solution Topology

3.2 Integrated Parking and Driving Solution

As shown in Figure 3-2, in L2+/L3 autonomous driving applications, the processor receives video signals transmitted via SerDes (in this configuration, 4 surround-view cameras + 4 side cameras + 3 forward cameras + 1 rear camera form a classic 12-camera solution). The fused perception results, such as lane lines, traffic signs, and pedestrian positions, are simultaneously delivered to the instrument cluster and HUD via the DSS subsystem, with AR navigation arrows overlaid. Additionally, the system can distribute raw camera video streams to rear-seat entertainment screens, allowing passengers to view real-time road conditions.

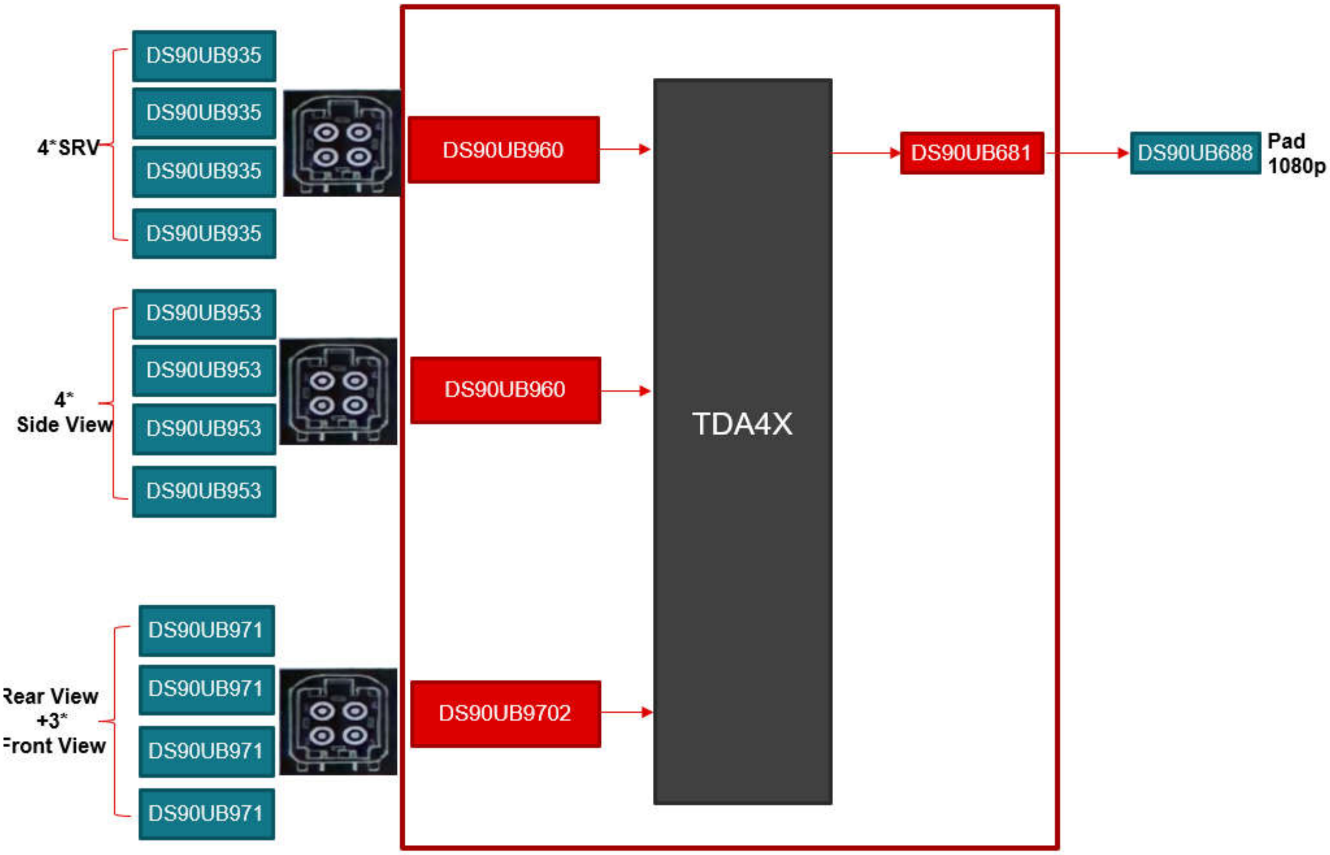

Figure 3-2. Integrated Parking and Driving Solution Topology

3.3 In-Cabin Display Solutions

As the number of displays in the cabin continues to increase, a single SoC is required to support more screens, yet the number of available SoC interfaces is typically limited. Therefore, adopting SerDes technologies such as Daisy-Chain, Superframe, and MST can effectively expand our display solution capabilities.

3.3.1 MST Solution Reference

Leveraging the flexibility of the MST functionality inherent in the DP protocol, multiple display applications can freely mix and match different video streams across each DP port, enabling support for multiple video streams with a limited number of DP ports. Refer to the MST application example in Figure 3-3. In this case, each DP port outputs two data streams, and the UB983 delivers these two streams to different displays via the UB984. The other path operates in a similar manner.

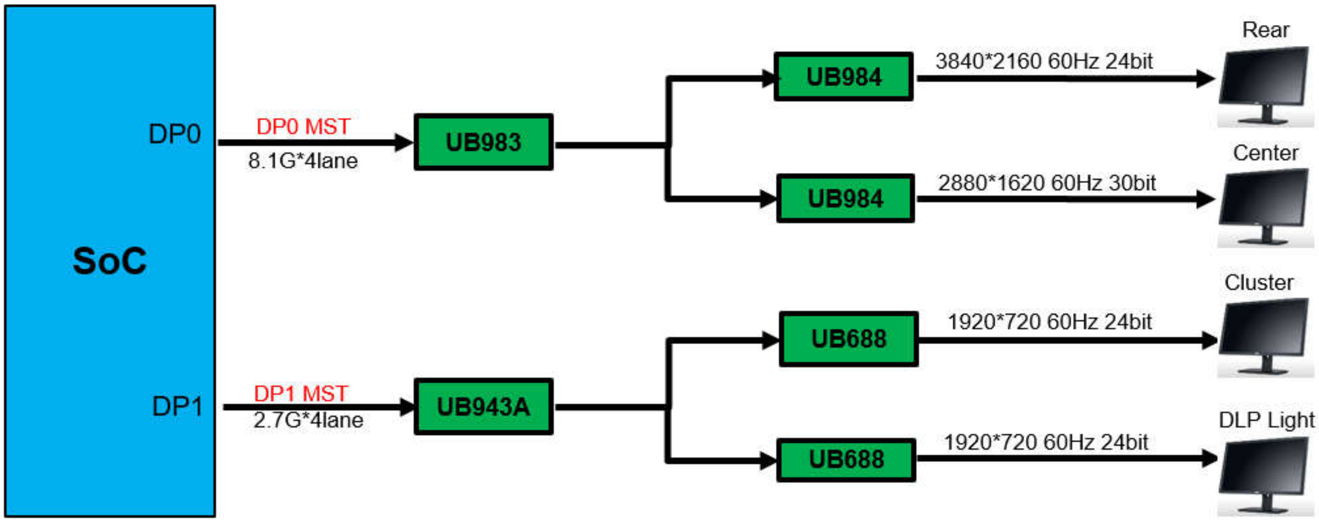

Figure 3-3. MST Application Example

3.3.2 Superframe Solution Reference

When using the DSI interface, MST functionality is not available. If the video streams have different timings, the SoC can insert vertical blanking intervals into the video streams to align the vertical dimensions of two or more streams. After processing by the serializer, the original-resolution video streams are recovered and transmitted to the downstream deserializer. As shown in Figure 3-4, a single image passes through the UB681, where it is split into two separate images sent to two UB688 deserializers, which then drive their respective displays.

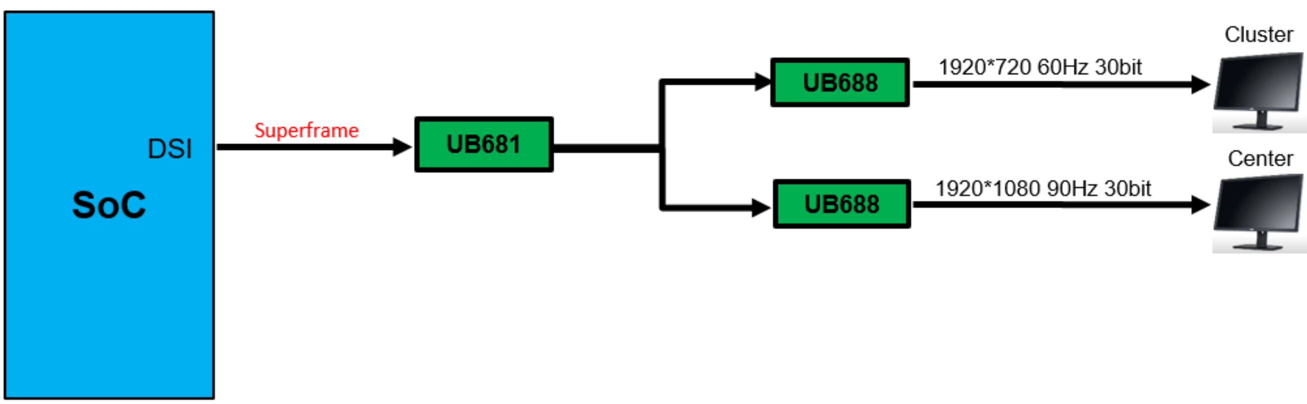

Figure 3-4. Superframe Application Example

3.3.3 Daisy-Chain Solution Reference

As shown in the Daisy-Chain application example in Figure 3-5 below, multiple video streams are output from the SoC's DP ports, split by the serializer, and then forwarded sequentially to downstream stages using deserializers in a "cascade" configuration. Note that FPD-Link III deserializers can serve as the final stage in a daisy chain; however, intermediate stages in the chain must use FPD-Link IV deserializers, as FPD-Link III deserializers only support receive functionality and cannot transmit to the next deserializer stage.

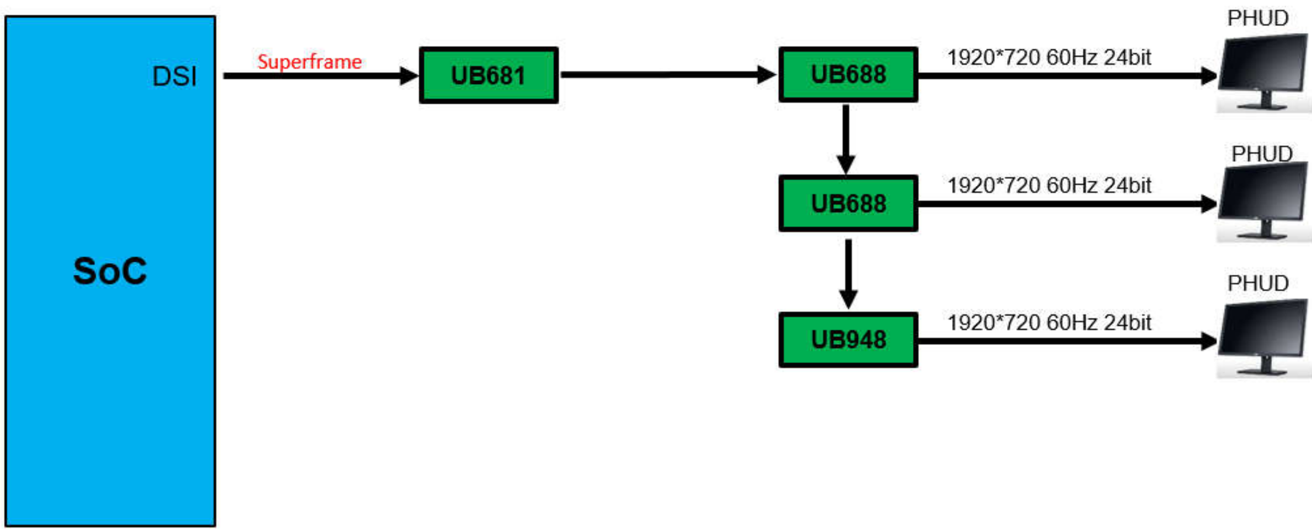

Figure 3-5. Daisy-Chain Application Example

4 SerDes Technology Outlook

Automotive SerDes technology is evolving rapidly, driven toward higher-level ADAS systems, higher-resolution in-vehicle infotainment, more demanding functional safety requirements, and smarter power management.

- **Higher Resolution and Bandwidth:** Supporting 8MP+ cameras and data rates of up to 30Gbps for audio/video and radar data, delivering finer-grained environmental perception for L3/L4 autonomous driving.
- **Functional Safety Upgrades:** Combined with ASIL-D grade safety ICs, enabling full-stack functional safety monitoring across cameras, transmission links, and processors.
- **Intelligent Power Management:** Dynamically adjusting power modes of FPD-Link and TDA4x devices to extend the driving range of new energy vehicles.

5 Conclusion

The combination of TI SoC processors and FPD-Link technology not only addresses the high-bandwidth, low-latency transmission requirements of automotive camera systems but also provides an end-to-end solution for intelligent cockpits and autonomous driving through powerful heterogeneous computing capabilities and multi-display support. Looking ahead, as sensor counts and resolutions continue to increase, this technology portfolio will continue to drive automotive electronics toward safer and more intelligent evolution.

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