DS90UB901, DS90UB902, DS90UB903, DS90UB904

Driving High-Speed Data Against the Traffic

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No. 124

Driving High-Speed Data Against the Traffic

— Andy McLean, Design Director

Driving Against the Flow of Traffic

Introduction

Vision-based safety systems are poised for explosive growth in next-generation automobiles. Multiple high-definition displays are appearing in the center console, rear seatbacks, and even the instrument cluster for both information and entertainment (infotainment) purposes. Cameras are also increasingly deployed to increase safety and for driver assist applications, such as improved visibility for backup and parking. Recently, the National Highway Traffic Safety Administration (NHTSA) proposed new vehicle safety regulations calling for standard rear-mounted video cameras and displays in all vehicles. Aimed at reducing the hundreds of fatalities and thousands of injuries that occur each year as a result of back-over accidents, the NHTSA said 10 percent of new vehicles must comply by September 2012, 40 percent by September 2013, and 100 percent by September 2014. While unquestionably increasing safety and adding to the driving experience, the addition of all these cameras also raises new challenges for automotive system designers.

Transmitting High-Speed Video Links

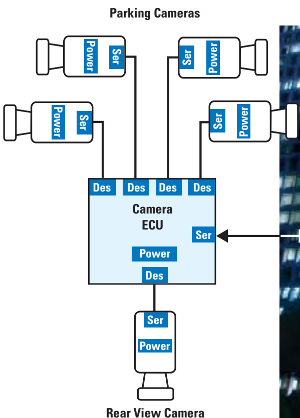
Each display or camera added to improve the driving experience is connected by a dedicated high-speed video link to a control (head-end) unit. In the simplest case, a single coaxial wire is used to display an NTSC signal from a back-up camera on a display in the center console. However, the trend is clearly to improve image clarity and quality with mega-pixel digital cameras displayed on high-resolution LCD panels. High-speed serial digital links connect the video components, providing a seamless connection from the digital imagers used in cameras to a digital LCD display. The most common and reliable high-speed digital interface technology deployed for automotive video links is based on the ANSI/TIA/EIA-644-A Low Voltage Differential Signaling (LVDS) standard.

LVDS provides a robust data transmission standard capable of long distances, low power, high noise rejection, and low EMI. Instead of a single-ended signal referenced to ground, LVDS uses a differential scheme to enable the desired attributes of the link. Interconnect savings are also realized by deploying smaller connectors and cables to reduce system size and weight—both critical features in automobile applications. As shown in ***Figure 1***, a serializer receives data from a video source, such as a camera's image sensor, then converts the wide parallel bus of RGB color and control signals to an LVDS serialized stream transported over a single, twisted wire pair cable. A companion deserializer at the other end of the cable expands the video signals back into a parallel interface for connection to a display or head unit.

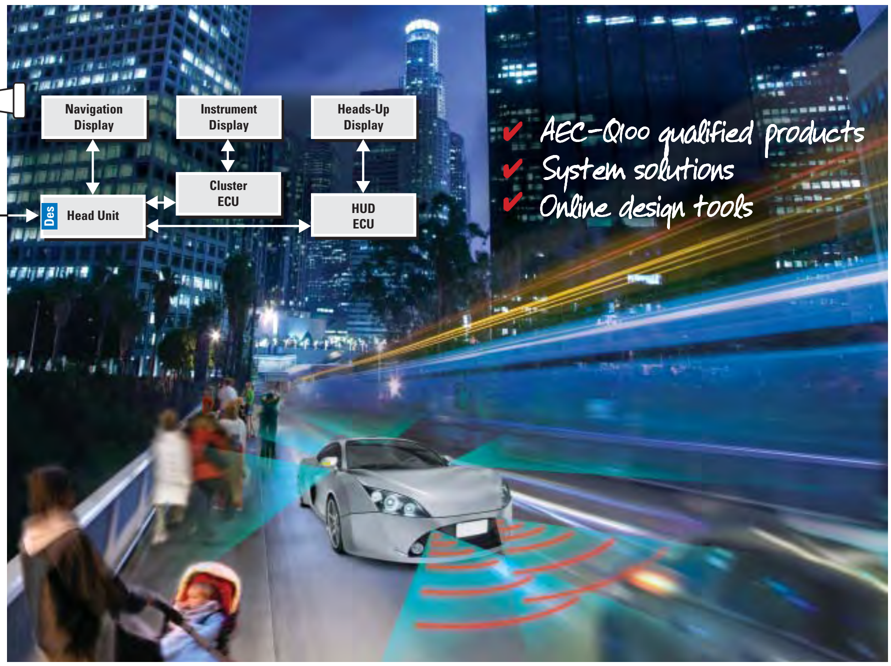
Peak Safety. High Reliability.

Improved Vehicle Safety and Driver Response Time

Camera systems are an increasingly important safety component. Multiple cameras and advanced image analysis help drivers monitor road conditions, detect hazards, and avoid collisions. Such systems require robust, uncompressed digital video links to deliver high-resolution data and enable signal processing. National Semiconductor's new FPD-Link III embedded clock SerDes with ultra-low EMI signaling integrate data, clock, and real-time control over a single twisted wire pair.



Shown: Driver Assist System Diagram



Designed for Automotive Cameras

The new DS90UB901/902 SerDes chipset uses 4-bit Cyclical Redundancy Check (CRC) to validate and monitor data integrity for safety-critical applications. Small package sizes and highly integrated components like the new LM34919B switching regulator enable sleek, compact camera modules.

Real-Time Bidirectional Control

Unlike products that depend on blanking periods to communicate to remote cameras, FPD-Link III solutions leverage a zero-latency embedded control channel that delivers continuous, real-time communication between camera and electronic control unit (ECU).

Proven EMI Mitigation

Spread Spectrum Clock Generation (SSCG) and progressive turn-on (PTO) in FPD-Link II and III products reduce peak harmonics to mitigate electromagnetic interference (EMI) and guarantee a robust data link.

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Driving High-Speed Data Against the Traffic

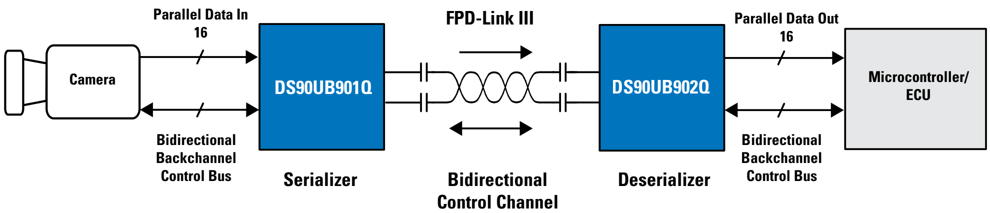


Figure 1. A Typical LVDS-Based SerDes Chipset Connects a Camera to an ECU

The FPD-Link III serializer/deserializer (SerDes) product family from National Semiconductor offers a number of advanced features that address the challenges of high-speed system design. Data skew issues are avoided by using a single serial data stream transmitted over a single differential pair. The serial data is encoded to contain an embedded clock that can be recovered without the need for a reference clock which allows for rapid initialization of the connection without special training sequences. The video data is also carefully randomized, scrambled to minimize electromagnetic interference (EMI), and DC-balanced to allow signal transmission and recovery over long lengths (10m+) of twisted pair cables. These measures help reduce EMI which is particularly critical in automotive environments with strict standards for electromagnetic conformance (EMC).

Driving Control Data Against Video Channel Data

As the number of displays, cameras, and sensors used in vehicles multiplies, so do the number of connections required between these modules and head units. Each cable added to a wiring harness increases both cost and weight and impacts production assembly cost and reliability concerns. Less obvious, however, is the increased number of data connections required to control and update the cameras and displays as the number of video links grows. For example, control settings are often sent from head unit to camera during initialization and operation. Brightness and back lighting settings can be automatically adjusted by a central controller based on driver settings or sensors in the cabin. Another example is with touchscreen displays where the position or multi-touch information needs to be sent back to the central unit. The key point is that control data is travelling against the direction of the video data flow.

To implement such a control channel, the standard approach is to run separate control wires in parallel to the video link—from camera to head unit—or from head unit to display. The design challenge is how to make more efficient use of existing wires and connectors for the video, control, and data signals.

Imagine for a moment driving against the flow of traffic on a highway without colliding with oncoming vehicles. This isn't a suggested application for collision avoidance systems, but is analogous to the challenge of providing a control path that flows in the opposite direction of the main high-speed video data. As previously noted, the ideal solution would also provide this control channel using only existing wiring and can, in fact, be implemented in a number of ways.

Driving High-Speed Data Against the Traffic

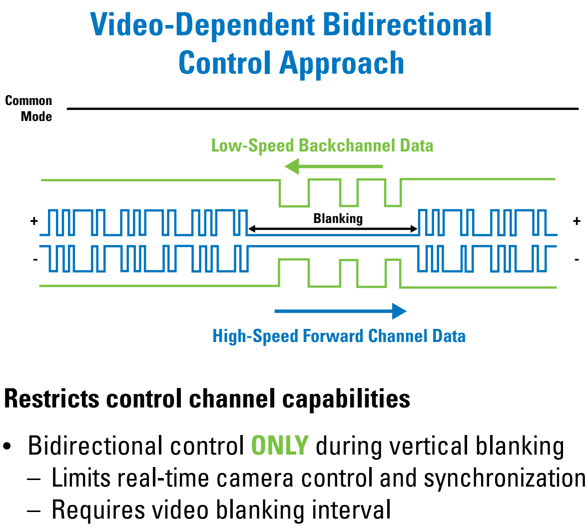


Figure 2. Control Channel Implemented During Video Blanking

Displays tend to use the video blanking period inherited from the old CRT days to send non-video data. CRT displays required blanking periods added at the end of every active video line and field to allow for the 'fly-back' time of the beam. Over the years, creative video system designers have used the blanking interval to transmit information such as closed captioning text or video timecode information. Newer display technologies, such as LCD, have retained the blanking periods although they are no longer truly necessary. *Figure 2* shows a scheme that uses video blanking periods to send control information, however, the amount of data that can be transmitted is limited to the length and frequency of the blanking period. This is especially limiting if only the vertical blanking period is used in a system supporting a typical frame rate of 30Hz. There is also a trend in the industry to significantly diminish this wasted overhead as it has a direct impact on both power consumption and pixel clock rate.

A further disadvantage of this approach is that the control data must be queued for transmission. The resulting delay introduces a non-deterministic latency that can be unacceptable for many applications, such as collision avoidance systems where response times of micro-seconds are required. This is also restrictive for applications where the precise timing of the control data has relevance, for example, attempting to synchronize multi-camera systems using this approach would be a challenge.

Another approach, shown in *Figure 3*, makes use of the differential nature of the signal used for the primary video channel. Control data can effectively be coupled into the cable as a common-mode modulation of the digitized video signal, however, this presents a fundamental EMI issue. Automotive applications enforce very strict EMC standards to avoid interference between electronic subsystems. Remember all the good work to minimize EMI by avoiding any residual common-mode signal using differential signaling together with randomizing, scrambling, and DC balancing of data? This is largely negated if a common-mode signal is intentionally introduced as a means to transfer control data so this approach is clearly another dead end street.

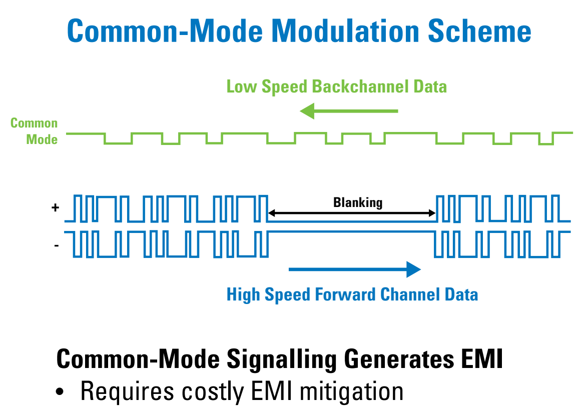


Figure 3. Control Channel Implemented Using Common-Mode Modulation of Video Data

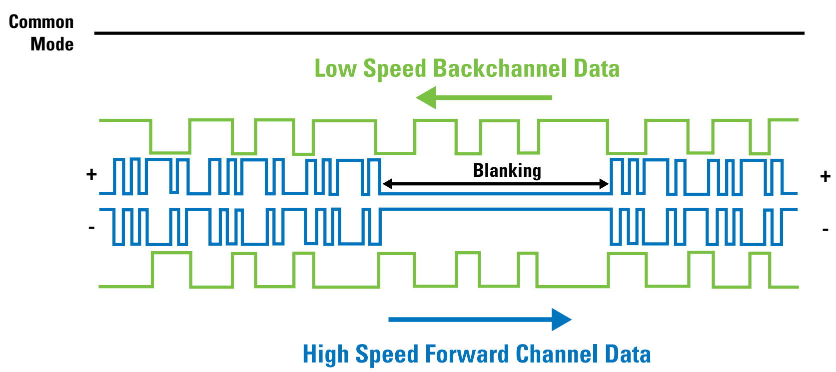
Continuous Bidirectional Control Channel

The FPD-Link III Ser/Des chipsets from National Semiconductor overcome the limitations of such alternative schemes with an entirely different approach. FPD-Link III technology simultaneously transfers both high-speed video data and control data over a single pair of wires. A bidirectional control channel runs continuously while video and audio data are being transmitted. Receivers in the serializer and deserializer are able to separate the forward (Tx to Rx) channel data from lower speed data travelling in the reverse direction (Rx to Tx.) This is possible based on the correlation of the data being transmitted and the compounded video, audio, and control data being received.

Because both forward channel data and control data are driven differentially onto the line, there is very little impact on EMI performance. Since the control data is transferred continuously, latency issues are minimized, as well. ***Figure 4*** illustrates how a continuous full-duplex control channel is established on the same pair of wires carrying the video and audio signal.

The DS90UB901/902 and DS90UB903/904 FPD-Link III chipsets include integrated I^2C controllers to simplify the interface from a host to the control channel. This allows a host on one side of the link to control or read status from an I^2C connected device—a CMOS imager, for example—up to 10m away on the other side of the link.

FPD-Link III True Bidirectional Control



Ideal for synchronizing multi-camera systems

- Single-pair, EMI friendly
- Low latency, full-duplex transmission
- Video independent – no waiting for blanking interval

Figure 4. FPD-Link III Continuous Simultaneous Control Channel

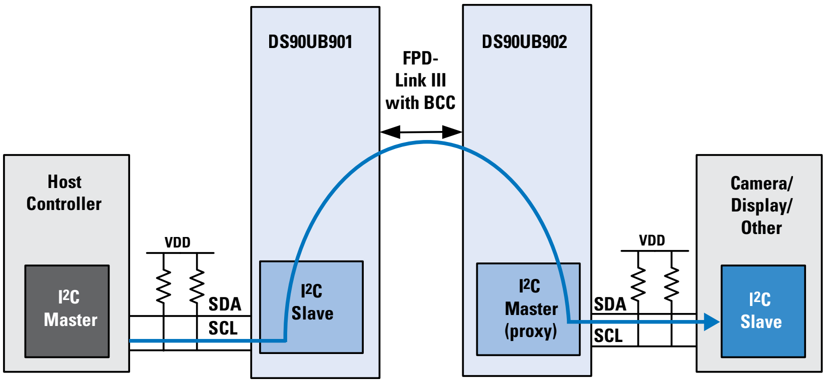


Figure 5. Accessing a Remote I²C Slave Using the FPD-Link III Bidirectional Control Channel

The system is very flexible and supports many of the I²C bus topologies just as if master and slave devices were connected on a local bus, as shown in ***Figure 5***.

General purpose input/output (GPIO) pins are also available to allow other control functions and protocols to be implemented. GPIO configured as inputs are over-sampled on one side of the link, transmitted as part of the FPD-Link III serial data stream, and regenerated as outputs at the other end which allows other control protocols—such as UART or SPI—to be implemented using the GPIO pins. The GPIO pins can also be used for applications requiring real-time, low latency synchronization signals or simple control functions, such as RESET. The GPIO pins can also be used with more advanced driver assist systems to stitch together images from multiple cameras to present a panoramic or sur-round view of the area around the vehicle.

To further reduce wiring harness size and weight, a remote power feed can also be provided on the same single pair of wires.

Since the FPD-Link III bidirectional control channel is implemented as a differential signal, DC power can be injected onto the wire and extracted at the other end without any impact on the video or control data. In this manner, the trio of video data, control, and power can be combined on a single pair of wires.

Conclusion

Camera-driven infotainment and driver assist systems both improve the driving experience and entertain passengers with theater-quality audio and video. The FPD-Link III chipset family is designed to help automotive suppliers provide this experience while improving responsiveness, simplifying wiring, and improving the robustness of video systems in the harsh automotive environment.

References

DS90UB901/902 Datasheets
FPD-Link III SerDes Evaluation Kit
AN-2173 DS90UB901/902 Chipset I²C Support

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