CAN bus, Ethernet, or FPD-Link: Which is best for automotive communications?

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Introduction

In 1915 Ford Motor Company introduced electric lights and an electric horn to its Model T automobile. Since then, the dependence on electrical and electronic systems in automobiles has been steadily increasing. The initial systems tended to be local and independent. For example, a switch that controlled the headlights was connected directly to the battery. Today, however, these systems are all interconnected. When a car's headlights are turned on, the dashboard lighting, mirrors, and other systems may all adjust to the new conditions. For this to work properly, the various different systems must communicate with one another. As the automobile has evolved, so have the networks used within it to make this communication possible. As autonomously driven vehicles continue to be developed, there will be an even greater demand for data transport within the vehicle and between vehicles. This article examines three automotive communications standards—the controller area network (CAN) bus, Ethernet, and Flat Panel Display Link (FPD-Link)—and explores which interface best suits which system.

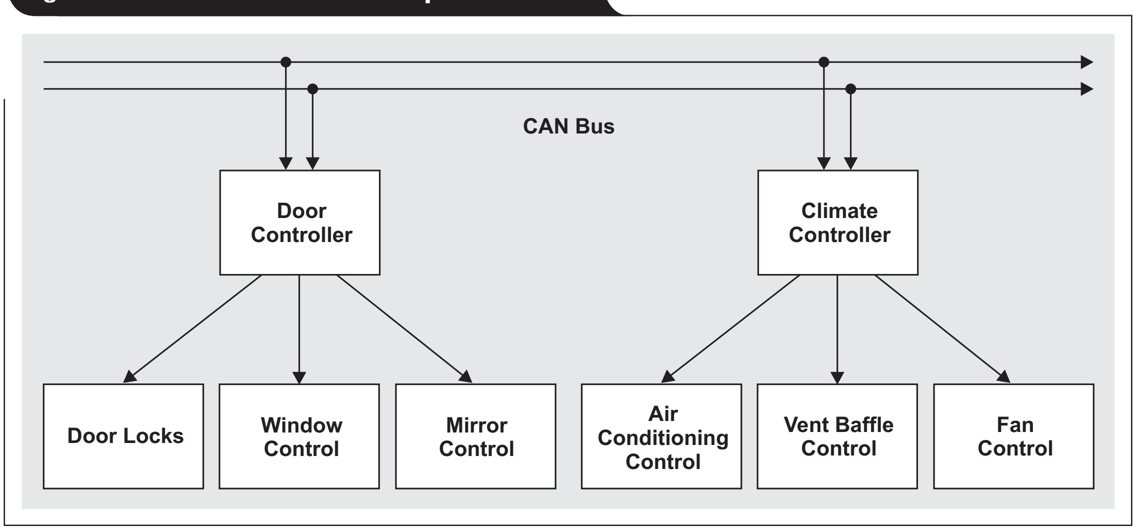
CAN bus

The CAN bus was initially developed by Robert Bosch GmbH in the 1980s. Today it is supported by several manufacturers of integrated circuits and subsystems and is used in all modern automobiles. The CAN bus allows different controllers or processors on the bus to communicate with one another via messages that are passed on the bus. There is a method for prioritization so that lower-priority messages do not interfere with higher-priority messages. The CAN bus operates at speeds of less than 1 Mbps, and message lengths (CAN frames) are typically 50 to 100 bits in length.

Since a CAN bus can be shared by many different controllers, it is generally not very good for sending messages that might require updates more than approximately 100 times per second. Ideally it is suited for relaying much slower status updates from sensors to the engine-control unit. This includes applications such as communication about other mechanical systems (transmission, braking, cruise control, power steering, windows, door locks, and others) where the amount of data is limited and the bandwidths involved tend to be relatively low.

Further reducing the overall transmission speed is the fact that automotive systems have become more complicated, with more sensors and processors being added to the network. Figure 1 shows a CAN bus being used for both door- and climate-control functions. Since each of these is a low-bandwidth application, there is little concern about one interfering with the other. However, if the same bus is also handling a higher-bandwidth, more critical function

Figure 1. Portion of a CAN-bus implementation



such as engine control, the priorities of door and climate control need to be set low enough so that these functions do not interfere with engine control.

The net result is that the CAN bus is well suited as a communications network between the mechanical sensors and systems within a car, but it is not readily extended to the higher-bandwidth requirements of applications such as entertainment systems or sensors for cameras or radar.

Ethernet

Ethernet is one of the most common high-speed interfaces found in homes and offices, and there are some automobiles where Ethernet is being used to transport a variety of high-speed data. Like the CAN bus, Ethernet is a packetized system, where information is transferred in packets between nodes on various parts of the network. Also like the CAN bus, Ethernet is bidirectional, and the speed possible on any individual link decreases as the number of nodes on the system increases. Still, Ethernet can transport data over a link 100 times faster than a CAN bus.

Ethernet is good for midbandwidth communications in applications such as navigation systems and control. It can be used in much the same way as a CAN bus while providing much more bandwidth. Ethernet would be an ideal choice to replace the CAN bus, but since Ethernet's cost per node is higher, it probably will not replace but rather will augment the CAN bus.

Some cars today are using Ethernet for data-intensive requirements such as backup cameras and entertainment systems. Of particular interest in automotive applications is the DP83848Q-Q1 from Texas Instruments (TI). This is an Ethernet PHY, screened to AEC-Q100 grade 2, and includes a loopback test mode for facilitating system diagnostics.

To transport video over an Ethernet network, even if there is only one video channel being transported, the video must be compressed at its source, then decompressed at the destination to avoid exceeding Ethernet bandwidth limitations. For an application such as a backup camera, this implies that there needs to be a relatively high-power processor in the camera to compress the image sufficiently to get it into the Ethernet network. This in turn means that the camera will be physically larger and more expensive and will have higher power dissipation than a solution that doesn't require much image processing. Another disadvantage of this solution is that video compression and decompression add latency to the link.

If the same Ethernet network is shared by several cameras or other video sources in the car, there is a trade-off between the amount of compression (and corresponding video quality) and the number of video channels that can be supported. This limitation could be mitigated by setting up multiple networks within the car in a hierarchical configuration. There might be one network that deals only with engine control and diagnostics, a second network that handles backseat entertainment and the audio system, and another network that handles driver-assist functions such as vision-enhancement cameras. In the end, Ethernet provides greater capacity than the CAN bus, at the expense of greater complexity, but still struggles to handle the highest-bandwidth applications such as video.

FPD-Link

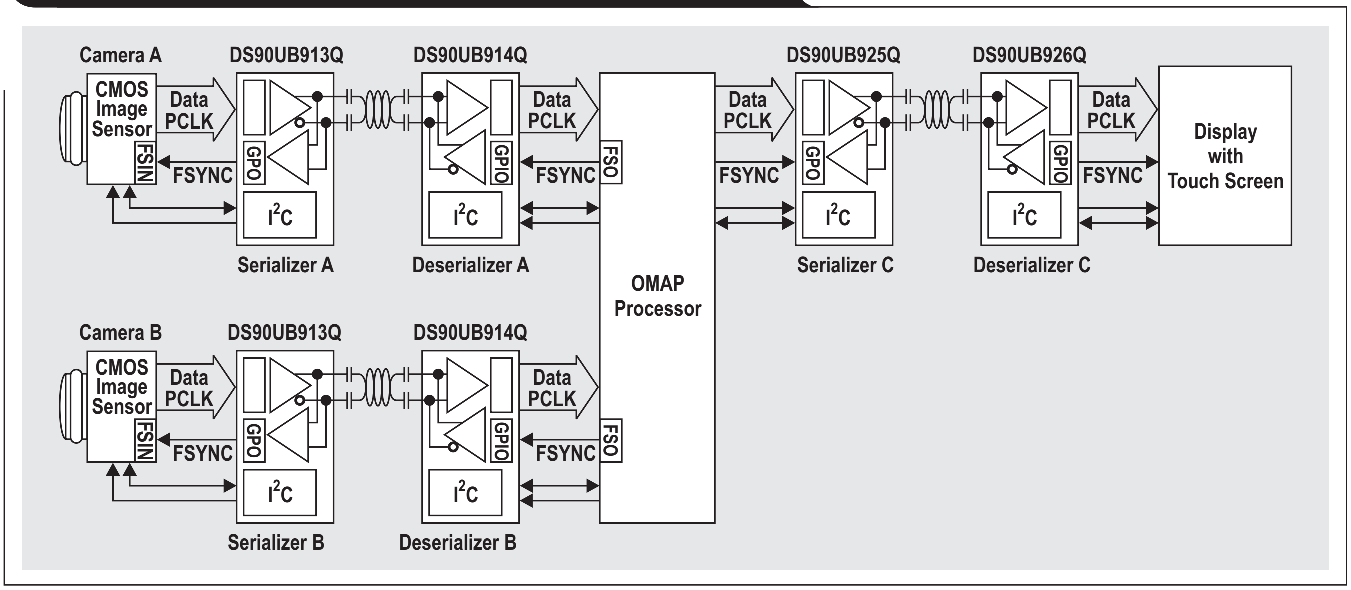
FPD-Link is a technology developed for point-to-point transport of high-bandwidth data. It has one forward channel with a very high speed of several gigabits per second and a low-speed back channel. The back channel can be used to transport an I^2C bus at 400 kbps or it can control GPIO lines at rates of up to 1 Mbps. FPD-Link was developed to transport video data within the car. For example, it can be used to send uncompressed video to a video display while the back channel sends information from a touch panel on the display screen back to the processor generating the video. The physical layer for FPD-Link is either a twisted-pair or coaxial cable. The wiring is dedicated, so if FPD-Link is used for a backup camera, one cable goes from the backup camera to a processor, and a second cable goes from the processor to the display in the cabin.

The big advantage of using FPD-Link in this application is that both the camera and the display can be much simpler circuits, since compression and decompression are not required. Additionally, since the links are dedicated, the image quality of one video system is independent of what else is going on in the vehicle. The back channel can be used to configure a camera, operate a zoom lens, or send touch-screen information back to a controller without interrupting video flow on the forward channel.

For autonomously driven vehicles, another important factor will be the amount of latency in the link. The processing required to compress and decompress an image adds to this latency. For an application such as backseat entertainment, a delay between reading the data from a DVD and its display on the screen is not important. However, if the image being transported is from a camera looking for pedestrians in the path of the vehicle, latency may have dire consequences.

FPD-Link is perfect for critical links where high bandwidth and low latency are the most important factors. Additionally, with the ability to support a back channel and power over a single twisted-pair or coaxial connection,

Figure 2. Using FPD-Link to connect dual cameras and display



wiring can be simplified. Figure 2 shows an OMAP™ video processor connected to two different cameras, and a display with a single twisted-pair cable going to each peripheral. This twisted-pair cable supports camera video data and touch-screen/camera-setup data. It can also provide power for the display or camera. Since each link is dedicated to one peripheral, there is no risk of interference between the signals from the two cameras.

Conclusion

So which interface is best for automotive communications? They all are—but each for its own purpose. The CAN bus reigns supreme for low-speed control applications where cost is a driving factor. When bandwidth requirements move up, Ethernet can step in as an enhanced interface to support moderate bandwidth requirements. When the highest bandwidth and lowest-latency link are required, such as for a surround-view camera system providing input to an autonomous vehicle pilot, then FPD-Link is ready to meet the challenge.

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