A new generation of in-vehicle entertainment systems for automotive applications, featuring very high quality video as well as audio for rear-seat and passenger displays, is moving slowly but surely into view. Prototypes are being developed at the world's leading automotive manufacturers, and production models may be available as early as 2008. Based on standards such as the IDB-1394 and Media Oriented Systems Transport (MOST), the networks required for these applications -- such as rear-seat entertainment systems and real-time cameras -- demand high bandwidth and optimal quality of service.

A basic outline of these systems as envisioned by Nissan Corporation in its prototype in vehicle network is shown in Figure 1, which illustrates the network using the IDB-1394 standard. By providing bandwidth of up to 400 Megabits/second, IDB-1394 can meet the video and audio demands of the multimedia network.

Figure 1: network diagram from Molex

IDB-1394 is a network protocol that enables bandwidth required for these multimedia applications in the vehicle. The IEEE standard 1394b-2002 defines an extension from 100 Megabits/second to 400 Megabits/second for the physical layer, along with the ability to connect different system nodes at distances up to 100 meters without the need for repeaters. With almost 400 Mbps available, the network is capable of connecting numerous communication channels on a single wire harness, serving DVD players, PCs, handheld products, and related peripherals. IDB-1394 also allows multiplexed transmission of audio and image contents, which can be divided and transmitted simultaneously on different logical channels.

Concerning temporal options, the IDB-1394 protocol provides different types of transmission packet
with isochronous (real-time) channels available to guarantee a defined bandwidth and latency for the payload; and asynchronous channels, which typically are used to move user commands. Video and its associated audio content are routed through isochronous channels along with any audio signals synchronized to the image data at the receiving node.

Any type of channel carries transport streams (TS) which can be in the form of raw or encoded data. (Encoding and decoding functions are not incorporated as part of the IDB-1394 standard; see below for the solution). Host processors are not required, as they almost always are with other standards such as USB. In IDB-1394, streaming enables a protocol handler independent of a host processor.

The network has a ring structure. Disconnecting any but one branch within the network will not lead to a system failure. Nor will it lead to any other sort of video delivery degradation. Thus, a reliable level of system availability is obtained as an intrinsic feature of the IDB-1394 network. In the demonstration network two DVD-streams coded as MPEG2-TS are fed into the network. They are available at any time for any receiving node, allowing random selection by a rear seat passenger.

The **IDB-1394 controller**

In order to implement the in-vehicle network, a specialized standards-based controller is required. Fujitsu has developed an IDB-1394 controller, designated the MB88387, which has been specifically designed for these rear-seat entertainment systems. It is a single chip solution that comprises physical layer and data link layer. It supports Audio/Video protocol processing including Digital Transmission Copy Protection (DTCP), which has been developed by industry leaders such as Sony, Intel and Hitachi industry, among others, to pre-empt illegal copying of copyrighted content.

The functions of the MB88387 IDB-controller are shown in the block diagram in *Figure 2*. Three different paths for the transmission and reception of payload data and commands are available. The arrow at the bottom of the diagram, identified as MPEG2-TS, illustrates the path of the video data transport stream (TS). It is typically encoded as MPEG2. The device provides two TS-interfaces for routing data through the DTCP unit towards the local application. From there forward, two bridges connect to the link layer implementation of the IDB-controller. Finally, the transport stream is routed to the double-port physical layer implementation.

![Figure 2: MB88387 controller block](image)
These 1394b-compliant ports drive the lines to the next node. They support bus speeds compliant with the various physical layer specifications of the 1394 standard, including S100, S200, and S400 physical layer specifications. The block named 'PHY/LINK layer control' ensures that the complete IDB-1394 data stream is copied in full duplex between both ports.

Networks based on the IDB-1394 standard require only a simple ring structure for the wire harness wiring. Other protocols generally require point-to-point connections or even separate routing for command transfer and analog audio. The versatility of IDB-1394 effectively renders these supplemental bus systems obsolete by the IDB-1394 specification.

**Next: Using the IDB-1394 controller**

**Using the IDB-1394 controller**
The MB88387 controller provides one isochronous interface for audio, two channels of MPEG2-TS video interfaces, and one asynchronous interface for command data. In parallel, the video signal can be fed into a separate transport stream interface using the second isochronous channel. The audio stream, which is handled via a separate channel as noted by the middle arrow in the block diagram, can be fed into an I2S interface buffered by a 2kbyte FIFO, independent of the 2kbyte FIFO assigned to video data streaming. Both linear PCM audio as well as DVD audio can be transmitted via this path.

For the command interface, the asynchronous transmission channels are used. The host processor interface is buffered by two 512 byte FIFOs for reception and transmission. Parallel processing is possible for all data types, due to the separate buffers. Even two streams can be processed simultaneously. For example, digital TV and DVD video signals can be transmitted in parallel while the corresponding audio signals are bundled in separate channels.

At the receiver side the video and the respective audio stream need to be re-synchronized following transmission. Before passing the data to the DTCP unit and in a first step, the units called bridge A/B put together the isochronous packets of matching audio and video contents.

In the second step, the TSP-IC interface synchronizes these packets according their time stamps. The TSP-IC unit adds the time stamps to both the MPEG2-TS and audio streams when transmitting. Audio and video streams are separated and re-assembled automatically. Packet headers are also stripped automatically. The buffering of all streams assures a continuous transmission.

**IDB-1394 based rear seat entertainment system**
The MB88387 supports the design of rear seat entertainment (RSE) systems, which are illustrated in *Figure 3*. 
The system consists of a main unit (M) located in the front panel, two rear seat displays (R), and an amplifier (A). The main unit, typically carrying the navigation too, supplies DVB-T, DVD-Video, and DVD-Audio. All sources can be randomly selected by the rear seat passengers because all streams are transmitted in parallel at all times. The DVB-T signal converted to a MPEG2 transport stream, which provides approximately 30 programs simultaneously, needs approximately 32 Mbps. The DVD video is also encoded as MPEG2-TS and occupies slightly more bandwidth than the DVB-T stream, or approximately 36 Mbps. The linear PCM Audio signal requires less than 10 Mbps.

All of the bandwidth allocations in this example require only approximately 30 percent of the available bandwidth of a S400 class IDB-1394 network, leaving plenty of bandwidth for adding DVD sources onto the same network, or to mount PCs, storage peripherals, or handhelds.

**Next: The IDB-1394 starter kit, SmartCODEC**

**IDB-1394 starter kit**

How to start a design with a reasonable amount of effort? For this purpose a starter kit is a suitable tool. Typically, users want to set up a system similar to the block diagram. A basic software package is available also, in order to get designers started.

The starter kit (see Figure 4) can be configured as receivers or transmitters. On the left hand side a DVD-player can be connected and feed its A/V signals into the transmitting node. The starter kit provides onboard Fujitsu MPEG2 encoders and decoders (MB83691 and MB86H22 (SmartMPEG)) that create and decompress the MPEG2-TS, which is sent along the IDB-1394 network. At the receiving node, the transport stream is decoded again. An LCD connected to the receiver displays the video data.

**Figure 4: starter kit**
While the host system, including MPEG2 CODECs, is located on the larger main board, the IDB-1394 controller device resides on a plug-in board. This means that future 1394 devices developed for these in-vehicle video applications can be supported within the same environment.

**IDB-1394 demonstration network**
The IDB-1394 demonstration network is similar to the basic IDB-1394 network created with two starter kits. This time four nodes are mounted to the network. The network as illustrated in *Figure 5* shows the system block diagram with two data sources in form of two DVD-players and two displays, which act as rear seat data sinks.

![Figure 5: IDB-1394 system](image)

The network itself has a ring structure. Disconnecting any but one branch within the network will not lead to a system failure neither to any sort of other degradation. Thus a certain level of system availability is obtained as an intrinsic feature of the IDB-1394 network. In the demonstration network two DVD-streams coded as MPEG2-TS are fed into the network. They are available at any time for any receiving node, allowing random selection by any rear seat passenger.

There are some different requirements for the design of rear seat entertainment (RSE) systems compared with the real-time camera systems that are going to provide rear view images in real-time to the driver of the vehicle. *Figure 6* shows an example of a future rear seat entertainment application with enhanced coding/decoding support. In rear seat systems using the MB88387 as the 1394 controller, it is necessary to add an MPEG encoder and MPEG decoder at every node separately.
These are required for connecting DVD-players and all of the rear seat displays. The additional hardware units increase the overall system costs moderately. But they resolve the potential drawback encoding and decoding MPEG, which can cause significant delay times for the video signal, adding approximately 200 to 300 milliseconds.

This fairly significant delay can be recognized by the human eye, particularly at the time when the user selects an operation on the menu display and the corresponding action is delayed by a noticeable time lag. In particular, real-time images provided by a rear view camera will be affected by a noticeable delay that makes the images unusable.

**Next: SmartCODEC**

**SmartCODEC can resolve encoding/decoding issues**

In order to avoid such bottlenecks, a SmartCODEC can be implemented in the system, as shown in Figure 6 in the form of an IDB-1394 controller capable of transmitting DVD-Video, digital TV, and navigation images without any external MPEG encoders and decoders. The raw data in the form of YUV digital signals and RGB digital signals is compressed by a new, more efficient and creative codec algorithm that compresses the raw data to one-third of its original size. The algorithm can be designed to meet real-time demands while also opening more opportunities for conventional systems that have no MPEG2-TS interface to be integrated to the same IDB-1394 bus system.
The SmartCODEC
The SmartCODEC, which will be introduced with a new IDB-1394-compliant controller from Fujitsu in the fourth calendar quarter, is a type of almost lossless video codec. It compresses and expands the YUV-signals as well as high resolution RGB-images as they are frequently applied in navigation displays.

It will deliver encoding and decoding times of between two and three milliseconds, and a constant compression ratio of one to three with the BT.601 standard for component video. Using the SmartCODEC yields average video image transfer rates in megabits/second that are just one-third the rates possible without it. Compression is near lossless, providing high image quality for natural images and for line drawings. It is only using line memory, without frame memory.

This CODEC will provide designers with two useful benefits. New applications for the in-vehicle entertainment network, such as real-time camera systems as shown in the Nissan prototype in Figure 1, will become feasible. And, existing applications like rear seat entertainment systems can be built at lower cost than is now possible.

The progress toward in-vehicle entertainment and information systems continues, and with the addition of new integrated technologies will move past the prototype stage and into production vehicles.

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