



White Paper

Automotive USB Connectivity for Portable Devices

Freescale's ColdFire® MCF5251 USB Solution



Overview

To reduce the technical issues and bill of materials cost of adding USB connectivity to automotive head units, Freescale Semiconductor has introduced a fully AEC-Q100 qualified version of its ColdFire® MCF5251 audio processor and associated reference software solution.

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Automotive Audio Challenges

In 2005, annual sales of portable media players (PMPs) such as the Apple iPod™ and other hard drive and NAND flash-based devices topped 140 million units and are expected to surpass 280 million units by the end of 2010¹. With media capacities of 1 GB to 60 GB common in the market today, consumers can listen to most if not all of their entire music collection from a single device. And as with any consumer product, the market is constantly evolving, adding new services such as subscription music from providers such as Napster, Real Networks, Yahoo! and MTV where users can download as much content as they want from a number of different artists and genres. While these new products and services bring tremendous entertainment value to the consumer, they also bring numerous challenges when interfacing to another ubiquitous music playback device: the car radio.

While PMPs come in a wide array of form factors and media sizes, the common thread that bonds nearly all of these devices is the ability to connect to a PC using standard USB protocols. The obvious path to supporting these devices is to add a USB host to existing car radios. However, the technical challenges and costs can be substantial when factors such as external memory requirements, multiple USB protocols and a variety of audio decoders are taken into account to ensure that the car's head unit supports as many portable devices as possible.

To reduce the technical issues and bill of materials cost of adding USB connectivity to automotive head units, Freescale Semiconductor has introduced a fully AEC-Q100 qualified version of its ColdFire® MCF5251 audio processor and associated reference software solution.

Mass Storage Class Protocol

The most common USB protocol used in portable media players is also implemented in other devices such as USB flash drives and portable hard disk drives (HDD). Mass storage class (MSC) devices are represented on the PC as an external drive, and PMPs using MSC can act as simple data storage devices. This also allows consumers to place data files on the device that can be transferred to other PCs. While MSC has become somewhat ubiquitous, supporting it in an embedded host system such as a car radio is not as simple as it may seem.

PCs have been supporting MSC devices without the need to load external drivers since the launch of Microsoft Windows® ME. A driver released for Microsoft Windows 98 required over 600 KB of program space. This was beyond the scope of many embedded systems, where entire programs typically range from 512 KB to 2 MB. While MSC was specified by the USB Implementers Forum (USB IF), the actual specification is open to the developer's interpretation, particularly when the device being developed does not undergo USB-IF certification. Many manufacturers of PMPs and flash drives often trade USB-IF certification for faster time to market and other value-added factors.

When the first USB High Speed devices came on the market, there was value in the High Speed USB logo which indicated successful certification. Today, High Speed USB devices are the rule rather than the exception, and companies generally do not undergo formal certification. Instead, they often choose to test in-house to save cost and time.

MCF5251 Certification

Freescale has certified its ColdFire MCF5251 hardware and software solution at a USB-IF certified independent test laboratory to ensure the highest level of interoperability with other USB-IF certified devices. To cover more extreme cases where the slave device is not certified, Freescale tests numerous Flash drives and PMPs to ensure compatibility with Freescale reference software. Additionally, if a new device comes to market and is not supported, Freescale offers a maintenance program to add that support. This allows for a wide window of MSC device support, with updates for new products that may come to market in the future. Freescale's reference software for the ColdFire MCF5251 audio processor helps ensure that customers' automotive designs—which can take one to two years to develop—can support the latest MSC devices and PMPs through software upgrades.

¹ *Portable Digital Audio Players: Market Growth Exceeds Expectations*, In-Stat Inc., April 2006

Comprehensive Microsoft Compatibility

To compete with Apple's iTunes™ music service in the pay-per-download content distribution market, Microsoft created a new digital rights management (DRM) technology called Windows Media DRM 10 (WMDRM10). This new DRM scheme allows content providers to distribute content under various use models. These models include time-based, where tracks automatically expire in a set amount of time; playcount-based, where tracks expire based on the number of times they are played; and subscription-based, where consumers can subscribe to a service and download as much content as they wish. This new DRM model is driving the business models behind popular music services such as Urge from MTV Networks, Napster To Go, Yahoo! Unlimited, and Rhapsody from Real Networks—with more services coming online each year. WMDRM10 can also be used for video distribution under the same models, as well as for streaming audio and video to media adaptors to enable PCs and other connected devices to act as content servers within the home.

Media Transfer Protocol

To enable these unique content distribution models, Microsoft created a new open standard USB protocol called Media Transfer Protocol (MTP). MTP is based on the Picture Transfer Protocol (PTP) used in digital still cameras. MTP uses unique “object identifiers” to uniquely identify digital media files stored on a device. These object identifiers can then be used by the download service via the host PC to maintain information on each specific track or file that has been downloaded.

Today, most implementations of MTP are visibly slower than MSC. However, the advantages of this new protocol, along with consistent software improvement, increase transfer speeds and outweigh any performance advantage of MSC. At some point, users can expect nearly all PMPs to support MTP, and MTP-only players are not out of the realm of possibility. While unprotected content on a PMP can be accessed by a USB-enabled head unit using the simple mass storage class USB protocol, MTP must be used to access WMDRM10 content as well as to guard against the possibility that the portable media market would support only MTP as a USB protocol. Currently only Microsoft Windows XP has native support for MTP; native support is planned for Windows Vista. Microsoft has also made MTP available for download to enable MTP in Windows 98.

MTP is enabled on many semiconductor suppliers' software development kits (SDKs) for portable media solutions, including the consumer version of the Freescale ColdFire MCF5251 audio processor and the i.MX applications processor family that are used in a number of PMPs. Freescale also offers the host format of MTP to support ColdFire MCF5251 USB host applications such as automotive head units. By serving both the host and slave sides of the market, Freescale is in a unique position to apply learning from the host side to the slave side—and vice versa—resulting in a superior solution for both host and slave MTP applications.

PlaysForSure, PlaysFromDevice and Automotive USB Connectivity

To help make consumers more aware of interoperability with new WMDRM10-enabled services, Microsoft also instituted a logo program called PlaysForSure™. A player receives PlaysForSure certification after it passes a series of performance and interoperability tests that are run at an independent testing facility. Once the player passes the tests, the PlaysForSure logo can be applied to the packaging to make consumers aware that the device can operate with WMDRM10-based content distribution services.

While the first instantiation of the PlaysForSure certification allowed many devices to pass, Microsoft continues to ratchet up the performance and interoperability requirements of WMDRM10-enabled devices. One that is of interest to automotive head unit manufacturers is PlaysFromDevice functionality.

In its PlaysForSure 2.0 Requirements for Portable Devices, Microsoft added an optional requirement for devices to support a new command, control and streaming protocol called PlaysFromDevice. Although currently optional, it is expected that PlaysFromDevice will become a full requirement in a future version of Microsoft's PlaysForSure certification.

One-Wire vs. Two-Wire

PlaysFromDevice can be enabled in two distinct ways: one-wire and two-wire. Two-wire PlaysFromDevice uses an MTP host to serve as a command and control interface to the PMP. Simple commands, such as next track or previous track, allow the host to effectively navigate content on a portable player. In the two-wire case, audio is played through the headphone or line-level output of the player and is fed into the host in analog format. The advantage over competing command and control technologies is the ability to apply the commands over USB without the need to add an extra serial connector such as a UART to the host. Nearly all portable media players have a USB connection, and the USB connection generally also serves as a power supply to the player.

The downside of the two-wire scenario is the need to provide an analog-to-digital converter on the host to bring the audio back into the digital domain for further processing. While relatively simple to implement, it is likely that the two-wire scenario will be replaced quickly by one-wire PlayFromDevice, which allows digital transfer of the content over USB to the host.

One-wire PlayFromDevice essentially streams encoded content over a protected USB line to a one-wire enabled USB host. Because the content is transmitted digitally, Microsoft's Cardea encryption scheme is used. This same encryption scheme is used when protected content is streamed from a PC to a media adaptor in the home in Microsoft's WMDRM10 Networked Device implementation. In the case of the head unit (MTP host) and the portable media player (MTP slave) the media player becomes the server to the head unit—similar to the PC in the home networking environment—and the head unit acts in a way similar to the media adaptor, receiving and navigating the content on the portable device.

While eliminating the need for the analog-to-digital conversion and adding the ability to transfer content digitally, one-wire PlaysFromDevice adds two levels of complexity to the USB host. Not only must the host be capable of supporting the MTP protocol for command and control of the player, but it must be able to decrypt the Cardea encrypted stream and decode the audio content. In most cases the content will be in Windows Media Audio (WMA) format. However, in order to use PlaysFromDevice universally across any file, other codecs such as MP3 and AAC should also be supported on the host.

Benefits of Freescale's Solution

Freescale's ColdFire MCF5251 USB audio solution is capable of supporting of the MTP host protocol, Cardea decryption and audio decode requirements of one-wire PlaysFromDevice. Additionally, the MCF5251 has 128 KB of embedded SRAM which allows full one-wire PlayFromDevice functionality without the need for costly external SDRAM. Other value-added functions in Freescale's software development kit for the MCF5251 are the ability to play back content from USB Flash drives, Secure Digital (SD) cards and Multimedia Cards (MMC), as well as the ability to encode directly from a CD input to USB or card-based media—creating a virtual CD changer in the head unit.

The MCF5251 is the first device to enable all of this hardware and software functionality in a fully AEC-Q100 automotive qualified IC. The MCF5251 has also undergone a full Production Part Approval Process (PPAP) to ensure the highest level of quality for OEM and aftermarket automotive applications. Furthermore, with Freescale's substantial presence in the consumer portable media market with its ColdFire and i.MX product families, automotive head unit manufacturers can be assured that their host applications can be future-proofed against any changes to transfer protocols, codecs and encryption schemes that emerge in the rapidly changing portable media player market.

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