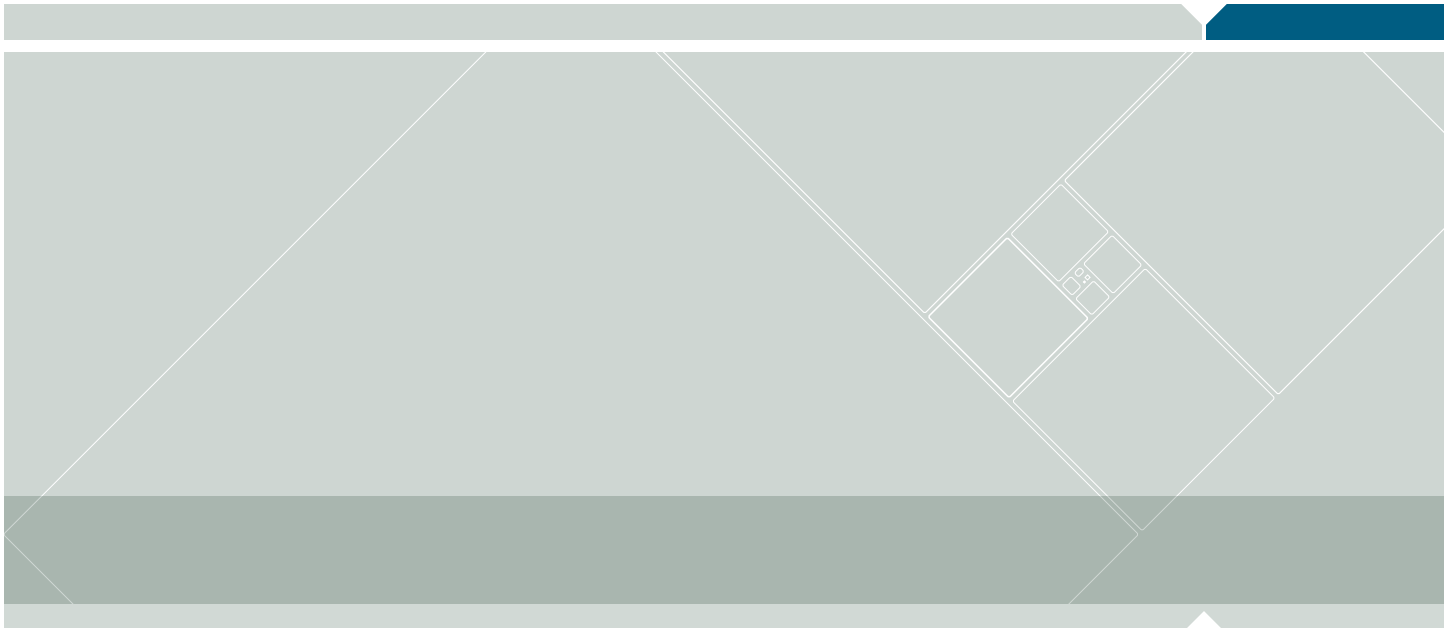

White Paper

Connecting the Automotive and Consumer Worlds

Freescale i.MX applications processors: solutions for automotive infotainment

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Overview

The automotive infotainment market is increasingly influenced by portable and mobile consumer electronics technology, where the pace of change is much more rapid. Consumers are coming to expect a wealth of multimedia features in their cars, and the market for in-car multimedia is growing. However, in the automotive world, durability and reliability requirements for semiconductors are much more stringent and cycle times are longer. Freescale's i.MX multimedia applications processors are multimedia engines, with millions sold in the consumer market. Now that the i.MX31 and i.MX31L processors have achieved automotive qualification, they are especially well positioned to perform at this intersection of markets. This paper discusses key technical and market requirements for portable consumer and automotive semiconductors, where those requirements intersect and where they diverge, and the technical characteristics that make i.MX processors a good choice for both.

Contents

1 Introduction

The automotive infotainment market is experiencing an extraordinary acceleration in the rate of change of technologies and user expectations. This is because the automotive world is increasingly influenced by portable and mobile consumer electronics technology, where the pace of change is much more rapid than has been the case in automotive infotainment. Thanks to portable consumer electronics devices such as MP3 players, cell phones and portable navigation devices (PNDs), users have access to entertainment, communication and information wherever they go.

This means that consumers now expect two things from their cars:

- Intuitive connectivity. Automotive entertainment and information systems should connect in an intuitive and seamless way to portable consumer electronics devices. Music from portable devices should be played back through the built-in car audio system. Mobile phones should be accessible and usable through a built-in, hands-free telephony system.
- Latest features. As new devices and use cases become popular in consumer electronics, the systems in the car should keep pace with them. User interfaces should reflect the features available in the consumer electronics world, such as high-resolution color screens and animated graphics. It should be possible to upgrade car systems to maintain connectivity with the most popular portable devices.

In addition, two other trends are increasing the complexity and rate of change of automotive infotainment systems:

- Safety legislation. Lawmakers are increasingly turning their attention to the number of road accidents where use of a hand-held mobile phone was involved. In many countries, it is already illegal to drive a car while making a phone call unless the driver uses a voice-activated hands-free system. In addition, the number and complexity of systems in modern cars—not just infotainment systems—makes it much more complex to design a user interface which does not unduly distract the driver. The answer to this challenge seems to be voice activation.
- Digital broadcasting. New audio broadcasting formats such as satellite and terrestrial digital radio (such as DAB, XM and DRM) and digital mobile television (such as DMB, DVB-H and ISDB-T), which also include audio-only channels, are changing the face of radio reception in the car. Most of these formats allow for the possibility of data transmission too.

To deploy these capabilities and still maintain the automotive industry's high expectations of reliability and ease of use, automakers have been turning to proven consumer platforms which have been adapted for automotive use. This paper discusses how the Freescale i.MX applications processor family, already a major force in portable electronics, is helping automotive infotainment systems designers to deal with the rapid changes outlined above.

2 Market Forecasts

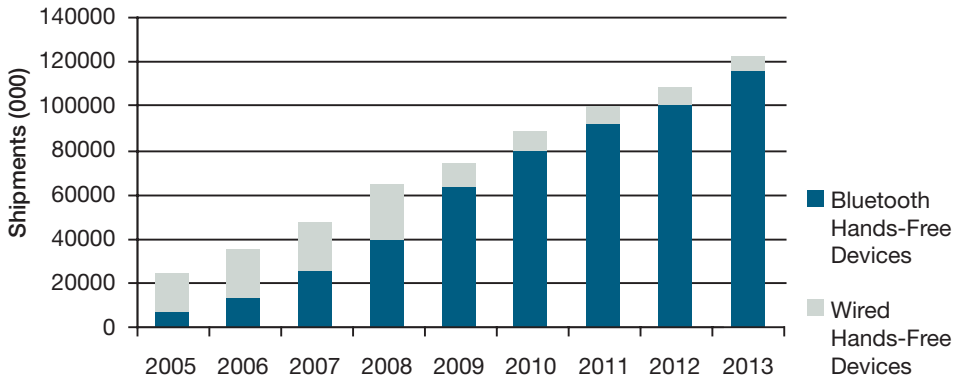
Analysts are forecasting rapid growth in automotive connectivity. According to Telematics Research Group (August 2007), connectivity with Bluetooth® cell phones and with portable music players is becoming a must-have technology. From a survey of 100 upcoming 2008 model year North American cars:

- 70 percent will offer Bluetooth hands-free interface
- 80 percent will offer navigation
- 50 percent will offer portable media player connectivity
- 90 percent will offer auxiliary audio input or flash card interface
- 20 percent will offer USB
- 30 percent will offer rear view cameras

In addition, Telematics Research Group found that 80 percent of announced MY08 models will offer navigation as standard or optional equipment. The demand for in-car navigation has also been fueled by the recent boom in sales of portable navigation, which has helped to create user awareness of navigation and its benefits.

According to Strategy Analytics, the market for automotive Bluetooth hands-free systems will reach 116 million units per year by 2013.

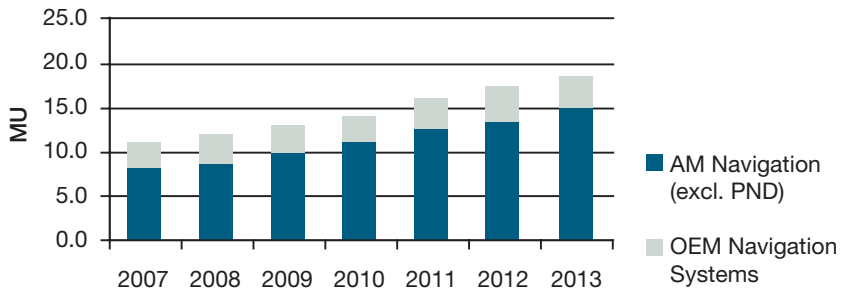
Figure 1. Automotive Communications Market Total Shipments



Source: Strategy Analytics, July 2007

Strategy Analytics also forecasts the automotive navigation systems market to reach almost 20 million units per year by 2013. Volumes are lower than for Bluetooth because navigation has higher availability than Bluetooth (80 percent vs. 70 percent), but lower "take-rates" than for Bluetooth. The navigation system "take-rate"—the proportion of car buyers who select it as an option—is forecast to be lower due to its higher cost. However the take-rate may well increase significantly if the cost of in-car navigation systems can be lowered. This is one of the areas addressed by Freescale's i.MX automotive solutions.

Figure 2. Automotive Navigation Systems Shipments Forecast



Source: Strategy Analytics, July 2007

3 Challenges

Freescale has identified several key challenges facing developers of automotive infotainment systems, including keeping pace with the consumer device life cycle and creating product differentiation.

3.1 Keeping Pace with Consumers

Portable consumer electronics devices typically have a production lifetime of 9 to18 months, whereas car models are normally in production for at least five years. In addition, the development cycle for portable devices is much shorter—one to two years versus three to five years—than that for cars due to the much more stringent automotive environmental, safety and quality requirements.

This dichotomy is unlikely to change: for built-in infotainment systems, consumers associate any quality defects with their overall satisfaction with the car, so that vehicle manufacturers cannot afford to let their quality standards slip. Equally, the portable electronics market seems likely to remain driven by features, fashion and competition, keeping product life cycles short.

Automotive infotainment systems suppliers, therefore, face a challenge of keeping up with the rapid pace of change in portable electronics, without taking their eye off their own stringent quality standards and model lifecycles. Unprecedented demand for complicated software-centric systems has led automakers to adopt proven consumer platforms. This also helps to ensure that middleware and DRM software is compatible with existing consumer electronics devices.

3.2 Differentiation

Automotive Tier 1 manufacturers have different positioning in the market. However, one thing in common to them all is the need to differentiate their offering from the competition. To achieve this, Tier1 automotive electronics suppliers need to deploy as much investment as possible in differentiated technology, with a powerful and flexible underlying system architecture.

For their part, car manufacturers need to offer up-to-date infotainment systems at an attractive price point, and keep pace with the latest developments from the world of portable consumer electronics.

4 Solution: i.MX

To confront the challenges identified above, Freescale is deploying its highly successful i.MX family of multimedia applications processors in the automotive infotainment market. Selected devices are put through an “automotive hardening” process to ensure they meet the exacting quality requirements of automotive applications, including the AEC-Q100 quality standard. Equally importantly, software solutions from the consumer world are reused and adapted to ensure that automotive infotainment systems closely track the capabilities of consumer systems.

4.1 Software

To reduce development time and expense, Freescale offers comprehensive board support packages (BSPs) for the leading operating systems on i.MX applications processors, including Microsoft® Windows® CE (WinCE) and Linux®. QNX’s popular Neutrino real-time operating system (RTOS) is among many operating system solutions offered by our third-party ecosystem. In addition, integrated software solutions for selected applications are available from Freescale and its partners, allowing customers to leverage mature software stacks and standardized solutions for common functions. This has the twin benefits of faster time to market and enabling customers to concentrate development resources on their own differentiating technology.

4.2 Open OS Support

Many automotive customers are convinced of the benefits of an “open” operating system, which allows standardization and reuse of third-party application software. In automotive applications, the main open OS solutions preferred by customers are Microsoft WinCE, QNX Neutrino and Linux, all of which are supported by i.MX processors. Freescale typically provides Linux and WinCE board support packages for download from its Web site, while Neutrino for the i.MX31 processor is available from QNX. A range of middleware such as multimedia codecs is also available from Freescale’s third-party ecosystem.

4.3 Multimedia Software Suite

For low- to mid-range audio and connectivity applications, Freescale offers its own multimedia software suite running on a real-time OS. Known as TRIO, this suite includes connectivity stacks, audio and video play control, codecs, DRM, buffering, file systems and power management for a variety of connectivity options including USB, CD, HDD, SD cards, etc. Bluetooth and Wi-Fi connectivity is also supported via third-party partners. TRIO has a very small memory footprint and is appreciated by customers looking for the lowest system cost.

4.4 Hardware

Derived from Freescale's highly successful family of ARM-based mobile applications processors, the i.MX family of Infotainment processors is also architecturally similar to our cell phone baseband devices, and can therefore share advanced technology and multimedia software with them. There is also a wide range of third-party middleware and applications available.

Freescale's i.MX hardware design philosophy is based on the following key principles:

- Single, high-performance CPU. This simplifies software development and frees the customer to concentrate on differentiated software. Development engineers do not have to deal with the complex development tools and real-time interdependencies associated with multiple embedded cores. Industry-standard ARM® CPUs are used to support a wide range of cost and performance points.
- Cost-effective accelerators. Hardware acceleration implemented for most computationally-intensive tasks, such as image processing, graphics and video codecs. Hardware accelerators offer the best combination of high-performance, low-power and low silicon area for image, video and graphics processing.
- Smart Speed™ Technology. Only spend power when you need to. Architectures optimized for most efficient use of external memory bandwidth with a high level of parallelism and advanced power management techniques. The Smart Speed MAX crossbar switch allows multiple bus transactions to occur in parallel without collision or wait states.

Adhering to these philosophies, i.MX processors can offer the following capabilities for infotainment systems:

Microsoft, Freescale and Ford SYNC™

To meet the growing demand from consumers for connectivity, Ford and Microsoft are offering motorists SYNC, a new factory-installed in-vehicle communications and entertainment system. SYNC allows consumers to bring nearly any mobile phone or digital media player into their vehicles and operate them by voice command or by using the steering wheel or radio controls. Voice recognition, long considered one of those just-around-the-corner technologies, has finally arrived, enabled in part by the smart speed technology of Freescale's i.MX31 multimedia applications software, the brains behind SYNC.

Some of SYNC's unique features are:

- Smart voice recognition: SYNC's sophisticated technology allows you to operate a variety of portable digital music players and Bluetooth-enabled mobile phones with simple voice commands.
- Upgradeable: As the technology evolves, SYNC's capabilities can grow. Upgrades and new features will be made available to make your driving time more fun.
- Uninterrupted connections: In the middle of a call when you enter your car? Simply touch the Telephone button and SYNC will instantly connect to your Bluetooth phone. The system can also transfer the call back to your phone when you leave.

4.4.1 Security

Infotainment systems must be able to implement secure cryptographic techniques in order to deal with media that is protected by Digital Rights Management (DRM), ensure proprietary map data cannot be duplicated, and for secure software upgrades. i.MX processors have secure RAM, security controllers, high assurance boot (HAB) and secure JTAG technology to ensure that cryptographic software is executed securely and that no unauthorized access is possible.

4.4.2 Graphics

Graphics processing is one of the computationally intensive tasks and can benefit from the hardware acceleration on i.MX processors. Freescale's i.MX31 processors include an Image Processing Unit (IPU) which performs alpha blending and image rotation and scaling in hardware. The IPU also takes care of the LCD control and refresh. In addition, the i.MX31 device includes a 3-D graphics accelerator that is capable of rendering up to 1M polygons/second and provides powerful acceleration for drawing 2-D and 3-D maps and user interfaces. The graphics accelerator works in tandem with the ARM11 Vector Floating Point Unit which is used for calculating the vertices of the polygons to be drawn. Graphics drivers compliant with OpenGL:ES and Direct3D Application Programming Interfaces are available.

4.4.3 Audio and Speech

With it's DSP instruction extensions, high clock frequency and floating-point unit, the i.MX31's ARM11 CPU is an excellent audio signal processing engine. Typical audio decoders such as MP3 require less than 20 MHz of CPU bandwidth and an optimized MP3 encoder runs in less than 50 MHz. For speech processing, acoustic echo cancellation requires around 50 MHz, while speech recognition also benefits from the i.MX31's efficient cache and memory architecture. Speech recognition when optimized using the floating point unit can recognize a speech command up to five times faster than competitive solutions.

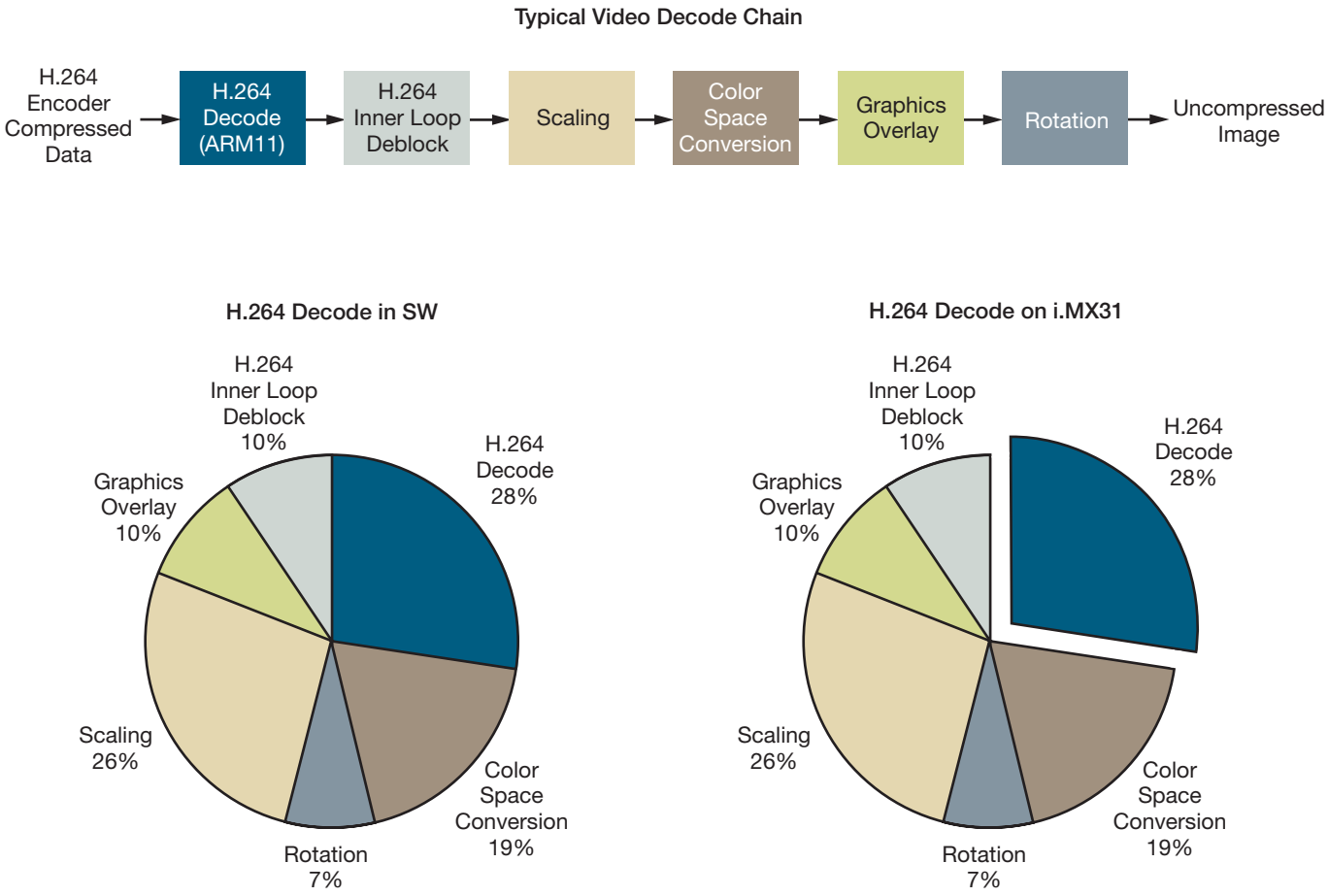
4.4.4 Video

As can be seen in the H.264 case study below, 72 percent of the computation required for video decoding is accelerated by the i.MX IPU. This is equivalent to greater than 1.2 GHz of ARM11 performance. On the i.MX31 processor, the actual format-specific video decoding is performed in software. The ARMv6 instruction extensions and optimized memory architecture mean the ARM11 is capable of performing up to D1 30 fps video decode in software. Other members of the i.MX family provide full hardware acceleration of video decode and encode, freeing up the CPU to run other tasks.

Figure 3 shows the different tasks which have to be performed in order to decode and display a video stream compressed using the H.264 standard. In addition to decoding the H.264 datastream, the resulting video must be resized, rotated, be converted from YUV format to RGB format, and overlaid with the HMI graphics. The pie chart on the left shows the percentage of CPU loading if all of these tasks were performed in software. We can see that the H.264 decode and H.264 inner-loop deblocking functions account for only 38 percent of the CPU load.

The pie chart on the right shows how the i.MX31's IPU can perform all of the non-decode functions in hardware, leaving only 28 percent of the task to be done in software.

Figure 3. H.264: A Case Study in CPU Load



4.4.5 Quality

Freescale i.MX processors are developed from the start with the high-quality design methodology required to deliver devices that are right the first time, using leading-edge technology. The i.MX31 and i.MX31L devices have recently achieved AEC-Q100 qualification. Developed by the Automotive Electronics Council, the specification consists of a host of stress tests an integrated circuit must meet to ensure OEMs it will deliver a consistent level of quality and reliability within the harsh automotive environment.

The fact that millions of i.MX applications processors have usually been shipped in consumer devices before they begin volume manufacture in automotive applications means that the software and hardware has already reached a mature quality level.

Thanks to Freescale's understanding of automotive requirements that comes with being the number one semiconductor supplier in this market, customers know they can rely on the i.MX31 processors to consistently and reliably deliver high quality. Freescale backs this quality with dedicated after sales design-in support.

4.4.6 Power Management

Freescale i.MX processors are designed from the ground up for low power consumption. The latest techniques from the portable world are available, enabling i.MX processors to consume less than one-third the power of competitive infotainment processors. This helps to reduce heat buildup in the dashboard and means that costly and space-consuming heatsinks are not needed. Low power consumption also allows customers to use the same i.MX platform for embedded navigation as for portable aftermarket navigation devices, saving on development costs.

5 Summary

Freescale is the number one semiconductor supplier to the automotive electronics market and is a top three player in the wireless and mobile systems market. Automotive infotainment systems built on Freescale's i.MX multimedia solutions are able to keep pace with consumer electronics devices while meeting typical automotive quality and lifecycle requirements.

The automotive infotainment market is experiencing uprecedented acceleration in the rate of change of technologies and user expectations thanks to the dynamism of the consumer electronics world. Freescale i.MX applications processors offer the best of both worlds by combining leading edge technology from consumer systems with automotive know-how, quality and industry alliances.

For more information, visit **www.freescale.com/imx**.

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