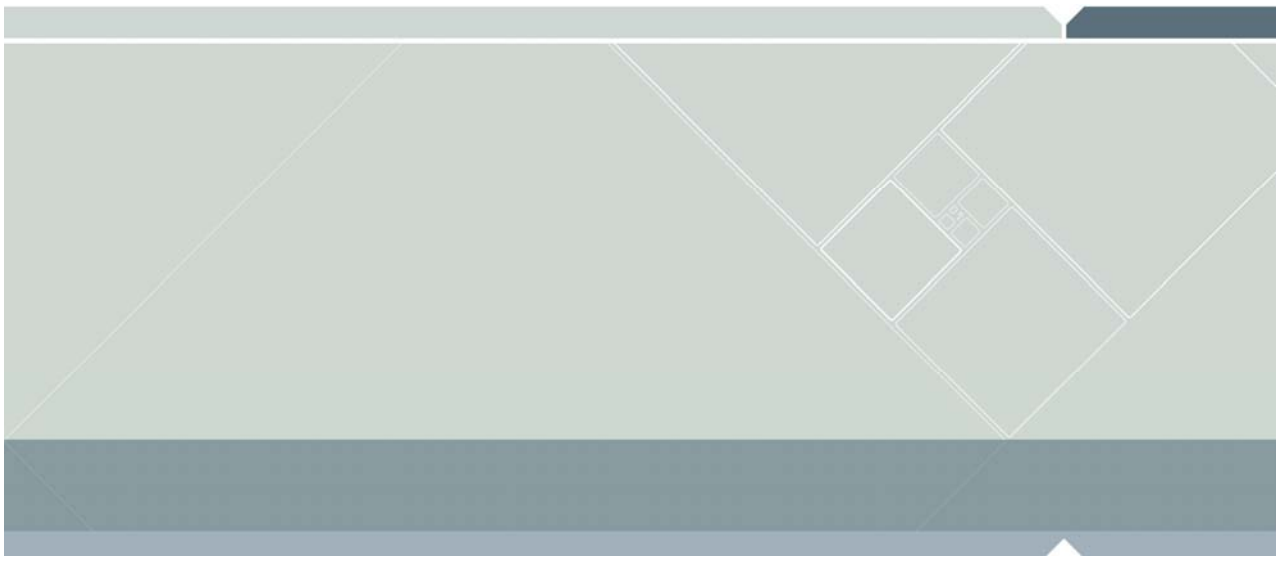

White Paper

Building Portable Media Players with Freescale STMP3700 SoCs

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Overview

The portable media player (PMP) market is a fast-growing segment, with shipments expected to reach more than 250 million units by 2011. End prices for these devices are dropping—yet consumers expect the same, if not more, features in each generation of players.

Freescale STMP3700 product family SoCs have the right balance of integration, features and low power consumption for manufacturers who want to compete in this market. The SMTP3700 product family provides a comprehensive SoC solution with software, hardware and a software development kit that is designed to simplify development and speed time to market. The following document describes the STMP3700 product family in general and specifically the STMP3738, which is engineered for PMPs and personal navigation devices (PNDs).

Contents

1 The State of the Portable Media Market

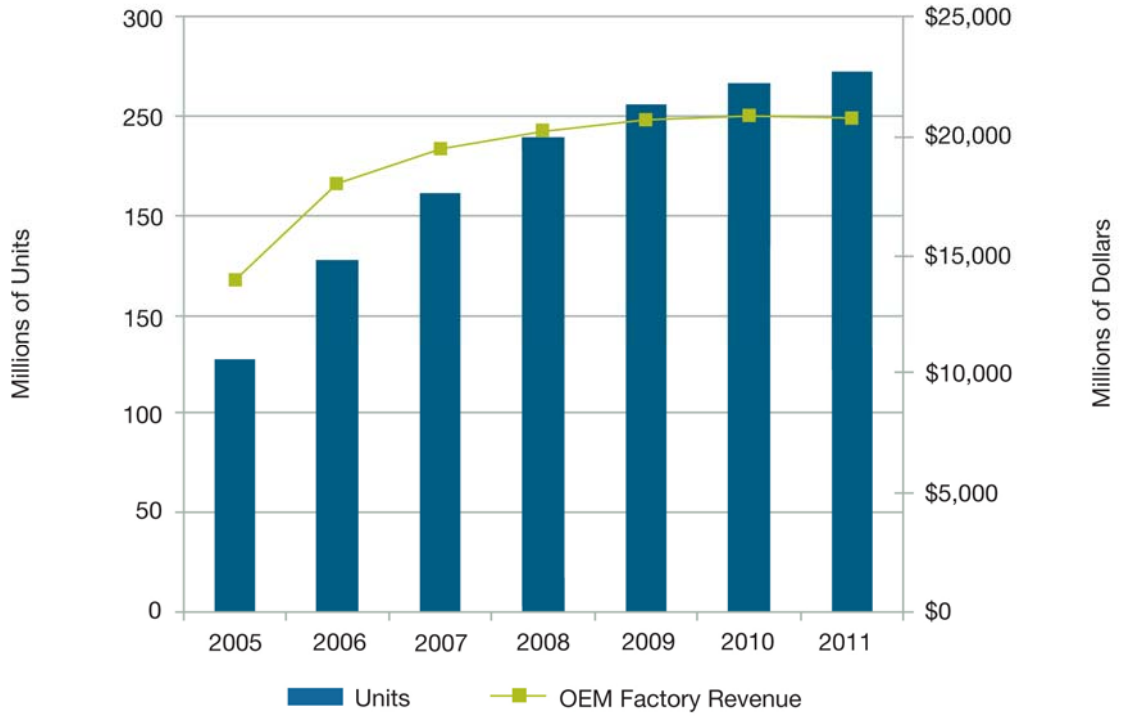
Over the last few years, the market for MP3 players and portable media players (PMPs) has undergone dramatic growth, accompanied by an ever-increasing list of features that typical devices support. In fact, what used to be the MP3 market is becoming simply the low-end segment of the overall market. Features such as large LCD displays, video and very rich user interfaces are becoming mainstream, and are essentially characterizing PMP devices.

It is worth noting that while general market growth is slowing, the PMP share is projected to increase significantly, with the non-PMP portion declining over time.

Another key aspect is that storage is increasingly based on NAND Flash even for high-end devices. Hard drive devices are confined to the very top of the market, mostly in products with low volume. This has been made possible by increasing capacity and reducing cost for NAND Flash, along with power consumption and reliability advantages.

The net result is that NAND Flash PMPs will be a very interesting segment to pursue for OEMs and semiconductor vendors in the next few years.

Figure 1. PMP/MP3 player shipments, 2005 to 2011[1]



The first generations of MP3 players were basic, with simple user interface capabilities. Succeeding generations support more sophisticated features such as video playback in addition to audio, and have very sophisticated user interfaces.

Despite the increases in storage and features, the cost of these players has been declining. Declining prices for players are forcing a significant reduction in semiconductor average selling price (ASP), while at the same time features must be maintained or even improved. Furthermore, existing features are expected to cost less for newer devices.

[1] "Does Apple have the right touch?" Chris Crotty, iSuppli, November 2007

Figure 2. PMP/MP3 players by type, 2005 to 2011[2]

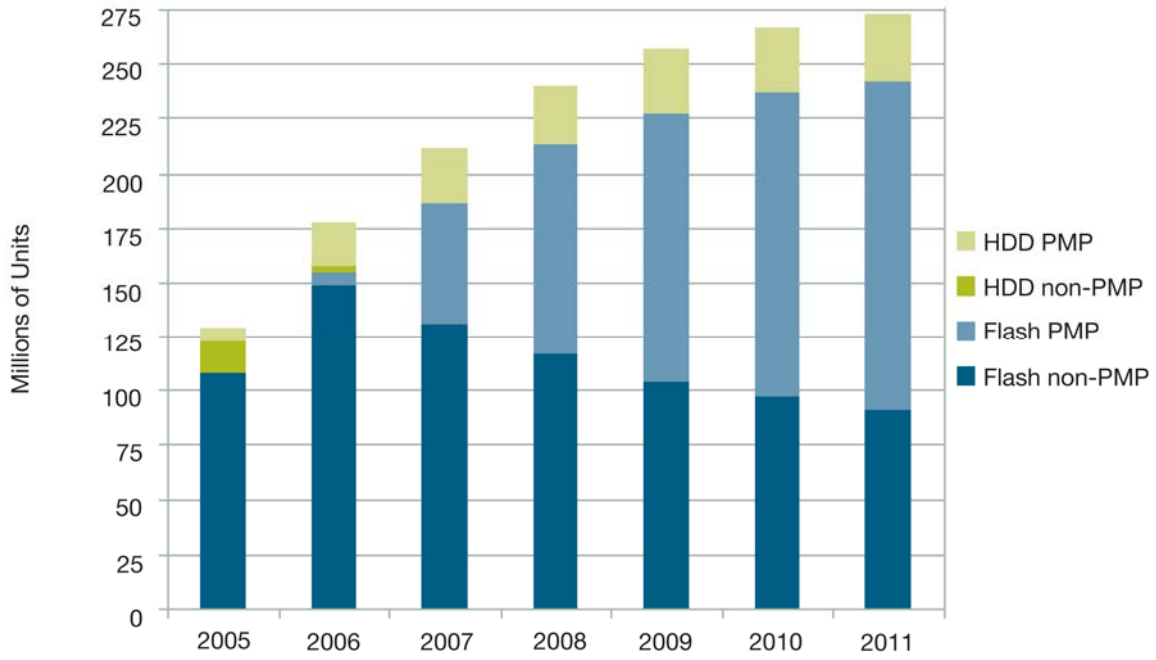
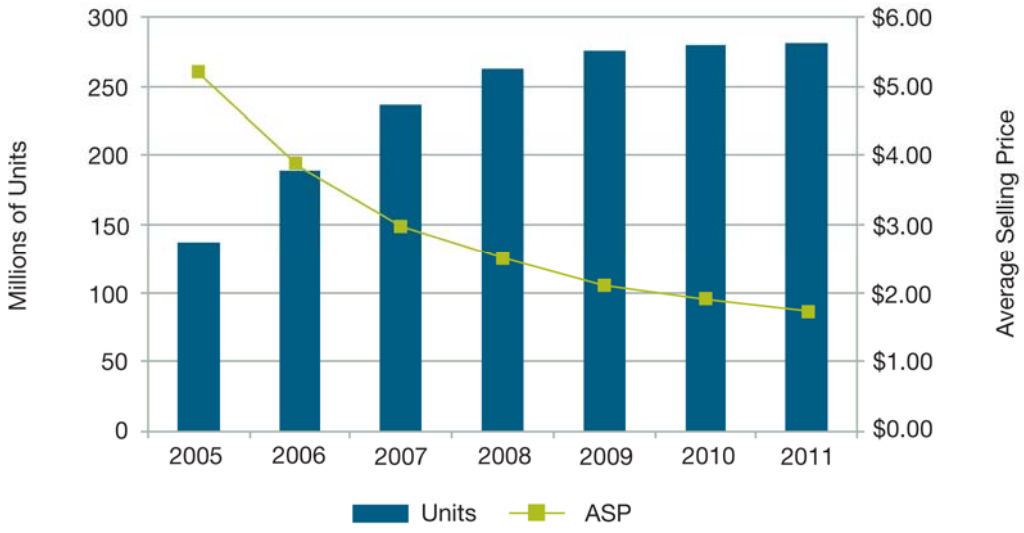


Figure 3. PMP/MP3 controllers and average selling price (ASP), 2005-2011[3]



The main consequence for semiconductor companies providing system on a chip (SoC) solutions in this market is that high integration has been the key to success, because it allows for an incremental feature increase along with a decreased total system cost. Integration entails pulling features traditionally provided by several chips—the application processor, NAND controller, DAC and ADC—into a single SoC, as well as reducing the number of discrete and passive

[2] "Does Apple have the right touch?" Chris Crotty, iSuppli, November 2007
[3] Ibid.

components necessary for the board design. This approach also helps reduce power consumption, because the control firmware has a much tighter control over all the involved elements.

Flexible solutions that can support as many NAND devices as possible are paramount. The increased versatility improves the operating efficiency of player manufacturers, given that storage cost is the dominant BOM factor. Certain NAND devices are subject to market shortages and may be hard to source during periods of peak demand.

2 The STMP3700 Family

The Freescale STMP3700 product family is our next-generation multimedia SoC family targeted at portable consumer products. They offer a blend of performance, low-power, integration and flexibility for a low-cost solution.

Given the recent and expected market trends in the PMP space, the STMP3700 SoC platform was designed with the portable video experience in mind. This posed a unique challenge: meeting both the increased processing requirements for decoding compressed video, while maintaining Freescale's traditional low cost and power consumption.

The STMP3738 solution is an even lower-cost variant of the 3700 family, developed specifically for video players in China. The STMP3738 retains the same flexibility but does not support digital rights management (DRM) and MP3 encode. Because there are multiple content providers and limited DRM in China, this solution is ideal for Chinese OEMs and ODMs that want to offer next-generation video to consumers. This variant is available in both 169BGA and 128LQFP packages. The latter is intended for Chinese manufacturers because this allows lower-cost board assembly. Despite the lower pin count of the 128LQFP package, the necessary features for this market were maintained. This illustrates another aspect of the STMP3700 product family flexibility, namely support for various package configurations which allow cost/feature-set tradeoffs.

Figure 4 shows a block diagram of a 128LQFP STMP3738 SoC in the context of a typical PMP system. Figure 5 shows the key features of the STMP3700 product family with supported interfaces. The heavy level of on-chip integration allows for a minimalist system design, with maximum flexibility. The following section explores the key technical features which make up these characteristics.

Figure 4. STMP3738 SoC in a typical PMP system

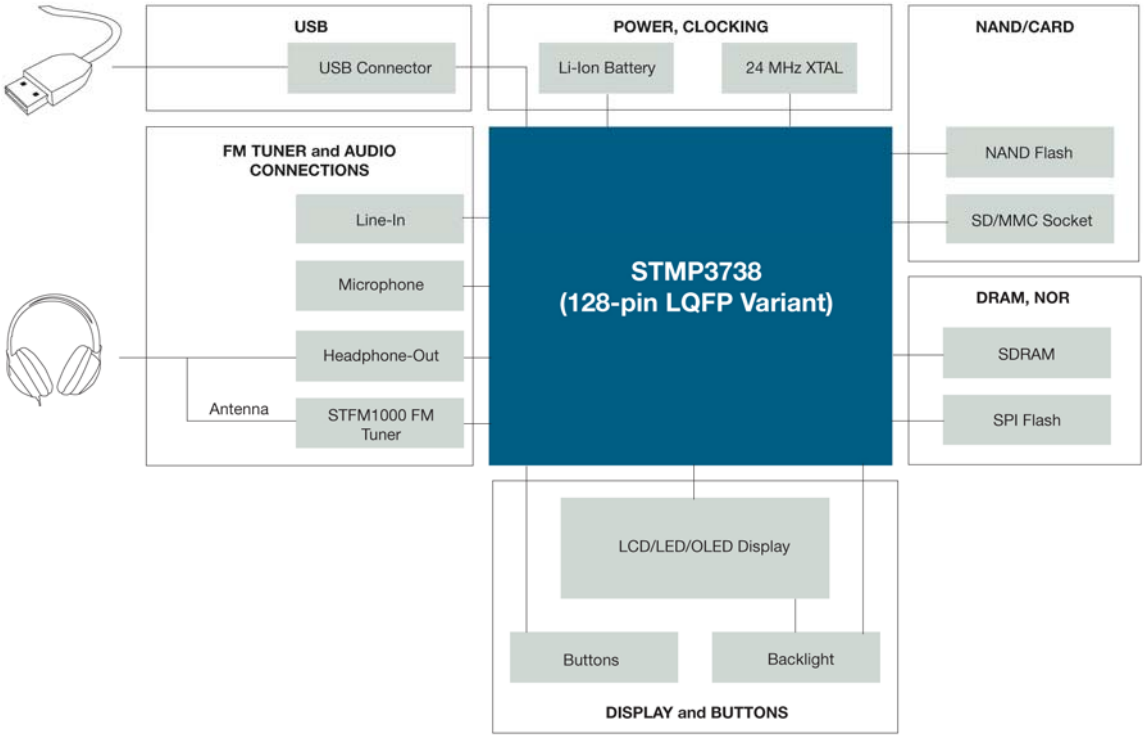
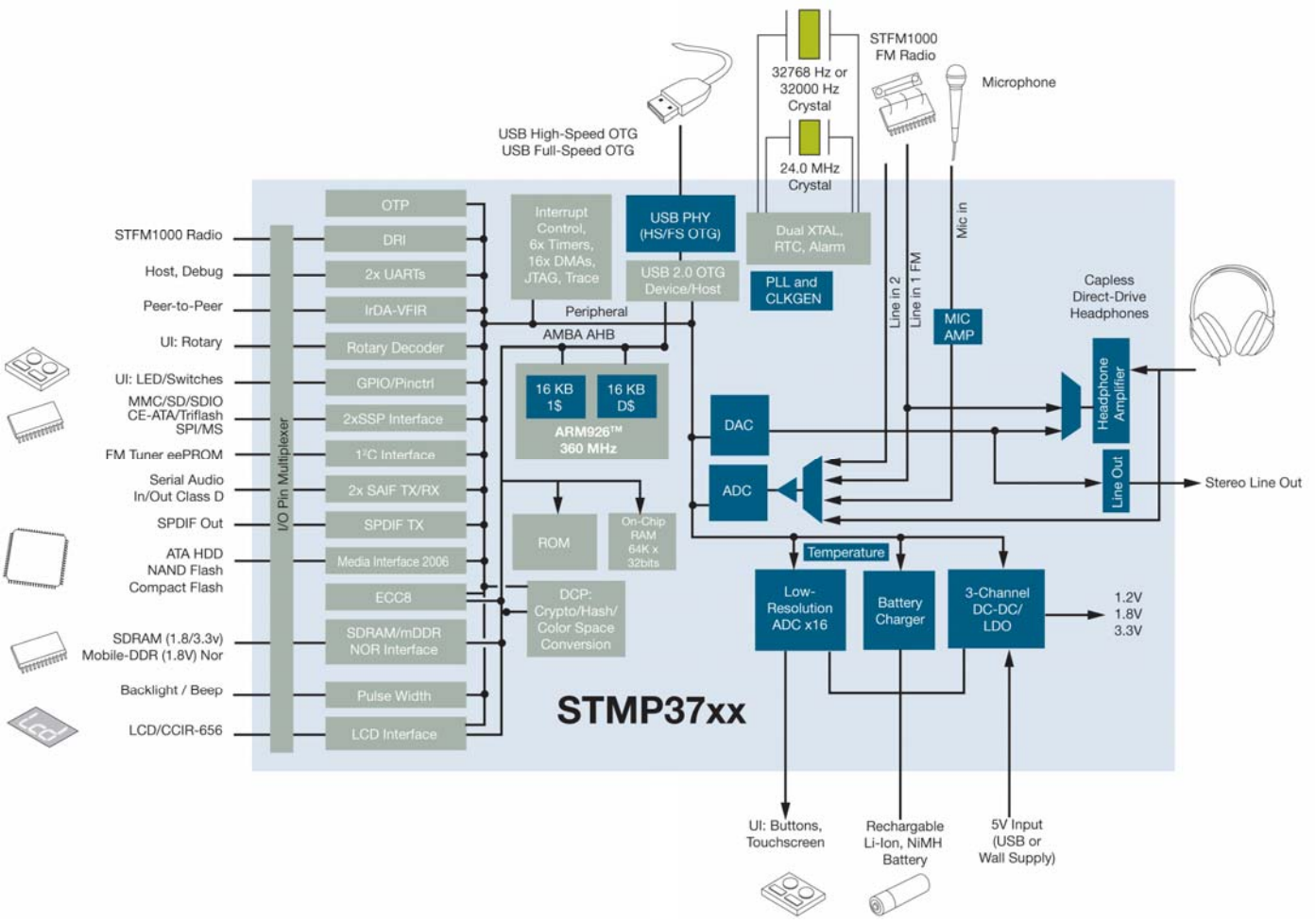


Figure 5. Key STMP3700 family features with supported interfaces



The high level of mixed-signal integration in the STMP3700 product family has a number of distinct advantages:

- Lowest system bill of materials (BOM) cost
- Fewer external components to deal with in the board design and manufacturing assembly
- Removing bulky board components allows smaller form factors and thus, simplified industrial designs

Some of the key analog components integrated within the 3700 product family (shown in dark blue in Figure 5) are as follows:

- Power management unit (PMU) with multi-channel outputs
- Battery charger with support for all common battery configurations and external 5V power (e.g. USB, wall charger)
- Stereo DAC with 99dB SNR provides audio quality equivalent to a high-quality external solution at far lower cost and power consumption. DAC output drives both a direct-drive headphone amplifier and stereo line-out
- Multi-input stereo ADC supporting dual stereo line-in and mono microphone input
- High-speed USB PHY

2.1 Low-Power 90nm Mixed-Signal Technology

Freescale's STMP3700 product family was implemented in a low-power 90nm process. This represents a two-node process jump compared with its predecessor, the 180nm STMP3600 family. Some of the challenges at this node included sustaining analog performance at the lower voltage 90nm transistor and containing leakage power. Attaining the correct balance of power, performance and silicon die-area required an advanced proprietary implementation methodology.

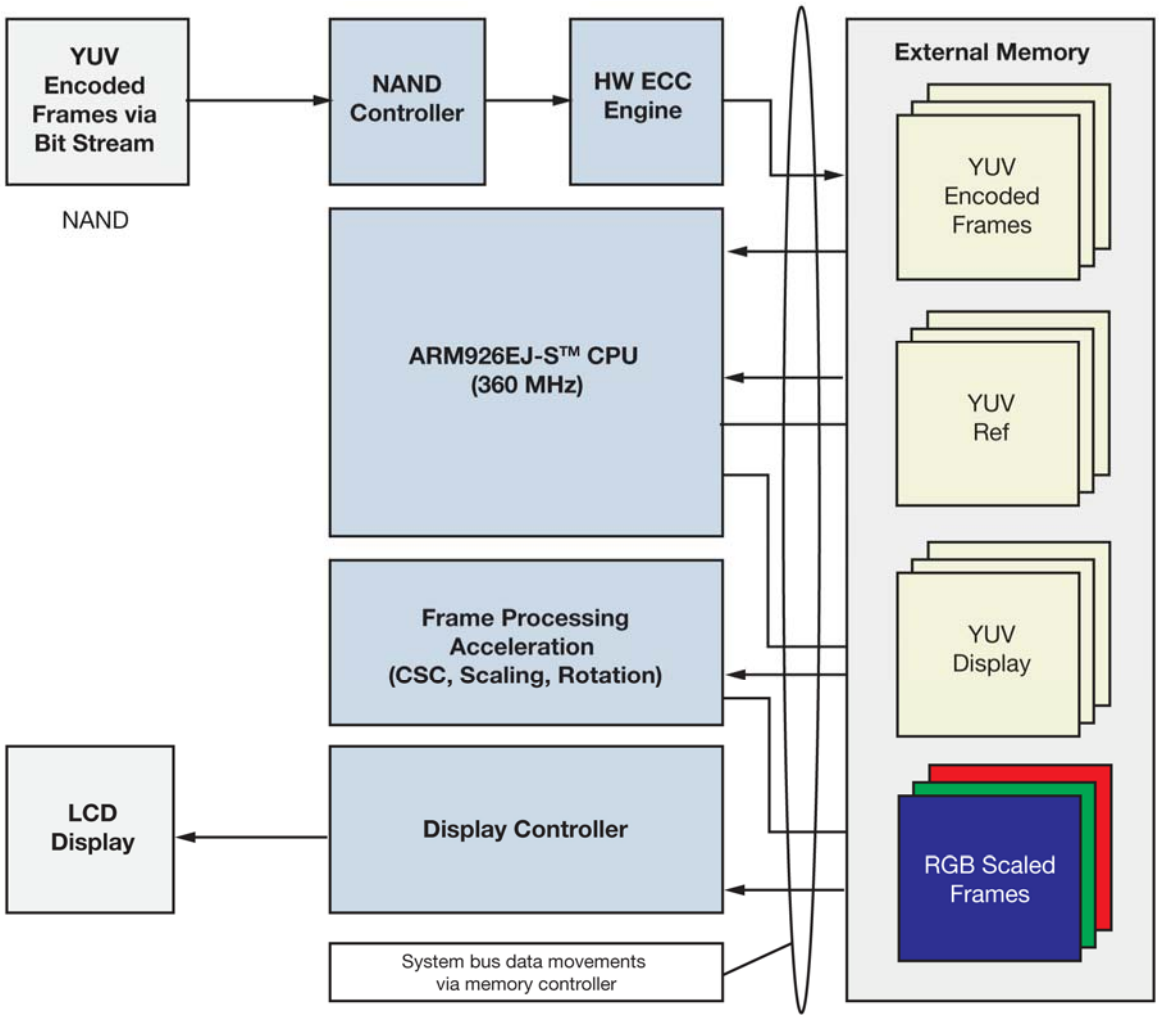
In addition to the increases in feature density and performance, dynamic power is greatly reduced at 90nm even at higher frequencies. For example, this allows video playback at voltage levels well below minimum levels required for simple audio playback at 180nm. In addition to various hardware-level power-saving features, the on-chip PMU, in conjunction with the Freescale-provided power management firmware, allows application-controlled voltage and frequency scaling to further optimize power consumption.

This technology is perhaps best demonstrated by the industry-leading 60 hour-plus battery life during audio playback in a typical system based on an STMP3700 family SoC.

2.2 Multimedia Processing and Display

The key components in a multimedia processor can be highlighted by examining a simplified flow of video data through the system. Figure 6 shows how video data flows through the STMP3700 product system buses during video decode and display.

Figure 6. STMP3700 video data flows during decode and display



Examining Figure 6, we can see the following:

- Compressed video data is read as a bitstream from external storage. The video stream is de-muxed via the CPU and compressed video frames are stored/buffered in system memory. Video frame data is stored and processed in the YUV color-space format where:
    - Y represents luminance (weighted sum of red, green and blue)
    - U and V are subtractive components representing blue and red colors
    - Because the human visual system is more sensitive to the luminance, it is possible to store a lower ratio of U and V components for every Y component
    - The YUV 4:2:0 format, for example, is used in compressed video storage. In this format, a 2x2 block of pixels has four Y samples and a single UV sample. This represents a 50 percent storage efficiency advantage over RGB
- The software video-decoder executing on the CPU builds decoded frames via a mix of compressed frames and “reference” frames (YUV Ref)
- Assuming RGB output, the hardware color space converter (CSC)/scaler/rotator is run on the decoded frames (YUV Display)
- At this point, there may be blending or other pixel processing steps performed by the CPU, after which processed frames are fetched via the display controller

We see that the above steps require not only high levels of CPU processing power, but also sufficient bandwidth from both system and external memory buses. Architecting system buses and components for a video application can easily lead to feature and gate-count “bloat”, resulting in a part that is unattractive from a cost and power perspective. Attaining the correct level of performance requires detailed system modeling of the processor, system buses, hardware acceleration and memory controllers.

The following key processing units and peripheral features comprise the multimedia processing and display capabilities of the 3700 product family:

- **320MHz ARM926EJ-S™ processor**: 16K+16K caches enable software-based video decode at QVGA resolution at 30 fps
- **Multi-layer AHB bus architecture**: Allows truly parallel access to on-chip and off-chip memories. For example, multiple masters can simultaneously access the on-chip RAM
- **Frame processing acceleration**: CSC, scaling and rotation operations are accelerated in hardware, allowing CPU offloading for maximum video decode MIPS
- **Flexible display support**: System mode, VSYNC, RGB/DOTCK and BT.656 allow a wide variety of display types including connection to external video DACs/TV-encoders for TV-out support
- **Flexible external memory support**: Options for 3.3V SDRAM, 1.8V mobile-SDRAM, 1.8V mobile-DDR and 3.3V parallel NOR allow flexibility in power/performance and cost tradeoffs
- **Flexible NAND support**:
    - Highly configurable NAND controller architecture
    - Dedicated hardware error correction code (ECC) engine supporting 4- and 8-bit correction “on-the-fly”, allowing corrected data to be stored directly to memory without CPU intervention
    - Future NAND support via on-chip one-time-programmable-ROM

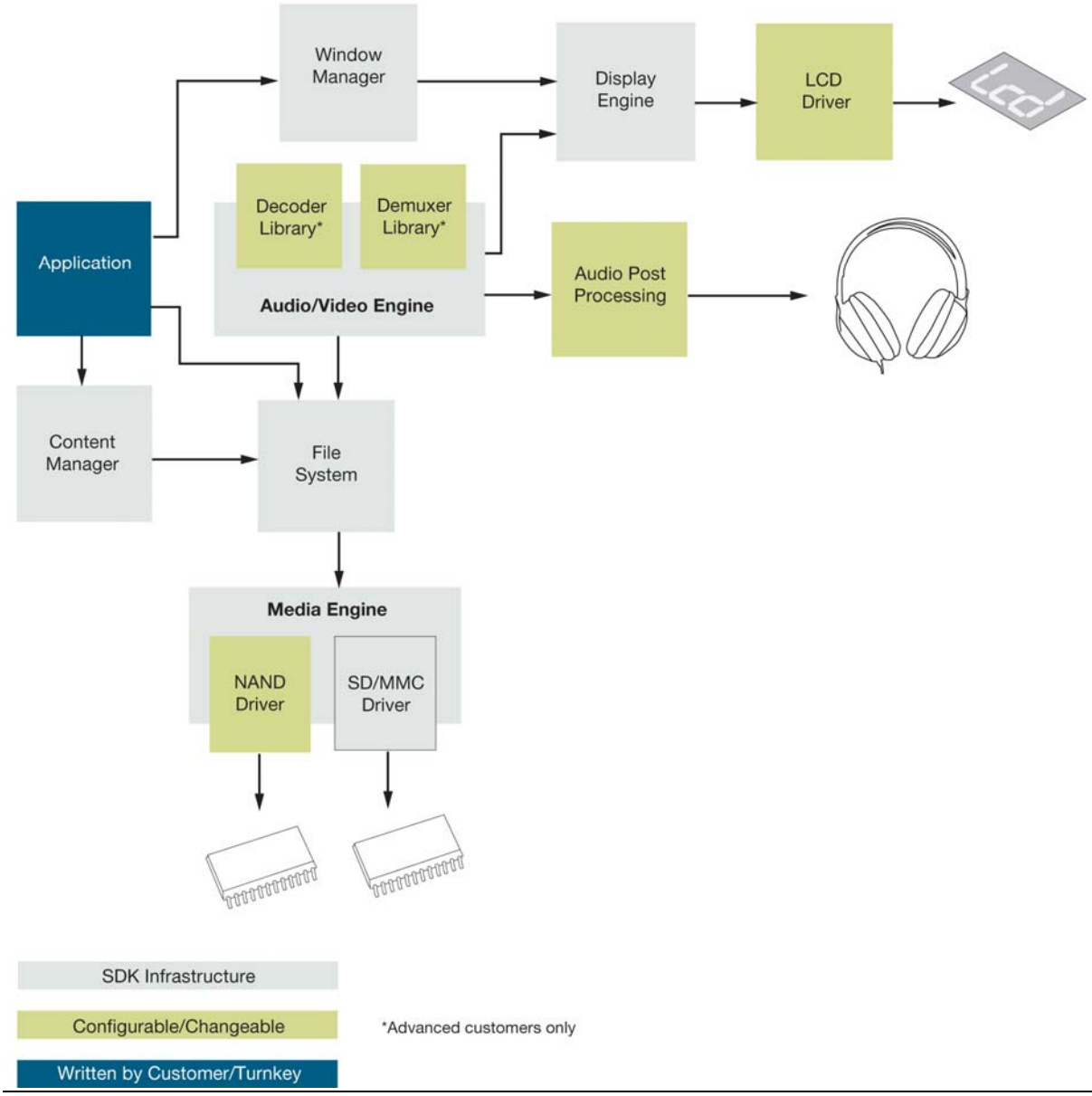
3 Simplified Development

A successful PMP product development involves more than just the multimedia processor and associated hardware system components. Building consumer electronics products always entails a large and long software development effort.

The Freescale SDK has always been instrumental to the commercial success of our solutions, largely because it allows Freescale's customers to make the most of available SoC platforms. The SDK provides the fundamental building blocks for that software development effort, thereby enabling customers to focus on their own solution and value-added features, rather than reinventing the wheel for each design. Effectively, this allows customers to implement more in less time and with fewer resources.

Version 5.0 of the SDK has been developed from the ground up specifically for the 3700 product family, with the goal of maximizing performance, in addition to the usual objectives of high flexibility and modular architecture. Figure 7 illustrates the SDK architecture and its key components.

Figure 7. Key components of software development kit architecture

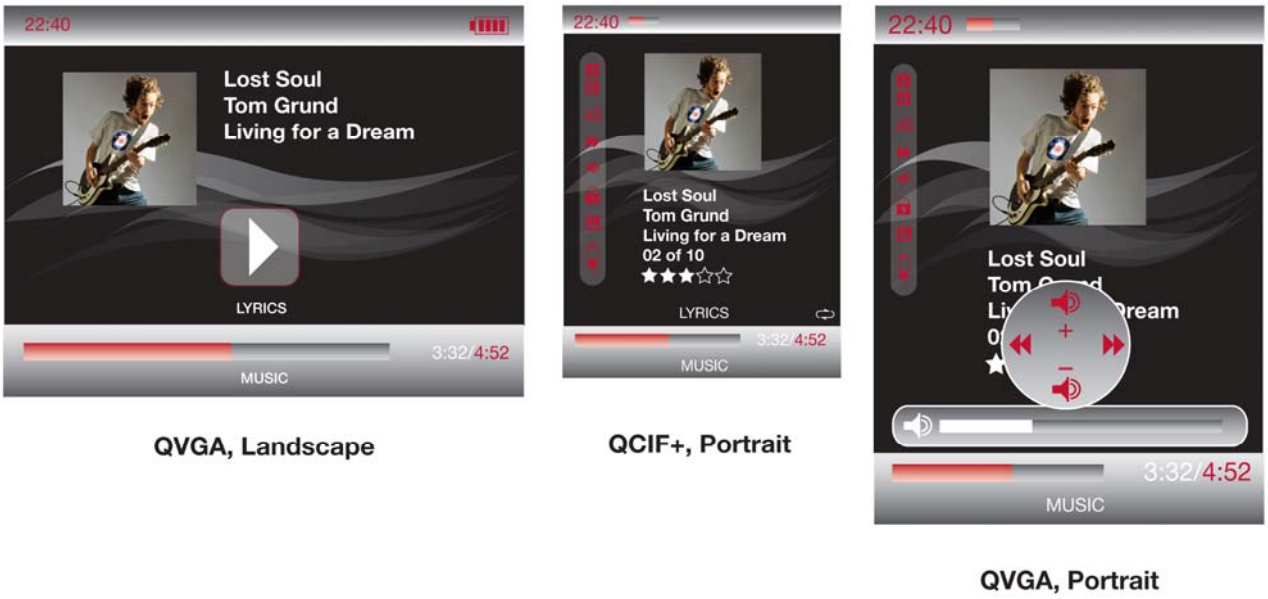


The application is normally completely rewritten by advanced customers so that the player can exhibit the look-and-feel that the manufacturer requires. The SDK facilitates that task by providing clean APIs that the application can use to control the main modules. The SDK also ships with some fully functional sample applications that can be used as a starting point and as reference code.

In the case of the STMP3738 turnkey solution, the approach is taken one step further. Freescale's customers are only required to customize the existing application with some simple choices including menu layout, language and fonts, bitmaps and display resolution. This means a quicker and easier development cycle, which is particularly useful for Chinese manufacturers; because the turnkey environment is very rich in terms of features, only a small expense in terms of flexibility is incurred.

For video display options, the Freescale SDK allows flexible configurations for slightly different schemes, LCD size and orientation. These include QVGA and QCIF+ schemes, and landscape or portrait orientations.

Figure 8. Flexible configuration for different screen sizes



3.1 Media Engine

The NAND driver has been written to take advantage of the flexible hardware platform, along with its 4-symbol and 8-symbol Reed-Solomon correction schemes. Therefore nearly all NAND flashes can be supported with minimal modifications, if any, required. Natively supported NAND devices include small and large-block SLC as well as large-block MLC.

3.2 LCD Driver

A similar approach has been followed for the LCD driver, which thanks to its hardware interface can support all typical displays, including system-mode (with and without VSYNC timing), DOTCLK and BT.656. A large collection of display drivers ships with the SDK, and the modular architecture makes it easy to add support for any LCD modules that are not included.

3.3 Content Manager

The content manager provides all typical functions including MTP, lyrics and playlist handling (via metadata sorting).

3.4 Audio/Video Engine

The audio/video engine was developed in-house with the design goal of easy configurability and extensibility. The engine natively supports several formats including MPEG4, H.264, VC-1 and FLV; advanced customers can add different decoders to their platforms, because the APIs between the decoder and the engine are well-defined and documented and the hardware was designed with enough overhead for all typical video processing.

The same concept applies to the demuxers, which parse the file format of the audio/video stream and extract the relevant information for each decoder. Support for AVI, MP4 and ASF is already present, but further demuxers may be added as needed.

The engine makes it possible for the application to easily perform JPEG decode with concurrent audio playback, which makes the user interface nicer.

4 Summary

With the SMTP3700 family, Freescale provides a comprehensive SoC solution, with software and hardware to drive next-generation low-cost multimedia PMPs which provide a high-quality music, photo and video experience. The STMP3700 is an ideal fit to power these industry-leading multimedia devices because of its integration, power management and customizable user interfaces. Finally, using the STMP3738, customers can design and implement PMP video devices with minimal resources, cost and time to market.

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