

Low Power Applications Processors and Power Management ICs for Portable Multimedia Devices

White Paper

Freescale Semiconductor, Inc.

Document Number # PWRMGTIMXAUDIOWP
Rev #0
10/2006



OVERVIEW

The mobile device market continually demands new features, such as enhanced multimedia capability or high-resolution color graphics, which require more power than ever. To keep product form factors from growing in size due to larger batteries, engineers are constantly challenged to squeeze more efficiency into battery-powered systems and drive further miniaturization through aggressive integration.

The combination of Freescale's MC13783 power management and user interface IC and the i.MX31 multimedia applications processor is a highly integrated all-in-one power management and audio solution, optimized for low power consumption and excellent multimedia performance in portable devices. Together, these components provide everything you need to create a portable multimedia player or audio device while providing all the interfaces for Wi-Fi®, Bluetooth® or other connectivity.

CONTENTS

| | |
|--|---|
| The Ultimate Low Power Multimedia Solution ... | 2 |
| Benefits of All-In-One Design | 2 |
| Power-Saving Partners..... | 3 |
| Low Power Modes..... | 3 |
| i.MX31 Power Management Techniques.... | 5 |
| Power-Saving PMUI | 5 |
| Carkit and USB Standards | 7 |
| Analog to Digital Converter | 7 |
| Backlight Functions | 7 |
| Audio Options..... | 7 |
| Digital and Analog | 7 |

The Ultimate Low Power Multimedia Solution

Freescale's MC13783 is a highly integrated power management, user interface and audio component for gaming devices, smartphones and portable media players. The i.MX31 multimedia applications processor is optimized for low power consumption and excellent multimedia performance in portable devices. Together, these components provide everything you need to create a portable multimedia player or audio device while providing all the interfaces for Wi-Fi®, Bluetooth® or other connectivity.

Benefits of All-In-One Design

There are several advantages to an all-in-one power management and audio solution. Design engineers have the freedom of multiple options for tasks such as power sequencing, amplification, charging, display lighting and more. Manufacturers can build tiered products with one part, without the need to redesign from the ground up when the market changes. Consumers ultimately can benefit from the lower overall costs of a highly integrated system.

Figure 1 is an example of the myriad of audio, video, storage, memory, security, interface and connectivity options that a portable device can have with this combination.

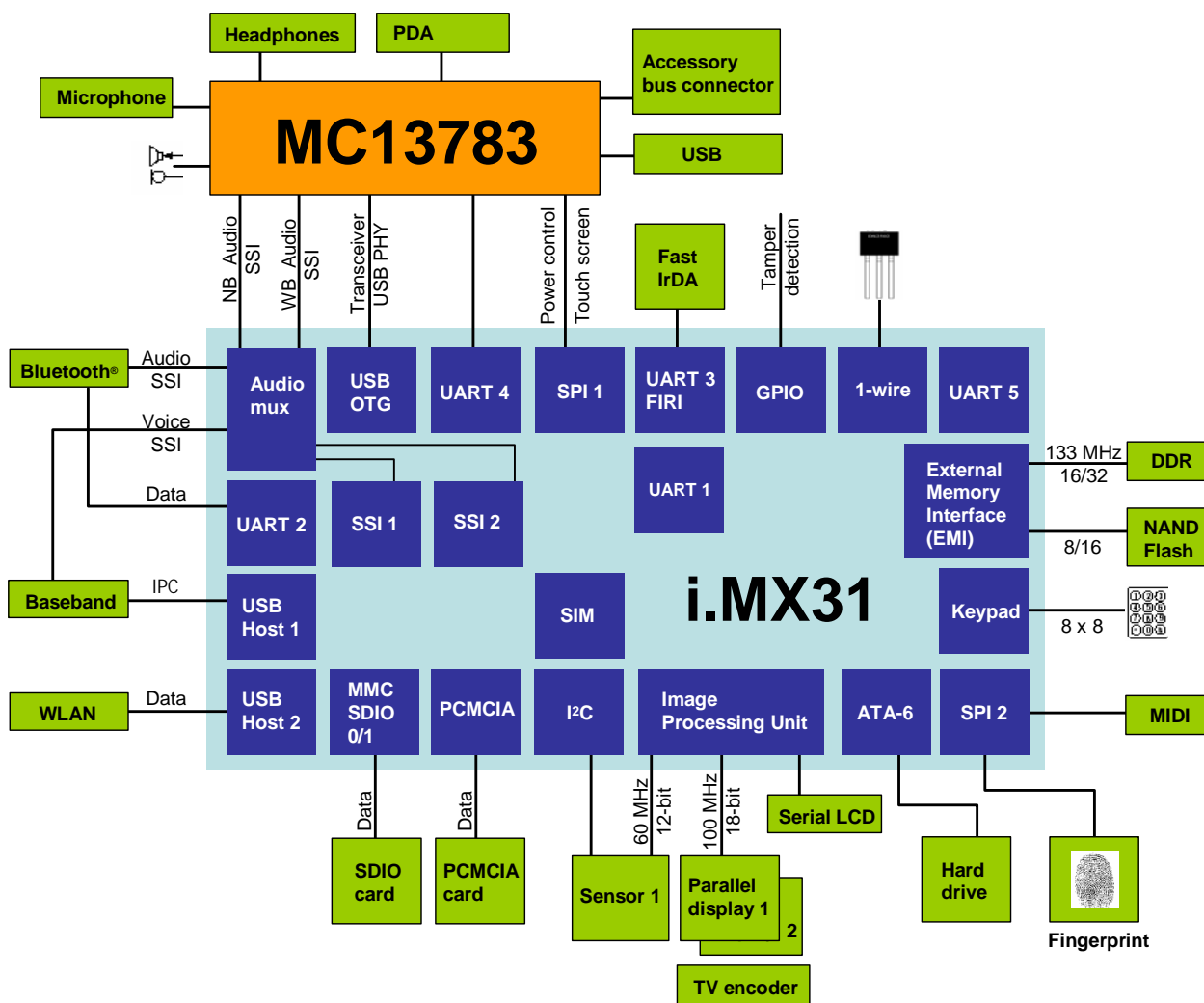


Figure 1. i.MX31 and MC13783 Compact System Architecture Example

Substantially integrated hardware platforms can reduce part count and inventory, and lower overall system costs. Combining the world-class power management capabilities of the MC13783 with the multimedia performance of the i.MX31 is the right choice for your next portable multimedia device.

Power-Saving Partners

Freescale's MC13783 power management and user interface (PMUI) IC is ideally suited for the i.MX31 multimedia applications processor and is included in the i.MX31 application development system. In fact, they were engineered to work together. The agile power management IC allows i.MX31 to take advantage of its built-in energy saving features, including dynamic voltage and frequency scaling and dynamic temperature process compensation.

The i.MX family of applications processors incorporates numerous features to enhance use time and battery life by reducing power consumption. These features include:

- Power gating
- Variety of low power modes
- Smart techniques for short wake-up time from low power modes
- Dynamic temperature process compensation (DTPC)
- Automatic dynamic voltage and frequency scaling (DVFS)
- Low-power clocking scheme
- Active well biasing (AWB)

Some of these features are implemented entirely within the i.MX31. To take full advantage of DVFS, DTPC and power gating require the use of a power management device, such as the MC13783, designed with i.MX31 in mind.

Low Power Modes

Having many power saving modes allows the designer to trade off between power consumption in standby and recovery times. One of the important features is the hardware handshake of the i.MX31 clock controller with peripherals before entering a low-power mode. This allows the relatively power-hungry ARM® core to enter a low-power mode immediately without waiting for the peripherals to complete their tasks.

Independent low-power modes for different power domains include:

- **Stop:** Clocks off
- **Doze:** Turns off the clocks and phase-lock loops (PLL). Clocks for specific peripherals can be switched off automatically in doze mode by pre-programming the clock controller module. This mode is useful for processes that require quick reactivation.
- **Wait:** In this mode, the ARM11™ MCU clock is stopped, but the i.MX31 bus switch (MAX) and all peripherals' clocks remain active. This mode is useful for running low-MIPS applications that primarily involve peripheral activity, such as a viewfinder that can be run with minimal ARM11 involvement.
- **Hibernate:** The power supply of the entire IC is shut down. All internal data is saved to external memory prior to Hibernate.

- **State retention:** In this mode, all clocks are switched off and the PLL is disabled. External memory is put in low-power (self-refresh) mode. State retention uses less power and has a longer wake-up time than Doze mode, but there is no need to recover any data after the wake-up.
- **Deep sleep:** In this mode, the power supply of the ARM platform (a major power consumer) is shut down. Any relevant register data should be saved before entering deep sleep mode.

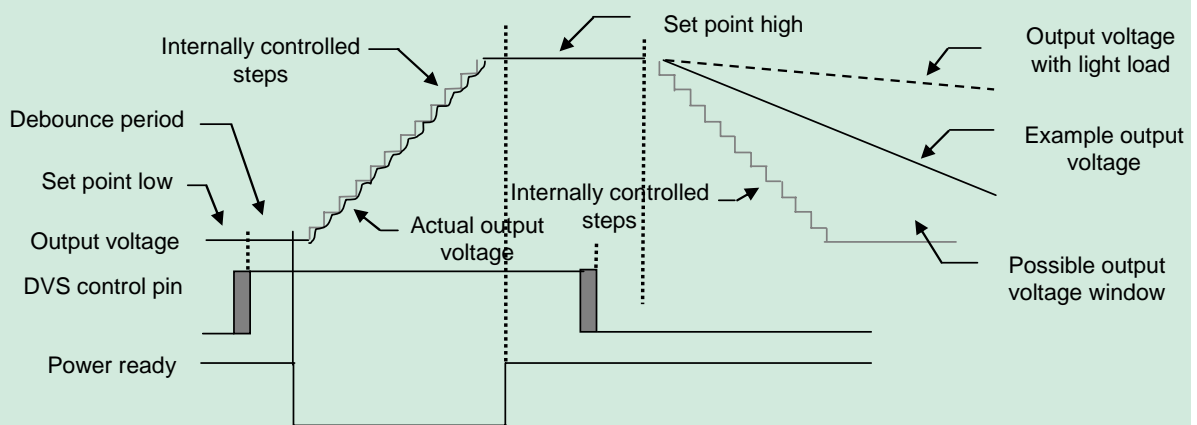
Three separate power domains—the ARM CPU, peripherals, and the PLLs—provide the ability to save power in one domain while the others remain functional. Power gating provides the ability to shut down the most power-hungry platform power domains in standby mode.

Dynamic Voltage Scaling

Dynamic voltage scaling (DVS) is a mechanism that allows designers to balance the performance demands of processors with the high amount of power needed to satisfy those demands. Freescale was a leader in developing this important technology and holds some of the first patents in the field.

Full processor and software system performance happens at the maximum run speed when operating at the highest voltage needed for that particular part and temperature. During less demanding periods of nominal run speed, the required performance can be obtained at a slightly lower voltage, resulting in a significant power savings. When the software is idle, the processor can be stopped and the voltage can be lowered further, since speed is not needed and the system requires only enough voltage to hold the state of registers. Some typical examples include 0.9 V STOP, 1.2 V RUN at nominal speed and 1.6 V RUN at maximum speed.

The transition between two set points must be smooth and controlled. This is achieved on the MC13783 with a DVS range of 0.9 V–1.70 V, which transitions in mini-steps of 25 mV each in configurable time steps. This appears as a ramp from one voltage to the next. This figure shows the ramp up and down of the voltage domain as a result of DVS.



i.MX31 Power Management Techniques

The i.MX31 multimedia applications processor is built using Freescale's Smart Speed™ Technology with some powerful enhancements. The DPTC mechanism measures reference circuits' delays dependent on the process speed and temperature. The DPTC then lowers the voltage to the minimum level needed to support the current operating frequency. Automatic DVFS allows on-the-fly frequency and voltage adjustment according to the current performance requirements of the system. By lowering the frequency it is possible to lower the operating voltage, thereby dramatically reducing the power consumption. The automatic DVFS hardware mechanism monitors the processor load and controls the supply voltage and the frequency with minimal software and operating system involvement.

Active well biasing reduces standby leakage by up to 15 times by lowering the well voltage of the transistor. Standby leakage is a great concern in sub-micron manufacturing processes' IC designs in the semiconductor industry. Traditionally, the only shortcoming of this technique is the necessity to add an AWB charge pump to support the separate well supply. The i.MX31 processor solves this problem by integrating its own AWB charge pump on-chip.

In the i.MX31, careful and power-friendly IC design with three levels of clock hierarchy allows shutting down clocks to the parts of logic that are not used by the running application. Technology choice allows optimum trade-offs between speed and low power/high-performance/leaky transistors (low voltage threshold) versus ultra-low power semiconductor circuits (high voltage threshold) for functional modules with modest performance requirements.

Power-Saving PMUI

Freescale's PMUI family is built with energy efficiency in mind. Power domains are split and can be cycled on and off under processor control as needed. Buck switchers are used whenever practical for improved efficiency and battery life. Multi-mode regulators have low consumption standby operation. Smart system orchestration of power is facilitated by monolithic integration and centralized control, addressing supply sequencing, operational modes, streamlined programmable interface and more.

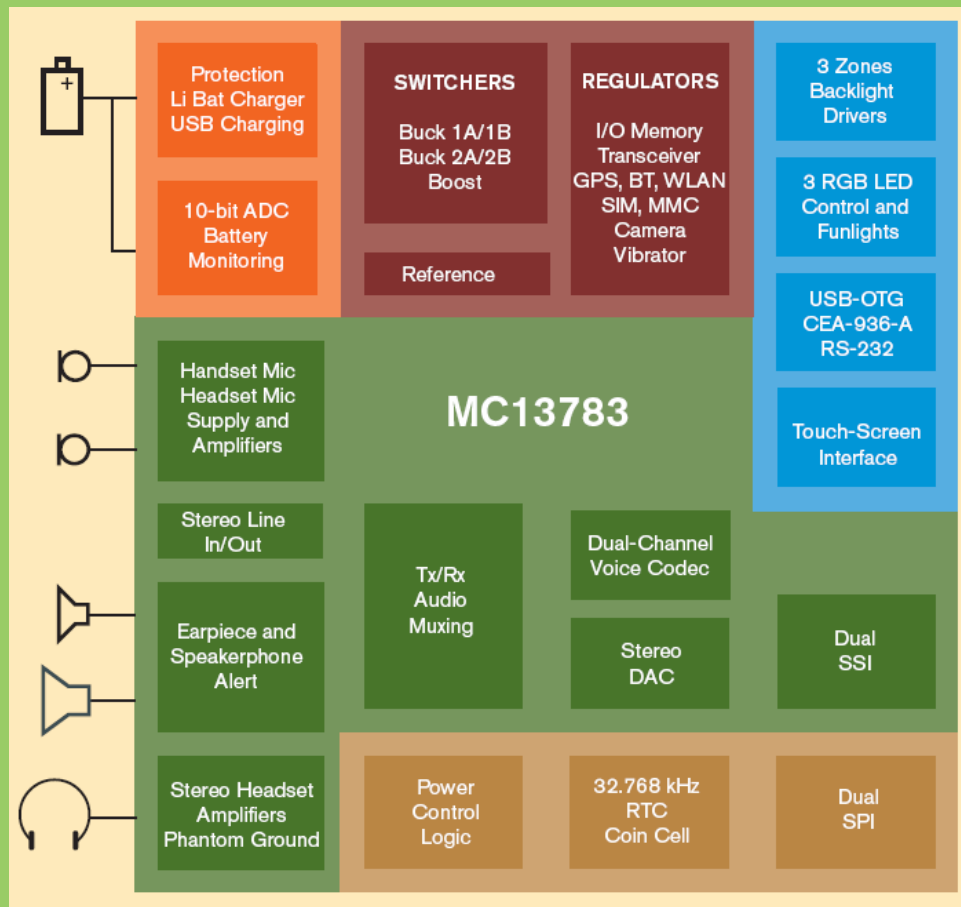
The four buck switchers on the MC13783 can operate in several modes, including pulse width modulation (PWM) and pulse frequency modulation (PFM). Two PWM modes are available: the first mode trades light load efficiency for continuous switching. The second mode offers better light load efficiency by allowing the absence of switching cycles at light output loading. This "pulse skipping" feature improves efficiency by reducing dynamic switching losses simply by switching less often. PFM, the lowest power mode, provides a "free running" power level that requires less clock precision and allows switching whenever the application demands it. PFM can be combined with the DVS control for greater power savings.

The MC13783's 32.768 kHz crystal oscillator provides a power advantage in timekeeping. Ordinarily a function such as a PDA alarm will drain current because more components have to remain on. In a portable device powered by the MC13783/i.MX31 combination however, each component—including the i.MX components—can shut down, and only the crystal oscillator and timekeeping module (RTC) will remain powered. Upon a turn-on event detection such as the PDA alarm, the MC13783 will then wake up the entire handheld.

Flexible power-up sequencing on the MC13783 can eliminate the need to add extra costly controllers. There are 15 selectable power-up sequencer modes; this suits a wide variety of platforms and allows designers to manipulate power-up sequences. At power-up, after an 8 ms initial delay during which the core circuitry is enabled, all regulators and switchers are sequentially enabled at equidistant steps of 2 ms to limit inrush current. A designer could choose to use I/O lines on the i.MX processor to control the regulators powering the vibrator motor or a SIM card, instead of using the slower SPI bus.

About the MC13783

The MC13783 implements high-performance audio functions suited to high-end applications such as personal media players, smartphones and cellular handsets. The highly integrated mixed-mode power management, audio and user interface content of the MC13783 is ideal for battery-powered devices such as portable MP3 and DVD media players, digital still cameras, PDAs, educational toys, remote-controlled devices and cellular phones. The device can support a variety of mobile handset system architectures including GSM/GPRS/EDGE/UMTS and code division multiple access (CDMA). It is also specifically designed for the latest 2.XG and 3G protocols.



Freescale's portfolio of power management and user interface (PMUI) ICs takes a tiered solution approach, from discrete-displacing integration for cost-conscious applications to high-end features and emerging capabilities. Our highly integrated PMUI IC solutions are power-efficient and feature-rich with coordinated power sequencing, low consumption standby modes, and seamless power switching. Protocol independence supports a variety of system architectures; modular integration with a single programming interface simplifies hardware and software application design. Freescale provides optimized platform solutions with PMUI, baseband, RF and power amplifiers.

For more information, visit www.freescale.com/pmui.

Carkit and USB Standards

Integrated, optimized routing for the CEA-936-A carkit interface standard and USB On-The-Go provides ease of use and reduces system cost. The carkit standard is driving new capabilities for battery charging, data communications and audio routing through a standard mini-USB connector. An i.MX/MC13783 mobile device would allow users to charge their batteries directly from a PC or car stereo through a USB cable or plug-in cradle. Hands-free phone calls or stereo playback can be directly interfaced to a carkit-capable stereo. With CEA-936-A compatibility, a mobile device only needs one connector for both USB connectivity and a charger. The single mini-USB connector can even work as a headset output.

Analog to Digital Converter

The MC13783's ADC contains 11 general purpose inputs that can take the place of many kinds of external circuitry, helping to save cost at the system level. They can be used to enable conversion on other elements in an application such as a temperature sensor or ambient light sensor. Designers can use these inputs for a range of tasks, including comparator logic and resistive touchscreen capability. The ADC is also used for accurate battery capacity metering, including on-chip scaling for voltage and current readings.

Backlight Functions

Three sets of tricolor RGB LED drivers support a wide variety of lighting use cases such as alerts, displays, keypad lighting, fun lights or other product differentiators. These LEDs could be used for applications such as case lighting, or a navigation button with a backlight which is independent of the backlight for other keys. Partial lighting, especially for keypads, can save a great deal of current.

In the MC13783, one single boost switcher provides power for backlight and USB On-The-Go applications. An adaptive boost mode can scale the boost output voltage to the minimum necessary, reducing power dissipation across the current-sinking main display backlight drivers. This improves overall power efficiency when the backlights are active for extended periods.

Audio Options

The MC13783 contains all of the components needed to play and output stereo audio, from the 16-bit stereo codec to a variety of line, headset and speaker amplifiers with adjustable gain paths. Dual voice ADCs provide for stereo recording from two microphones, or stereo recording from an analog source such as an FM radio module.

Two audio bus interfaces provide flexible audio architecture with either wideband or narrowband audio, or both, and support for dual processors. The i.MX/MC13783 combination provides mixing, volume and balance control of voice, stereo audio and FM radio for increased flexibility and a richer user experience.

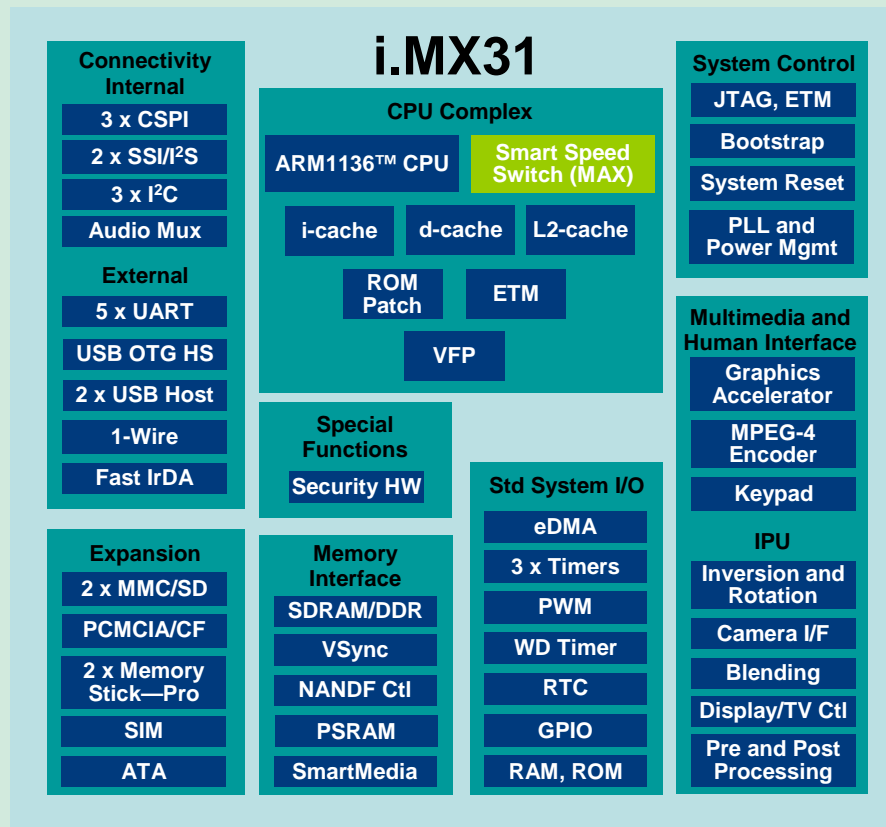
Digital and Analog

i.MX is a mixed analog and digital audio system with multiple audio ports. When you combine MC13783 and the i.MX31, the analog and digital signals can be mixed. For example, one port could handle a narrowband signal and one could simultaneously handle a wideband signal. Analog mixing of the converted audio streams enables applications such as simultaneous voice conversation and MP3 playback. The mixed audio can be output to any output amplifier.

Battery-supplied loudspeaker amplifier with high power supply rejection ratio (PSRR) provides high output power, and can also be used as an earpiece amplifier with a single speaker. The MC13783 is prewired for stereo loudspeakers, for an easy upgrade to stereo loudspeaker applications. Stereo headset and line-out amplifiers are also provided.

About the i.MX31


Based on an ARM1136JF-S™ core, Freescale's i.MX31 multimedia applications processor, starting at 532 MHz with a vector floating point coprocessor and L2 cache, is designed for any wireless device running computationally intensive multimedia applications such as digital video broadcast and videoconferencing. It is also ideal for mobile devices favored by the power user who keeps several applications running at once. Target devices include feature-rich smartphones, digital video recorders, digital cameras, mobile gaming consoles, mobile multimedia players and many other mobile wireless applications.



The i.MX31's built-in Image Processing Unit (IPU) includes the functionality required for image processing and display management including deblock, deringing, color space conversion, independent horizontal and vertical resizing, blending of graphics and video planes, and rotation in parallel to video decoding. The IPU accelerates loop deblocking for H.264 decode as well as encode. It provides acceleration of image processing to deliver up to VGA 30 fps video quality. The IPU is equipped with powerful control and synchronization capabilities to perform tasks with minimal to no involvement of the ARM® CPU.

An integrated 3-D Graphics Processing Unit (GPU) delivers an incredible 1 MTri/sec (double textured, bi-linear, Gouraud shaded) at about 100 Mpix/sec (effective). The GPU is built around the ARM MBX R-S™ graphics accelerator. It offers full scene anti-aliasing for superior image quality and provides OpenGL® ES and Java Mobile 3-D support.

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



Freescale's mobile multimedia technology is helping designers push mobile multimedia devices into new territory with highly integrated platform solutions for cell phones, smartphones, portable media players and more. From reduced bill of materials to world-class audio and power management, the combination of our MC13783 PMUI IC and the i.MX31 multimedia applications processor offers a host of benefits for your next design.

How to Reach Us:

Home Page:

www.freescale.com

e-mail:

support@freescale.com

USA/Europe or Locations Not Listed:

Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
1-800-521-6274
480-768-2130
support@freescale.com

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064, Japan
0120 191014
+81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate,
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:

Freescale Semiconductor
Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447
303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright license granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.



Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. ARM is the registered trademark of ARM Limited. ARM9, ARM11, and ARM1136JF-S™ are the trademarks of ARM Limited.
© Freescale Semiconductor, Inc. 2006.

Document Number: PWRMGTIMXAUIOWP

