White Paper

Freescale i.MX537 Solution for the Industrial Market

Introduction

In recent years, the consumer space has led the technology development of new multimedia features. With the growing trend toward rich user interfaces and the influence of consumer devices, industrial human-machine interface (HMI) customers are beginning to leverage this technology for their next generation of products. Examples include:

- Appliance products with an embedded color TFT screen for a more informative and interactive user interface
- Factory automation solutions with hardware graphic acceleration for a more impressive and simplified user interface
- Building automation employing the latest multimedia codecs (H.264, MPEG-4) in elevators
- Wireless networking solutions resulting in reduced infrastructure costs
- Home automation with integrated multimedia, graphics and wireless technology

Embedding these new technologies allows industrial customers to become more active in the process of defining next-generation applications processors. And with application processors gaining in popularity within the industrial market, integrated chip providers must meet requirements which are not necessarily technical but are linked to the surrounding environment. This white paper describes some of the challenges of the industrial market and how i.MX technology is uniquely positioned to address them.

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Challenges of the Industrial Market

Within the industrial segment, designers face challenges related to the industrial environment rather than that of consumer devices. “Will the device run 24 hours a day and for how many years?” “Where will this device be and what temperature will it be exposed to?”

One of the primary challenges of industrial customers is the limited amount of time between a processor or component introduction and the end-of-life phase. Consumer-geared components generally have a short one to three year ordering span. Historically, Freescale has supplied products to automotive customers during the production phase of their device. With a focus on the industrial space, Freescale has expanded its product longevity and can target up to 15 years of availability for specific products in the automotive and medical markets. Freescale will make a broad range of devices available for a minimum of 10 years for all other market segments. This long period of device availability allows industrial customers to design their end product without fear of having to redesign with another new or more complex processor. Most newer devices within the i.MX family launch with the minimum availability of 10 years, while the i.MX53 family of processors will support up to 15 years minimum. Life cycles for participating Freescale products will begin at the time of general product launch and will include the standard Freescale end-of-life notification policy (typically, a one-year notice for placement of final orders and an additional year until the last ship date). Freescale will manage the program through our own factories, outside foundries and other manufacturing resources. If it becomes necessary to transfer the production of a participating product to an alternate manufacturing facility, Freescale will re-qualify that product. For a list of participating devices and their estimated product availability, visit **freescale.com/ProductLongevity**.

In the consumer space, the technical support model requires direct support to key consumer opportunities. The industrial segment model includes all sizes of opportunities from 1000 units up to millions of units per year. Duplicating the consumer technical support model can only fit with the industrial OEMs. However, supporting thousands of smaller opportunities worldwide requires a specific infrastructure with a flexible technical model. Our support model includes:

- A centralized technical support team available online 24 hours a day, seven days a week
- Simple solutions
  - Evaluation boards with a simplified out-of-box experience
  - Application notes and technical documentation
  - Support for a variety of operating systems
  - Schematics, layouts and guidelines
  - Example or reference code
  - Optimize board support package (BSP) drivers and multimedia codec portfolio

Some customers within the industrial segment may not want to start a 32-bit CPU design due to a lack of 32-bit knowledge or the low quantity of their end product not justifying a hardware and software redesign. An alternative solution would be to use a module manufacturer, allowing customers to concentrate energy and time on their core competency rather than hardware development. Freescale has developed a strong ecosystem which includes key module manufacturing leaders. By encompassing the module manufacturer business model, the collateral support model and the direct technical support model, the Freescale i.MX group has earned a strong reputation within the industrial space as a key contributor to customer success.

Manufacturing cost is another issue faced by industrial customers. The current consumer technology trend is to reduce space by raising the number of PCB layers through high-density interconnect (HDI) via technology. However, for HMI, factory automation, building automation and other facets of the industrial segment, board space does not present an issue—eliminating the need for HDI via. One way to remove the HDI via involves using a larger pitch package, so long as performance meets customer expectations. Also, using a larger pitch package allows

industrial customers to avoid investing in a new manufacturing line. Historically the i.MX product family targeted only the consumer markets where the level of integration represented the de facto requirement. In fact, i.MX products supported the 0.5 mm pitch with high pin count, requiring PCB with HDI via and resulting in added cost. Migrating toward the 0.8 mm pitch package reduces cost by removing the HDI. In line with the industrial target, the i.MX product family has supported the 0.8 mm pitch since introduction of the i.MX27, i.MX25, i.MX31, i.MX35, i.MX233, i.MX28, i.MX51 and the i.MX53 applications processors.

Industrial devices are often exposed to difficult environmental conditions. Unlike the automotive segment where the IC device works only when needed, within the industrial environment, the product operates 100 percent of the working time, often 24 hours a day for seven days a week. This is particularly evident in factory automation, building automation, robots, metering applications and with some medical devices. To reflect the difficult operating environment of devices within the industrial segment, the associated qualification process takes into account constant operation of the device. An industrial-qualified processor has an expected 10-year lifetime and is assumed to operate on a full-time basis at the maximum temperature specified in the data sheet. Though this results in a more difficult qualification and testing process it ensures our customers are receiving reliable parts fit for industrial environments. The i.MX537, like its predecessors, is industrial qualified based on these specifications.

With growing demands to reduce energy consumption, attention has been focused on the amount of energy a device consumes in standby mode. Through our history of designing ICs for portable consumer devices where low-power operation is key, Freescale is well suited to meet this challenge.

Dynamic voltage/frequency scaling (DVFS): This technique allows the frequency of a microprocessor to be automatically adjusted “on-the-fly,” either to conserve power or to reduce the amount of heat generated by the chip. Dynamic voltage scaling is another power conservation technique that is often used in conjunction with frequency scaling, as the frequency at which that a chip may run is related to the operating voltage. These two power conservation techniques are used in the i.MX537.

Low-power modes

- Run mode: This is the normal mode of operation where a decrease in power is a result of DVFS support.
- Wait mode: The ARM® clock is gated. All other clocks are functional and can be gated through programming.
- Stop mode: In this mode all system clocks are stopped. PLLs are stopped. Power gating can be performed on the ARM platform and other different blocks.

Embedding hardware acceleration: Freescale embeds dedicated hardware IP to offload the ARM core from software-intensive tasks that drive higher power consumption. Multimedia codecs, 3-D and 2-D accelerators have been supported since 2006, illustrating our experience and leadership in driving a high level of integration and optimization for reduced power consumption and improved performance.

Similar to the automotive segment, the industrial space requires support of devices operating at extreme ambient temperatures ranging from –40 °C to +85 °C. To complement the industrial temperature coverage, the i.MX537 will also cover the extended temperature ranges.

In terms of technology improvements, the industrial space primarily uses existing technology and rarely drives development of new features. However, the complexity of industrial applications with different peripherals to support requires a high level of flexibility.

i.MX537 Product Introduction

The i.MX53 family of multimedia applications processors represents Freescale's latest addition to a growing family of ARM Cortex®- A8 core-based products offering high performance processing and low power consumption. The i.MX537 applications processor operates as high as 800 MHz for the industrial segment and interfaces with DDR2, LP-DDR2, LV-DDR2 and DDR3 memories. This device is suitable for the following industrial applications:

- Patient monitoring and diagnostics for the medical segment
- HMI for factory, building and home automation and high-end applicances
- Advanced module manufacturing
- High-end ePOS terminals
- Single board computing
- Industrial PCs

The i.MX537 applications processor embeds the following features:

- Cortex-A8 core running at 800 MHz for the industrial segment
- ARM NEON™ coprocessor and Vector floating point unit
- MMU with L1 instruction and L1 data cache
- Unified L2 cache
- ARM TrustZone® technology

The memory system consists of the following components:

- Level 1 cache
  - Instruction with 32 KB
  - Data with 32 KB
- Level 2 cache
  - Unified instruction and data (256 KB)
- Level 2 internal memory
  - Boot ROM including HAB (64 KB)
  - Internal multimedia/shared, fast access RAM (128 KB)
  - Secure/non secure RAM (16 KB)
- External memory Interface
  - 16-bit NOR flash
  - 8/16-bit NAND SLC/MLC flash, up to 66 MHz, 4/8/14/16-bit ECC
  - OneNAND and managed NAND, including eMMC up to rev4.4
  - 16/32-bit LP-DDR2, DDR2-800, LV-DDR2-800 or DDR3-800 up to 2 GB

The i.MX537 makes use of the dedicated hardware accelerators to achieve optimal multimedia performance. The use of hardware provides both high performance and low power consumption while freeing up the CPU for other tasks.

The i.MX537 incorporates the following accelerators:

- 3-D graphics processing unit, OpenGL™ ES 2.0 with 33 Mtri/s, 200 MP/s and 800 MP/s z-plane performance with 256 KB RAM memory
- 2-D graphics accelerator, OpenVG™ 1.1 with 200 MP/s performance
- Image processing unit
- Asynchronous sample rate converter (ASRC)
- Video processing unit supporting multi-standard HD resolution video decode and video encode, as well as multi-stream video support

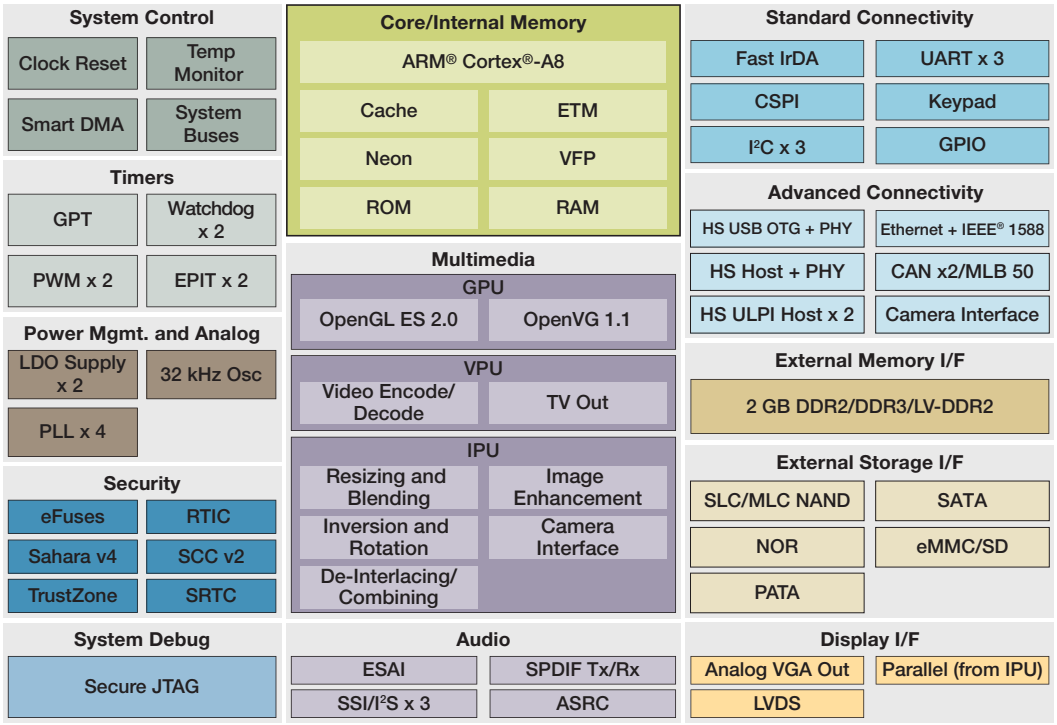
The i.MX537 includes following interfaces:

- Hard disk drives
  - P-ATA up to U-DMA mode 5, 100 Mbps
  - S-ATA II with 1.5 GB
- Displays
  - Five interfaces are available. The total rate of all the interfaces is up to 180 Mpixels/s, 24 bpp. Up to two interfaces may be active at once
  - Two parallel 24-bit displays ports
  - LVDS serial ports: One dual-channel port up to 165 MP/s or two independent single-channel ports up to 85 MP/s
  - TV-out/VGA port up to 150 MP/s
- Camera sensors
  - Two parallel 20-bit camera ports. The primary sensor accepts up to 180 MHz peak clock frequency and the secondary sensor up to 120 MHz peak clock frequency
- Expansion cards
  - Four SD/MMC card ports where three ports can support up to 416 Mbps and one port can reach 832 Mbps (8-bit, eMMC4.4)
- Universal serial ports
  - High-Speed USB 2.0 OTG (up to 480 Mbps) with integrated High-Speed USB PHY
  - High-speed USB 2.0 (480 Mbps) host with integrated High-Speed USB PHY
  - Two high-speed USB 2.0 hosts for external high-speed/full-speed transceivers through ULP/Serial, supports IC-USB
- Miscellaneous Interfaces
  - Three I2S/SSI/AC97 ports supporting up to 1.4 Mbps each connected to audio multiplexer providing four external ports
  - Enhanced serial audio interface (ESAI), up to 1.4 Mbps per channel
  - Two high-speed CSPI ports and one full-speed CSPI port
  - Fast Ethernet controller IEEE® 1588 compliant
  - Five UART RS232 ports up to 4.0 Mbps each
  - Sony®/Philips® Digital Interface, Rx and Tx
  - Two CAN interfaces, 1 Mbps each
  - GPIO with interrupt capabilities
  - Three I²C ports up to 400 Kbps
  - Two pulse width modulators
  - Secure JTAG controller
  - One Wire port
  - Keypad port

The system supports efficient and smart power control and clocking. This includes:

- Supporting DVFS techniques for low power modes
- Support for various levels of system power modes
- Power gating: SRPG for ARM core and NEON technology
- Flexible clock gating control scheme
- On-chip LDO voltage regulators for PLL
- On-chip temperature monitor
- On-chip 32 kHz oscillator

i.MX537 Block Diagram



i.MX537 Market Positioning

Traditional HMI has long been used to operate machinery, robots and any other industrial devices. This user interface must be easy to operate, feature a fast response time and must perform in a variety of difficult environments (high/low temperatures, humidity and any other extreme conditions). These industrial devices are often ruggedized for a longer life cycle.

The so-called “Apple Effect”, combined with the rising popularity of consumer electronics devices has created a high demand for a user interface evolution in the industrial market. By combining the system requirements with the possible software investment, the traditional HMI is rapidly moving towards an enhanced user interface and increasing the demand for segment and graphical LCD interfaces. However, developing with new technologies must incorporate some technical aspects to ease the deployment.

The OpenVG and OpenGL ES application program interfaces (APIs) can drive developers’ adoption, as these APIs ease the transition from an old and closed system to an open and affordable framework. A reduction in die size, combined with process technology improvements have resulted in the reduction of power consumption required for higher rendering capabilities.

One of the key challenges industrial customers face is a new business model and the associated ecosystem. Freescale can provide help by introducing key partners to ease the development of new HMI solutions.

How i.MX537 solves the industrial challenges

Increased processing power

Migrating from traditional user interfaces to a more advanced model requires more processing power. The new technology, techniques and additional implementations can easily enable the software programmers to create an excellent user interface equivalent to consumer electronics at a low cost with affordable frequency availability. The i.MX537 is designed to meet these expectations. Designed in 65 nm technology for reduced power consumption while remaining cost-competitive, this product embeds a hardware accelerated IP (both 2-D and 3-D) compatible with standard

API, OpenVG 1.1 and OpenGL ES 2.0 respectively. Combined with the 800 MHz CPU frequency bandwidth, this allows developers the flexibility to design attractive advanced user interfaces.

User interface optimization can also be achieved through the on-chip LCD controller in the i.MX537. Optimizing the data transfer, reducing the software impact and decreasing the overall power consumption, the i.MX537 embeds a specific architecture with dedicated bus without interfering with the CPU during the data transfer.

Managing the BSP software by optimizing the code and reducing the CPU bandwidth is another effective method of optimizing the user interface.

Reduced power consumption

The i.MX537 includes several features which can help to reduce power consumption:

- Designed in CMOS 65nm technology with specific low-power technology and accelerated hardware (2-D, 3-D and multi-standard multimedia codec)
- DVFS techniques

Cost effectiveness

One of the most difficult design challenges is how to provide value to the user interface without impacting the cost of the development and the final cost of the solution. Freescale has designed the i.MX537 in this direction. The following features show the cost advantages of the i.MX537:

- Designed-in advanced c65nm technology
- 0.8 mm pitch to avoid HDI Via on the PCB
- High level of integration with the following peripherals:
  - USB PHY
  - Serial interface: UARTs, SPI, CSI and I²C
  - P-ATA and S-ATA interfaces
  - 10/100 Fast Ethernet bus and hardware capable IEEE 1588 standard time stamping
  - Complimentary BSPs and codecs
  - Support for lower cost DDR2-800 and DDR3-800

Implementing wireless and wire line connectivity

Interconnectivity between the HMI system and the rest of the factory automation product involves a variety of links and other customer-dependant protocols. This requires flexibility in the connectivity offering. The i.MX537 embeds the traditional serial port with five UART ports up to 4 Mbps where one port supports 8-wire while the other four ports support 4-wire, two high-speed serial peripheral interfaces and three I²C ports. The demand for higher bandwidth drove the adoption of the USB port (High- and full-speed USB) with PHY integration for cost reduction and ease of implementation. The i.MX537 hardware also includes a Fast Ethernet controller with IEEE 1588 time stamping mode to reflect the high demand of real-time Ethernet protocols. Two CAN interfaces (1 Mbps each) have been added upon customer request for some industrial applications.

Aside from the wireline data transfer link, the ease of portability through the wireless stack drives the adoption of ZigBee®, Wi-Fi®, Bluetooth® and other wireless technologies.

Conclusion

Like the rest of the i.MX portfolio, the i.MX537 provides key environmental differentiators for the industrial market. These include 3.3 V I/O support, a 0.8 mm pitch package to reduce PCB and manufacturing costs, extended temperature coverage for harsh environments, industrial qualification for extended reliability, a formal long product supply to support product life spans and a strong ecosystem, including module manufacturers, software integrators and development tools. Those value-added features are also combined with optimized Linux®, Android™ and Windows® Embedded Compact 7 BSPs, schematics, layout and collateral. Customers in the industrial segment will optimize their time to market by shortening the development phase with the newest Cortex-A8 core from Freescale.

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