
An ADI Engineering Whitepaper

An Overview of ADI Engineering’s Unique Single-Chip COTS and Semi-Custom Products for the Intel E6xx

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WITH THE RELEASE OF THE E6XX FAMILY OF PROCESSORS, Intel has added a number of useful features to its very popular low-power embedded Atom offerings, such as improved graphics performance, a built-in hardware video encoder, and industry-standard PCIe Express (PCIe) instead of a proprietary front side bus (FSB) as the primary interface to the CPU. The E6xx processor’s use of PCIe as its primary interface also allows third party silicon vendors to offer application-specific I/O Hub chips (“IOHs”), and developers can also develop their own FPGA or ASIC-based custom IOHs. But the main innovation of the E6xx is that it’s Intel’s first embedded Atom system on chip (SoC). An IOH such as the Intel EG20T can be used to add USB, SD, SATA and other features when needed, and the open PCIe interface allows third-parties to develop new IOHs targeted to a wide range of applications – in-vehicle entertainment, IP video phones and surveillance, networking and security, storage, and IP media players, to name a few.

The E6xx is Intel’s first-generation embedded Atom SoC, raising hopes that it can serve deeply embedded “thin” applications where Intel Architecture (“IA,” or x86) processors are highly desired for their extensive software support, but have long held significant disadvantages in cost, size and power consumption. Unfortunately, despite Intel’s marketing of the E6xx as an Atom SoC, the E6xx has several major shortcomings that when left unaddressed preclude it from fulfilling its potential as a true single-chip Atom CPU. The unfortunate fact is that the IOH is not just an optional I/O companion chip that developers can add when needed. Rather, the IOH is mandatory simply to boot an Operating System (OS), one of the most fundamental requirements of a typical embedded processor. The result: The E6xx remains a two-chip CPU chipset consisting of the E6xx plus an IOH, at the same (or higher) overall cost, size and power consumption as previous-generation Z5xx two-chip embedded Atom CPU chipsets. The promise the E6xx holds to meaningfully reduce cost, size and power is compromised with this conventional design approach.

Why Standard Design Approaches for the E6xx Fall Short
To understand how this situation came to be, and what can be done to correct it, we need to examine the specific shortcomings of the E6xx SoC, which are are:

- Lack of an on-chip interface for an OS boot device – SATA, SD, PATA, USB, or NAND Flash controller. Intel’s E6xx system architecture partitions this function to the IOH even
though it is fundamental to the operation of the SoC in any real-world embedded system. The result is that an IOH is always required, and the E6xx remains a two-chip CPU, negating hopes for true single-chip cost and power savings. The primary architectural difference between the new E6xx and prior-generation Z5xx is the use of PCIe instead of a proprietary FSB to connect the CPU with the IOH.

- The need for complex system management and power control hardware and firmware represents a significant added cost for the E6xx compared to competitive non-IA processors.
- The need for BIOS is a burden that only IA processors carry. Cost-sensitive thin applications typically do not need a full-function BIOS, which carries a significant per-unit royalty expense with little or no real value for most deeply embedded applications.

Bottom line, while the E6xx is marketed as an Atom SoC, it is an incomplete one. Deeply embedded device developers are eager to migrate to the E6xx because of the substantial cost and power savings it promises, but conventional two-chip E6xx designs largely fail to deliver on this promise. Fortunately, with innovative design approaches from ADI, the E6xx’s shortcomings are overcome and its potential as a true single-chip Atom SoC is unlocked.

**Thin Deeply Embedded Applications for the Intel E6xx**

With the rapid growth of IP-based audio/video technologies, a new class of deeply embedded product requiring high-performance IP A/V streaming or playback, wired or wireless networking, user interface, security, embedded control, and content management is rapidly emerging. Applications include digital signage, consumer electronics, video surveillance, in-vehicle infotainment, military, medical, and industrial control. While low-cost ARM+DSP processors can meet some of the low-level IP A/V decode requirements, these processors typically fall short of meeting all the higher-level requirements because of their limited performance headroom while performing HD decoding. And software support is a challenge.

Many developers of deeply embedded thin applications are eager to adopt new IA processors to gain substantial improvements in performance, scalability, and software support. If the single-chip cost and power savings potential of the E6xx SoC could be realized, it is an ideal CPU for thin IA applications. Key characteristics of these thin IA applications include:

- Require high-performance IP high-definition A/V decoding or encoding
- Require substantial CPU performance headroom for user interface, networking and wireless, management, control, content management, and other high-level tasks
- Have I/O needs that are rather modest and specifically targeted to the end application, instead of “kitchen sink” collections of non-targeted I/O typical of previous-generation embedded IA products. Often, an Ethernet port, video port, and small handful of other ports are all that is needed.
• Have a strong preference for x86 instruction set compatibility, to tap into the large base of OS’s, software applications, drivers, middleware, A/V CODECs and media players that support IA.
• Have aggressive requirements for production cost, power consumption, and size that cannot be met by traditional multi-chip IA CPU chipsets.
• Frequently require Adobe Flash, which has significant limitations on non-IA processors.

Two examples of Thin E6xx applications are shown in Figures 1 and 2. Figure 1 shows an 802.11n-to-HDMI streaming HD media player, and Figure 2 shows an extended-temperature outdoor digital signage controller. Both systems run embedded Linux, both require 1080 HD video decode, both require near-desktop performance with significant headroom while decoding 1080 video, and both must run the latest version of Adobe Flash (10.1). The E6xx is an ideal CPU meeting all the technical requirements, but the conventional two-chip E6xx design approach exceeds BOM cost targets by 60% or more.

![Figure 1: 802.11n-to-HDMI Streaming HD Media Player](image1)

![Figure 2: Extended Temperature Outdoor Digital Signage Controller](image2)

**ADI’s “Thin E6xx” Offerings Deliver Up To 60% Cost Reduction**

To overcome the limitations of conventional two-chip E6xx architectures in thin deeply embedded applications, ADI Engineering has developed a novel “Thin E6xx” approach. ADI’s Thin E6xx approach is a fresh, innovative new strategy that departs from conventional thinking
to unlock the full potential of the E6xx as a single-chip Atom CPU with substantial savings in cost, power consumption, size, and complexity.

ADI’s Thin E6xx offerings include single-chip E6xx commercial off-the-shelf (COTS) single board computers, pre-validated hardware and software designs, and rapid time-to-market semi-custom OEM products. ADI’s Thin E6xx offerings deliver up to 60% savings in production cost, along with large reductions in size and power consumption. And for approximately the same cost as lower-end ARM-based offerings, ADI’s Thin E6xx designs make available the significant advantages IA holds in video encode/decode performance, CPU core performance, and network throughput. The advantages also extend to software, with the broad-based OS, driver, application software, CODEC and media player software support of IA finally made available to thin applications.

ADI’s Thin E6xx Approach Explained

ADI Engineering’s Thin E6xx approach is enabled by three primary technologies pioneered by ADI: A low-cost NAND Flash controller designed and optimized for the E6xx, “BLDK” Royalty-Free BIOS Replacement, and a low-cost E6xx System Manager, as explained below.

**E6xx NAND Flash Controller**

The biggest shortcoming of the E6xx is the lack of any on-chip non-volatile storage device controller – SATA, PATA, SD, USB, or NAND Flash. While the conventional approach is to simply use the Intel EG20T IOH with the E6xx to add SATA, SD or USB as the OS boot device controller, this also transforms the E6xx into a two-chip CPU chipset with substantial penalties cost, size and power consumption. The EG20T power consumption can be as much as the E6xx SoC in some cases.

ADI has developed a low-cost NAND Flash controller specifically optimized for the E6xx. This design uses a small, low-power, inexpensive CPLD connected to the E6xx LPC bus to serve as a low-level NAND Flash controller, at far lower cost, power and size than the EG20T IOH. Eliminating the IOH causes a ripple effect of other savings throughout the system, such as management and power control circuits and board area. And with four PCIe x1 interfaces, application-specific I/O such as Ethernet, USB and RS-232 can be tailored to each specific application at lower overall cost and power than a large IOH.

**“BLDK” Royalty-Free BIOS Replacement**

Traditional IA designs, including those based on the E6xx, normally use a commercially available BIOS. The history of BIOS is firmly rooted in the evolution of the desktop PC, but in deeply embedded applications – especially those running Linux - BIOS often has little or no real value. Even worse, BIOS carries a substantial per-unit royalty cost to IA-based designs that isn’t incurred by competitive processors. The E6xx is competing in deeply embedded applications
with processor architectures that do not require BIOS, and this can result in a significant cost disadvantage.

Fortunately, Intel and ADI are pioneering a new royalty-free BIOS replacement for the E6xx. Called “Boot Loader Development Kit” (BLDK) or “Trinity Lake,” this is a new bootloader for E6xx that serves as a royalty-free BIOS alternative. Note that BLDK is not meant to be a full replacement for BIOS in all situations, since BLDK cannot boot desktop Windows (WinCE may be OK, though), and it does not offer the extensive configurability, control, and user interface of a commercial BIOS. However, for deeply embedded devices running Linux, BLDK offers a viable alternative to commercial BIOS that removes a significant cost disadvantage long incurred by IA.

**Thin E6xx System Manager**
E6xx designs require a relatively complex system manager to handle power-on sequencing and sleep state and power control, among other features. Simply eliminating the EG20T reduces the system management requirements. Further, the need for sleep states and dynamic power control is reduced or eliminated in thin designs, since eliminating the EG20T greatly reduces system power consumption to begin with to the point that active power management is not a pressing need.

ADI’s thin E6xx design approach uses a low-cost, small CPLD to perform system management and power control functions. ADI’s system controller is lower cost than conventional microcontroller-based system manager designs, and it is readily adapted to new products.

**ADI’s Thin E6xx Offerings**
The Thin E6xx strategy is being used in two offerings from ADI: COTS single board computers (SBCs) and rapid, low-NRE semi-custom designs.

**Thin E6xx-Based Cinnamon Bay EX SBC**
In Q1 of 2011, ADI is releasing its new “Cinnamon Bay EX” SBC based on the Intel E6xx processor. Cinnamon Bay EX is a next-generation offering in ADI’s Cinnamon Bay deeply embedded SBC family, and is form-fit-function compatible with the existing Z5xx-based Cinnamon Bay SBC product line. Cinnamon Bay EX is available in multiple SKUs both with and without the EG20T IOH. ADI’s thin Cinnamon Bay EX SKU eliminates the EG20T IOH to offer an unprecedentedly low price point for deeply embedded IP media applications with modest I/O requirements. An on-board PCI Express MiniCard slot allows for expandability and the easy addition of a NAND Flash module or a boot device controller card.
Rapid, Low-NRE Semi-Custom Thin E6xx Designs
For the ultimate in low cost, ADI’s semi-custom Thin E6xx designs can be rapidly developed at low NRE to your exact needs, at the absolute lowest BOM cost. ADI’s pre-validated design blocks and rapid-deployment engineering capabilities reduce the NRE, time and risk of the semi-custom design program, and the substantial production cost savings of a thin design tailored to your precise requirements can quickly deliver a large ROI.

Both offerings from ADI – COTS SBCs and semi-custom designs – are fully supported by ADI’s groundbreaking Open IP business model of “We Build/You Build” customer-directed manufacturing and IP licensing. With Open IP, ADI empowers its customers to retain full control over their supply line even when using COTS or semi-custom products. Unlike traditional ODMs and OEMs that rely on closed IP, ADI’s bold Open IP model eliminates the large single-source risks that are inherent with traditional outsourcing approaches.

For more information on Thin E6xx COTS, Semi- or Full-Custom Products or Open IP, please contact ADI Engineering at info@adiengineering.com.