

EUROTECH'S LOW POWER INTEL[®] ATOM[™] - BASED CATALYST MODULE DESIGN:

**The industry's lowest power Intel[®] Atom[™] – based
modules.**

Whitepaper

By Glenn DeYoung; Field Applications Engineer, Eurotech



Abstract

The low power Intel® Atom™ Processor family delivers Intel Architecture (IA) compatibility and performance at a fraction of the power consumption of a laptop or desktop computer. This feature set has enabled embedded designs to take advantage of IA compatibility while maintaining low power dissipation, thus eliminating the need for fans or heat sinks. In order to achieve the lowest power dissipation, designers must understand details of the hardware, software and overall system architecture that affect power dissipation. With this knowledge, designers can select the right low power Intel® Atom™ processor-based solution for their embedded design.

Introduction

Since the Intel® Atom™ processor family was introduced, many embedded control companies have introduced Intel Atom-based solutions targeting low power applications. The Intel® Atom™ processor's low power dissipation, with IA performance and compatibility has enticed many designers to move their designs to this platform. Choosing the right solution is critical when embedded systems require an optimized design for very low power dissipation. This paper outlines the design considerations implemented by Eurotech which makes the Intel® Atom™ - based Catalyst family which started with the Catalyst XL, the lowest power Computer-on-Module (COM) in the industry and makes it the compelling choice for power optimized embedded systems. The Eurotech Catalyst XL is based on the Intel® Atom™ Z500 processor series and the Intel® System Controller Hub US15W (Intel® SCH US15W).

Eurotech's background in low power solutions

Eurotech has offered low power ARM-based solutions for many years including several designs based on processors from the former Intel XScale processor family. As a result, Eurotech's relationship with Intel has always been very strong. When Intel was developing the Intel®



Atom™ processor family for embedded applications; they realized the importance of keeping the processor and system power dissipation as low as possible. Consequently, Eurotech worked very closely with Intel during early phases of development to fully understand and implement the capabilities of the Intel® Atom™ family of processors.

Eurotech's focus on low power was evident with the introduction of the Eurotech Catalyst Module platform and the Eurotech Standard Development Kit. The development kit includes a maintenance/debug port that allows real-time monitoring of the Catalyst XL module's power dissipation. The power is measured by the Catalyst XL's system controller, so the Intel® Atom™ processor's performance or power dissipation is not affected by the measurement. The Catalyst XL -based computer can be running any application while the power is monitored. The monitoring application runs on a desktop or laptop and displays the instantaneous power on a graph and can log the data to a file for later analysis.

Eurotech's design approach to the Intel® Atom™ -based Catalyst Module

The question has often been asked, "How does Eurotech achieve lower total system power than its competitors when everyone is using the same Intel® Atom™ processor?" The answer is in the design approach to the Catalyst XL module. Eurotech has a guiding design discipline that we will have the most power-efficient designs in the industry. This discipline is deeply rooted in our history as a supplier of low power ARM systems. Going from sub 1Watt ARM systems to multi-watt Atom systems was a large increase in power for us. We wanted our Atom solutions to be a stepping stone to higher processing performance without a correspondingly large increase in power dissipation. This balance allows our customers to easily transition from ARM-based designs to Intel® Atom™ -based designs. In order to accomplish this goal, we needed our Intel® Atom™ designs to be as power efficient as possible.

The heart of the Eurotech Catalyst family is the Intel® Atom™ processor. Eurotech designed the Catalyst XL from the ground up, looking for ways to lower the power dissipation and improve performance. We didn't settle on using the Intel® Atom™ reference design for our module and

release to the market. Instead, we started with the Intel® Atom™ reference design and improved upon it. These changes resulted in improved total system power. Some of the changes include:

- High efficiency voltage regulators: An analysis of the Intel® Atom™ reference design revealed the voltage regulators are not very efficient. In order to optimize a voltage regulator's efficiency, the loads need to be fully characterized and regulator designs adjusted for maximum efficiency. This practice takes time and effort. Our design team invested the time and effort to characterize and optimize the voltage regulators on the Catalyst XL. In doing this we were able to more closely match the regulator to the circuit than what was used in the reference design. We didn't go for the lowest cost solution; instead we opted for higher efficiency and performance over lowest cost. As a result, the voltage regulators on the Catalyst XL have much higher efficiencies than those on the Intel® Atom™ reference design.
- Lower power components: Eurotech's philosophy of design, based on performance, not cost, was also followed with regards to component selection. We didn't select components for the lowest cost solution; instead we opted for higher efficiency and performance over cost. We carefully evaluated the components used throughout the Catalyst XL module and the development kit carrier boards so they provided the lowest power dissipation for each interface. We make these carrier board designs available to our customers so they can use the same efficient designs in their systems.
- Minimal interfaces embedded on the Catalyst XL: We did not include an extensive number of interfaces on the Catalyst XL. Instead, we routed the buses (PCIe lanes, SMBUS, LPC bus, I²C bus, USB, LVDS, etc.) to the carrier board. Routing the buses to the carrier board provides an easy method of adding specific interfaces on the carrier board. This design minimizes the amount of power dissipated in the system by eliminating unused interfaces. For example, we do not include a SATA controller or an Ethernet controller on the Catalyst XL like other vendors do on their COMExpress modules. Instead, both PCIe buses were routed to the carrier board so these or other interfaces can be included in the system if required. This flexibility gives the system design engineer the option to include only the interfaces needed for the product.

- **System Management Controller:** We chose not to use the hard-coded system controller from the Intel® Atom™ reference design. While using Intel's system controller would be easier than designing a custom system controller, it doesn't give the flexibility to improve on performance. We designed our own system controller which allows fine-tuning the system in areas other vendors can't.
- **Custom Eurotech BIOS:** Eurotech licensed BIOS source code from Insyde for use on our Catalyst modules. We provide a standard BIOS, but can also provide a customized BIOS when required. This customization allows us to manage the power better for specific system design needs.
- **Full engineering support:** We provide design assistance to customers designing their own system carrier boards. This includes helping with component selection, doing design reviews (block diagram, schematic and layout) and consulting on board bring up. Eurotech can provide years of low-power design experience to help customers achieve the lowest system power possible.

Advantages of Eurotech's Low Power Catalyst Module

There are many advantages to using the Eurotech Catalyst module designs based on Intel® Atom™ processors. Among these are:

- Eurotech's design approach to the Catalyst XL resulted in the lowest power dissipation of an Intel® Atom™ design in the industry. The Catalyst XL's lower power also equates to the lowest total system power based on Intel® Atom™ processors. Having the lowest power has several advantages:
 - ❖ **Battery Size:** You can either shrink the battery size for the same hours of use or you can keep the same size battery for more hours of use.
 - ❖ **Self Heating:** Having less heat generated allows the designer to eliminate or reduce heat sinks and usually remove fans. This freedom results in simpler system designs, smaller enclosures or ability to run in higher ambient temperatures without overheating.




- ❖ Even in designs where power dissipation is not a large concern, lower power solutions are beneficial. Lower temperatures always result in improved reliability. Everyone wants the most reliable design: lower power dissipation and reduced system temperatures are major steps to achieving high reliability.

➤ Flexibility designed in for custom applications

- ❖ In house design of the system controller. Eurotech wrote the source code used on the system controller and wrote application programming interfaces (APIs) that allow user applications to take advantage of the features of the system controller. These APIs allow Eurotech boards to provide additional features not found on other systems. Some of the available APIs are:
 - Firmware (System Management API and BIOS): provides fine adjustment of system resources that can be adjusted dynamically from the application. Included capabilities of the firmware are the following:
 - Dynamic clock stepping and sub-system power down
 - Power rail voltage stepping for processor core power
 - Dynamic processor cache re-sizing and set associativity management
 - Advanced processor state management including new ultra low power state with fast resume capability
 - Dynamic I/O port enumeration, power up/down and re-numeration
 - Integrated thermal sensing and management hardware (CPU core, chipset, DRAM temperatures)
 - Smart Battery Management API. The system controller can do this in the background under direction from the application.
 - Watch Dog Timer API. The system controller can act as an external watch dog timer to the system and can be controlled by the application.



- I2C bus with API. The system controller has a true I2C bus that is available to the application to communicate with peripherals on the I2C bus.
 - GPIO with API. Additional GPIO pins from the system controller are available to provide unique control of special functions.
- Compatibility options across the Catalyst roadmap allow existing designs to be updated with new modules as new Intel® Atom™ platforms are introduced. The first Catalyst Module used the standard 0.5mm pitch Atom Z5xx processor. When the large package (XL) Atom became available, we designed a fully compatible Catalyst Module XL which has an industrial temperature option. Since then, additional modules in the same Catalyst form factor have been introduced such as the Catalyst LP (based on the Intel® Atom™ N450 and dual-core D510 processors), Catalyst TC (based on the Intel® Atom™ E600 series) and the Catalyst CV (based on the Intel® Atom™ N2000 series). These modules offer backwards compatibility with older Catalyst designs so that hardware and software designs can be migrated up the technology path with minimal engineering effort and costs.

Intel Atom	
Catalyst XL based on Intel® Atom™ Z500P/PT series	
Catalyst LP based on Intel® Atom™ N450 and D510	
Catalyst TC based on Intel® Atom™ E600 series	



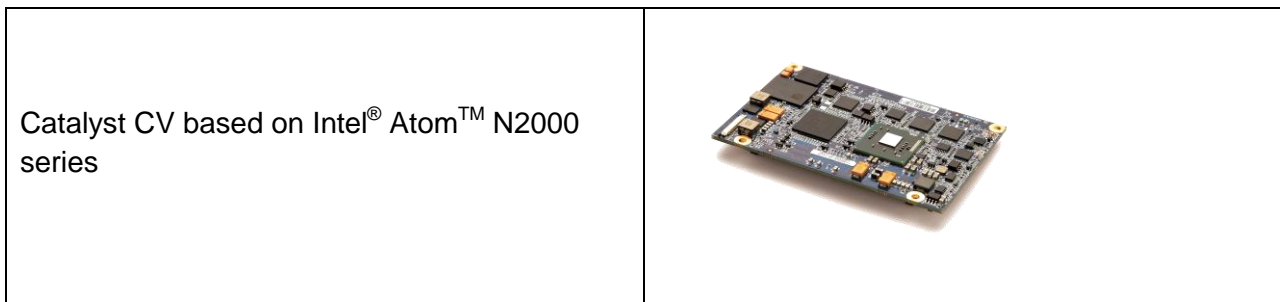


Figure 1: Eurotech's Catalyst family includes modules across the Intel® Atom™ roadmap that all conform to the same 67 x 100 form factor and offer backwards compatibility with previous generation Catalyst designs

- First to Market. Eurotech has demonstrated we are consistently the first to market with several Intel® Atom™ platforms. With the list below, you can be assured when Intel comes out with a new Atom-based platform, Eurotech will be there. These firsts include:
 - ❖ First Intel® Atom™ Z5xx based commercial module: Catalyst Module (0 to +70C)
 - ❖ First Intel® Atom™ Z5xx based Catalyst standard development kit. Intel's initial development platform for the Intel Atom Series Z5xx processors was the Eurotech Catalyst Module standard development kit.
 - ❖ First Intel® Atom™ Z5xx based industrial temperature module: Catalyst XL– available in both commercial temperature (0 to +70C) and industrial temperature (-40 to +85C)
 - ❖ First Intel® Atom™ Z5xx design with 2G DRAM
 - ❖ First Intel® Atom™ N450 and D510 processor designs

Summary

The Intel® Atom™ processors offer significant performance improvements for embedded systems with very low power. As new Intel® Atom™ platforms come out, further enhancements in performance and/or lower power dissipation will continue to evolve. Eurotech has shown it is



the leader in low power dissipation on Intel® Atom™ designs and will continue to provide that leadership in the future.

Low power is not just an advantage for mobile hand-held battery-powered designs. It is an advantage for every design. Low power designs result in smaller size, lower internal temperatures, improved reliability (due to lower operating temperatures) and high performance computing without the need for fans or heat sinks. Low power dissipation is one defining capability that separates Eurotech from the rest of the market.

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