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Getting Started With Blackfin® Processors

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ANALOG DEVICES

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CONTENTS

SUPPORT OPTIONS

PREFACE

Thank you for your interest in the Blackfin® family of processors by Analog Devices, Inc.

Purpose of This Manual

Getting Started With Blackfin Processors provides you with information about the design and evaluation process, Analog Devices tools, training, documentation, and other informational resources.

This manual provides an overview of a variety of documentation available in online form as well as a guide for evaluating Blackfin processors. This manual also describes the resources available to help you move your evaluation/design along quickly.

For engineers already using Blackfin processors in their designs, this guide provides resources and pointers to help transition your system to take advantage of the newest series of processors. For detailed descriptions of a processor's internal architectures, refer to the applicable processor's hardware reference manual. For detailed descriptions of processor software, refer to the *Blackfin Processor Programming Reference*. For a complete list of documents that support Blackfin processors, refer to "Support Options" on page 3-1.

Intended Audience

The primary audience for this guide is comprised of system designers, programmers, and hardware engineers who want to learn whether a specific Blackfin processor matches their design requirements for new applications.

Manual Contents

This manual consists of:

- Chapter 1, "Introduction"
  This chapter briefly describes the processor architecture, available models, and processor features.
- Chapter 2, "The Evaluation Process"
  This chapter focuses on available software and hardware tools.
- Chapter 3, "Support Options"
  This chapter describes support (documentation, training, and more) available during the evaluation and development processes.

What's New in This Manual

Revision 6.0 of *Getting Started With Blackfin Processors* provides information about a new Blackfin processor and EZ-KIT Lite® package.

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  processor.support@analog.com (World wide support)
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Product Information

Product information can be obtained from the Analog Devices Web site and the VisualDSP++® online Help system.

Analog Devices Web Site

The Analog Devices Web site, www.analog.com, provides information about a broad range of products—analog integrated circuits, amplifiers, converters, and digital signal processors.

To access a complete technical library for each processor series, go to http://www.analog.com/processors/technical_library. The manuals selection opens a list of current manuals related to the product as well as a

link to the previous revisions of the manuals. When locating your manual title, note a possible errata check mark next to the title that leads to the current correction report against the manual.

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For easy printing, supplementary Portable Documentation Format (.pdf) files for all manuals are provided on the VisualDSP++ installation CD.

Each documentation file type is described as follows.

File	Description
.chm	Help system files and manuals in Microsoft help format
.htm or .html	Dinkum Abridged C++ library and FLEXnet License Tools software documentation. Viewing and printing the .html files requires a browser, such as Internet Explorer 6.0 (or higher).
.pdf	VisualDSP++ and processor manuals in PDF format. Viewing and printing the .pdf files requires a PDF reader, such as Adobe Acrobat Reader (4.0 or higher).

EngineerZone

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Use EngineerZone to connect with other DSP developers who face similar design challenges. You can also use this open forum to share knowledge and collaborate with the ADI support team and your peers. Visit http://ez.analog.com to sign up.

Social Networking Web Sites

You can now follow Analog Devices processor development on Twitter and LinkedIn. To access:

- Twitter: http://twitter.com/blackfin
- LinkedIn: Network with the LinkedIn group Analog Devices Blackfin: http://www.linkedin.com

1 INTRODUCTION

This chapter briefly describes the Blackfin processor's architecture and key features and compares available models.

Topics include:

What are Blackfin Processors?

Blackfin processors from Analog Devices embody a new breed of 16/32-bit embedded processor. They have the industry's highest performance and power efficiency for applications where a convergence of capabilities—multi-format audio, video, voice and image processing; multi-mode baseband and packet processing; and real-time security and control processing—are critical.

Blackfin processors deliver breakthrough signal processing performance and power efficiency with a RISC programming model. Blackfin processors present high-performance, homogeneous software targets, which allow flexible resource allocation between hard real-time processor tasks and non real-time control tasks. System control tasks can often run in the shadow of processor and video tasks.

Blackfin processors combine a 32-bit RISC instruction set, dual 16-bit multiply/accumulate (MAC) digital signal processing functionality, and 8-bit video processing performance that had previously been the exclusive domain of very long instruction word (VLIW) media processors.

Blackfin processors include advanced memory management that supports memory-protected and non memory-protected embedded operating systems such as µClinux™, ThreadX® (Express Logic), INTEGRITY®, velOSity™, Nucleus® (Mentor Graphics), Fusion™ (Unicoi Systems), RTXC Quadros™ (Quadros Systems), and µC/OS-II (Micrium).

Combining RISC MCU and Signal Processor Functionality

Blackfin processors provide microcontroller (MCU) and signal processing functionality in a unified architecture, allowing flexible partitioning between the needs of control and signal processing. If the application demands, the Blackfin processor can act as 100% MCU (with code density on par with industry standards), 100% signal processor (with clock rates at the leading edge of signal processor technology), or a combination of the two.

The Blackfin family of processors from Analog Devices integrates a 32-bit RISC instruction set with an 8-bit video instruction set with dual 16-bit MAC units. The processor's variable-length instruction set extends up to 64-bit opcodes used in processor inner loops (one single instruction, multiple data [SIMD] and two load/store/cycle), but is optimized so that 16-bit opcodes represent the most frequently used instructions. As a result, compiled code density figures are competitive with industry-leading MCUs, yet its interlocked pipeline and algebraic instruction syntax facilitate development in both C/C++ and assembly.

Figure 1-1 shows a block diagram of a single-core ADSP-BF549 Blackfin 16/32-bit processor.

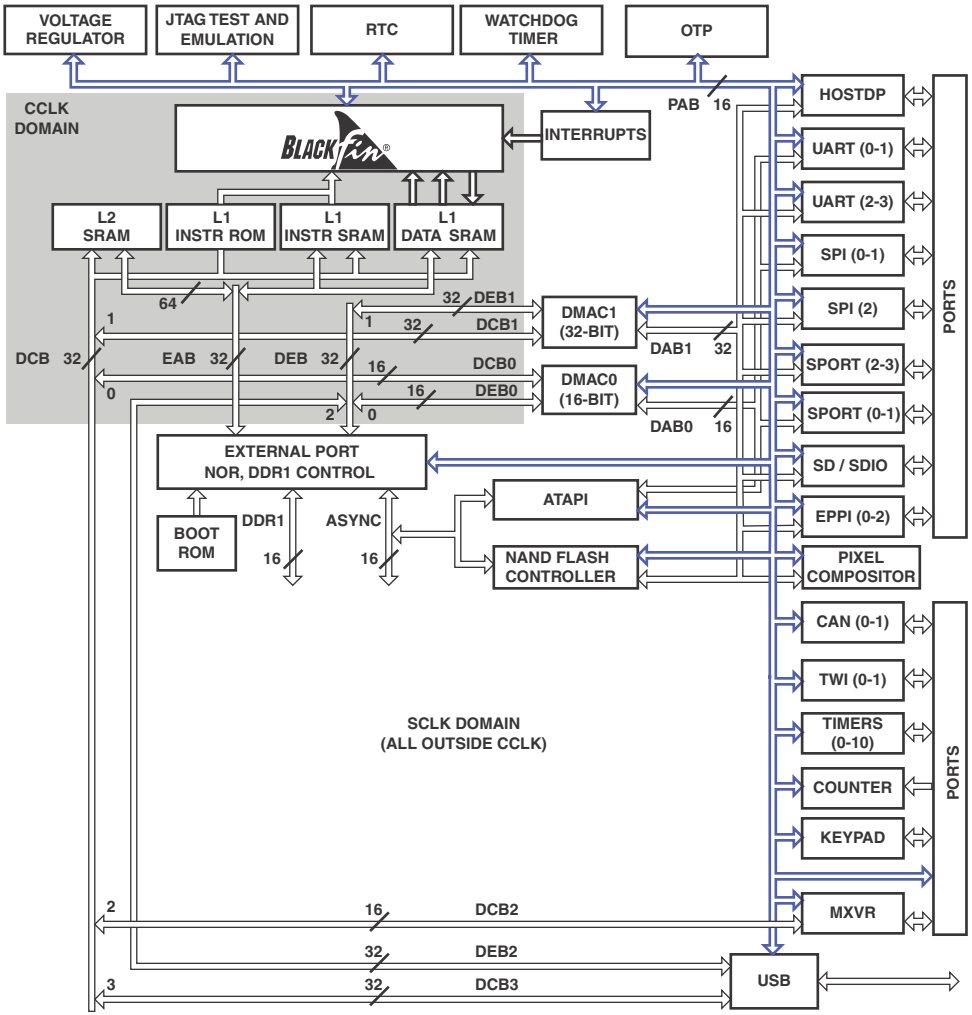

Figure 1-1. Single-Core ADSP-BF549 Blackfin 16/32-Bit Processor

Blackfin processors support both protected and unprotected operating modes that prevent users from accessing or affecting shared parts of the system. In addition, the processors provide memory management

capabilities that enable users to define separate application development spaces. This design feature prevents distinct code sections from being overwritten. At the same time, the Blackfin processor's architecture allows asynchronous interrupts and synchronous exceptions, as well as programmable interrupt priorities. Thus, Blackfin processors are well suited as targets for embedded operating systems.

Approaches to Application Development

Blackfin processors have a peripheral set that supports high-speed serial and parallel data movement. In addition, Blackfin processors include an advanced power management feature set that allows system architects to craft designs with low dynamic power profiles.

In today's design model, MCU (microcomputer unit) and traditional processor programmers often partition their code development into two separate groups, interacting only at the system boundary level where their two functional worlds meet. This makes some sense, as two separate groups of designers can develop their own sets of design practices based on application requirements. For instance, signal processing developers may want to implement techniques to improve performance. Another group may have opposing design goals; MCU programmers, for example, may prefer implementing a turnkey system and letting it perform all tasks without user intervention.

With this in mind, Blackfin processors were designed to support both DMA and cache memory controllers to move data through a system. Multiple high-speed DMA channels shuttle data between peripherals and memory systems, allowing the fine-tuning controls sought by processor programmers without using up valuable core processor cycles. Conversely, on-chip configurable instruction and data caches allow a hands-off approach to managing code and data in a manner very familiar to MCU programmers. Often, at the system integration level, a combination of both approaches is ideal.

Another reason for the historical separation of MCU and processor development groups is that the two processors have two separate sets of design imperatives. From a technical standpoint, engineers responsible for architecting a system often hesitate to mix a "control" application with a "signal processing" application on the same processor. Their most common fear is that non real-time tasks interfere with real-time tasks. For instance, programmers who handle tasks such as the graphical user interface (GUI) or the networking stack should not have to worry about hampering the system's "real-time" signal processing activities. Of course, the definition of real time varies based on the specific application. In an embedded application, the focus is on the time required to service an interrupt. For this purpose, assume there is a time frame of less than 1 microsecond between an interrupt and the time that the system context is saved at the start of the service routine.

With the introduction of the Blackfin processors, a C/C++-centric unified code base can be realized. This enables developers to leverage enormous amounts of existing application code developed from previous efforts. Because Blackfin processors are optimized for both control and signal processing operations, compilers can generate code that is both tight (from a code density standpoint) and efficient (for computationally-intensive signal processing applications). Of course for veteran programmers, targeted assembly coding is still an option for optimizing critical processing loops.

Operating system (OS) support is also key. Several layers of tasking can be realized by supporting an operating system or real-time kernel. An interrupt controller that supports multiple priority levels is needed to ensure that targeted performance is still achievable. Context switching must be attainable through hardware-based stack and frame pointer support. This enables developers to create systems that include both worlds—control and real-time signal processing—on the same device.

In addition, the Blackfin processor's memory protection facility permits OS support for memory protection. This allows one task, via a paging mechanism, to block memory or instruction accesses by another task.

An exception is generated whenever unauthorized access is made to a protected area of memory. The kernel services this exception and takes appropriate action.

The high processing speeds achieved by Blackfin processors translate into several tangible benefits. The first is time to market. There can be considerable savings in reducing or bypassing the code optimization effort when there is plenty of processing capacity to spare. A second benefit is reduced software maintenance, which can otherwise dominate a product's life cycle cost. Finally, for scalable Blackfin architectures, designers can base their work around the most capable member of the Blackfin processor family, and can use a cost-optimized processor.

Dual-Core Processors Add Flexibility

Blackfin processors are also available as dual-core devices. The traditional use of a dual-core processor employs discrete and often different tasks that run on each of the cores. For example, one core might perform all of the control-related tasks, such as graphics and overlay functionality, networking, interfacing to bulk storage, and overall flow control. This core is also where the operating system or kernel most likely resides. Meanwhile, the second core is dedicated to the application's high intensity processing functions. For example, compressed data packets might be transferred over a network interface to the first core for preprocessing, and then passed to the second core for audio and video decoding. Figure 1-2 shows a block diagram of a typical dual-core processor.

The use of a dual-core processor is preferred for designs built by separate software development teams. The ability to segment these types of functions allows a parallel design process, eliminating critical path dependencies in the project. This programming model also aids the testing and validation phases of the project. For example, a code change on one core does not necessarily invalidate the testing efforts already completed on the other core.

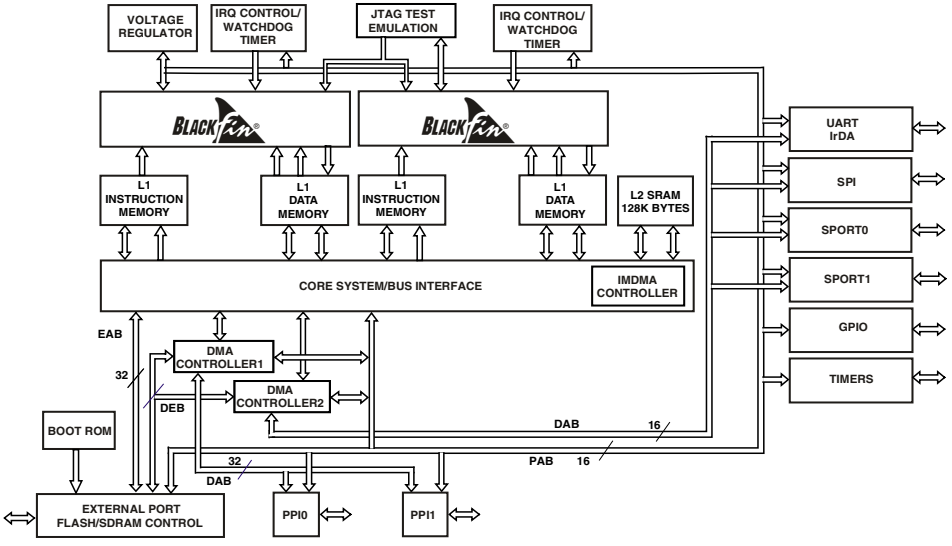

Figure 1-2. Functional Block Diagram

The Blackfin Family of Processors

New high-performance Blackfin processors are available now, while plans for additional Blackfin processors are designed to offer feature-packed, future-ready architectures for media-rich applications.

Blackfin Processors (Currently Available)

The ADSP-BF535 was the first released Blackfin processor, followed in March 2003 by three pin-compatible devices, the ADSP-BF531, ADSP-BF532, and ADSP-BF533 Blackfin processors. These three devices offer a range of memory and speed options, providing maximum scalability and design flexibility with standard serial interfaces such as SPI, UART, and a flexible programmable serial ports (SPORTs). The devices also offer 16-bit parallel peripheral interfaces (PPI) to connect gluelessly to high-speed converters and imaging components.

In January of 2005, Analog Devices introduced three Blackfin processors with embedded connectivity: the ADSP-BF536, ADSP-BF537, and ADSP-BF534. These three devices are also pin-compatible with each other and include a controller area network (CAN) and a two-wire interface (TWI), and on some models, a 10/100 ethernet MAC.

In May of 2006, Analog Devices introduced the ADSP-BF538 Blackfin processors, which added the complement of on-board flash memory and also more instances of the communications peripherals for enhanced connectivity.

In November of 2006, Analog Devices introduced five new Blackfin processors: ADSP-BF542, ADSP-BF544, ADSP-BF547, ADSP-BF548, and ADSP-BF549. These ADSP-BF54x processors focus on higher system performance for convergent applications through increased (2x) I/O bandwidth, increased on-chip memory, and a rich peripherals set including high-speed USB, ATAPI, NAND flash, DDR1, and LockBox™ secure technology. The PPI was also enhanced to support more high-speed parallel devices; up to three PPIs are available on some models.

In March of 2007, Analog Devices introduced ADSP-BF52x Blackfin processors, which focus on the next generation of mobile devices. The ADSP-BF52x series is pin-compatible and is comprised of the ADSP-BF522, ADSP-BF523, ADSP-BF524, ADSP-BF525, ADSP-BF526, and ADSP-BF527 processors. This series concentrates on connectivity, including combinations of high-speed USB, 10/100 ethernet, NAND flash controller, an audio codec, and so on. The ADSP-BF52x processors offer lower dynamic and static power consumption over previous Blackfin processors.

In November of 2008, Analog Devices introduced the ADSP-BF51x processors. The ADSP-BF512, ADSP-BF514, ADSP-BF516, and ADSP-BF518 processors extend the Blackfin family further into the industrial and instrumentation market with the availability of an on-chip eMAC which supports 1588 version 2, a 3-phase PWM generation unit, and a quadrature encoder.

In January of 2010, Analog Devices unveiled the latest entries in its Blackfin family of processors: the Blackfin ADSP-BF50x Blackfin series. Delivering up to 100% greater performance than competing processors in its price class, single-core ADSP-BF50x series processors enable designers to achieve significant gains in signal conversion and computational precision, and apply advanced power control techniques to yield greater energy efficiency for industrial applications.

In September of 2010, Analog Devices introduced the ADSP-BF592 processor, the lowest priced member of its successful portfolio of Blackfin processors. With 800 MMACs/400 MHz of performance for just $3 (in 10K quantities), the ADSP-BF592 makes high performance DSP now practical for many more applications in the industrial, medical, video, audio, and general-purpose markets. In addition, the ADSP-BF592 low power requirements and the small size (9 mm x 9 mm) enable designers to include high-performance signal processing in power-constrained and small form-factor applications.

All Blackfin processors mentioned above are single-core processors.

Analog Devices also developed a dual-core symmetric multiprocessor, the ADSP-BF561 Blackfin processor. This processor uses a dual-core processor and increases performance without switching processor architectures. In fact, by running both processor cores at lower frequencies and lower voltages, power consumption is lowered. The advantages of this technique are described in “Dual-Core Processors Add Flexibility” on page 1-6. In addition, the ADSP-BF561 processor offers a second PPI, making video in/out possible simultaneously.