BA22-DE
32-bit Deeply Embedded Processor

Implements a basic 32-bit processor for deeply embedded applications that use on-chip instruction and data memories, and is an excellent step up from the 8051 and other 8- and 16-bit microcontrollers. Part of the royalty-free BA22 family, this processor core is extremely competitive in terms of high performance and low power consumption, and has best-in-class code density.

The core has an AMBA® AHB™ or Wishbone system bus interface and dedicated buses for the on-chip instruction and data memories. It includes 16 general purpose registers (GPRs), a tick-timer (TTimer), a programmable interrupt controller (PIC), an advanced power management unit (PMU), and an optional debug unit (DBGU). Additional microcontroller peripherals may be ordered for pre-integration and delivery with the core, individually or in a complete platform. IP Integration Services are also available to help integrate any BA22 processor configuration with memory controllers, image compression, or other CAST IP cores.

The processor’s BA2 instruction set is relatively simple and extremely compact. Programming is facilitated with the included C/C++ tool chain, Eclipse IDE, architectural simulator, and ported C libraries.

The BA22-DE core synthesizes to 15k gates, can be clocked at nearly 400MHz in a 65nm technology, and performs up to 2.53 DMIPS/MHz.

The BA22 family of processors has been designed for easy reuse and integration, has been rigorously verified, and is production proven. Contact CAST Sales for details.

Applications
- Mixed signal embedded processing
- Internet, networking and telecom
- Home entertainment consumer electronics

Block Diagram

Features

High Performance 32-bit CPU
- 2.53 DMIPS/MHz
- 2.93 CoreMarks/MHz
- Variable length (16/24/32/48 bits) instruction encoding
- Single-cycle execution on most instructions
- Fast and precise internal interrupt response
- Custom user instructions

Small Silicon Footprint & Low Power Consumption
- Industry-leading code density
  - Minimizes instruction memory area & power
  - 32-bit architecture reduces power-draining memory accesses
- From 15k gates and low as 0.05mW/MHz on 90nm

Efficient Power Management
- Further reduces power consumption by 2x to 100x using dynamic clock gating for individual units
- Software controlled clock frequency in slow and idle modes
- Interrupt wake-up in doze and sleep modes

Advanced Debug Capability
- Conventional target-debug agent with a debug exception handler
- Non-intrusive debug/trace for both CPU and system
- Complex chained watchpoint and breakpoint conditions
- Industry standard Amontec JTAGKey USB to JTAG interface

Integrated Peripherals
- Standard: 32 bit tick timer, programmable interrupt controller
- Options include:
  - AMBA bus infrastructure
  - Microcontroller peripherals such as GPIO, UART, Real-Time Clock, and Timers
  - Serial communication cores such as I2C and SPI
  - Memory controllers, interconnect IP and more

Easy Software Development
- Eclipse IDE for Windows, Linux
- ANSI C/C++ compiler, debugger, linker, assembler, & utilities
- Architectural simulator
- Ported libraries & RTOS
**Processor Description**

The BA22 family uses a 32-bit processor architecture designed for high performance with great silicon and power efficiency.

The highly configurable design may include caches and memory management units, enhanced arithmetic processing capabilities such as a divider and floating point unit, a sophisticated power management unit, and an interactive, JTAG-based debug capability.

The BA22-DE is one pre-configured version of the BA22, targeted for relatively simple deeply embedded applications.

BA22 processors are also designed for quick, efficient software development. The BA2 instruction set they use provides the highest code density in its class, without compromises on performance, ease of use, or scalability. It features:

- A linear, 32-bit or 64-bit logical address space
- An instruction length of 16, 24, 36, 48, or 64 bits, which reduces memory requirements by as much as 40%.
- Simple memory addressing modes
- Configurable general purpose registers (12 to 32 GPRs)
- Efficient memory transfer instructions

The BA22 has already proven itself in multiple production designs.

**Implementation Results**

BA22-DE reference designs have been evaluated in a variety of technologies. The following are ASIC pre-layout results reported from synthesis with a silicon vendor design kit under typical conditions, with all core I/Os assumed to be routed on-chip.

| Technology    | $F_{max}$ (MHz) | Area ($\mu m^2$) | Logic Eq. Gates |
|---------------|-----------------|-----------------|----------------
| TSMC 180nm (wl30, typ) | 50 | 266647.6 | 16,032 |
|                | 170 | 392804.6 | 23,617 |
| TSMC 130nm (wl30, typ) | 50 | 148828.0 | 17,536 |
|                | 150 | 186841.3 | 22,915 |
|                | 225 | 297939.3 | 35,064 |
| TSMC 90nm (wl30, typ) | 50 | 76719.9  | 15,532 |
|                | 100 | 84013.7  | 17,099 |
| TSMC 65nm (wl30, typ) | 50 | 46671.6  | 11,668 |
|                | 200 | 65960.0  | 16,490 |
|                | 380 | 127420.4 | 31,855 |

The provided figures do not represent the higher speed or smaller area for the core. Area, power and speed depend on optimizations, process, and libraries. Furthermore, power consumption depends on power management, software and memories configuration. For accurate characterization on your application please contact CAST.

**Support and Services**

The core as delivered is warranted against defects for 90 days from purchase. Thirty days of phone and email technical support are included, starting with the first interaction. Additional maintenance and support options are available.

IP Integration Services are also available to help minimize time to market for BA22-Based systems.

**Deliverables**

The core is available for ASICs in synthesizable HDL, and includes everything required for successful implementation:

- Verilog RTL source code
- Verilog Testbench
- Silicon-proven Reference SoC/ASIC Design
- Software development tools for Cygwin on Windows and Linux, with Eclipse IDE interface
- Operating systems and board support package

A reference design board running Linux and FPGA versions of the core are also available; contact CAST Sales for information.

**Related Products**

The BA2x™ Processor Family includes a set of royalty-free, pre-configured products intended for different applications:

- **BA25** 32-bit Application Processor, for demanding systems running applications on general-purpose operating systems such as Linux and Android.
- **BA22-AP** 32-bit Basic Application Processor, for embedded applications that may need to run a full OS.
- **BA22-CE** 32-bit Cache-Enabled Embedded Processor, for deeply embedded systems using off-chip instruction and data memories and possibly running an RTOS; 5-stage pipeline, caches but no MMU.
- **BA21** 32-bit Low-Power Deeply Embedded Processor, implements a 32-bit low-power processor that delivers better performance than most processors of its size.

**Platforms**

- **BA2x-AXI-PP** Pre-integrated peripherals platform for the AMBA3 AXI bus.
- **BA2x-AHB-PP** Pre-integrated peripherals platform for the AMBA2 AHB/APB buses.