BA51

## Ultra-Low-Power Deeply Embedded RISC-V Processor

The BA51 is a configurable, low-power, deeply embedded RISC-V processor IP core. It implements a single-issue, in-order, 2-stage execution pipeline and supports the RISC-V 32-bit base integer instruction set (RV32I), or the 32-bit base embedded instructions set (RV32E).

Configuration Options for Broad Application Support

The processor core can be configured to meet different application requirements. It can optionally support user, supervisor and hypervisor privilege modes, as well as the ISA extensions for Compressed Instructions (C), Integer Multiplication and /Division Instructions (M), Atomic Instructions (A), User-Level Interrupts (N), Control and Status Register (Zicsr), and Instruction-Fence (Zifencei). Support for the single-precision floating-point (F) and double-precision floating-point(D) extensions are available upon request.
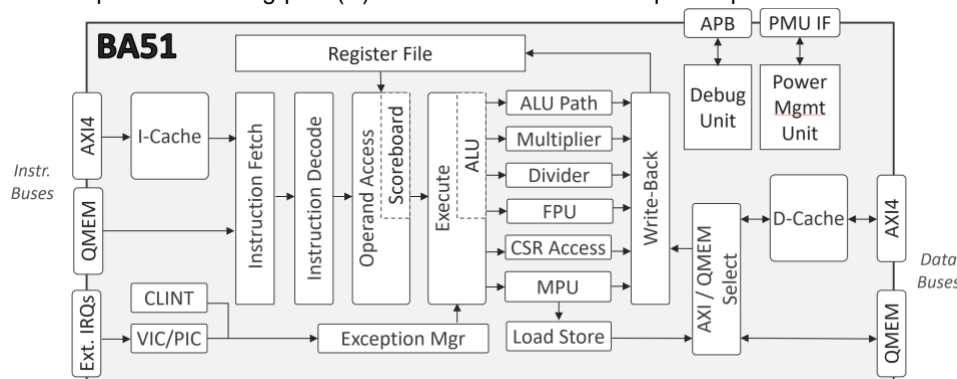
Furthermore, the BA51 supports software and timer interrupts and up to 64 external interrupt lines. It features a remarkably low interrupt response time, which makes the core ideal for real time control applications. The time elapsed from when an external interrupt is asserted until the first instruction in the resolved interrupt handler can be issued is just 4 clock cycles.

The user can minimize the core's silicon footprint by choosing not to implement internal modules such as the machine mode internal timers and counters; the vectored interrupt controller (VIC); or the debug, power management (PMU), or memory protection (MPU) units. Finer-grained controls give designers the means to further tune the processor's features and size to their specific design needs, including the number and size of memory regions for the MPU, the mapping of memory addresses to interfaces, and the width of the instruction and data buses.

The processor can optionally be equipped with highly configurable instruction or data caches. The set associativity of these L1 caches can be specified from 1 to 4, while their block size and total size are also configurable at synthesis time,

Compact & Energy Efficient

Designed for low energy consumption the BA51 is compact and enables advanced power management. Under its minimal configuration the processor size is just 16k gates. This small silicon footprint is critical for minimizing leakage currents during idle or standby modes and for reducing dynamic power consumption. The BA51 also enables dynamic clock gating, unused modules power shut-off, and software or hardware dynamic frequency scaling of the bus and the CPU.

Furthermore, delivering more processing power per MHz than most processors in its class, the BA51 can be configured to operate at low frequencies to further save power, or to meet the most demanding embedded processing requirements, or any optimum combination of both.

FEATURES

Low-Power Embedded Processor

- Small silicon footprint for lower leakage and dynamic CPU power
  - From 16k gates
- Advanced power management
  - Dynamic clock gating and unused units power shut off
  - Software- and hardware-controlled clock frequency scaling
- Single-issue, in-order, 2-stage pipeline
- Harvard architecture with separate instruction and data AXI-Lite and Quick-access Memory (QMEM) buses
- Optional L1 instruction or data cache with synthesis-time configurable associativity, and size

Performance

- 3.0 Coremarks/MHz
- Over 500 MHz in 16 nm

RISC-V Features

- 32-bit Base RISC-V ISA (I/E) with optional M, A, Zicsr, Zifencei, C, N, F, D, and Zc Extensions
- Supervisor, User, and Machine Modes, and optional Hypervisor (H) extension
- Memory protection unit with a configurable number of regions and optional S-Mode Physical Memory Protection (SPMP)
- Core Local Interrupt Controller (CLINT) for timer and software interrupts, and Sstc support
- Programmable and/or Vectored Interrupt Controller (PIC or VIC) for up to 64 direct external interrupts
- Debug with hardware triggers (Sdtrig) support

Available Pre-Integrated Platforms

- Integrate bus fabric with peripherals such as GPIO, UART, Real-Time Clock, Timers, I2C, and SPI
- Optionally customized to include memory controllers, interconnects and more from the CAST IP line

Low Risk & Flexible Licensing

- Reliable vendor with an extensive track record and excellent support
  - Thousands of IP core licenses, and billions of units shipped with IP from CAST since 1997
  - Experienced and responsive support team with a 24/7 culture
- Industry-standard licensing terms with royalty-free options

Easy Integration and Low Risk

The processor core uses AMBA®, AXI-4 and low-latency Quick-access Memory (QMEM) interfaces for fetching instructions and accessing data and peripherals, while the debug unit connects to an external JTAG/TAP controller via an APB port.

Part of the family of processor cores available from CAST for more than a decade and used by hundreds of customers, the BA51 IP core has been designed for easy reuse and integration, has been rigorously verified, and is LINT-clean, scan-ready and silicon-proven. It is available in Verilog source code for ASICs or FPGAs

Applications

The royalty-free, energy-efficient BA51 processor can be employed as an effective replacement for existing 8-bit and 16-bit microcontrollers, or used as secondary, housekeeping or peripheral controller processor in complex SoC designs. It is suitable for a wide range of deeply embedded applications such as mixed-signal embedded processing (e.g. SERDES control), wireless communications ICs (e.g. Bluetooth, Zigbee, or GPS), and industrial microcontrollers.

Software Development

The BA51 can be used with RISC-V compatible toolchains, libraries and IDEs. However, the BA51 processor users can also benefit from using BeyondStudio™, an Eclipse-based Integrated Development Environment (IDE) that combines an instruction level simulator and a GNU cross-compiling toolchain. Employed by numerous BAx processor users for over a decade, BeyondStudio is a complete and fully featured IDE.

Reference designs on FPGA development boards are available to ease evaluations and accelerate code development. Contact CAST Sales for more information.

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 BA51-based systems. The processor core can be delivered pre-integrated with bus infrastructure cores, typical microcontroller peripherals, memory controllers, and interconnect IP cores. Contact CAST Sales for details.

Deliverables

The core is available for ASICs in synthesizable Verilog. It includes everything required for successful implementation: extensive documentation, a testbench, a sample SoC design, and sample synthesis and simulation script.