



# Real-time Low-power Java™ Processor aJ-100

## Introduction

The aJile Systems aJ-100 is the first device in a family of single-chip Java microcontrollers that directly execute Java Virtual Machine™ (JVM) bytecodes, real-time Java threading primitives and a number of extended bytecodes for embedded operations. The native JVM bytecode implementation eliminates the typical interpreter or JIT software layers and provides the most optimal Java performance in both memory requirements and execution time. In addition, Java threading primitives (wait, yield, notify, monitor enter/exit) are implemented as extended bytecodes eliminating the need for a the traditional RTOS. The result is extremely low executive overhead with thread to thread context switch times of less than 1µsec.

The aJ-100 features on-chip memory and all the I/O functions required for use in many real-time networked embedded applications. The powerful combination of direct JVM bytecode execution, direct multithreading support, and fully protected multiple JVM environments is ideal for efficient, safe, and robust Java execution. The aJ-100 is ideally suited for real-time networked embedded products such as industrial controllers, smart mobile devices, consumer appliances and automotive communications devices.

## Features

### JEM2 32-bit Direct Execution Java Processor Core

- Native JVM bytecode
- Extended bytecodes for I/O and threading support
- IEEE-754 floating-point arithmetic
- Writeable control store supports custom extended bytecodes

### Native Java Threading Support

- Hard real-time, multi-threading kernel in hardware
- Threading operations are atomic including true Java synchronization
- Built-in deterministic scheduling queues
- Directly supports the Real Time Specification for Java (RTSJ)
- Thread to thread yield in less than 1µsec
- Eliminates traditional RTOS layer

### Multiple JVM Manager (MJM™)

- Support two independent JVM's
- Brick wall time and space protection
- Support external memory protection

### Internal 48KB RAM

- 32KB dedicated data memory
- 16KB microcode memory

### Memory Controller

- 8-bit, 16-bit or 32-bit interface
- Eight chip selects to support ROM, Flash, SRAM, and peripheral devices

### Dual 16550 compatible UARTs

- 128-byte FIFO on Rx and Tx
- Support IrDA physical layer protocol

### Three 16-bit Timers/Counters

- Flexible count control and counter I/O
- Pulse Width Modulation (PWM)
- Waveform measurement

### Serial Peripheral Interface (SPI)

- Master/Slave operation
- Four external chip selects
- Programmable transfer length

### Five 8-bit General Purpose I/O Ports

- I/O programmable on a per-bit basis
- Flexible interrupt generation

### Phase Locked Loop (PLL) and Power Management

- Transparent CPU power down when the "run queue" is empty
- Individual peripherals can be deactivated when not in use
- Global clock disable with external wake-up pin

### IEEE 1149.1 (JTAG) Interface

- Boundary scan
- Low-level debugger interface
- JPDA Java Debugger Interface

### Designed for ultra-low-power operation

- Less than 1mW/MHz power consumption
- Fully static operation up to 100 MHz
- Implemented in 3.3V and 0.25µm CMOS process
- Core operates at 2.5V

### Housed in 176-lead LQFP package

## System Development Support

The aJ-100 processor, bundled with Sun's Java 2 Micro Edition (J2ME) Connected Limited Device Configuration (CLDC) Java runtime system, optimizing application builder, debugging tools and evaluation board provides a complete solution for implementing real-time networked embedded Java applications. Using commercial Java IDEs, application developers can create standalone real-time Java applications totally in Java with the performance and memory efficiency of systems programmed in C and assembly. Utilizing the aJ-100EVB evaluation system, application developers can readily explore the features of the aJ-100 and assess the efficiency and performance of real-time embedded Java.

An aJ-100 based system can be configured to execute in real-time and/or dynamic environments to support a wide range of applications. The dynamic runtime supports the CLDC Mobile Information Device Profile (MIDP) to allow Java "MIDlets" to be downloaded and executed dynamically in separate JVM environments. Multiple "MIDlets" can be run simultaneously under the control of the Java Applications Manager (JAM) that maintains memory and execution time allocations. aJ-100 can also be configured to execute both real-time and dynamic applications in deterministic time sliced schedule.

The primary components of the development and runtime environments are summarized as follows:

### Optimizing Linker/Application Builder

- GUI based application build configuration and control tool - JEM Builder
- Utilizes standard JVM class files generated by commercial Java IDEs
- Statically resolves class files and eliminates unused methods and fields
- Performs bytecode optimizations
- Performs method substitutions (method invokes replaced by extended bytecodes)
- Builds boot tables, class initialization code, and assigns interrupt and trap handlers
- Configures JVM's and memory layout

### Java Runtime System

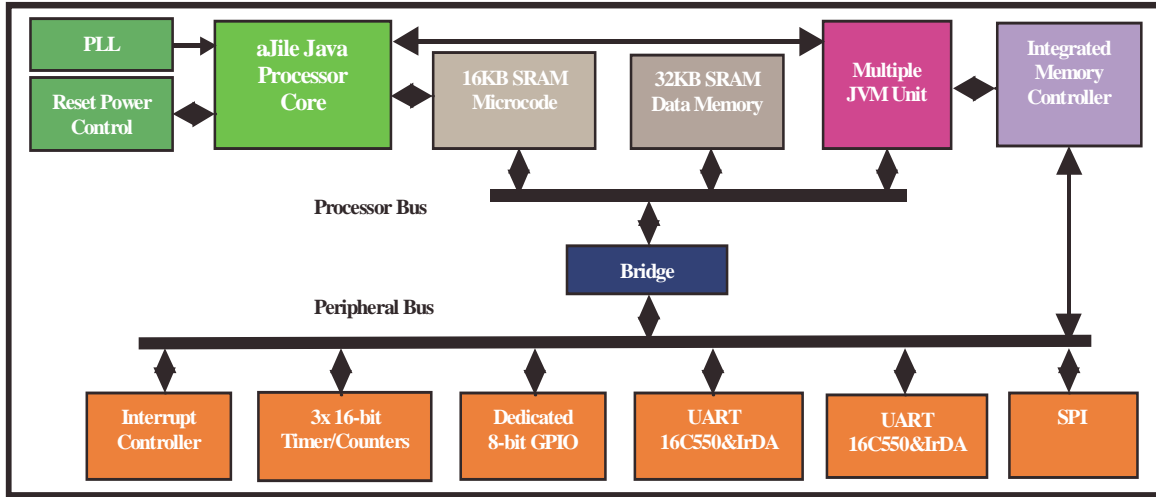
- Java run-time environment based on a J2ME CLDC
- Includes networking classes, storage classes, and Java communications API
- Dynamic runtime includes the JAM (class loader, verifier, scheduler) and GC components
- Device drivers for integrated peripherals and generic physical device interfacing in Java

### Application Debugging Tools

- Host-target communications via an IEEE 1149 (JTAG) interface using a simple inexpensive IEEE-1284 cable
- Host-based full featured low-level debugger - Charade (Target level debugger threads and routines are not required)
- Host-based JDI provided to interface to commercial JDI compliant source-level debuggers

### aJ-100EVB Evaluation System

- 100 MHz aJ-100 microcontroller
- Standard configuration has 1 MB Flash and 1MB SRAM
- 10BaseT ethernet
- LCD controller, keypad encoder, and touch screen controller
- 2 serial I/O ports (IrDA option)
- 40 GPIO ports
- 4 SPI ports
- Optional Compact Flash, SDRAM, and local bus connector



Block Diagram for aJ-100

