

## CPU for PlayStation®2

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### Abstract

Processors designed for computer entertainment must perform 3D graphics calculations, especially geometry and perspective transformations. In the PlayStationR2, we introduced the new idea of synthesizing emotion called Emotion Synthesis and devised a new processor architecture to support its graphics demands. The architecture is embodied in the PlayStationR2's "Emotion Engine" CPU, which uses vector units (VUs) as the key units for floating-point calculations. Emotion synthesis means the real-time synthesis of a computer graphics animation scene that projects a great deal of atmosphere. For example, when a female character walks into a video game scene, her motion must be determined by solving physical equations in response to interactive events instead of replaying prerecorded data. Moreover, differential equations with a large number of variables must be used to describe, for example,

the waving motions of her hair in a breeze. For authenticity in emotion synthesis, the CPU must execute these calculations in real time. "Emotion Engine" ("EE") is a system LSI including a 300MHz 128-bit 2-way superscalar RISC core, two Vector Units ("VU"s), Image Processing Unit ("IPU") for MPEG-2 stream decode, a 10-channel memory access (DMA) controller, two channel RambusR memory controller (RAC) and other peripheral modules. 13.5M transistors are integrated on 15.02mm x 15.04mm die with 0.25um device technology with 0.18um gate length. Design strategy and LSI design methodologies and CAD for "Emotion Engine" LSI are presented with emphasis on practical aspects of verification and timing closure. A combination of simulation, emulation and formal verification ensured the functional first silicon for system evaluation. In order to control wire delay in early design stage, floor-plan based synthesis and wire load estimation are adopted for quick timing closure.