Mixed Mode Simulation of Electronic Circuits Containing Silicon and Silicon-Germanium Semiconductor Devices

Computational Engineering & Design Centre

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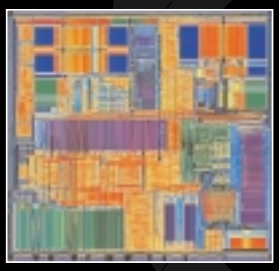
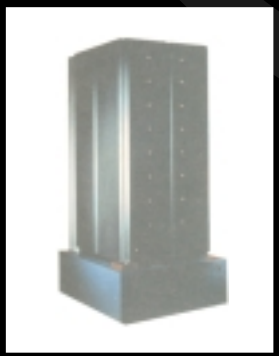
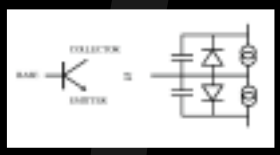
As technology has advanced, and integrated circuits and other electronic packages have grown in complexity, manufacturers have increasingly had to turn away from the physical benchtesting of their products and embrace more computational modes of analysis and design.





Computer simulation packages fall into essentially two classes: circuit simulators (such as SPICE), which model arrays of electronic elements; and device simulators, which model individual non-linear devices.

Until recently, limited computational resources have required circuit simulators to employ compact models for devices, rather than full-blown device simulators. For example, an npn bipolar transistor might be modelled as follows:

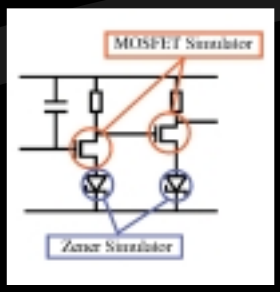


Above Left: Pentium processor. This single chip contains roughly 3.3 million transistors.

Above: An npn transistor modelled by an Ebers-Moll circuit. This approximation is valid only at low frequencies.

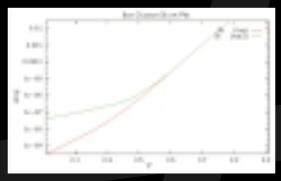
Left: The IBM SP2, on which much of the work of this project will be carried out.

Compact models of this type tend to be trustworthy only over a limited range of operating conditions, and there is an increasing demand for mixed mode packages - software which marries circuit and device simulation - to meet the high precision requirements of (for example) analog design and analysis. Recent developments in high performance computing have made such an approach feasible.



The aim of this project is to develop a circuit simulator which will allow for the incorporation of arbitrary device simulation packages. Standard matrix techniques will be employed to solve the set of network equations resulting from a nodal analysis of the input circuit, with the device simulators invoked as function calls. The code is being written in C, and a parallelised implementation will be produced using the Message Passing Interface (MPI).

It is intended to place especial emphasis on a particular device simulator, BIPOLE3. This offers high precision numerical simulation of a range of semiconductor bipolar devices including discrete bipolar transistors, integrated BJTs, SiGe HBTs and diodes. It is a fast package, and offers the prospect of mixed mode simulation with a significant number of devices.



Above: Plot of an emitter-base tunnel current in a heavily P++ injected BJT, obtained using BIPOLE3.

Left: The mixed mode approach. Device simulation is delegated to packages outside the main circuit simulator.

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