Linear Products

Operational Amplifier Macromodels

As systems become more complex, ways of predicting their performance become essential. TI Macromodels provide one avenue for getting a better overview of the analog sub-system.

Simulation of analog and mixed-mode systems is becoming more common. One large stumbling block to widespread analog simulations has been the significant amount of computing time necessary for transistor level simulations of the analog components. Although the computing power available at the engineers' workstations has increased, these advancements have been overshadowed by the need to simulate more complex systems.

In response to the need to simulate more complex systems and the transistor level models used for analog components compressed models have been developed. The term 'macromodel' was coined for the compressed model of the operational amplifier.

The macromodel allows more efficient simulation and gives the designer a fairly accurate portrayal of the actual device. Despite the macromodel not being able to take into account all of the parameters associated with the op amp it is still a very effective tool, especially when trying to model more than one device.

Macromodel

The macromodel uses ideal elements in SPICE to simulate certain op amp characteristics. This is coupled with actual transistors in the input stages to yield the op amp macromodel. There are three main variants of the basic macromodel; JFET, NPN and PNP transistors in the input stage. These are used to model the different input characteristics of the op amps using these transistors. See Figure 1.

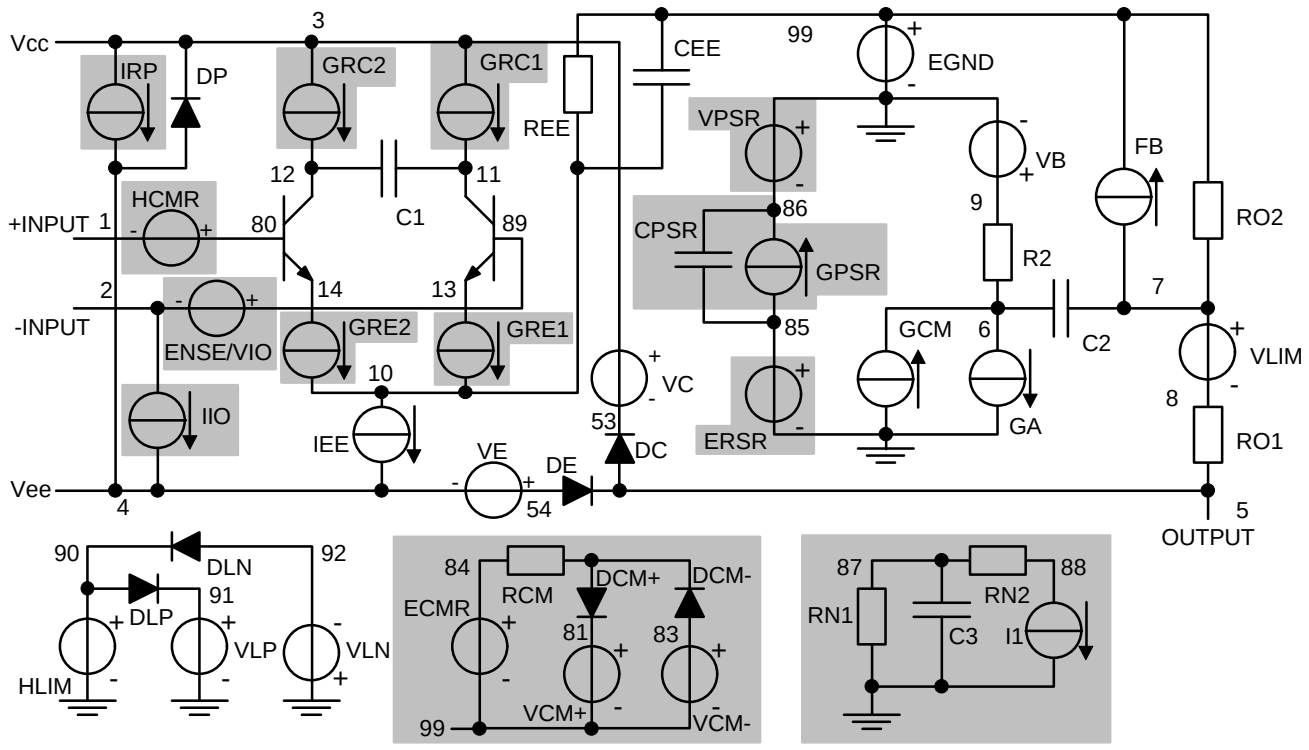

Figure 1. PSpice Macromodel - NPN Input

Application Brief

TI macromodels were derived from MicroSim Corporation's *PSpice*® *Parts*™ simulation software. The PSpice manual contains detailed discussion of the elements in the macromodel shown below.

The macromodel subcircuit is a listing of the code that the simulation software uses to model the device. The macromodel subcircuits contained on the floppy were created using the Parts software on an IBM-compatible PC. Typical data sheet values were used to define the macromodel subcircuit. All typical values are derived from an extensive characterisation process and represent a 'typical' device.

The macromodel is intended to help engineers evaluate system designs and make initial product selections in the beginning stages of the design process. However, their reduced complexity results in them not comprehending or accurately representing all device characteristics. For example the macromodels do not simulate variations in parametric values with temperature. While different values could be substituted to simulate performance at a specific temperature, the macromodels contained on the floppy provide only 25°C performance characteristics (as do most data sheet typicals).

Macromodels are well suited to board-level simulations, which frequently include digital components. Digital components have well defined I/O specifications with only two states, therefore their macromodels often only contain tolerances for timing and other parameters. Analog components have an infinite number of possible I/O states that are affected by temperature, supply voltages, and loading. These variations make it impossible to give worst case limits.

Macromodels can accurately reflect a small set of parameters (e.g., bandwidth or settling time), but since a macromodel only represents one operating point, this 'accurate' model only provides more precision on a typical specification. Several analog macromodels would be required to support the modeling of an op amp over temperature and supply voltage.

For this reason TI has chosen to provide only room temperature macromodels, which should give good first- and second-order simulation of the actual device.

Important Notice

TEXAS INSTRUMENTS