HA-5137 SPICE Operational Amplifier Macro-Model

Application Note | March 1997 | MM5137

Introduction

This application note describes the SPICE macro-model for the HA-5137, a wide bandwidth precision op amp. The model was designed to be compatible with the well known SPICE program developed by the University of California in hope that most simulation software venders follow this basic format and syntax. A schematic of the macro-model, the Spice net listing and various simulated performance curves are included. The macro-model schematic includes node numbers to help relate the SPICE listing to the schematic. The model is designed to emulate a typical rather than a worst case part. Most AC and DC parameters are simulated. Significant poles and zeros are included to give the most accurate AC and transient simulation with minimum complexity.

Model Description

Input Stage

DP and DN represent the differential input resistance. Input bias currents are created by I1 and offset current is modeled with FA. Source VN represents the input offset voltage. C1 limits slew rate. No input parasitics due to package capacitance and lead inductance are included.

Gain Stage

G2, R2, CC, GOL, and RD simulate open loop gain. CC is the macro-model dominant pole capacitor.

Poles and Zeros

The most significant singularities of the HA-5137 are modeled by RC networks. One pole-zero pair and four additional poles are used.

Output Stage

EX1, D1 and D2 model output current limiting. IH and IL are the power supply currents. DPH, DPL and GPS vary the supply currents based on the opamp's output current. DL, DH, ECC and EEE provide voltage clamping on the output to simulate the typical output voltage swing. Some effects of output parasitics due to package capacitance and inductance are lumped with the poles.

Parameters Not Modeled

To maintain a simple macro-model not all op amp parameters are modeled. Most of the parameters not modeled are listed below:

- **Temperature Effects**
- **Differential Voltage Restrictions**
- **Input Voltage and Current Noise**
- **Common Mode Restrictions**
- **Tolerances for Monte Carlo Analysis**
- **Power Supply Range**

Spice Listing

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*
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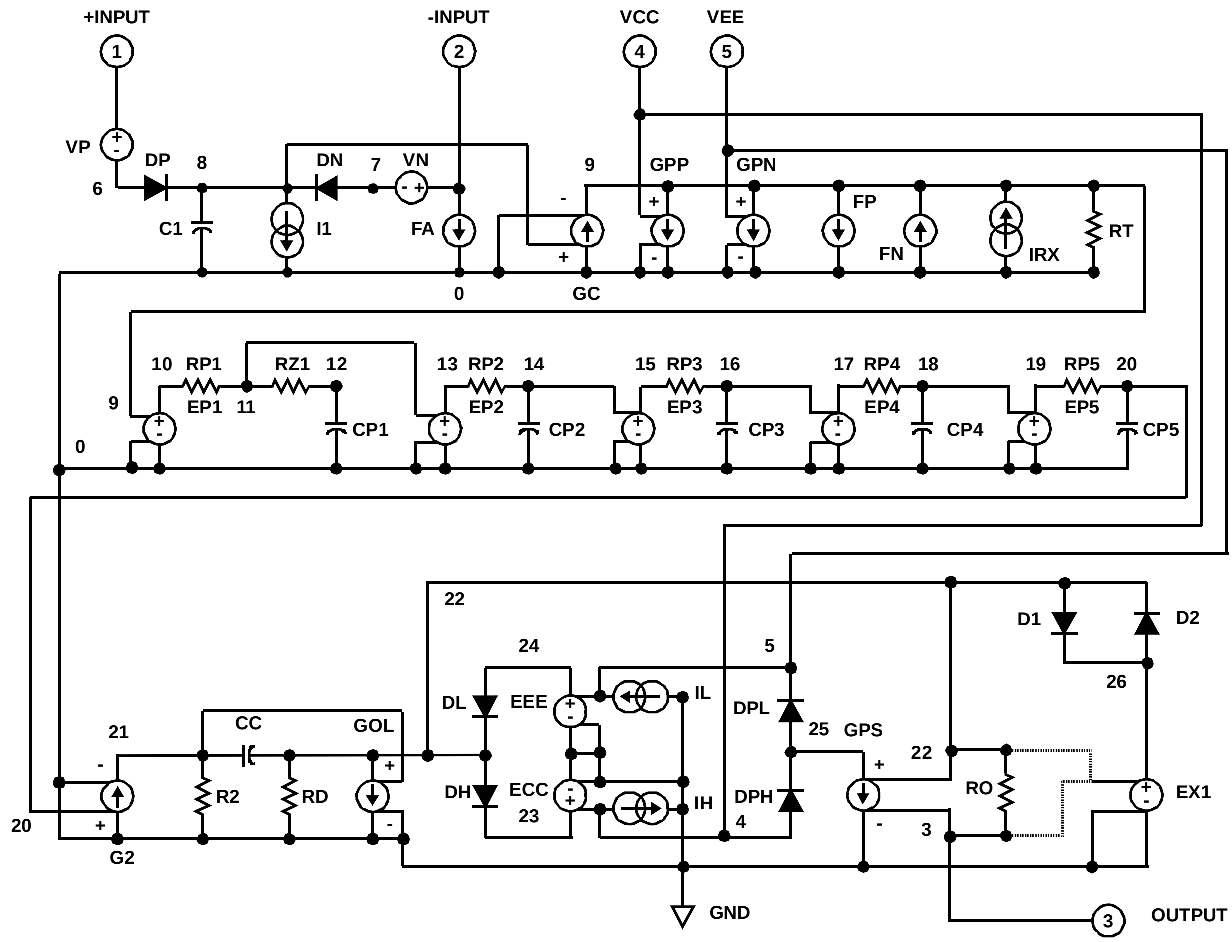
*
*HA-5137 MACRO-MODEL
*REV: 2-04-92
*BY:  D.W. RIEMER
*
*PINOUT          +IN -IN VCC VEE OUT
*
.SUBCKT HA5137  1  2  4  5  3
 .MODEL   DP   D   IS=1E-14         N=+6.6967E-01
 .MODEL   DN   D   IS=+8.5E-15      N=+6.6967E-01
 .MODEL   DV   D   IS=+1.1746E-14   N=.2
 .MODEL   D1   D   IS=1E-9          N=1
 .MODEL   D2   D   IS=1E-9          N=+1.0
 .MODEL   DX   D   IS=1E-20         N=+30.0

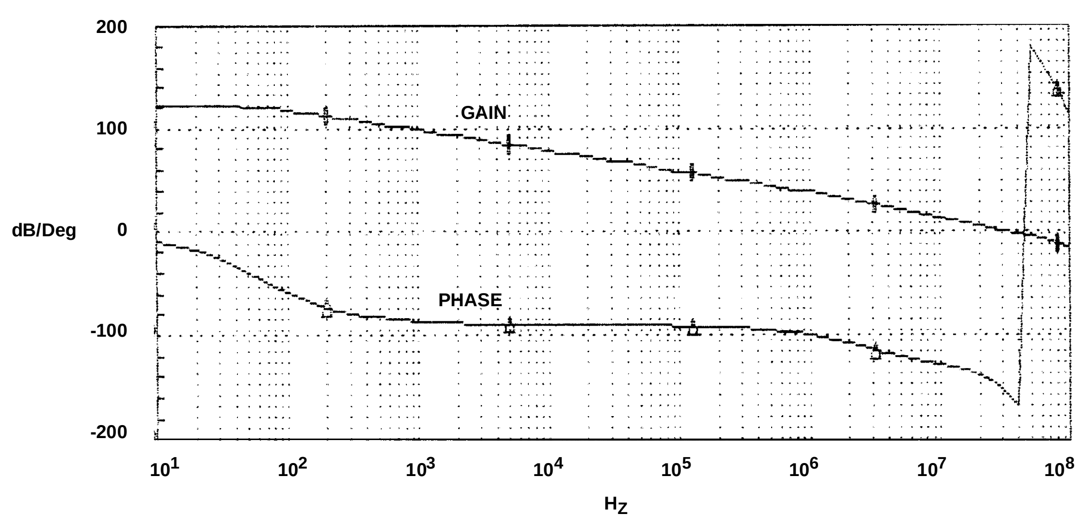
*INPUT STAGE
*VALUE OF SOURCE VN MODELS VIO AND
*MAY BE ADJUSTED AS DESIRED.
*
 VP    1  6  0
 VN    2  7  +1.0E-05
 I1    8  0  +1.295E-08
 FA    2  0  VN          +1.857E+00
 DP    6  8  DP
 DN    7  8  DN
 C1    8  0  +1.0792E-16     IC=-2.3157E-01
 FP    9  0  VP          +3.0579E+04
 FN    0  9  VN          +3.5975E+04
 GC    0  9  8     0     +1.2372E-08
 GPP   9  0  4     0     +2.2123E-08
 GPN   9  0  5     0     +2.2123E-08
 IRX   0  9  +2.865E-09
 RT    9  0  1.0
*
* POLES AND ZEROS
 EP1    10   0    9    0    1.0
 RP1    10   11   +2.21E+02
 RZ1    11   12   +1.77E+02
 CP1    12   0    1E-10
 EP2    13   0    11   0    1.0
 RP2    13   14   +1.592E+01
 CP2    14   0    1E-10
 EP3    15   0    14   0    1.0
 RP3    15   16   +1.0613E+01
 CP3    16   0    1E-10
 EP4    17   0    16   0    1.0
 RP4    17   18   +9.0971
 CP4    18   0    1E-10
 EP5    19   0    18   0    1.0
 RP5    19   20   +7.96
 CP5    20   0    1E-10
*
* OUTPUT STAGE
 G2    0   21  20  0    1.0
 R2    21  0   +6. 5577E+02
 CC    21  22  +2.2E-11
 GOL   22  0   21  0    +3. 6187E+03
 RD    22  0   +5. 0809E+01
 DH    22  23  DV
 DL    24  22  DV
 ECC   23  0   POLY   1   4   0  -2.7   1.0
 EEE   24  0   POLY   1   5   0  +2.7   1.0
 IH    4   0   +3.5E-03
 IL    0   5   +3.5E-03
 GPS   25  0   22  3    +8.5427E-02
 DPH   4   25  DX
 DPL   25  5   DX
 D1    22  26  D1
 D2    26  22  D2
 EX1   26  0   POLY   2   22   0   3   0   0.0   -7.2888E-01 +1.7249
 RO    22  3   +1.17059E+01
 .ENDS     HA5137
```

Macro-Model Schematic



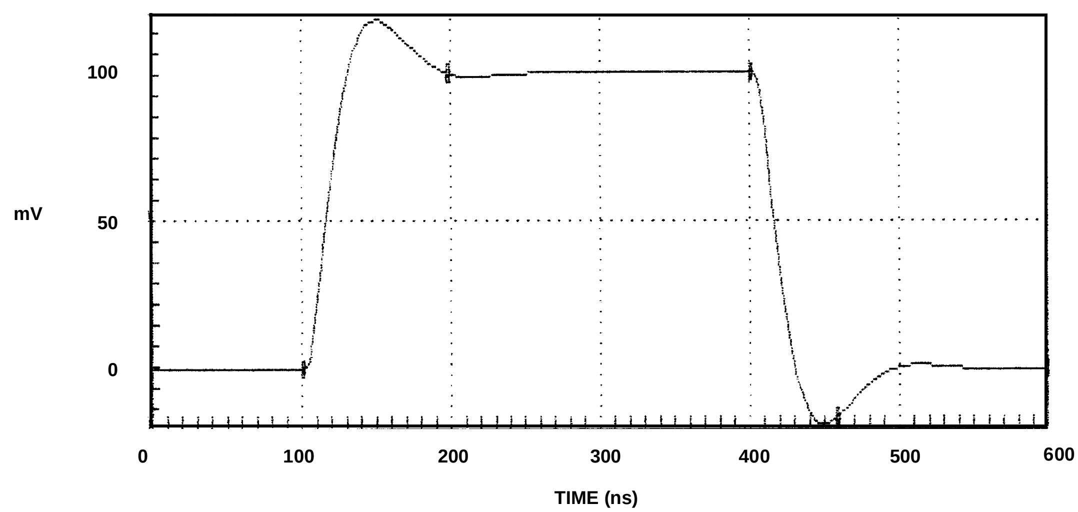
Typical Performance Curves

GAIN/PHASE RESPONSE vs FREQUENCY

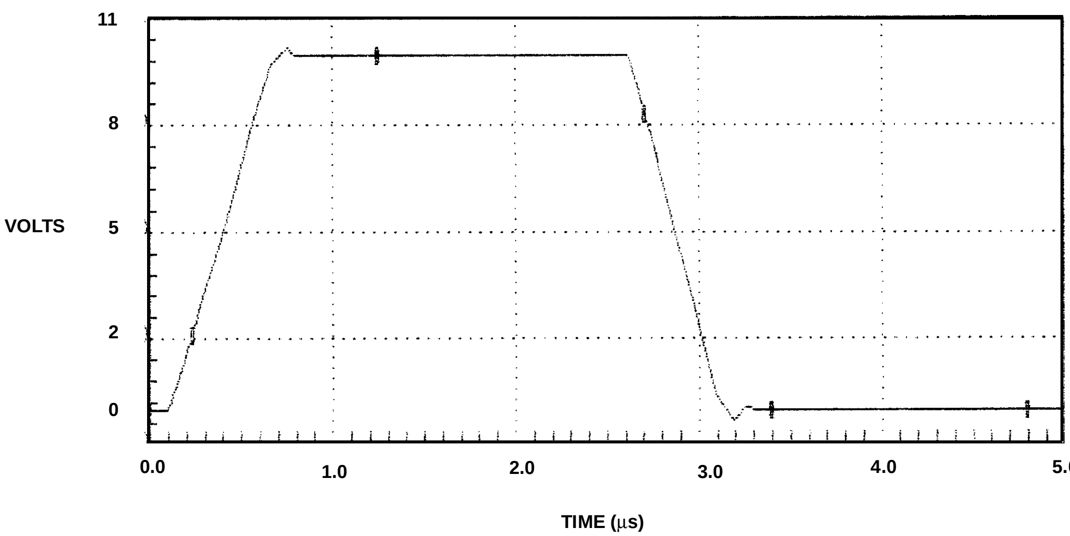


Typical Performance Curves (Continued)

SMALL SIGNAL RESPONSE



LARGE SIGNAL RESPONSE



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