$$H_c(s) = H_{C0}\frac{1-\frac{s}{z_{HC}}}{1+\frac{s}{p_{HC}}} \qquad (7)$$

where,

$$H_{C0}=G_1F_1R_L \qquad (8)$$

$$p_{HC} = \frac{1}{(R_L + F_1R_L + R_p)C_m} \qquad (9)$$

$$z_{HC} = \frac{1}{\frac{R_p}{F_1}C_m} \qquad (10)$$

Closed-loop output impedance is given by,

$$Z_{Cout} = Z_{C0}\frac{1+\frac{s}{z_{ZC}}}{1+\frac{s}{p_{ZC}}} \qquad (11)$$

where,

$$z_{DC}=z_{ZC} \qquad (16)$$

$$p_{DC} = \frac{1+G_1F_1R_L\beta}{\frac{1}{Z_{ZC}}+\frac{G_1F_1R_L\beta}{p_{ZC}}} \qquad (17)$$

Note that the pole frequency of the open-loop transfer, see expression (9), differs from the closed-loop zero frequency of the output impedance and the variation of distortion with frequency, see the expressions (13) and (16) respectively.

This is in accordance with the results found in simulations and measurements and verified by making a comparison between macro model results and simulations/measurements. Therefore numerical values used for the variables in the macro model expressions are derived from the PSpice output files.

G_1=50mA/V, R_p=4kΩ
F_1=driver h_{fe}.power h_{fe}=20000 (product of h_{fe}s)

The macro-model results on gain, bandwidth and output impedance fit quite well in with those found in PSpice and measurements in Table 1. The deviating value of the 3dB frequency of the output impedance and the frequency dependence of the distortion – 40kHz instead of 16kHz in PSpice – is caused by the simplification of leaving out the parallel capacitance at the input of A_2. This is carried out in order to make the expressions 7-17 simpler.

Adding C_p=800pF – extracted from PSpice – in parallel of R_p yields the far more satisfactory corner frequency of 20kHz.

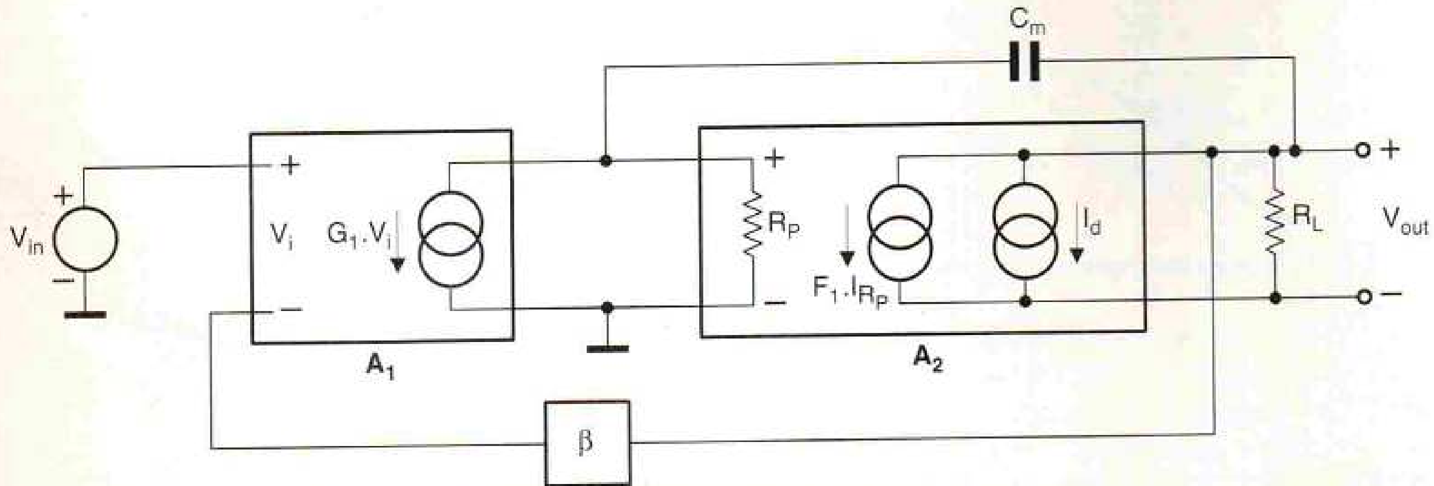

Fig. A. Macro-model of the common-emitter amplifier allows mathematical analysis.