# Spice technique compares frequency responses

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**Listing 1**'s Spice CIR file takes advantage of an analog-behavioral-modeling feature to compare the simulated frequency response of an actual circuit with its ideal transfer function. This technique can accurately evaluate circuits that depend on a precise frequency response, such as various equalizers. One such example is the familiar RIAA phonograph playback curve, which is defined by three time constants: 3180, 318, and 75μsec.

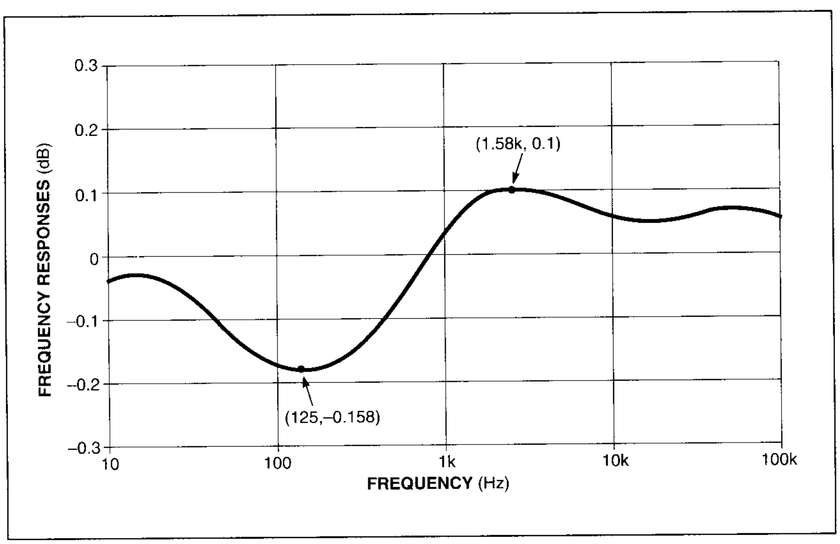


**Fig 1—Using the Laplace analog-behavioral-modeling option available in some versions of Spice, you can compare your circuit's simulated frequency response with that of the ideal transfer function.**

Using the Laplace option of PSpice (MicroSim Corp (Irvine, CA)) release 5.2, the **listing** defines an ideal frequency-response channel based on the three time constants. The Spice file presents a 1-mV test signal to VIN at node 1, which connects to the circuit under test across R6 and presents the same test signal to the input of the frequency-response reference module, controlled-source ERIAA.

ERIAA shapes the frequency response by the time constants and uses the ENORM scaling parameter to normalize the dc gain of the reference channel to match the gain of the channel under test. In this case, the extrapolated dc gain of the (lowpass) equalizer is (1+(R1/R3)), so ENORM is set equal to this number or 501. Thus, the simulator precisely controls the entire transfer function of the reference module. With the appropriate time constants and scale factor, the resultant output of source ERIAA is an ideal RIAA transfer function scaled to match the gain of the channel under test. In this example, the amplifier under test has a design gain of 35 dB at 1 kHz.

When using this form of the Laplace statement, you can combine one or more time constants to create an ideal scaled-transfer function without parasitic effects. The **listing** parameterizes the time constants as T1, T2, and T3, which in this case equal the RIAA values in microseconds. You can implement other transfer functions, noting their pole/zero functions.

**Fig 1** shows the 10-Hz to 100-kHz response of the test equalizer, as measured differentially between the amplifier output at node 56 and ERIAA at node 5 (Vdb(56)–Vdb(5)). The frequency response, which is the result using the listed and practical values for R1, R2, and C2, follows the ideal RIAA transfer function within ±0.2 dB. Although ±0.2 dB is reasonably close to ideal, the circuit can get even closer, specifically within ±0.05 dB, using the alternate values printed in the listing as comments. **EDN BBS /DI_SIG #1329**

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## Listing 1—Spice frequency-response comparison

```
RIAA_LP: RIAA de-emphasis circuit with ideal response comparison
*
.OPT ACCT LIST NODE OPTS NOPAGE LIBRARY
.AC DEC 10 10 100KHZ
.PROBE V(1) V(5) V(56)
.LIB C:\PS\LIB\AD_RELH.LIB
VIN 1 0 AC 1E-3
*
* ---------- V(5) = idealized frequency response ------------------------
*
* Uses Laplace operator of PSpice Analog Behavioral option for reference
*
* Enorm = ideal DC gain of U1 = 1+(R1/R3)
* T1 - T3 are time constants desired (in µs).
*
.PARAM ENORM  = {501}
.PARAM T1 = {3180}
.PARAM T2 = {318}
.PARAM T3 = {75}
*
ERIAA 5 0 LAPLACE {ENORM*V(1)}={(1+(T2*1E-6)*S)/((1+(T1*1E-6)*S)*(1+(T3*1E
-6)*S))}
*
RDUMMY5 5 0 1E9
*
* ---------------------------------------------------------------------
*
VCC 52 0 +17V
VEE 53 0 -17V
*
R6 1 0 100E3
R7 3 0 100E3
C5 3 1 100E-6
*
*R1 55 2 97.6E3
*R2 2 4 7.87E3
*C2 2 4 0.0103E-6
R1 55 2 100E3
R2 2 4 8.2E3
C2 2 4 0.01E-6
C1 55 4 0.03E-6
*
R3 2 20 200
C4 20 0 1000E-6
*
C3 55 54 100E-6
R4 54 0 100E3
R5 54 56 499
C6 56 0 3E-9
*
* OP-275 called from Analog Devices Rel. H library with ".LIB".
*
XU1 3 2 52 53 55 OP-275
*
.END
```