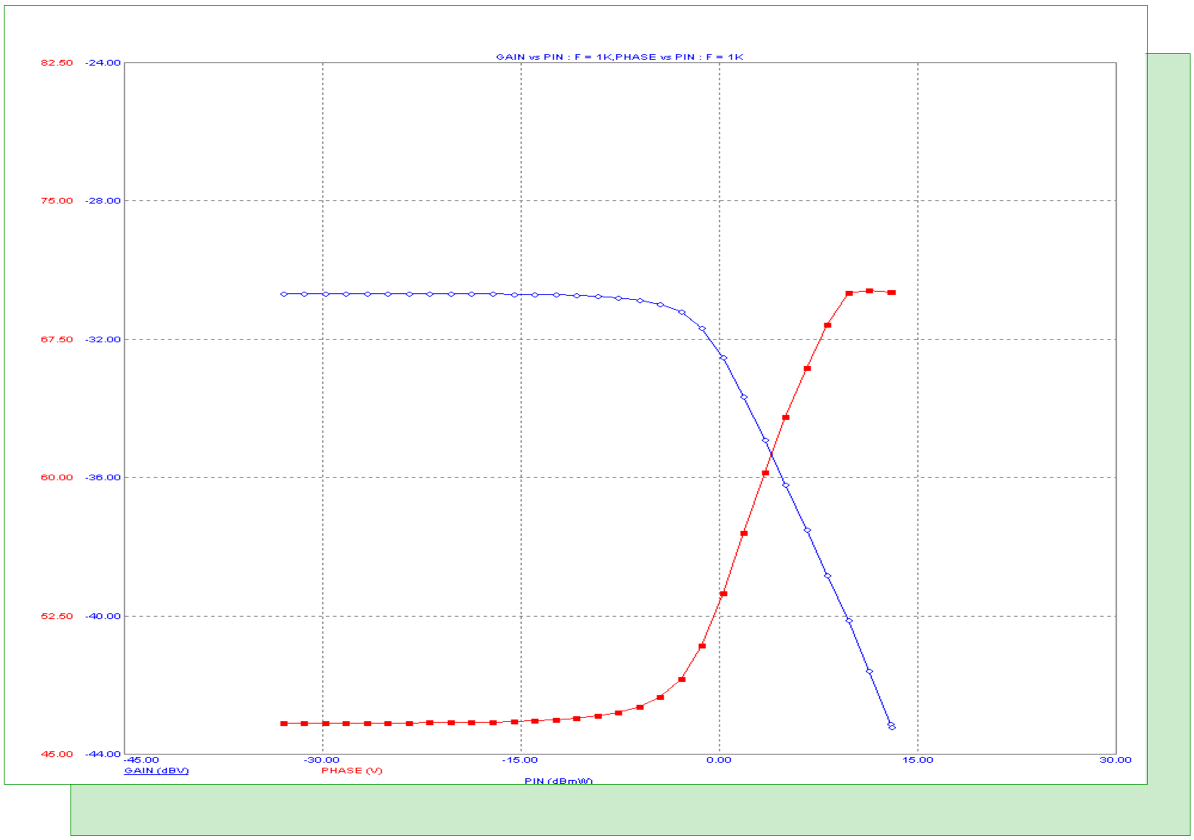
spectrum news

Applications for Micro-Cap™ Users

Summer 2012

News



New Harmonic Distortion Gain / Phase Plot

Featuring:

- Plotting Gain and Phase in Harmonic Distortion
- Using Array Variables
- Comparing Analysis Modes

News In Preview

This newsletter's Q and A section describes when threading is disabled by MC10, how to remove analysis text, and advice on how to use MC6 macros when switching data folders. The Easily Overlooked Feature section describes how to convert schematics to older file formats so they can be read by the older MC5-MC9.

The first article describes new features in MC10 Harmonic Distortion, gain and phase plots. These plots are useful in RF amplifiers.

The second article discusses the use of array variables and describes their use as stepping aides in transient, AC, and DC analysis.

The third article compares the results obtained in transient analysis, AC analysis, and DC analysis and demonstrates their equivalence.

Contents

Book Recommendations

General SPICE

• *Computer-Aided Circuit Analysis Using SPICE*, Walter Banzhaf, Prentice Hall 1989. ISBN# 0-13-162579-9

• *Macromodeling with SPICE*, Connelly and Choi, Prentice Hall 1992. ISBN# 0-13-544941-3

• *Inside SPICE-Overcoming the Obstacles of Circuit Simulation*, Ron Kielkowski, McGraw-Hill, 1993. ISBN# 0-07-911525-X

• *The SPICE Book,* Andrei Vladimirescu, John Wiley & Sons, Inc., 1994. ISBN# 0-471-60926-9

MOSFET Modeling

• *MOSFET Models for SPICE Simulation, William Liu, Including BSIM3v3 and BSIM4*, Wiley-Interscience, ISBN# 0-471-39697-4

Signal Integrity

• *Signal Integrity and Radiated Emission of High-Speed Digital Signals*, Spartaco Caniggia, Francescaromana Maradei, A John Wiley and Sons, Ltd, First Edition, 2008 ISBN# 978-0-470-51166-4

Micro-Cap - Czech

• *Resime Elektronicke Obvody,* Dalibor Biolek, BEN, First Edition, 2004. ISBN# 80-7300-125-X

Micro-Cap - German

• *Simulation elektronischer Schaltungen mit MICRO-CAP,* Joachim Vester, Verlag Vieweg+Teubner, First Edition, 2010. ISBN# 978-3-8348-0402-0

Micro-Cap - Finnish

• *Elektroniikkasimulaattori,* Timo Haiko, Werner Soderstrom Osakeyhtio, 2002. ISBN# 951-0-25672-2

Design

• *High Performance Audio Power Amplifiers,* Ben Duncan, Newnes, 1996. ISBN# 0-7506-2629-1

• *Microelectronic Circuits,* Adel Sedra, Kenneth Smith, Fourth Edition, Oxford, 1998

High Power Electronics

• *Power Electronics,* Mohan, Undeland, Robbins, Second Edition, 1995. ISBN# 0-471-58408-8

• *Modern Power Electronics,* Trzynadlowski, 1998. ISBN# 0-471-15303-6

Switched-Mode Power Supply Simulation

• *SMPS Simulation with SPICE 3,* Steven M. Sandler, McGraw Hill, 1997. ISBN# 0-07-913227-8

• *Switch-Mode Power Supplies Spice Simulations and Practical Designs*, Christophe Basso, McGraw-Hill 2008. This book describes many of the SMPS models supplied with Micro-Cap.

Micro-Cap Questions and Answers

Question: I am running on a computer with multiple cores. The program is able to see all cores but the stepped simulations are only using one thread. How do I get MC10 to use more threads? I'm using Windows7 64bit.

Answer: There are some conditions where use of threads is not allowed. Here are the main ones:

1) Use of certain Phillips devices (such as PSP NQS or Model 11)
2) Use of Optimization in any analysis
3) Use of Leave or Retrace option in transient analysis
4) Use of Animation in any analysis
5) Use of Dynamic AC or DC analysis
6) Use of the Save or Retrieve in any analysis

Generally, if the result of one analysis affects another analysis in a stepped set, then threading is limited to one thread. In these cases, a new thread cannot start until the prior thread is finished, so there is no point in having more than one thread. For example, if Leave is on, then each run affects the subsequent run, so threading is necessarily limited.

In some cases, it's not possible to incorporate the code separation such as in certain Phillips devices.

In other cases such as Dynamic AC and Dynamic DC threading buys no significant advantage.

Question: I placed text on my transient analysis for notes. Now I want to get rid of it. Also I have one performance function on the analysis. How can I get rid of that?

Answer: Any analysis object, including label text, formula text, performance tags, or any other type of object can be removed by selecting the object then pressing the delete (Del) key. You can delete all objects by using the Select All command (CTRL+A) followed by the delete key.

Question: I recently ported my MC6 to a new system. It works OK, except when I try to use any of the macro circuits provided with MC6. Then I get a "File not found" message. What am I doing wrong?

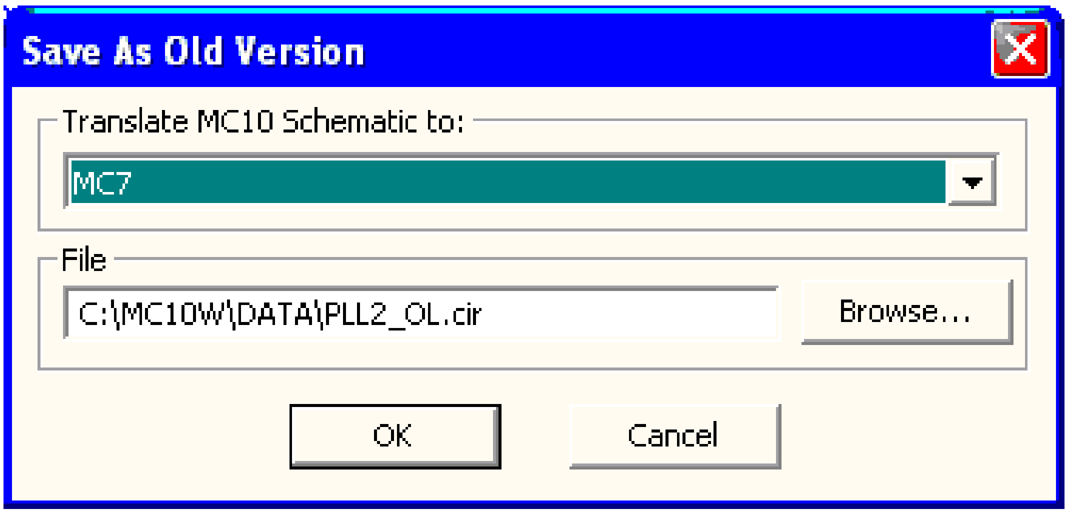
Answer: MC6 was the last version of Micro-Cap that stored macro files in the data folder. In MC7 and later versions, macro files are stored (and expected to be found) in the library folder currently specified by File menu / Paths / Library Folder. In your case, the macro files are probably still in the installed data folder, but you are probably using a different data folder. If this is the case, you can resolve the problem by either 1) copying all of your circuit files to the MC6 data folder and using it as a working folder, or 2) copying all of the macro files from the MC6 data folder to your current working data folder. Either of these should fix the problem.

Easily Overlooked Features

This section is designed to highlight features that may be overlooked among the many capabilities of Micro-Cap.

Converting schematics to older versions
If you have MC10, you can load any schematic back to and including MC5. Can MC5 read an MC10 schematic? No it cannot, because there are options listed in the MC10 file that MC5 doesn't know what to do with. However, there is a way to convert an MC10 schematic file to any predecessor file from MC5 through MC9.

The command is located at File Menu / Translate / Schematic to Old Version. Its dialog box looks like this:



Save As Old Version dialog box

If you invoke the dialog box, it presents a list of file versions. You merely select the file format that you want and the path and file name that you want for the translated file, then press the OK button.

Here are a few things to keep in mind:

1) Always choose a file name that is similar but different from the original file. Otherwise you'll overwrite the later file in the earlier format loosing some of your options in the process. The circuit will still run but some MC10 options may be lost. For example, MC10 has a feature called Periodic Steady State that does not exist in earlier versions. Whatever settings (that are unique to MC10) you have in the original MC10 file will be lost in the translated file.

2) If the MC10 version had a component that was not available in the earlier version, then in place of that component, a message "Component Not Found" is printed instead. You can easily patch the translated file by removing the component and replacing it with its earlier equivalent.

Plotting Gain and Phase in Harmonic Distortion

A new feature has been added to Harmonic Distortion to facilitate RF designs. The feature is included in 10.0.9.0 and can be downloaded from the MC10 Help menu / Check for Updates...

Harmonic Distortion analysis already plots H1 vs PIN. In this new version, we've added Gain and Phase, defined as follows:

GAIN = H1 / VIN, where VIN is the amplitude of the applied input sinusoid.

PHASE = ATAN(IMAG(H1)/REAL(H1)) - ATAN(IMAG(VIN)/REAL(VIN))

Since VIN is a sine wave,

PHASE = ATAN(IMAG(H1)/REAL(H1)) - 90.00

GAIN is defined as the ratio of H1 (1'st harmonic of V(RL) to VIN.

PHASE is defined as the phase difference between V(VIN) and V(RL).

To illustrate, we'll run the new plots on this circuit:

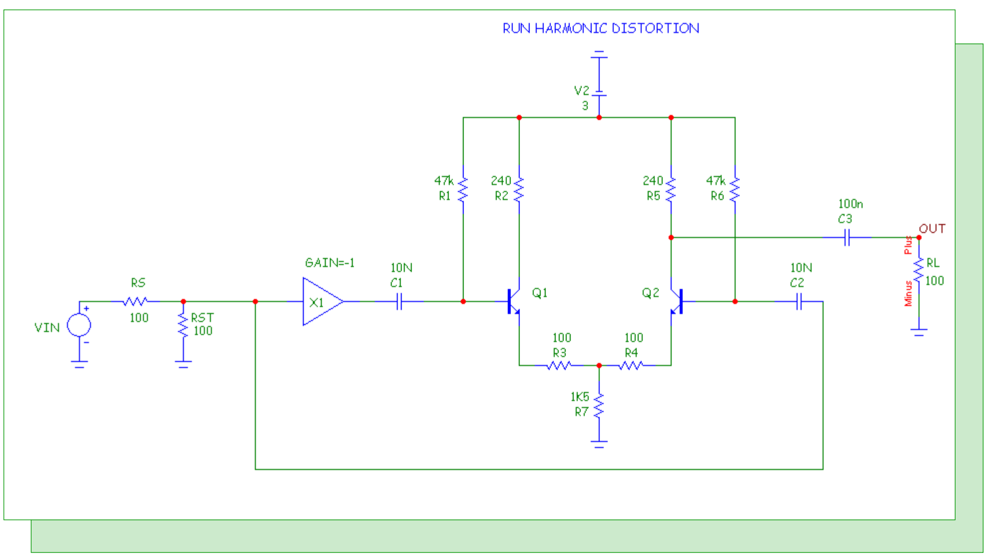


Fig. 1 - Differential amplifier for gain / phase plot

Select Harmonic Distortion analysis. The Analysis Limits dialog box looks like Figure 2

The only new item is Name of Source Resistor. Naming the source resistor serves the same purpose as in Intermodulation Distortion; it allows the input power to be calculated as

PIN = (VIN/2)*(VIN/2)/RSOURCE, a common RF definition for input power.

As in Intermodulation Distortion, if the source resistor is unnamed then input power is defined as

PIN = VIN*IIN

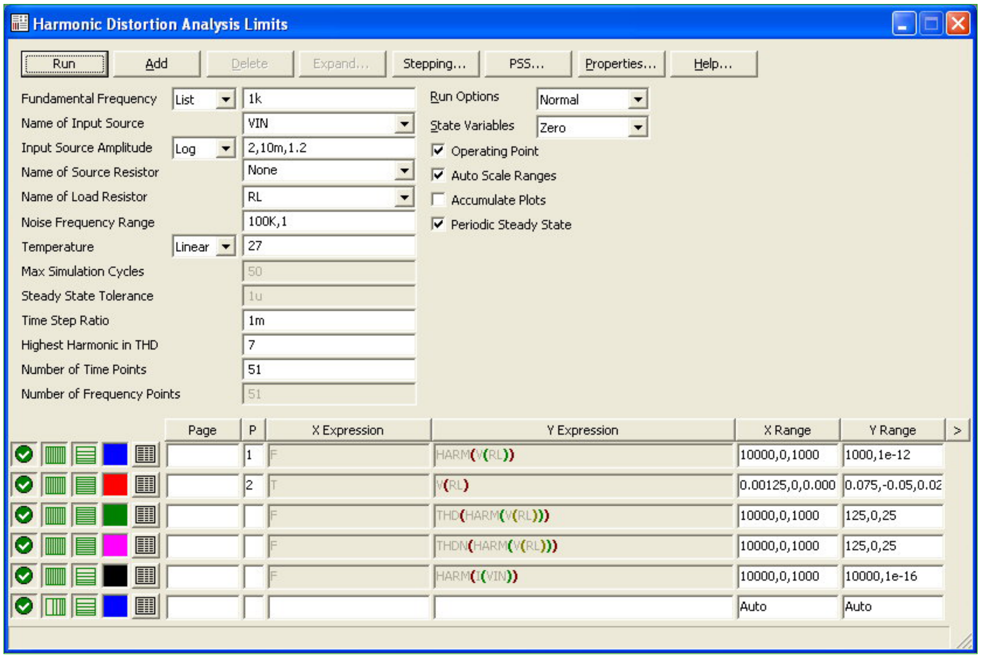


Fig. 2 - New Harmonic Distortion analysis limits

Click on the Harmonic Distortion Plot window and then press F10 to display its new Properties dialog box. There are only two new items, Gain and Phase. They are located at the bottom of the list of available Y-Axis Parameters. The dialog box looks like this:

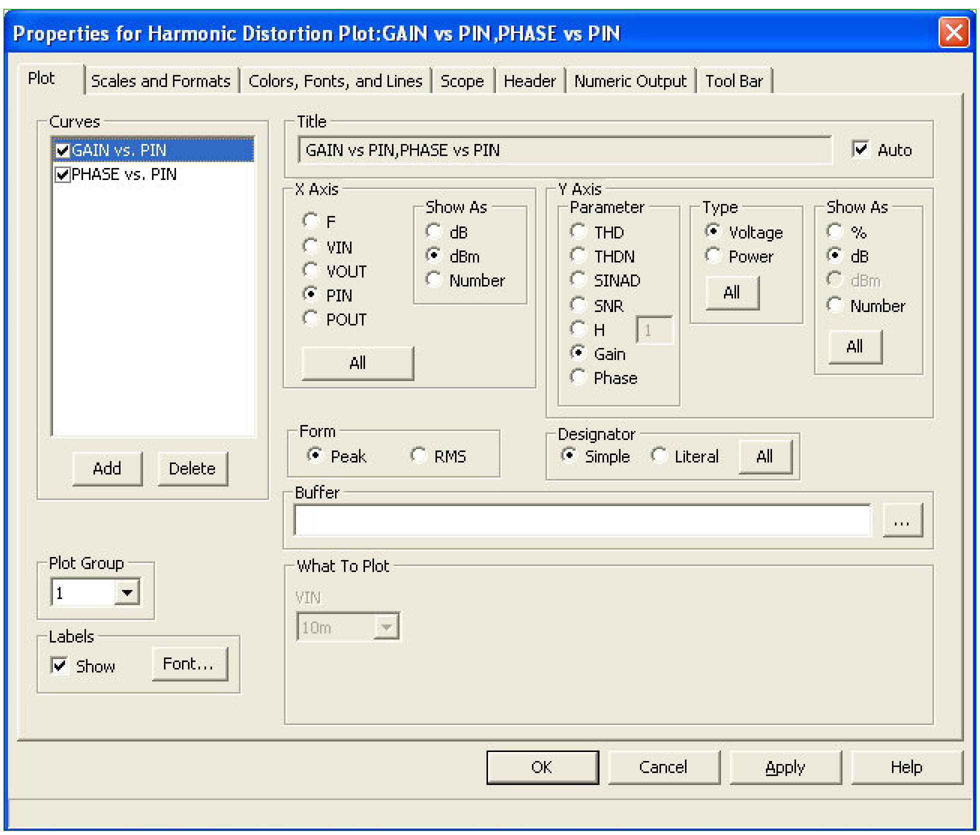


Fig. 3 - New Harmonic Distortion Properties dialog box

Here we're plotting gain (blue) and phase (red). Gain is the ratio of H1 (1'st harmonic of V(RL)) to VIN and Phase = ATAN(IMAG(H1)/REAL(H1)) - 90.00. Press F2 to start the run. The completed plot looks this.

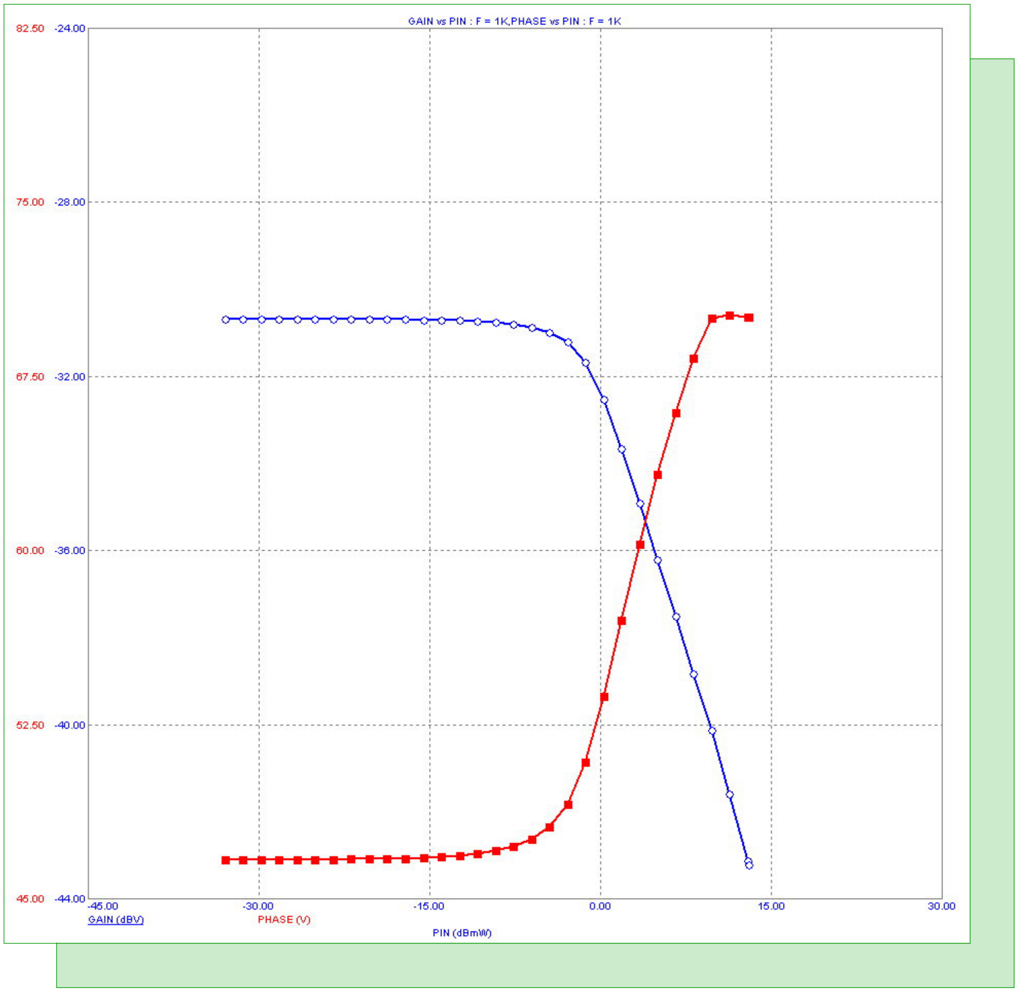


Fig. 4 - The Gain and Phase plot

You can plot Gain or Phase separately, or as in this plot, they can be plotted together using two separate scales.

This type of plot is especially useful in RF amplifiers. It shows gain compression in the amplifier much more directly than a plot of H1 vs. PIN. Gain compression is a type of distortion caused by the reduction in differential gain at higher input power. It is due to the nonlinearity of the amplifier's transfer function.

Using Array Variables

Array variables are real or complex symbolic variables accessed by an index variable which selects an element of the array. Here is the syntax for one dimensional arrays.

.ARRAY arrayname V1[,V2 [,V3...[,Vn]]...]

Note that there must be at least one element (V1) in the array and that a one-dimensional array of size N+1 has values located at 0, 1, 2, ...N.

You can define a one-dimensional array of real values like this:

.ARRAY CV 1n, 3n, 6n

To access the values you use an index variable that typically is created like this:

.DEFINE M 1

The index name may be any non-reserved name. You access the array contents like this:

CV(M)

For example, you could set the CAPACITANCE attribute of a capacitor to CV(M) and then the capacitor value takes on the CV array element that M is set to. If M is set with the .define statement to 1, then the capacitor value would be 3n.

If M is stepped through the values 0, 1, and 2, the capacitor value would take on the values 1n, 3n, and 6n respectively.

To illustrate how array variables can be used, we'll use this example.

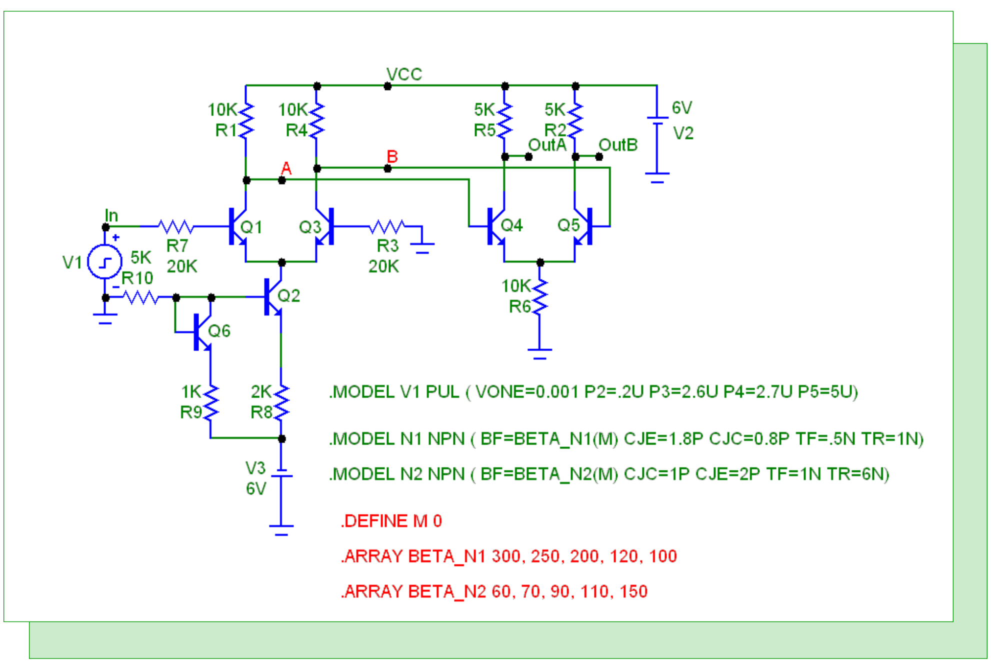


Fig. 5 - The ARRAY circuit

Here we have a circuit that uses several array variables to capture the beta values for two different transistors. The devices that use model N1 specify the forward beta as

BF=BETA_N1(M)

The devices that use model N2 specify the forward beta as

BF=BETA_N2(M)

So if M takes on the values 0, 1, and 2, the BF values will take on these values.

M	N1 devices	N2 devices
0	300	60
1	250	70
2	200	90

In this way you can use the M variable to select unique sets of BF values for the two types of bipolar transistors. These sets may represent worst case, or merely interesting, combinations of parameters.

Typically the index variable is stepped so that one run can show the effects of the BF combinations.

Here is the Stepping dialog box for transient analysis. Its settings step M from 0 through 4 accessing all of the defined array values.

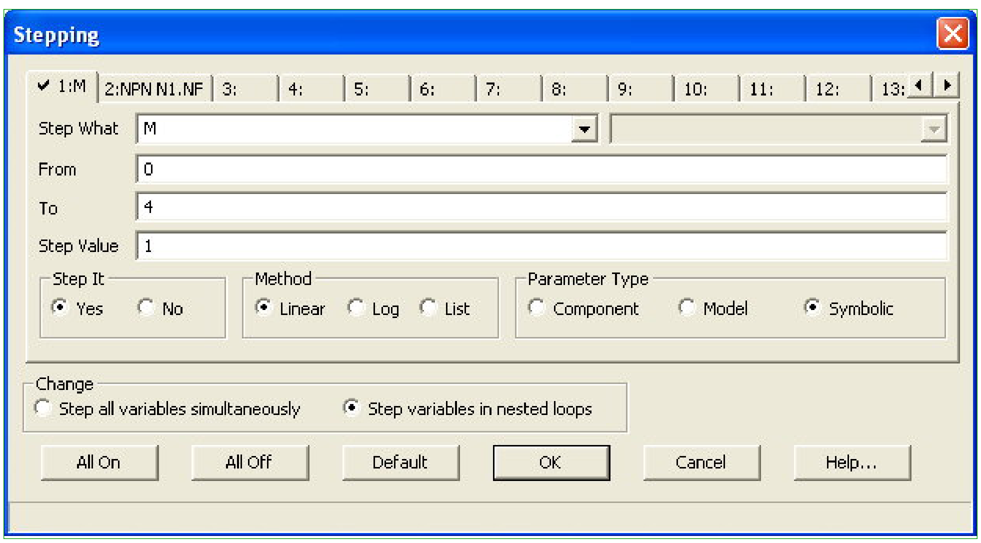


Fig. 6 - The Stepping dialog box for transient analysis

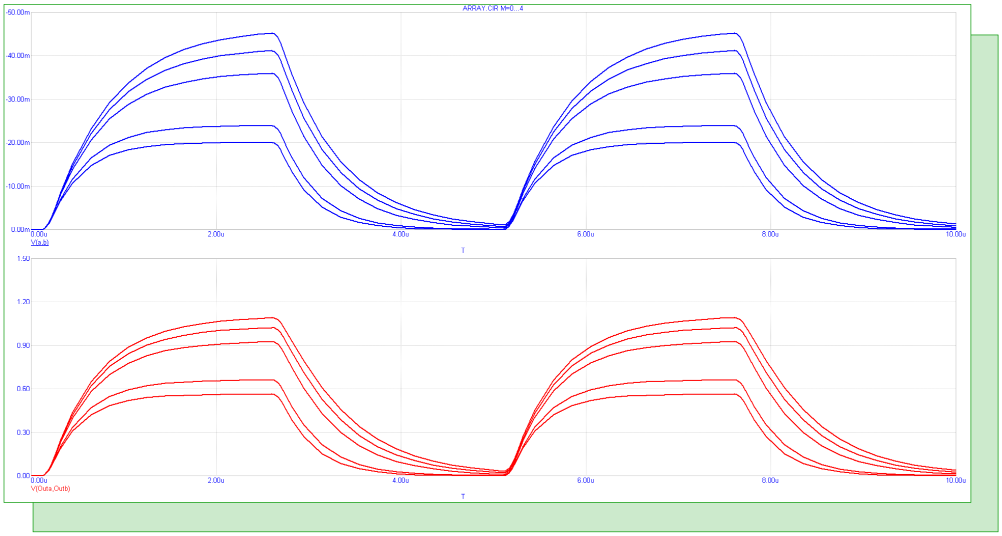


Fig. 7 - The transient analysis run

Figure 7 shows the transient run.

You can label the branches using the Scope Menu / Label Branches option. The Automatic option usually works well but you can override it and specify where to place the labels by picking the X-axis location where there is a nice separation between the curves.

Here is the run with the branches labelled. Note that you must select the Label Branches option for each plot group in turn.

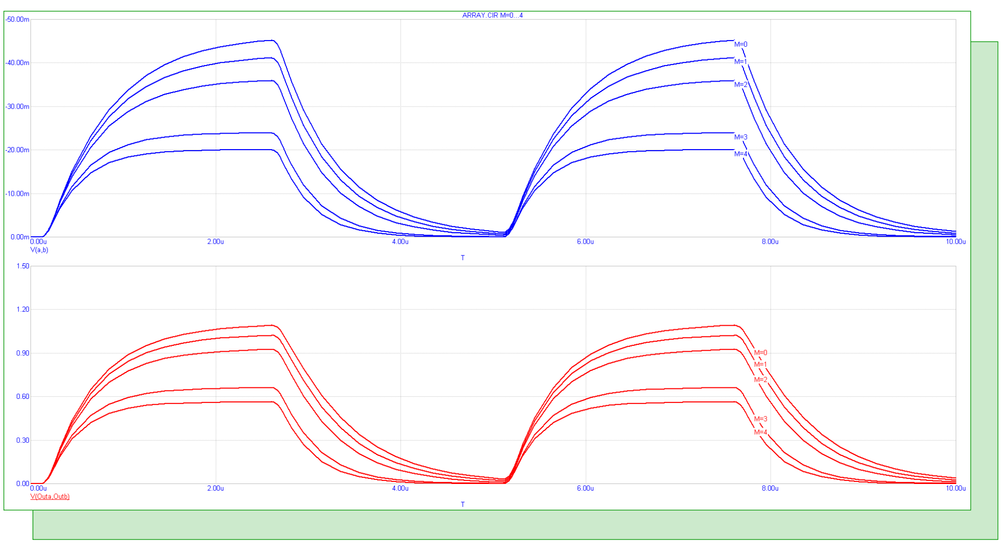


Fig. 8 - The run with labels

The labels are not updated with each run so if you do another run with different simulation parameters, the labels may need to be replaced. The labels are merely text are thus can be deleted individually or as a group with CTRL+A, then the Delete key.

Here is the AC analysis run using the same Stepping dialog box settings as used in transient analysis.

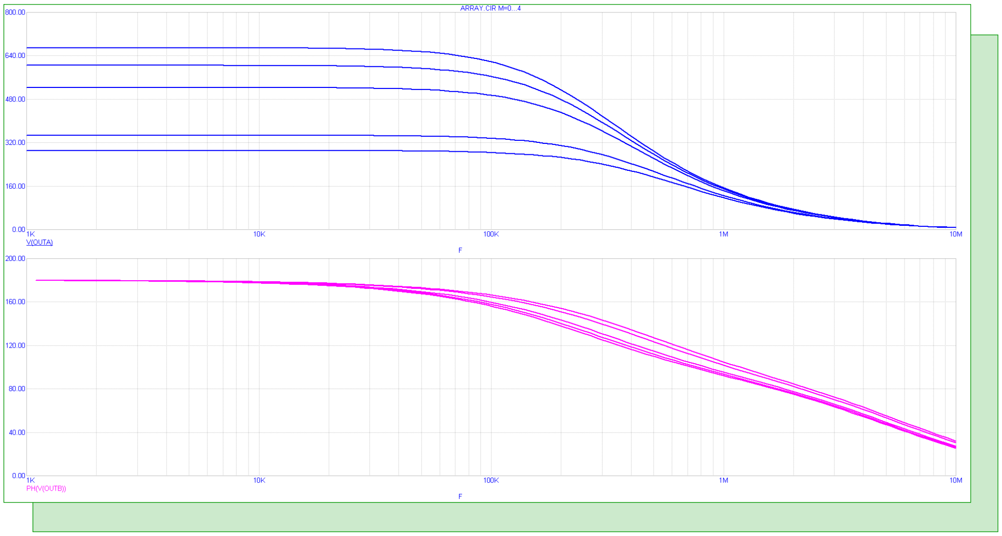


Fig. 9 - AC analysis

And here is the DC analysis run, again using the same Stepping dialog box settings as used in transient analysis.

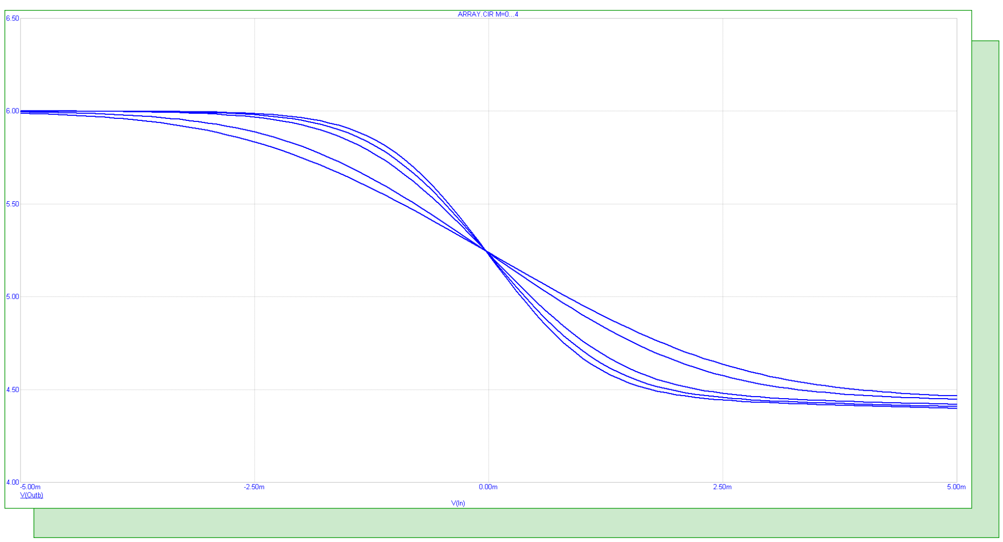


Fig. 10 - DC analysis

Array variables are powerful devices to specify complex simulation and stepping settings.

Comparing Analysis Modes

Have you ever wondered how transient analysis compares with AC analysis or DC analysis? They are in fact consistent even though they each measure something somewhat different.

Transient analysis gives time domain waveforms which are plots of voltage or current versus time.

AC analysis gives the voltage or current versus frequency in a linearized version of the circuit.

DC analysis gives DC voltage or current, usually versus a stepped voltage or current.

In principle, each analysis should give results that agree with the others, if looked at correctly. If we apply a very small sinusoid to a transient analysis run and compare the amplitude of the output voltage with the value we get in AC analysis, they should be the same. Similarly, if we compare the low frequency gain of AC analysis with the DC gain at the same zero-input bias, we should get the same value.

Let see if we do. Here is a schematic of an opamp, configured to have a gain of about 100 at low frequency.

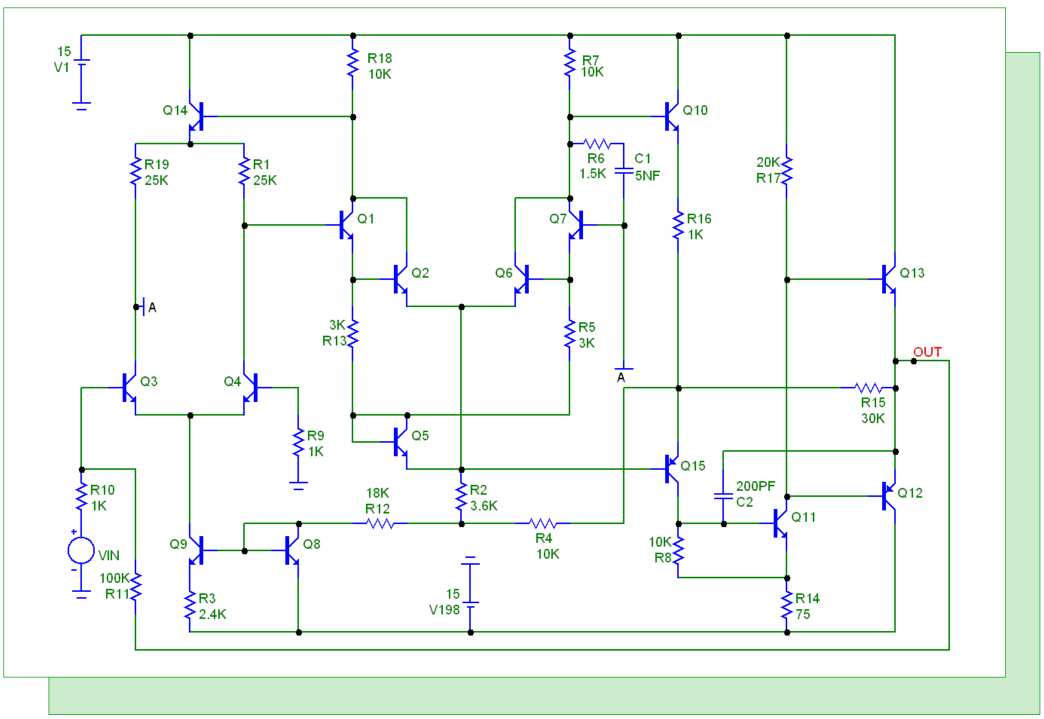


Fig. 10 - The opamp test circuit

The input signal is a 1mV, 1KHz sinusoid. 1mV is small enough so that the opamp produces a near linear response. The resulting transient analysis is shown in Figure 11. The top plot shows the voltage and current of the input voltage source. The bottom waveform shows the response at the output node.

The gain is measure with a Peak_Valley performance function, embedded in a piece of formula text. It looks like this

Gain = Peak_Valley(V(OUT),1,2)/2m = [Peak_Valley(V(OUT),1,2)/2m]

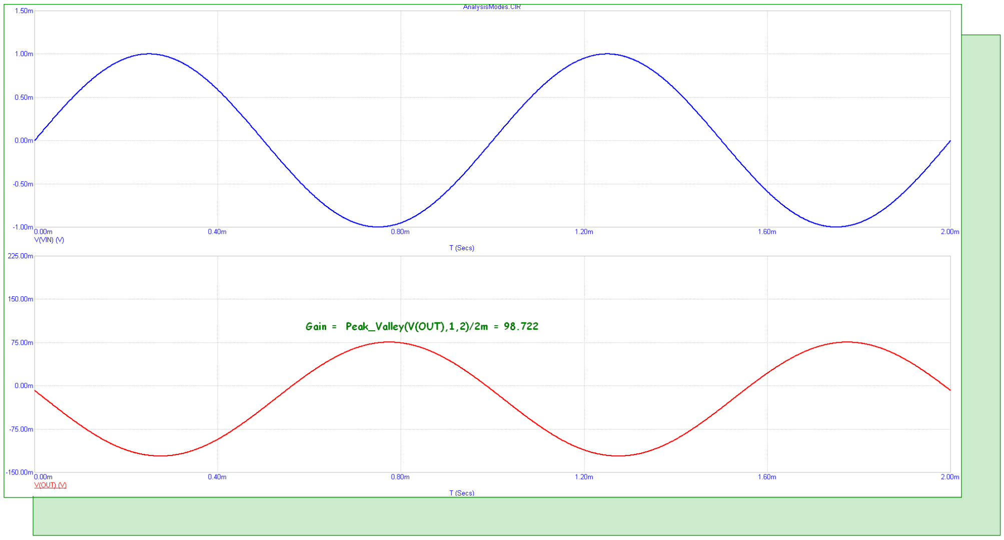


Fig. 11 - The transient run

The Peak_Valley function measures the distance from the 2'nd peak to the 2'nd valley and divides the result by the peak-to-valley distance of the 1mV input source (which is 2mv). If you didn't know this value, you could alter the formula to measure it as well, like this

Peak_Valley(V(VIN),1,2)

So the result is that the gain at 1KHz as measured in transient analysis is about 98.722. Let's see how that compares with what we get in AC analysis.

Here is the AC analysis run:

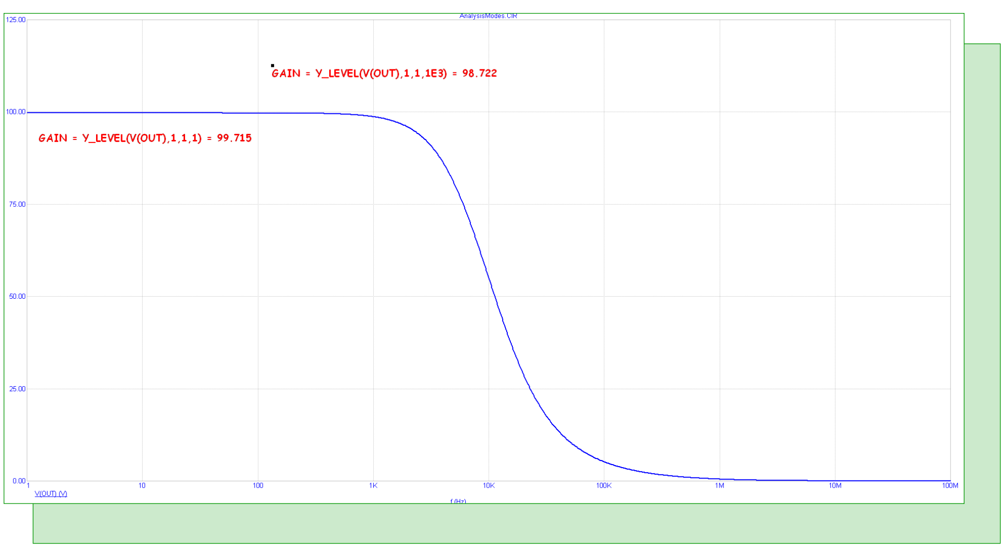


Fig. 12 - TheAC run

The analysis shows a plot of the voltage at the output node. The input voltage is the default 1.0V, so the plot is also a plot of the input to output gain. Again we use a performance function to measure the gain at 1KHz. The formula text used to do this is

GAIN = Y_LEVEL(V(OUT),1,1,1E3) = [Y_LEVEL(V(OUT),1,1,1E3)]

The result is 98.722. This is the same result we got in transient analysis to within five decimal places.

Notice that we used another performance function to measure the gain at low frequency. It looks like this

GAIN = Y_LEVEL(V(OUT),1,1,1) = [Y_LEVEL(V(OUT),1,1,1)]

The resulting gain at low frequency is 99.715.

Here we measure the value of V(OUT) at F=1, the lowest frequency of the AC analysis. If we wanted a more accurate result, we might use a low frequency of .001Hz and then modify the performance function as follows:

GAIN = Y_LEVEL(V(OUT),1,1,.001) = [Y_LEVEL(V(OUT),1,1,.001)]

Now lets see if this matches what we see in DC analysis. It looks like this:

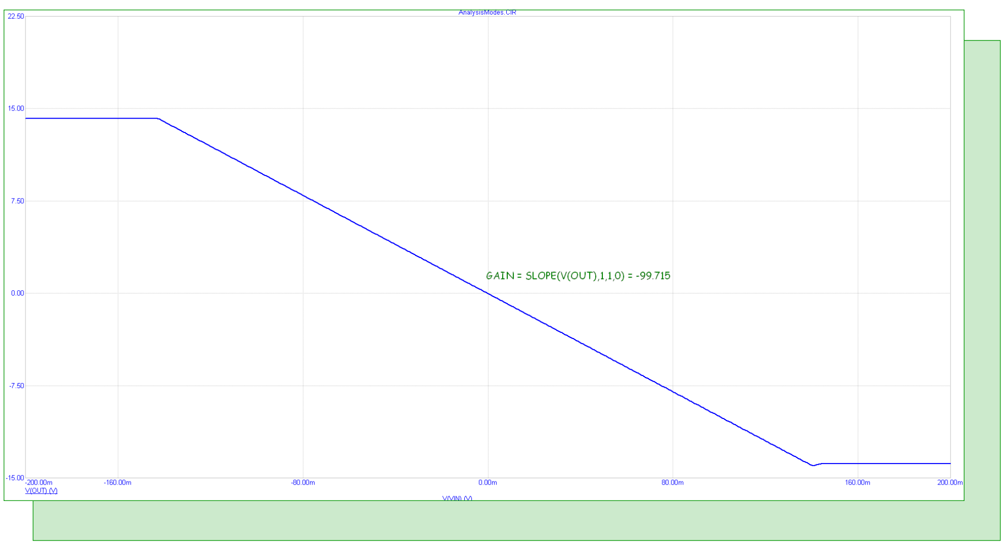


Fig. 13 - The DC run

In this analysis we sweep the input DC voltage and measure the output voltage. As expected, we see saturation for any voltage whose magnitude is larger than about 140mV. The gain at zero input voltage bias (the same DC bias used in AC analysis) is measured with a performance function like this:

GAIN = SLOPE(V(OUT),1,1,0) = [SLOPE(V(OUT),1,1,0)]

The gain is measured directly with the SLOPE function when the swept input DC voltage is zero. The result is a gain of -99.715. Except for the sign, this is the same result obtained in AC analysis.

Latest Version numbers

Micro-Cap 10 ....Version 10.0.9.0
Micro-Cap 9 ....Version 9.0.8
Micro-Cap 8 ....Version 8.1.3
Micro-Cap 7 ....Version 7.2.4

Spectrum's numbers

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