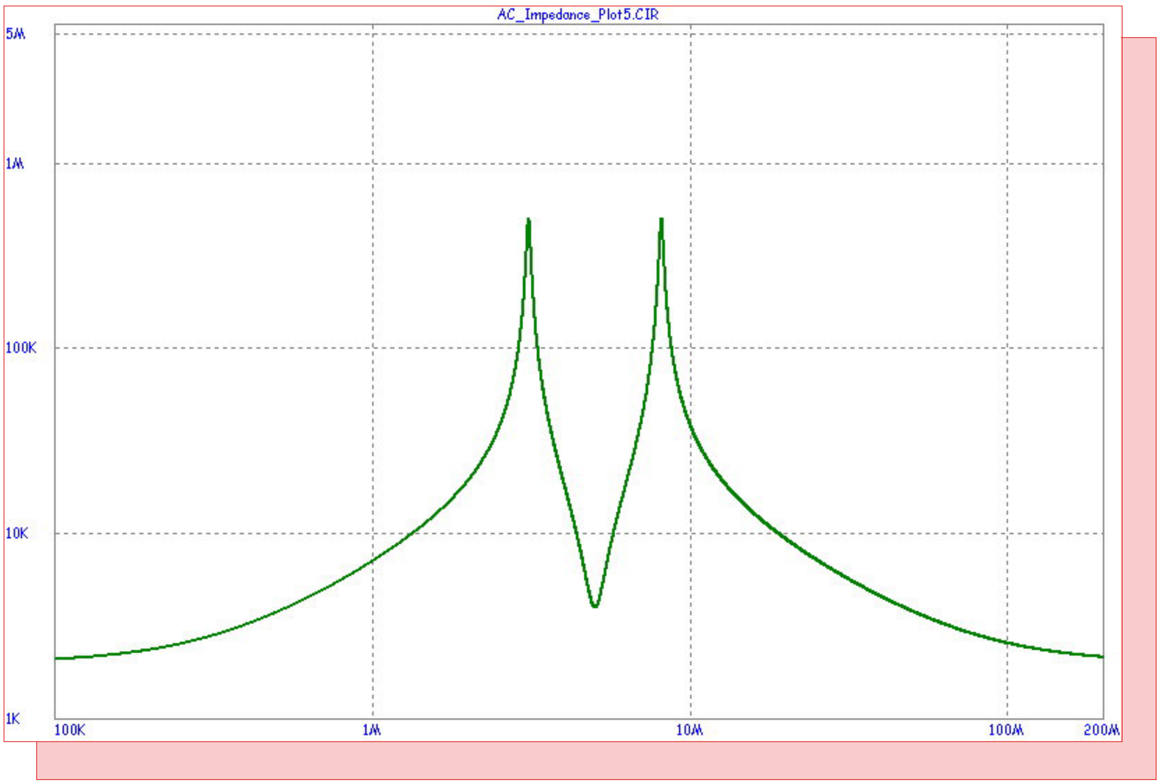
spectrum news

Applications for Micro-Cap™ Users

Fall 2012

News



AC Impedance Plots

Featuring:
- Plotting AC Impedance
- A Simple Current-Limiter
- Compact Current Meter
- Dynamic Analysis Mode

News In Preview

This newsletter's Q and A section describes how to handle networks containing subnets. The Easily Overlooked Features section describes the calculator tool and its usage.

The first article describes how to conveniently measure the AC impedance or conductance of a simple two-terminal device or of more complicated circuits.

The second article describes a simple but effective current-limiter macro.

The third article describes a simple compact part that measures and displays current flow for cases where the current is not automatically displayed, such as macros, subcircuits, and OPAMPs.

The fourth article describes dynamic analysis mode, an intuitive response mode in which analysis plots respond to schematic changes dynamically.

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 trying to install Micro-Cap on a network with multiple subnets. The main network has the license manager and the program security key plugged into one of the PCs. I can run the two instances of Micro-Cap and I can see them by using the monitor program supplied with Micro-Cap. The problem is that I cannot get any instance of Micro-Cap installed on either of several subnets to recognize the license manager. What am I doing wrong?

Answer: Each of your several installations of Micro-Cap will include a file called nethasp.ini. Inside the nethasp.ini file there is a line which defines the address of the server where the license manager is to be found. Its general format is as follows:

NH_SERVER_ADDR = <Addr1>, <Addr2>

Addr1 and Addr2 are IP addresses of the servers containing the NetHASP License Managers you want the client (local Micro-Cap installation) to search. Unlimited addresses and multiple lines are possible.

In this case you probably want something like this

NH_SERVER_ADDR = 192.168.0.10

In this example, 192.168.0.10 would be the address of the main network that contains the license manager and the USB security key.

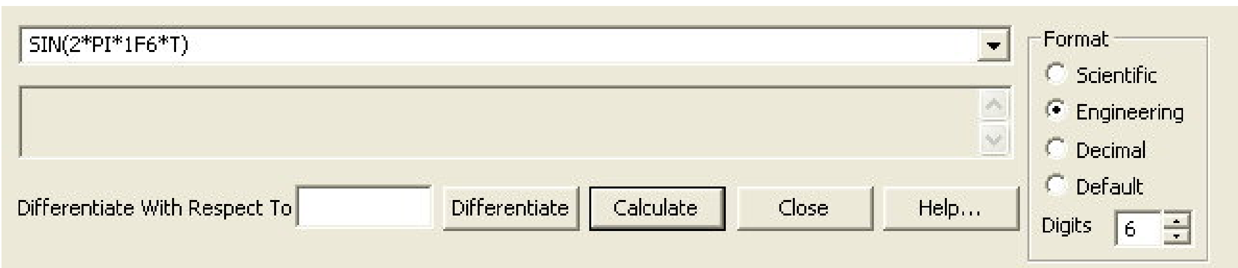
After editing the nethasp.ini file it is probably best to copy it to each of the client installations on the subnets.

Easily Overlooked Features

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

One feature that often gets missed is the Calculator. It is invoked from the Windows menu or by clicking on its icon:

When you invoke the calculator you get a display like this:

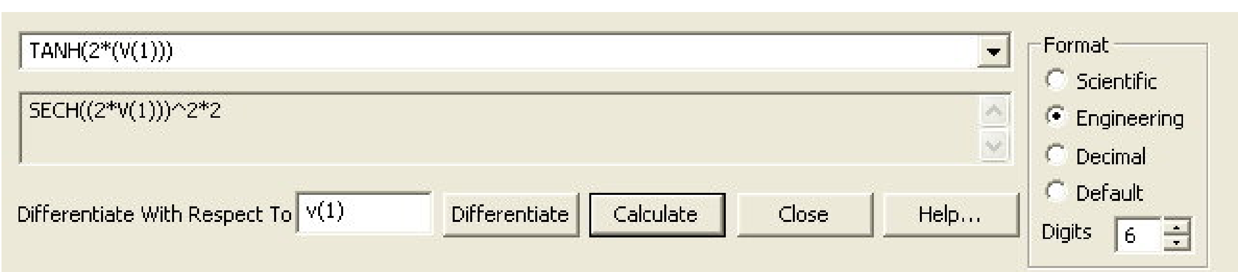


What can the calculator do? It can compute the value of any expression. If you are in an analysis, expressions can include the value of any legal circuit variable. For example you can compute something like this

IC(Q12)/IB(Q12)

This will calculate the effective beta of Q12. The values of IC(Q12) and IB(Q12) are the last values, those at the end of the simulation run.

The calculator can also differentiate expressions. For example, enter TANH(2*(V(1))), enter V(1) for the Differentiate With Respect To variable, press the Differentiate button, and the calculator will return this display:



SECH((2*V(1)))^2*2 is the derivative of TANH(2*(V(1))) with respect to V(1).

The calculator can express numeric results in several formats. If you click on the drop-down arrow, you'll see and can select from a list of previously entered expressions.

Plotting AC Impedance

To plot AC impedance for two-terminal devices like diodes, resistors, etc. you need to measure the current into and the voltage across the two terminals. Consider the simple circuit below:

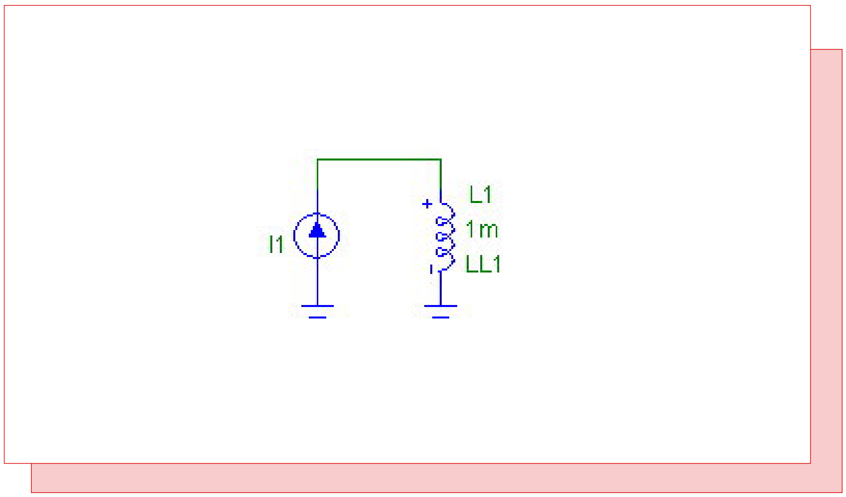


Fig. 1 - Circuit to measure AC impedance of an inductor

This inductor uses a model statement in which a 1pF parallel capacitance and a .01 ohm series resistance are specified. To measure its AC impedance we must plot V(L1) / I(L1). When we do we get the plot below:

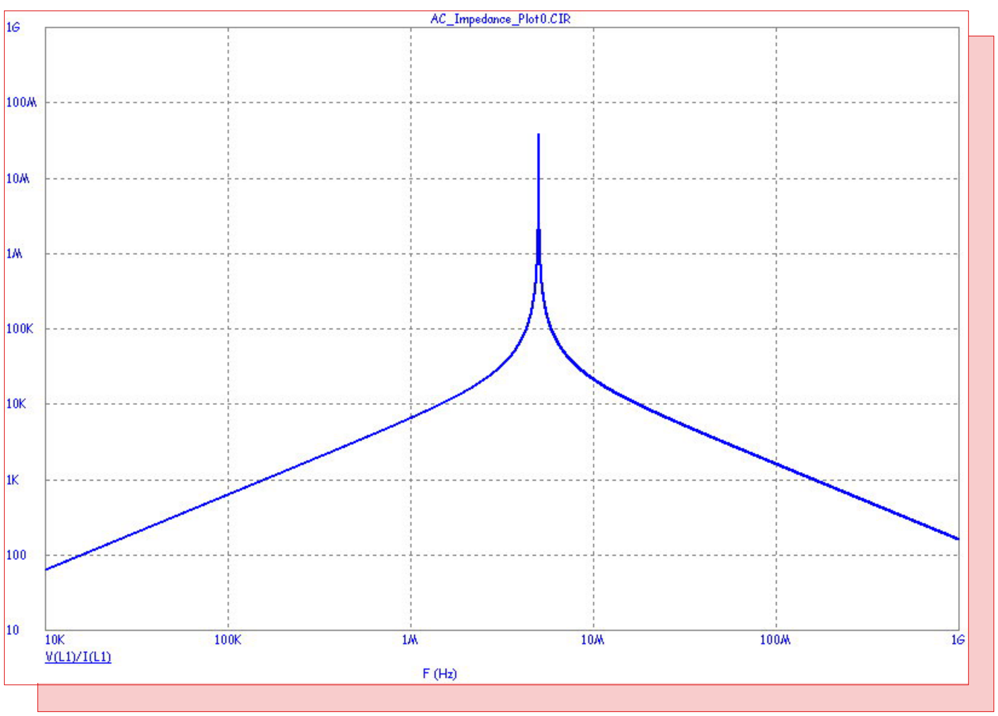


Fig. 2 - AC plot of V(L1) / I(L1)

Because this inductor has a parasitic capacitor in parallel with it, there is a resonance in the impedance which approaches infinity at about F0 = 5.032 MHz. Before this point the impedance is approximately the ideal inductor impedance of j*2*PI*F*1m. After F0 the impedance is approximately that of the 1p parallel capacitance, 1/(j*2*PI*F*1p).

For diodes, resistors, capacitors, and inductors there is an easier way to plot AC impedances. Simply plot Z(D1), Z(R1), Z(C1) or Z(L1). Here is the same plot with both V(L1) / I(L1) and Z(L1).

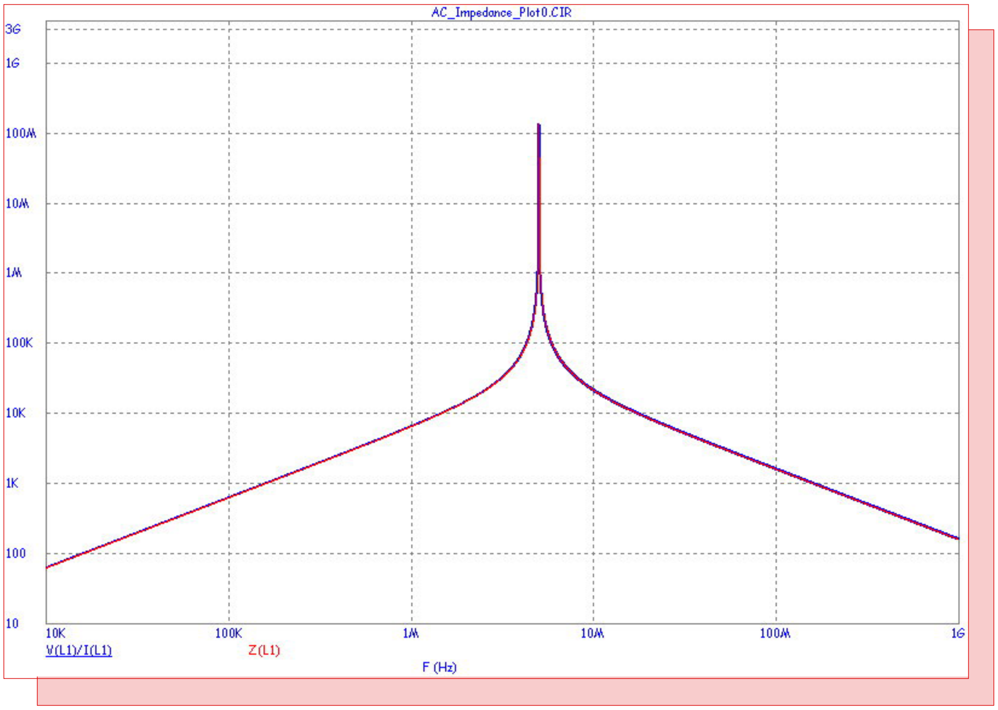


Fig. 3 - AC plot of V(L1) / I(L1) and Z(L1)

As you can see the plots overlap because Z(L1) gets internally computed as V(L1) / I(L1).

For another illustration of plotting two-terminal impedances here is a plot of the impedance of a zener diode, biased near breakdown. Here is the circuit.

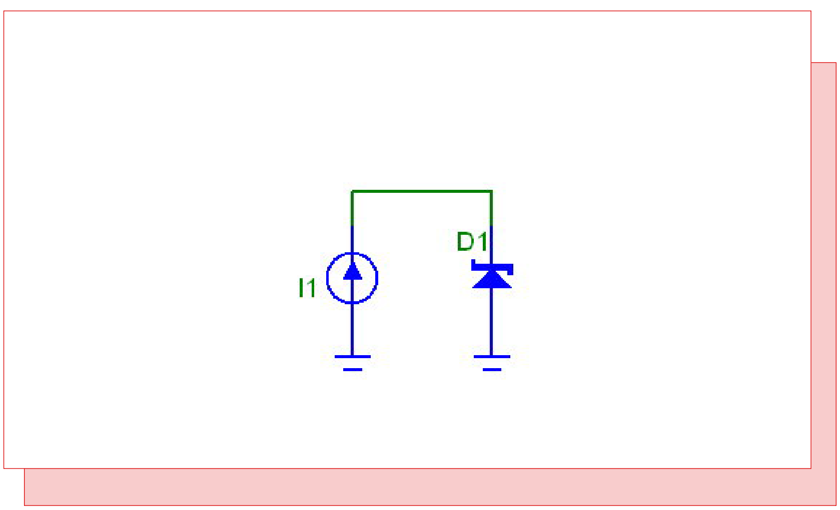


Fig. 4 - Circuit to measure AC impedance of a zener diode

Here is its AC impedance plot.

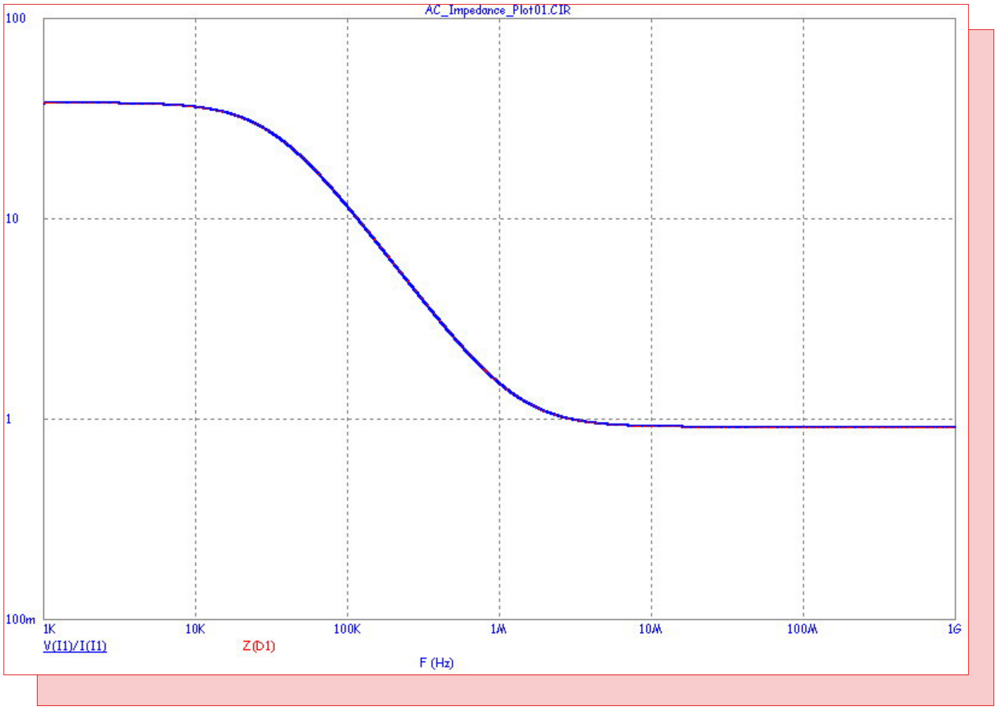


Fig. 5 - AC plot of V(D1) / I(L1)

In this case, the low frequency impedance saturates at about 38 ohms and the impedance at high frequency saturates at just under 1 ohm.

AC impedance is a complex quantity, having both real and imaginary parts. Z(D1) plots the magnitude of Z(D1). You can also plot PHASE(Z(D1)), RE(Z(D1)), and IM(Z(D1)).

You can also plot the inverse of AC impedance, AC conductance. The syntax is the same as impedance except that you use G instead of Z. For example G(D1) would plot the complex conductance of D1.

Could you use the same Z(X) or G(X) syntax for a general two terminal subcircuit? No, because there is no intrinsic way for Micro-Cap to measure the current through the two terminals, whereas for standard two-terminal devices there is a readily available way to measure the current.

For a two-terminal subcircuit you can always use the general method; plot V(VIN)/I(VIN), where VIN is a voltage source placed across the two terminal device. The source can be either a current or a voltage source. The main concern is that its DC conditions produce or at least not alter the desired operating point. In the zener circuit just used, the source has a small DC value to bias the zener near breakdown.

The same principle can be employed for more complex circuits like amplifiers or filters. You measure the current into the circuit and the voltage across two terminals that represent its input. Consider the simple circuit below:

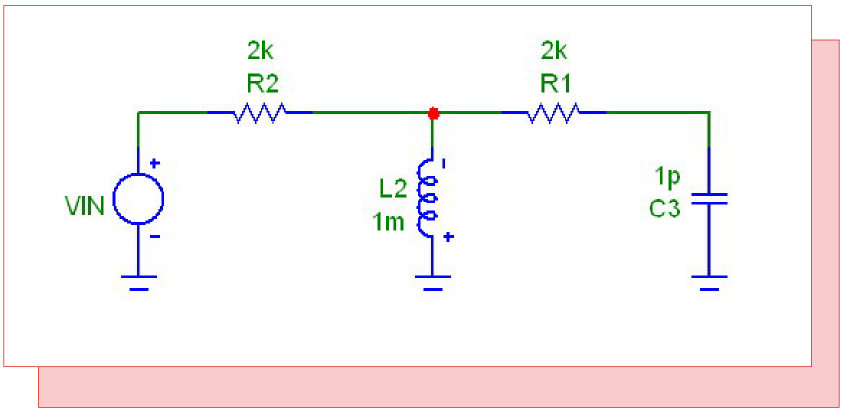


Fig. 6 - Test circuit to measure input AC impedance of a circuit.

Since the source VIN can be used to measure both the input voltage and the input current, all we need do is plot Z(VIN) (which internally translates to V(VIN)/I(VIN)). This plot, which shows both quantities, demonstrates their equivalence.

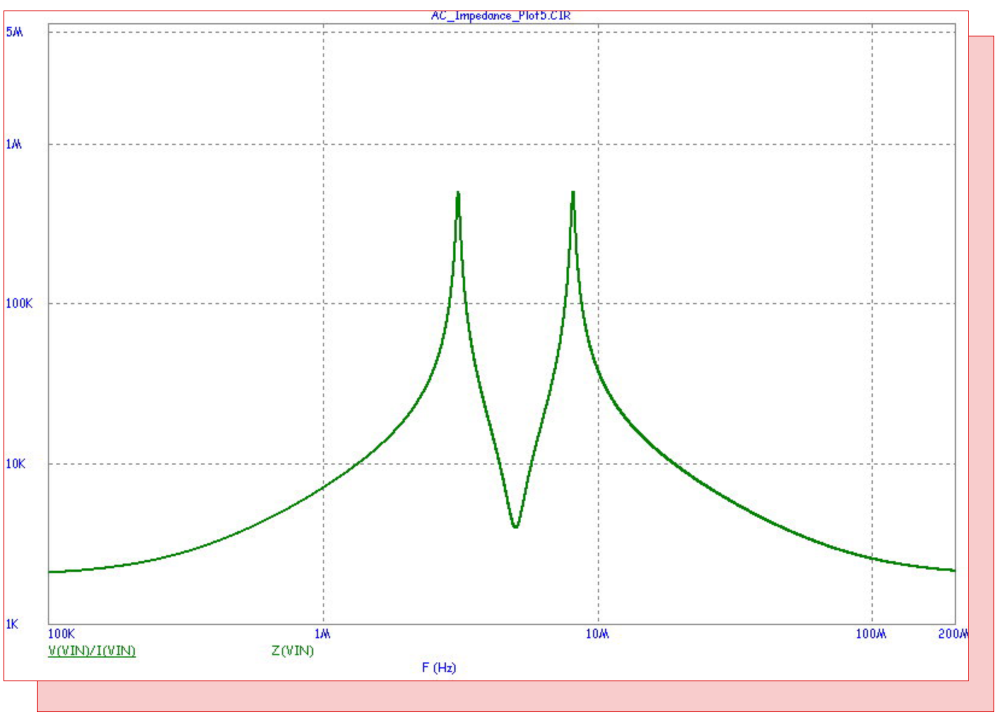


Fig. 7 - AC plot of a circuit's input impedance

A Simple Current Limiter

There are many applications where some form of current limiting is needed. There are a variety of ways to do this with circuitry. For example, here are two common methods.

http://www.radio-electronics.com/info/circuits/transistor_current_limiter/transistor_current_limiter.php

http://www.vidisonic.com/2008/07/10/current-limiting-circuit/

These are nice methods, but if what you want is a simple, effective way to limit current without having to design a particular circuit implementation, here is a good way to do it.

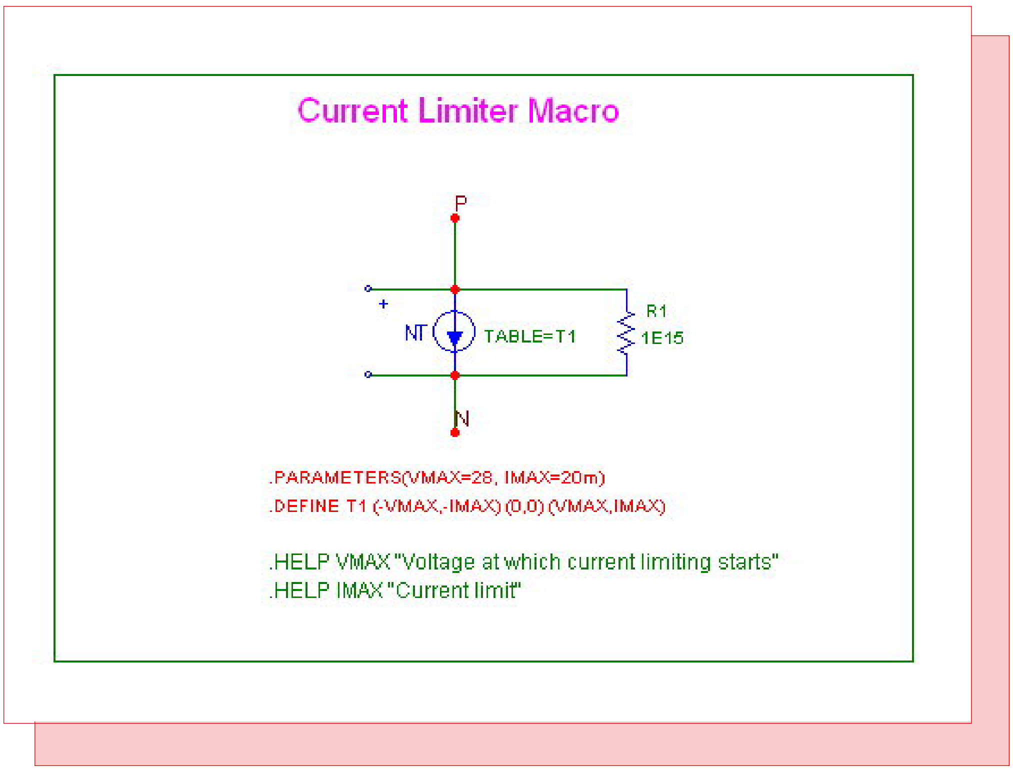


Fig. 8 - The current limiter macro

This macro uses an NTIOFV (Nonlinear Table I of V source) to limit the current to IMAX when the voltage across the device exceeds VMAX.

The default values are set to a common set for power systems.

The 1E15 ohm resistance serves as a convergence aide and can be eliminated if its fA of current leakage is a problem in your application. A high-valued resistance across a current source will often help convergence.

Here is a test circuit to be run in DC analysis to demonstrate the transfer function of the device.

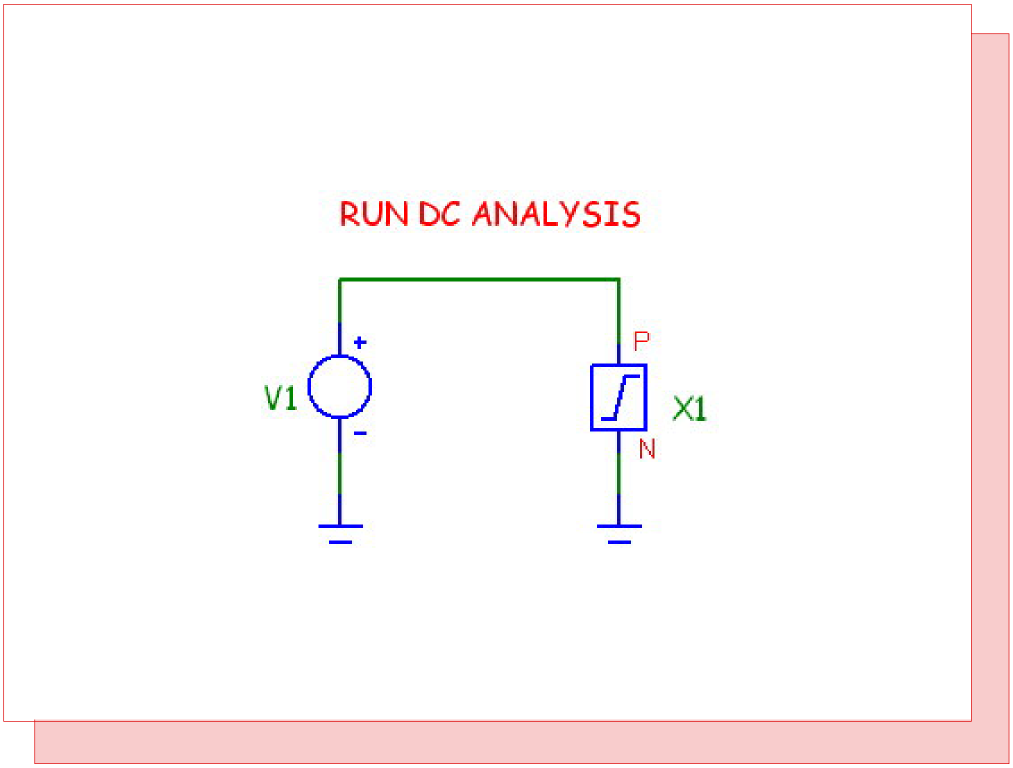


Fig. 9 - A DC test circuit for the macro

Here is the DC analysis showing the current limiting transfer function. As you can see, the device clips currents in both positive and negative directions to +-IMAX.

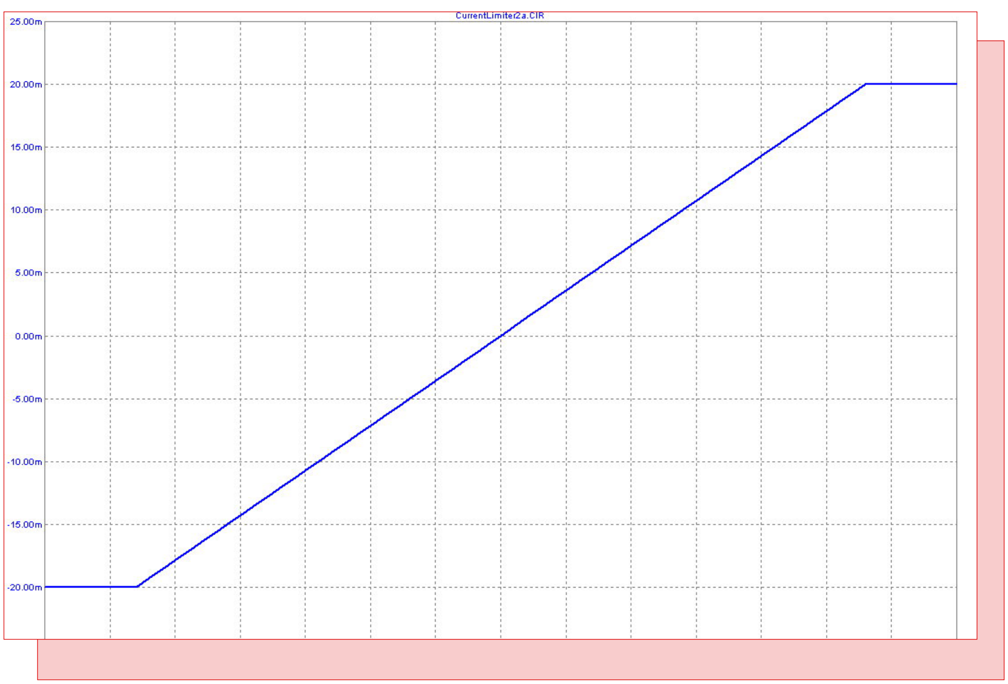


Fig. 10 - The DC transfer curve of the limiter

Here is a circuit to demonstrate the use of the current limiter.

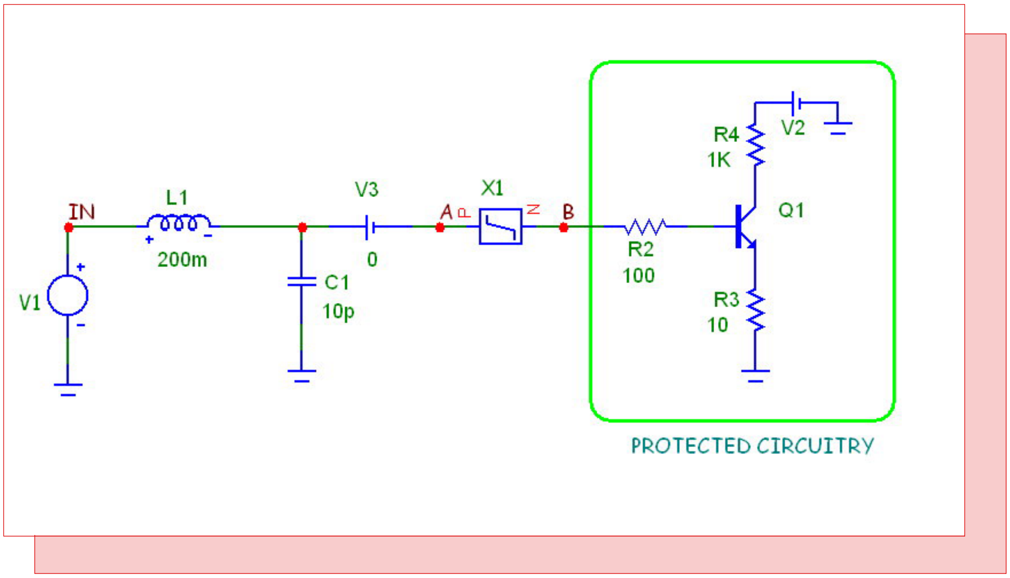


Fig. 11 - An example of how to use the macro

X1 is the current limiter macro and the area encircled in green is the circuitry whose input current is being limited. The bottom waveform in the transient analysis of this circuit shows the current through V3 and thus through the X1 limiter.

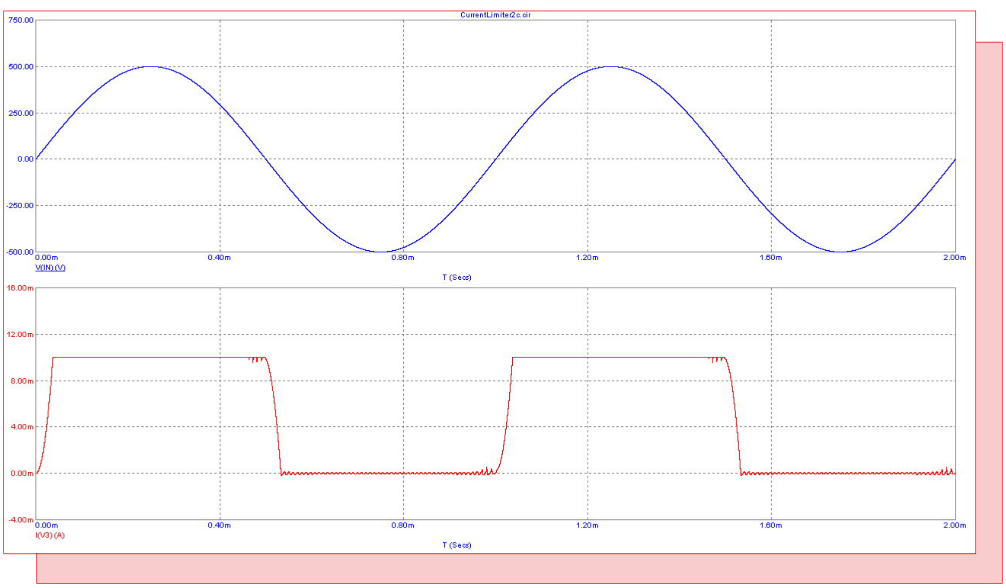


Fig. 12 - The DC transfer curve of the limiter

Compact Current Meter

Dynamic DC does a nice job of showing DC currents for most components, but not for macros, subcircuits, and OPAMPs. Since there is no built-in way to measure the currents into or out of these components it would be nice to have a simple way to measure the currents. For example, consider this circuit:

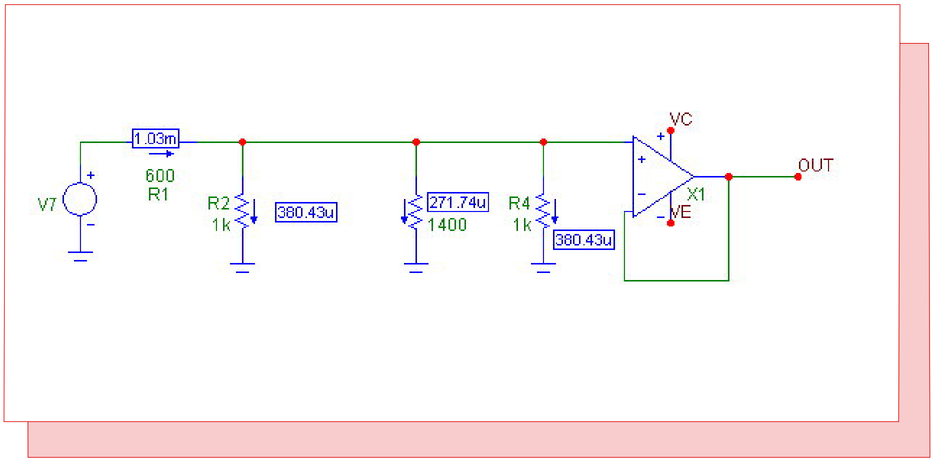


Fig. 13 - Circuit without current meter

The currents flowing into the + and - OPAMP input pins are not shown. The usual way to measure currents in a circuit where they are not otherwise available is to use 0V batteries like this:

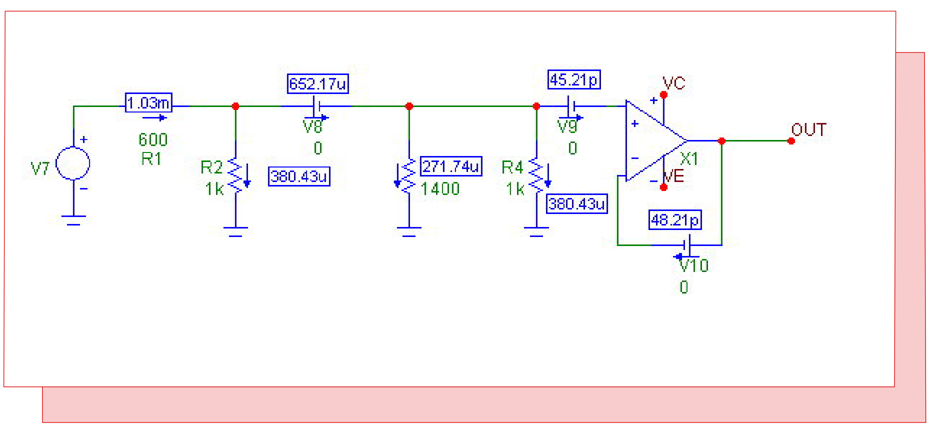


Fig. 14 - Measuring current using 0V batteries

This works well enough, but the batteries look a little out of place and to someone who doesn't know, they seem pointless since they are 0V.

Now consider this circuit.

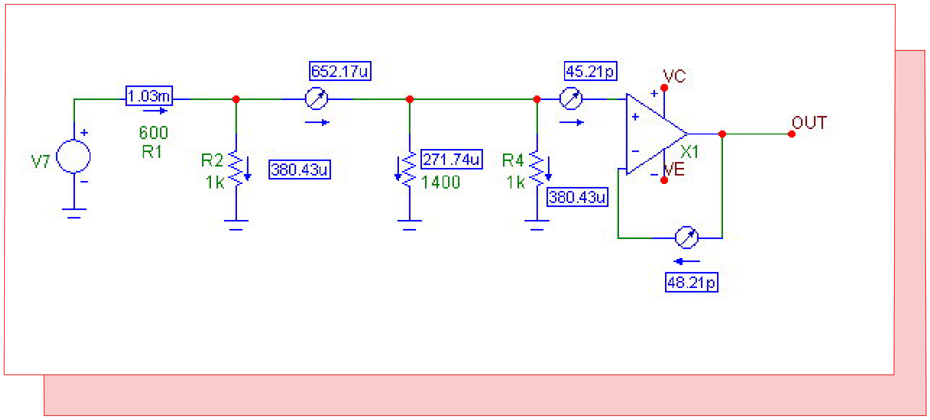


Fig. 15 - Measuring current using the Current Meter component

Here we've placed a simple current meter in the branches where we want to see the current flow. What is the Current Meter? As you can see by looking at its Component Editor entry its definition is Battery and it uses a shape called CurrentMeter, created expressly for the purpose of showing its purpose.

Of course, when you place the first one of these in a schematic, it will pop up the Attribute dialog box and ask for the battery's value. Enter 0. It will not normally display this value which is what you want. You may want to disable the Show Check box next to the PART value so that the NAME does not show and get in the way of the current reading.

Do you have to do all this every time you add a current meter? You don't if you use CTRL + mouse drag to create the next one. If you've never used CTRL+drag, you're in for a treat. It is the fastest way of creating and placing a component, especially one that is identical to an existing one.

To use CTRL + drag simply press and hold the CTRL key. Place the mouse over the part and click the left mouse button. Drag the part to where you want, then release the mouse button. Presto, you have an exact copy of the part. The big advantage here is that you only have to enter the 0 value and disable the PART attribute printing once. Thereafter it's a simple CTRL + drag to place another part.

The CTRL + drag procedure is especially useful when duplicating large parts of a circuit, such as the differential pair of an amplifier.

If you download the circuit CurrentMeter, it will import the Current Meter component and its shape, CurrentMeter into the Import section of the Component library where it will be available for use in other circuits.

Dynamic Analysis Mode

This article explains the dynamic analysis mode and how to use it.

How it works: In dynamic analysis mode you usually employ a screen split between two windows. One window shows the schematic or SPICE netlist (Micro-Cap can simulate either one). The other window shows the analysis plot. When you make a change to the schematic, the analysis is re-run and the analysis plot is updated.

Activation: Dynamic analysis is always active.

We'll use this circuit as a vehicle to explain how the mode is used.

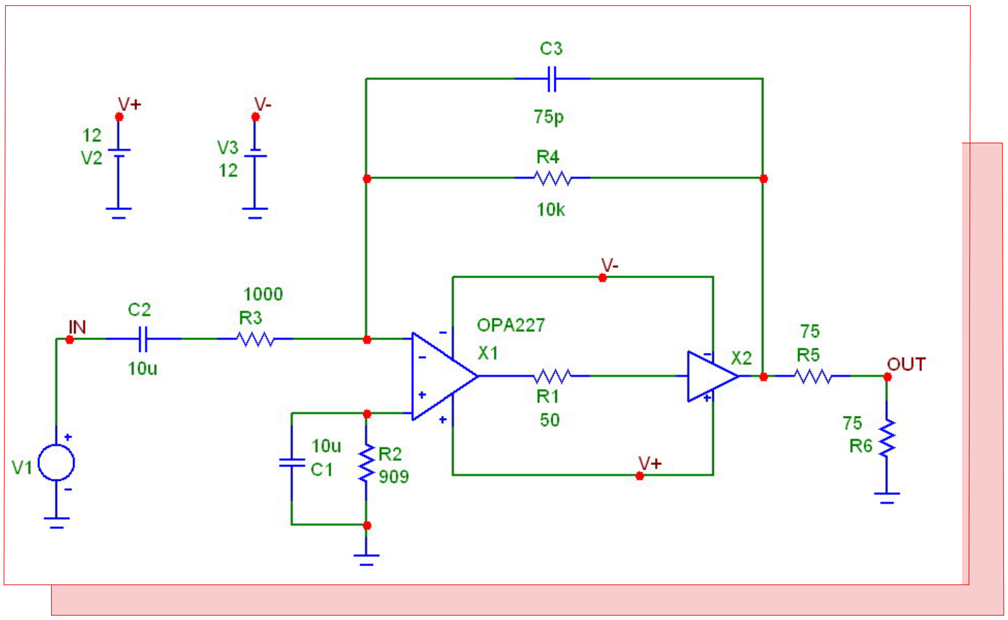


Fig. 16 - Using the dynamic analysis

This circuit is a microphone preamp. Press F2 and its AC analysis looks like this:

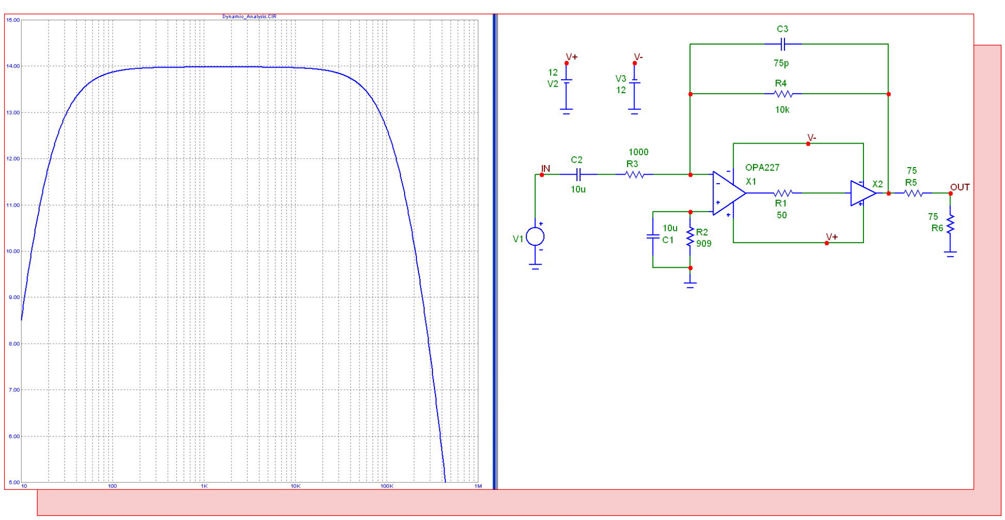


Fig. 17 - AC analysis

Notice that the Accumulate Plots option is enabled. This accumulates and displays all plots including the original and any changes made during the analysis session. Now click in the schematic on R3 and press the Up Arrow key. You should get this picture.

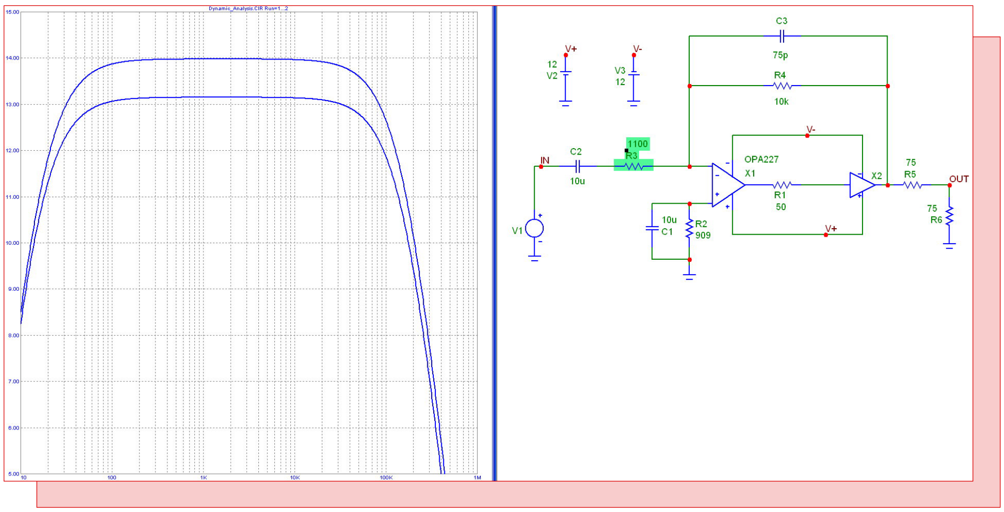


Fig. 18 - AC analysis with R2=1000 and 1100 ohms

Press the Up Arrow key twice more and you get this picture.

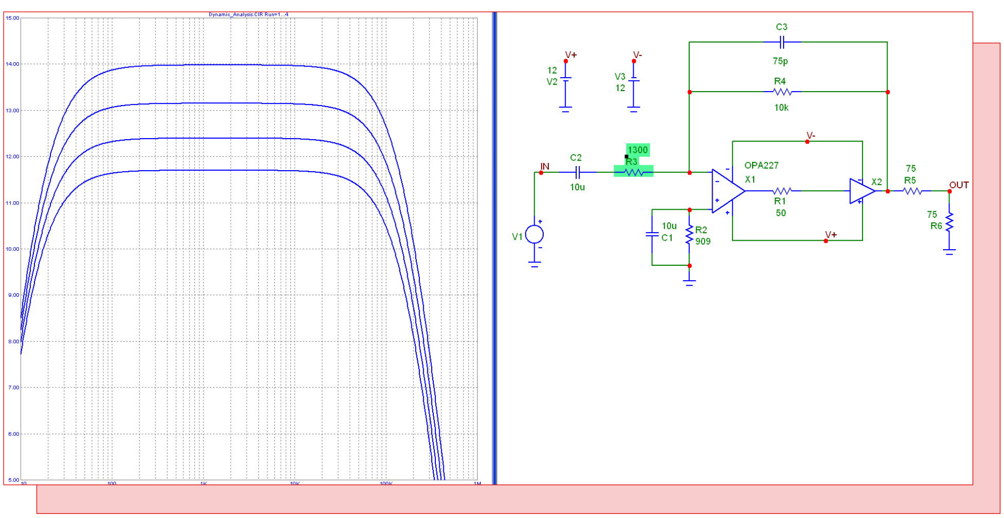


Fig. 16 - AC analysis with R2=1000, 1100, 1200, and 1300 ohms

For each change made in the schematic you get one more plot. In some instances, you may find it is easier to avoid the Accumulate Plots option. The simulation run is often so fast that you can alternately use the up and down arrow keys and get an intuitive feel for the effect a particular parameter has. For instance, in this example, the resistor R2 affects both gain and bandwidth. The capacitor C2 affects the low frequency cutoff and the capacitor C3 affects the upper frequency bandwidth.

Here, for example is the effect of doubling C2.

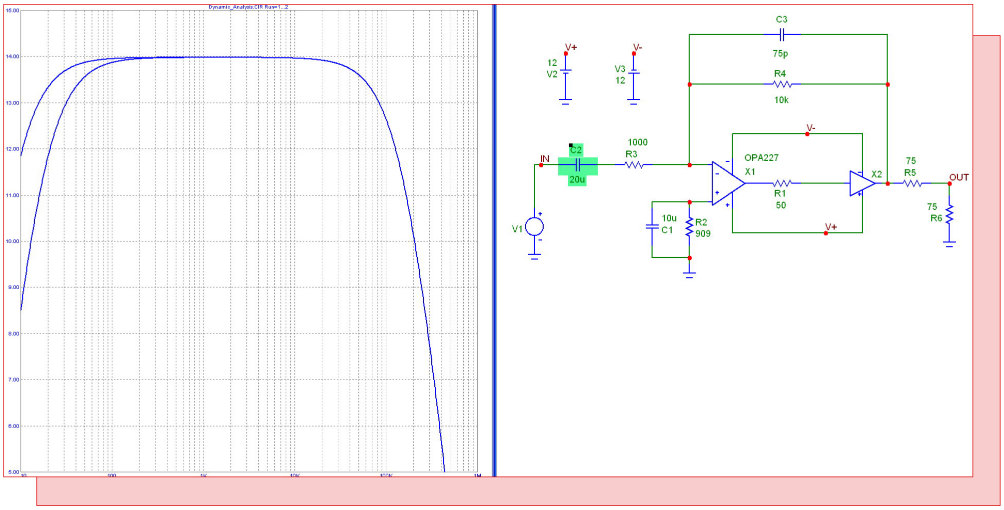


Fig. 19 - AC analysis with C2=10uF and 20uF

Here is the effect of doubling C3.

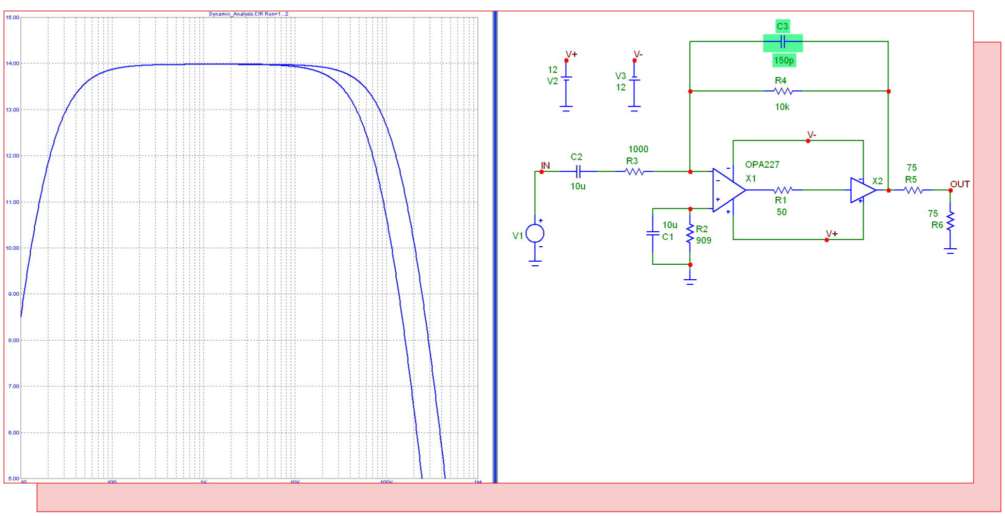


Fig. 20 - AC analysis with C3=75pF and 150pF

All of this you could do by stepping the component values and you probably should do it that way after you understand the nuances of your circuit. Until then it's nice to develop an intuitive understanding of the circuit function by seeing the effect that small changes have on the circuit behavior.

Note that the changes are not limited to using the arrow keys. You can double-click on a component and make any changes you want.

As with any schematic change, Undo (CTRL+Z) and Redo (CTRL+Y) can be used to restore the circuit.

Latest Version numbers

Micro-Cap 10 .... Version 10.0.9.1
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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