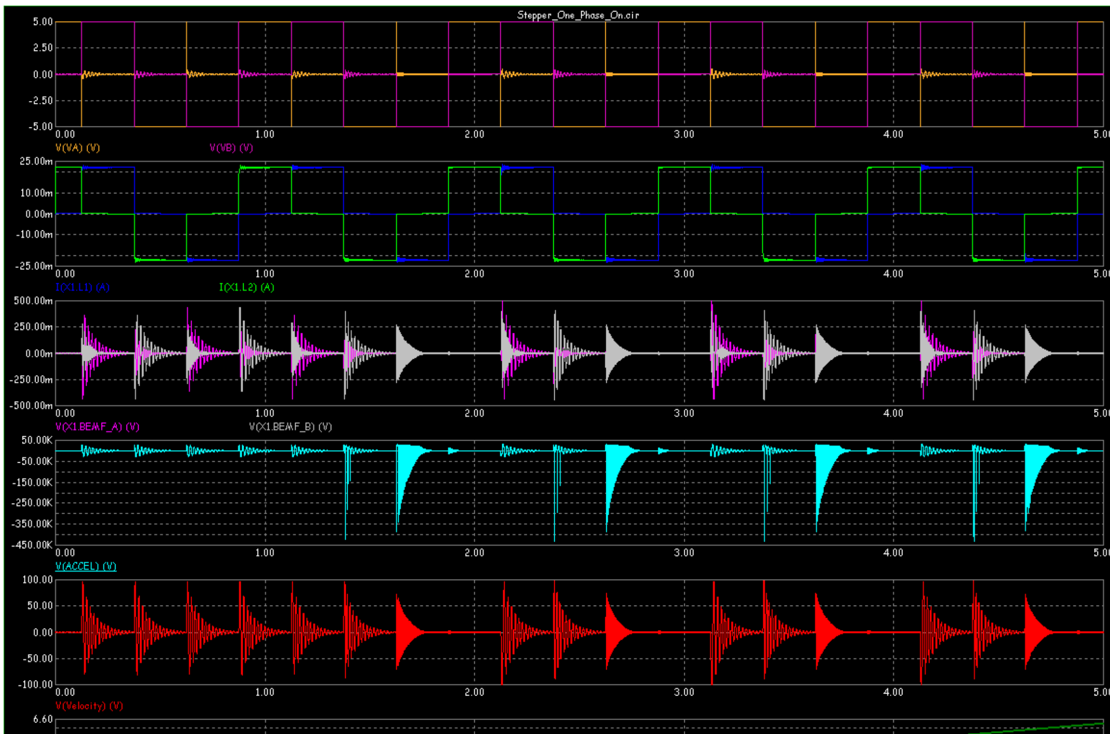
spectrum news

Applications for Micro-Cap™ Users

Spring 2014

News



Stepper Motor

Featuring:

- Exporting Data to Excel
- DC Stepper Motor Model
- AC Induction Motor Model

News In Preview

This newsletter's Q and A section describes the main factors that can be behind Permission denied errors. The Easily Overlooked Feature section describes the Localize command.

The first article describes how to export Micro-Cap generated waveform or curve data to Excel.

The second article describes a stepper motor model and gives several examples of how to drive the model and the resulting response waveforms.

The third article describes an AC induction motor model and gives several examples of how the motor responds to different loads.

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 using another computer of mine with a parallel port and installed the MC8 software. The system has Windows 7. However, I now get an error message stating Can't find the NetHASP Server . Any help?

Answer: MC8 will work with Windows 7 but only with the USB key. It will not work with a parallel port key. Your options include upgrading the parallel port key to a USB key or upgrading from MC8 to MC11 and doing a key exchange then.

Question: Is there a Macintosh version of Micro-Cap. If not, is there any way to run Windows Micro-Cap on the Macintosh?

Answer: There is no native version of Micro-Cap for the Mac but you can run the Windows version under several schemes.

Virtualization:
The first is Parallels for the Mac. This software provides hardware virtualization for Macintosh computers with Intel processors. It lets you run virtually any Windows application on the Mac including Micro-Cap.

Other virtualization products include VMware Fusion and Virtual Box.

Dual Boot:
Apple makes a product called Boot Camp. It provides the most compatibility with Windows software and peripherals, but does not allow you to run Windows and Mac OS X applications at the same time.

Easily Overlooked Features

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

Localize command:

Ever had to send a circuit to a colleague and had trouble sending the necessary files? Well there's an easy way to do it using the Localize command.

First some background: When you select an analysis, Micro-Cap accesses electrical modeling information for any parts in the circuit that require models. How does it do this? It searches for the modeling information (model parameter lists, model statements, subcircuits, or macro statements) in the following order:

Local Search within the circuit:

- In the grid text or text area
- In the file named in the File attribute (if the device has one).
- In one or more files named in a .LIB filename statement.
- In any files named in the NOM.LIB of the folder specified for the last used LIBRARY path.
- In any files named in the NOM.LIB statement found in any path from a .PATH LIBRARY command within the circuit.

Global Search using library paths:

• In any files named in the NOM.LIB statement found in any path from File menu / Paths / Model Library and Include Files. If more than one path is specified, it searches them in left to right order. For example, consider this path:

C:\Micro-Cap\LIBRARY ; D:\OTHER ; E:\ELSEWHERE

In this example, the search starts in C:\Micro-Cap\LIBRARY, then proceeds to D:\OTHER. Finally E:\ELSEWHERE is searched.

Because Micro-Cap first searches locally in the circuit, you can use the Localize command to place the needed model data within the circuit making it easier to send the circuit in a single file to your colleague.

Exporting Data to Excel

Have you ever needed to export a Micro-Cap generated waveform or curve data to Excel? How is it done? Well it's pretty easy, but there are a few steps to making it so. Here are the basic steps:

1) Setup the numeric output options to export the waveform or curve data.
2) Run the analysis.
3) Run Excel and use the Data / Get External Data / Import Text File option.

These are the basic steps, but there are details to be seen to. Here's an test circuit to work with:

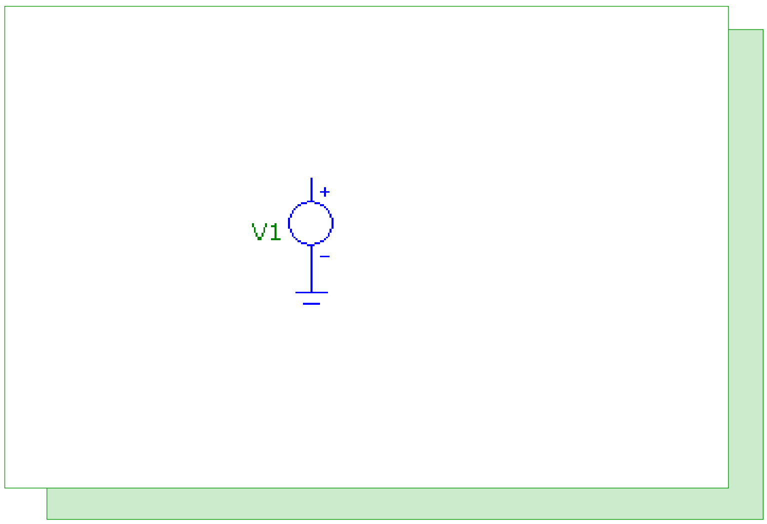


Fig. 1 - The test circuit

This circuit simply creates a waveform for us to import into Excel. The first step requires that we select transient analysis and then set up the numeric output using the Analysis Limits options:

Make this icon green to print the waveform to the numeric output file.

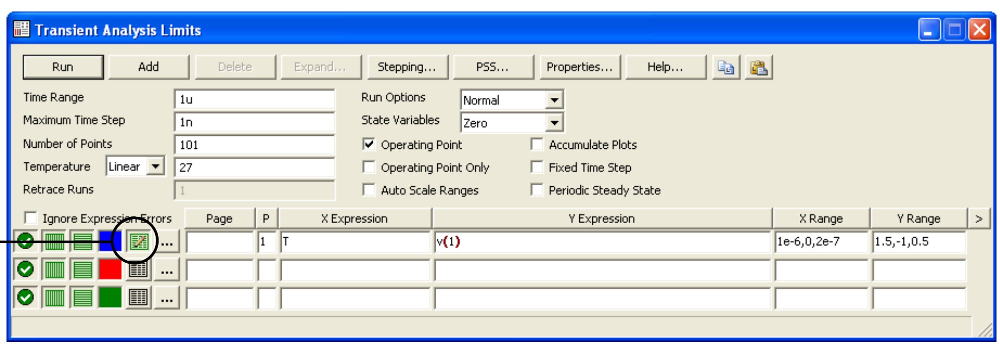


Fig. 2 - Enabling numeric output for a waveform

This will print the V(1) waveform to the numeric output file. To simplify the transfer to Excel a few more steps are helpful.

Press F10 to see the Transient Analysis Properties page and click on the Numeric Output tab. It should look like the next figure.

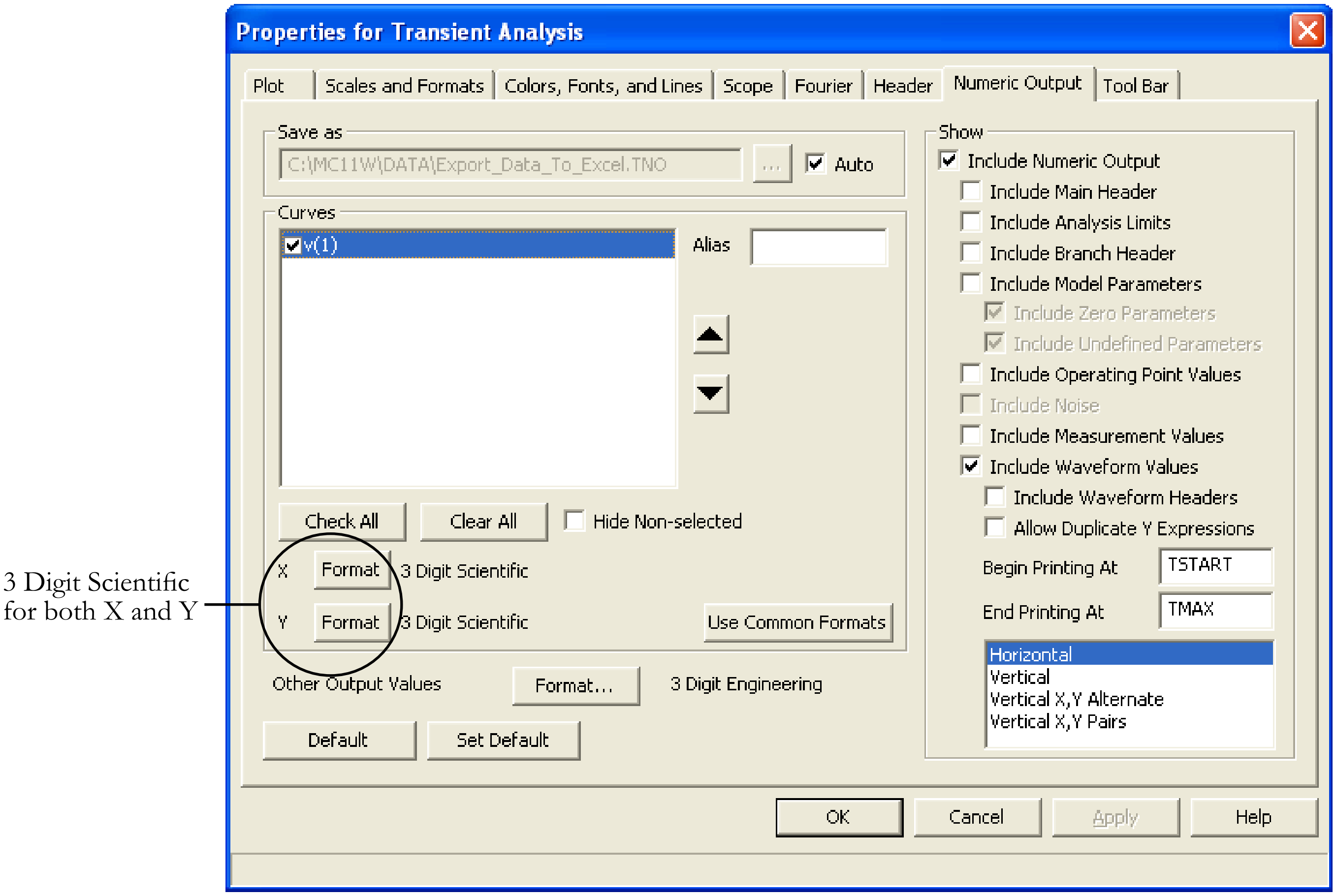


Fig. 3 - The Properties / Numeric Output page

On the left, we have selected 3 Digit Scientific format for both X and Y values because Excel doesn't understand the default engineering notation. On the right, we have disabled all numeric output normally printed and retained only the waveform values. Technically this is not necessary, but it will make it easier to import to Excel if the only thing in the file is the tabular waveform data. Press F2 to run the transient analysis. It should look like this:

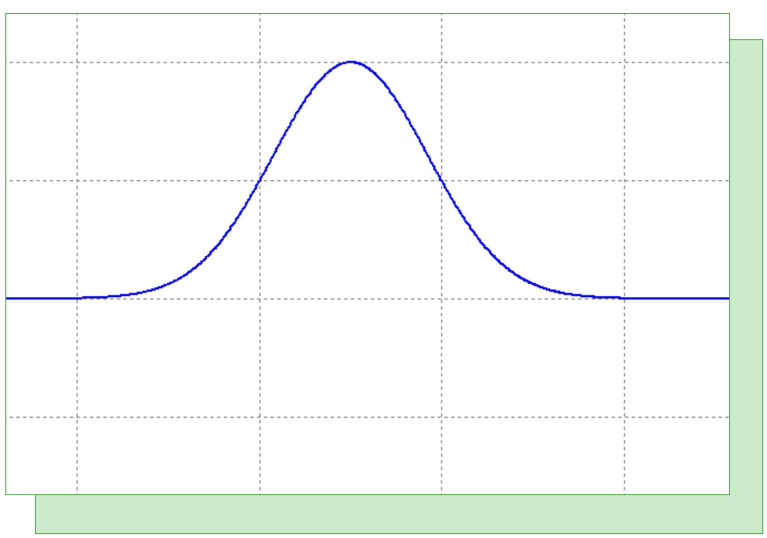


Fig. 4 - The waveform

Now press F5 to see the numeric output text file. It's name is Export_Data_To_Excel.tno and it looks like this:

```
0.000E+00    2.975E-08
1.000E-08    5.909E-08
2.000E-08    1.157E-07
3.000E-08    2.236E-07
4.000E-08    4.261E-07
5.000E-08    8.007E-07
6.000E-08    1.484E-06
7.000E-08    2.712E-06
8.000E-08    4.889E-06
9.000E-08    8.692E-06
1.000E-07    1.524E-05
1.100E-07    2.635E-05
1.200E-07    4.494E-05
1.300E-07    7.559E-05
1.400E-07    1.254E-04
1.500E-07    2.051E-04
1.600E-07    3.309E-04
1.700E-07    5.265E-04
1.800E-07    8.263E-04
1.900E-07    1.279E-03
2.000E-07    1.952E-03
2.100E-07    2.938E-03
2.200E-07    4.362E-03
2.300E-07    6.386E-03
2.400E-07    9.222E-03
2.500E-07    1.313E-02
2.600E-07    1.844E-02
2.700E-07    2.555E-02
2.800E-07    3.490E-02
2.900E-07    4.702E-02
3.000E-07    6.248E-02
3.100E-07    8.188E-02
3.200E-07    1.058E-01
3.300E-07    1.349E-01
3.400E-07    1.695E-01
3.500E-07    2.102E-01
3.600E-07    2.570E-01
3.700E-07    3.099E-01
3.800E-07    3.685E-01
3.900E-07    4.322E-01
```

Fig. 5 - Portion of the numeric output file Export_Data_To_Excel.tno

Here we show only a portion of the 101 waveform values. The first column is time and the second column is the V(1) values for the time. The usual text name headers have been removed by our choice of options.

Now run Excel and select from the Data menu Get External Data / Import Text File. That will bring up the File Open dialog box. Navigate to your data folder and open the file

Export_Data_To_Excel.tno

The screen should look like this:

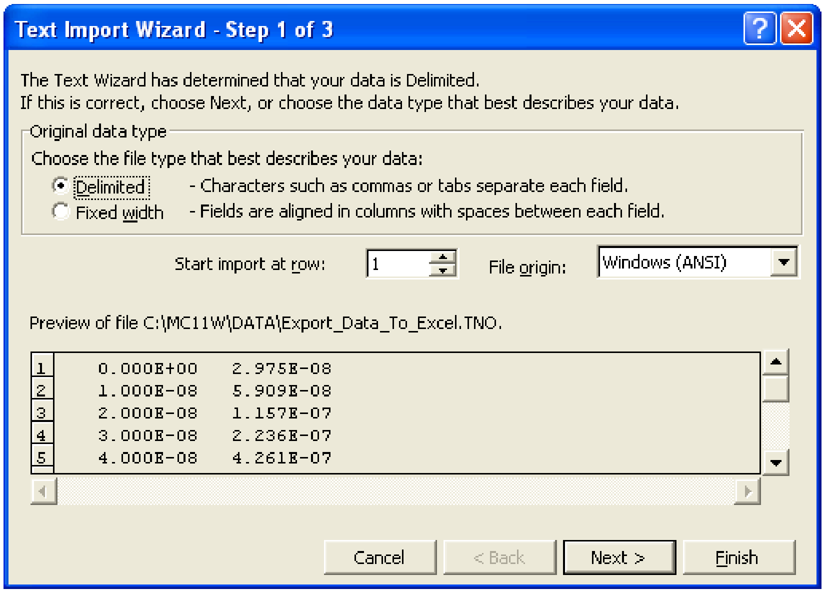


Fig. 6 - The first Excel Wizard page

This page lets you make certain choices about the data in the text file. Our Micro-Cap options have created a delimited set of data so we want to select the Delimited option. Since we have deleted all the other numeric output data we want to start the import at row 1. Click on the Next button and you see page 2 of the Excel Import Wizard. It looks like this:

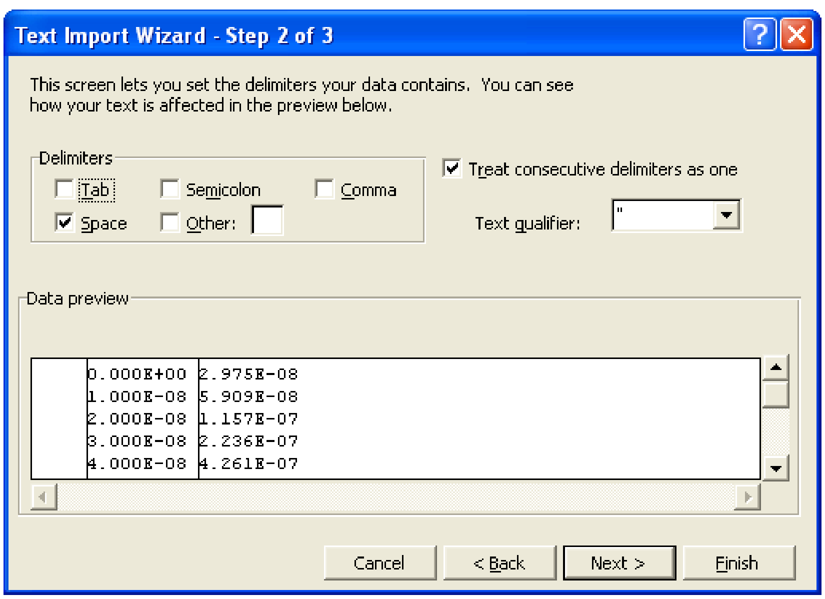


Fig. 7 - The second Excel Wizard page

This screen lets you select the delimiter used to separate the numeric columns. Micro-Cap can use any of several delimiters, including tab, semicolon, comma, space and other. The choice is made on the Micro-Cap Transient Analysis Properties page / Header tab. In our case we've opted to use the Micro-Cap default which is the space character, so we need to select the Space delimiter in the Excel page. Click on the Next button and you see page 3 of the Excel Import Wizard. It looks like this:

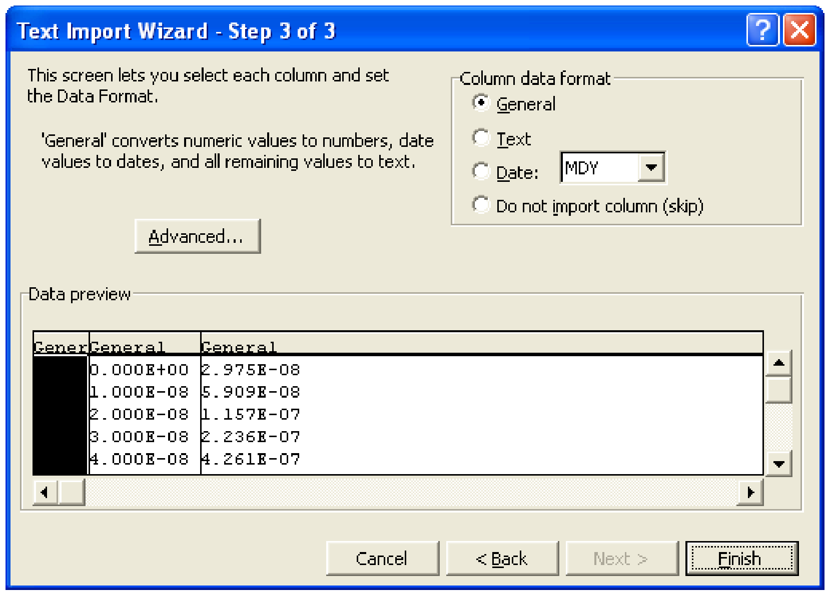


Fig. 8 - The third Excel Wizard page

This page lets you tell Excel how to translate the data. Since the data is in standard numeric format we need only click the Finish button.

The last page merely wants to confirm where to place the data. It looks like this:

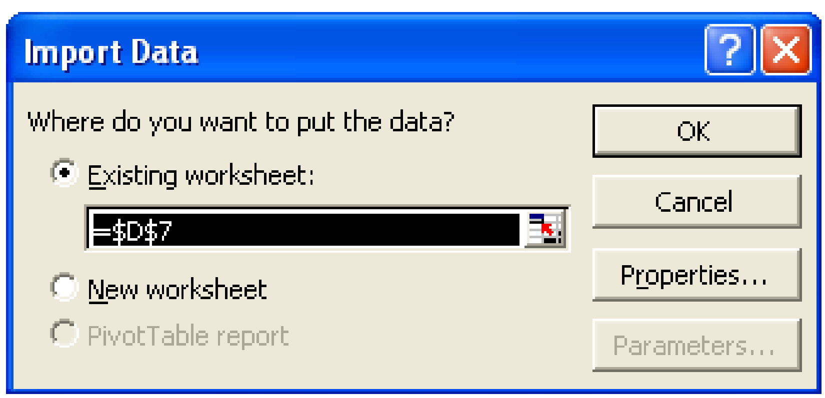
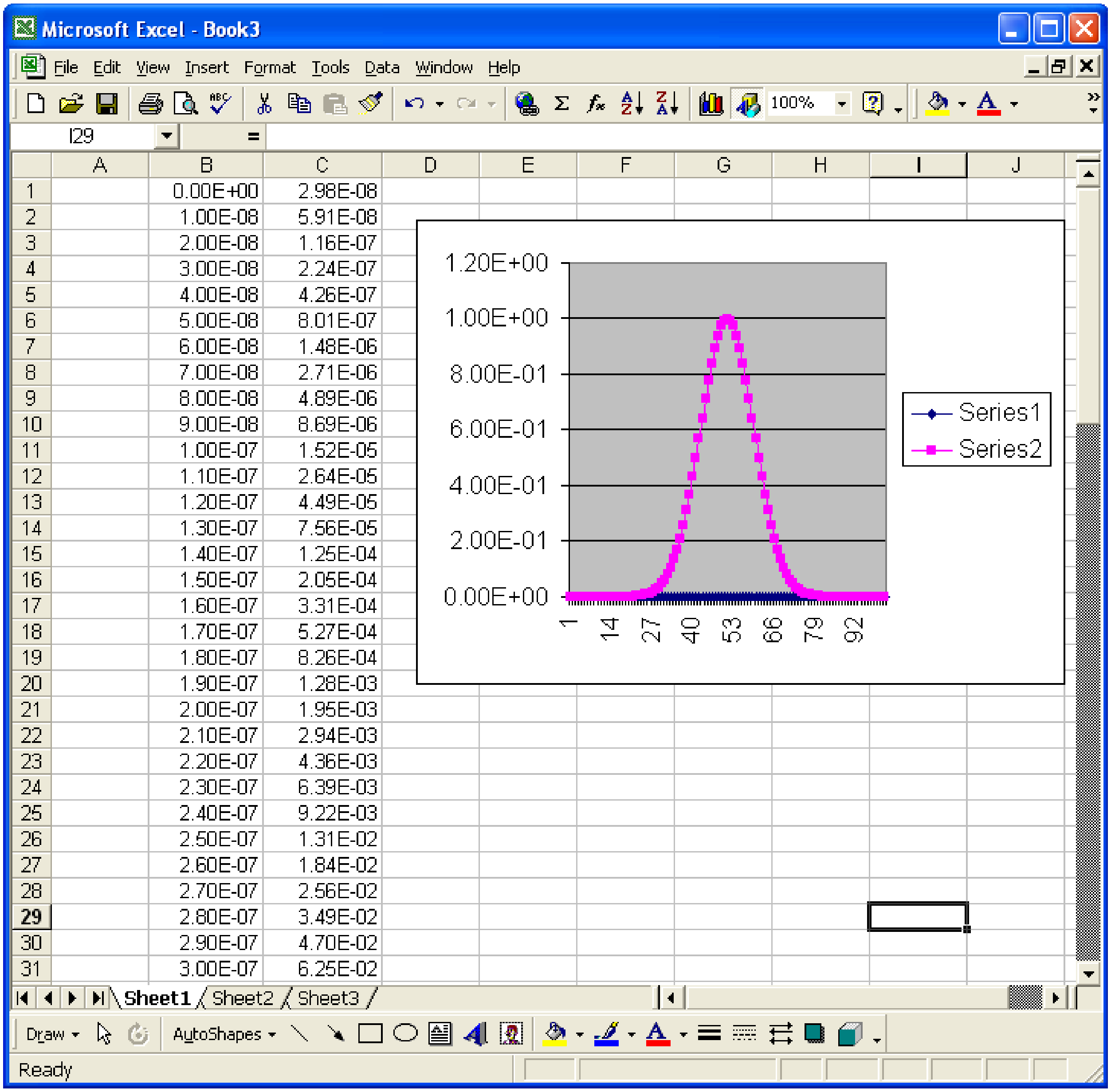


Fig. 9 - Starting cell for the imported data

The location is specified in Excel row and column notation and is the first cell to the right of the last cell you clicked on.

Click on the OK button and Excel imports the data. In our case it looks like this next figure.



	A	B	C
1		0.00E+00	2.98E-08
2		1.00E-08	5.91E-08
3		2.00E-08	1.16E-07
4		3.00E-08	2.24E-07
5		4.00E-08	4.26E-07
6		5.00E-08	8.01E-07
7		6.00E-08	1.48E-06
8		7.00E-08	2.71E-06
9		8.00E-08	4.89E-06
10		9.00E-08	8.69E-06
11		1.00E-07	1.52E-05
12		1.10E-07	2.64E-05
13		1.20E-07	4.49E-05
14		1.30E-07	7.56E-05
15		1.40E-07	1.25E-04
16		1.50E-07	2.05E-04
17		1.60E-07	3.31E-04
18		1.70E-07	5.27E-04
19		1.80E-07	8.26E-04
20		1.90E-07	1.28E-03
21		2.00E-07	1.95E-03
22		2.10E-07	2.94E-03
23		2.20E-07	4.36E-03
24		2.30E-07	6.39E-03
25		2.40E-07	9.22E-03
26		2.50E-07	1.31E-02
27		2.60E-07	1.84E-02
28		2.70E-07	2.56E-02
29		2.80E-07	3.49E-02
30		2.90E-07	4.70E-02
31		3.00E-07	6.25E-02

Fig. 8 - Excel sheet after importing showing its plot.

This shows what the Excel display should look like along with an Excel plot to show that the plotted waveform matches original the Micro-Cap waveform.

DC Stepper Motor Model

Here is a new model for Micro-Cap, the DC stepper motor. It is based on a model created by Dave Wilson, currently at TI. For more information, see http://e2e.ti.com/support/applications/motor_drivers/f/38/t/283566.aspx

This model handles detent torque and back EMF. It does not consider eddy current losses. To accurately simulate eddy current losses would require at least a rudimentary finite element analysis of the motor structure. This model does not consider such nonlinearlities. It is a linear, parametric model that produces reasonably faithful results. Note that the model internalizes a constant viscous friction load and a physical angular stop.

Here is what the model looks like:

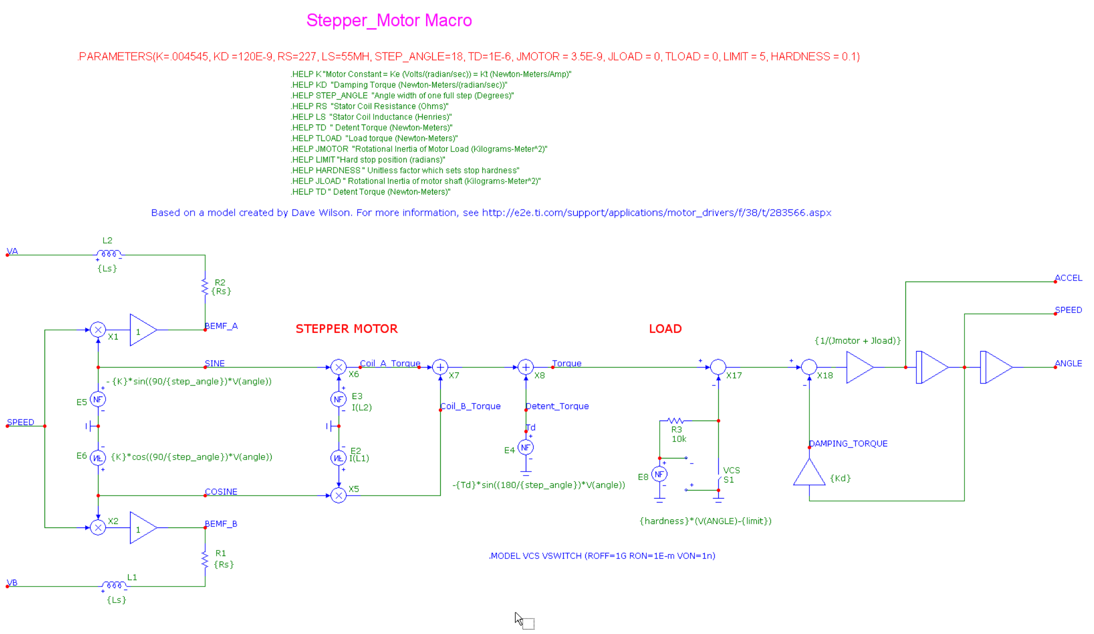


Fig. 9 - The DC Stepper motor macro

The model includes these parameters:

K	Motor Constant = Ke (Volts/(radian/sec)) = Kt (Newton-Meters/Amp)
KD	Damping Torque (Newton-Meters/(radian/sec))
STEP_ANGLE	Angle width of one full step (Degrees)
RS	Stator Coil Resistance (Ohms)
LS	Stator Coil Inductance (Henries)
TD	Detent Torque (Newton-Meters)
TLOAD	Load torque (Newton-Meters)
JMOTOR	Rotational Inertia of Motor Load (Kilograms-Meter^2)
LIMIT	Hard stop position (radians)
HARDNESS	Unitless factor which sets stop hardness
JLOAD	Rotational Inertia of motor shaft (Kilograms-Meter^2)
TD	Detent Torque (Newton-Meters)

How does it work? Well you can drive a stepper motor in a variety of ways. Here is one way using non-overlapping pulses.

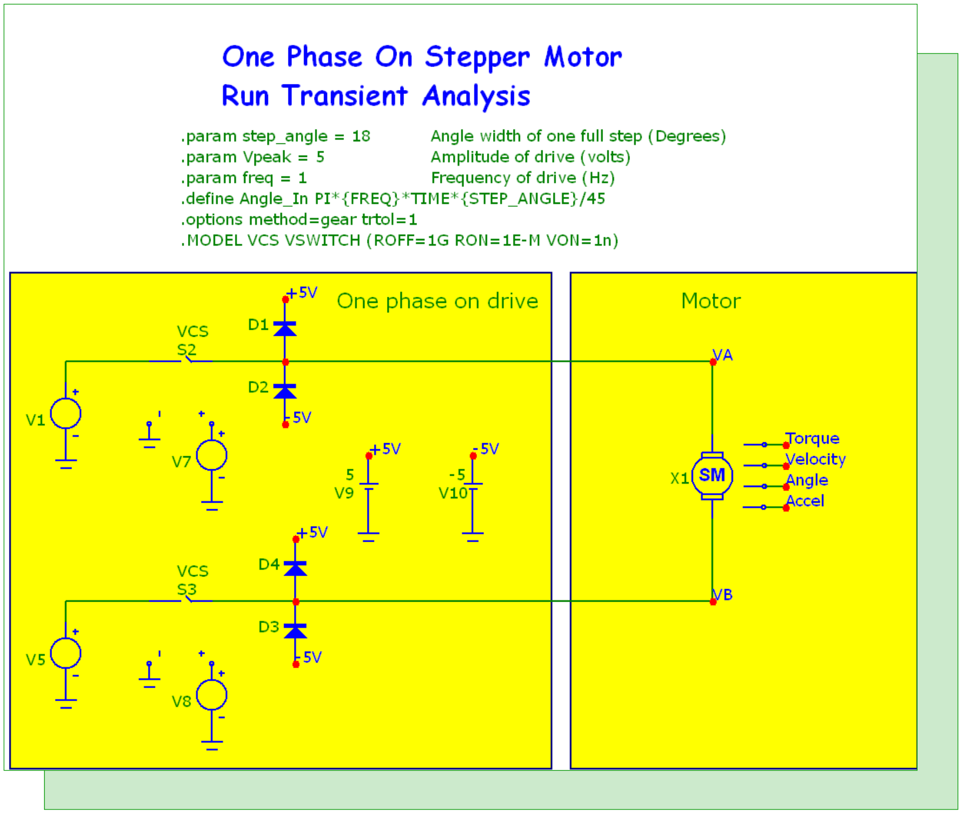
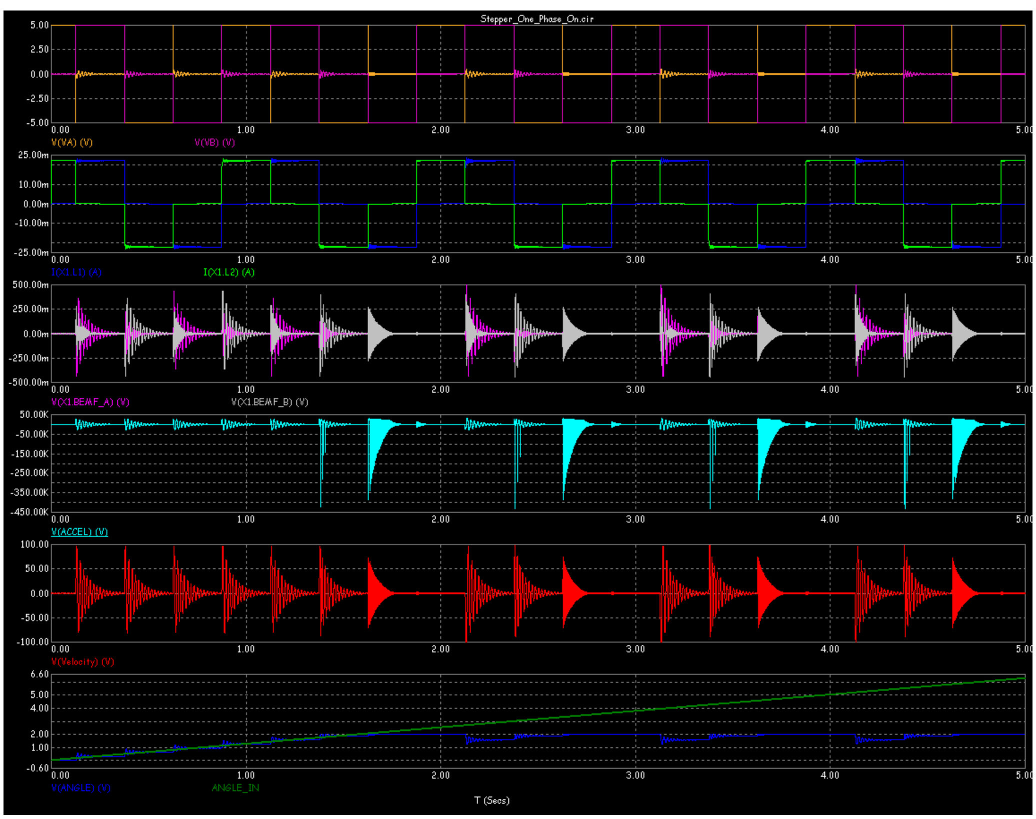


Fig. 10 - A one phase on drive of the stepper motor

Here is what the waveforms look like:



Here we've plotted the voltage at VA and VB, which consist of two non-overlapping pulses. Next we've plotted the armature currents flowing from the generators. Since the current values are not brought out to pins, you must plot them by referring to the motor's name (X1) like this:

I(X1.L1)
I(X1.L2)

where X1 is the proper name for the motor macro. In your circuit it may be different.

Similarly, we've plotted the back emf of the A and B coils this way:

V(X1.BEMF_A)
V(X1.BEMF_B)

The last three plots show the acceleration (radians/sec/sec), the velocity (in radians/sec), and finally the angle (in radians). The angle increases until it hits the LIMIT parameter value, which in this case is 2 radians.

Note that the model has two input pins, one for each phase. It has four outputs: Torque, Velocity, Angle, and Accel (Acceleration). The outputs have been labelled with grid text to make it easy to identify the plots.

Here is another way to drive the motor, using overlapping phases.

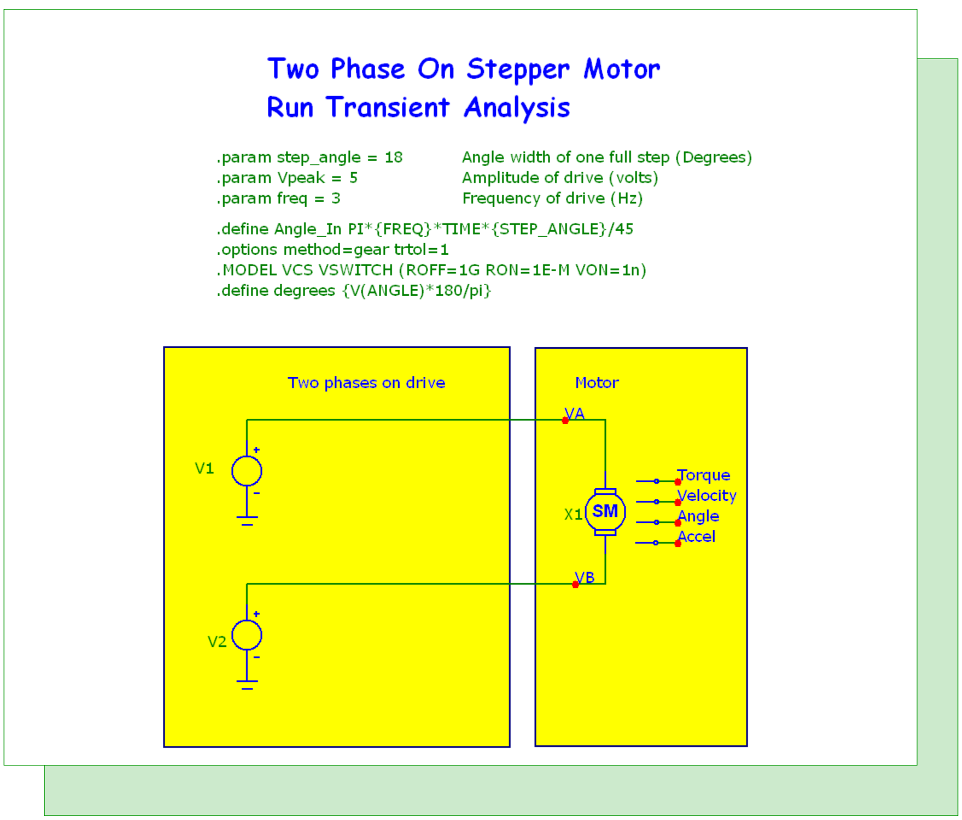


Fig. 12 - A two phase on drive of the stepper motor

Here is its transient analysis.

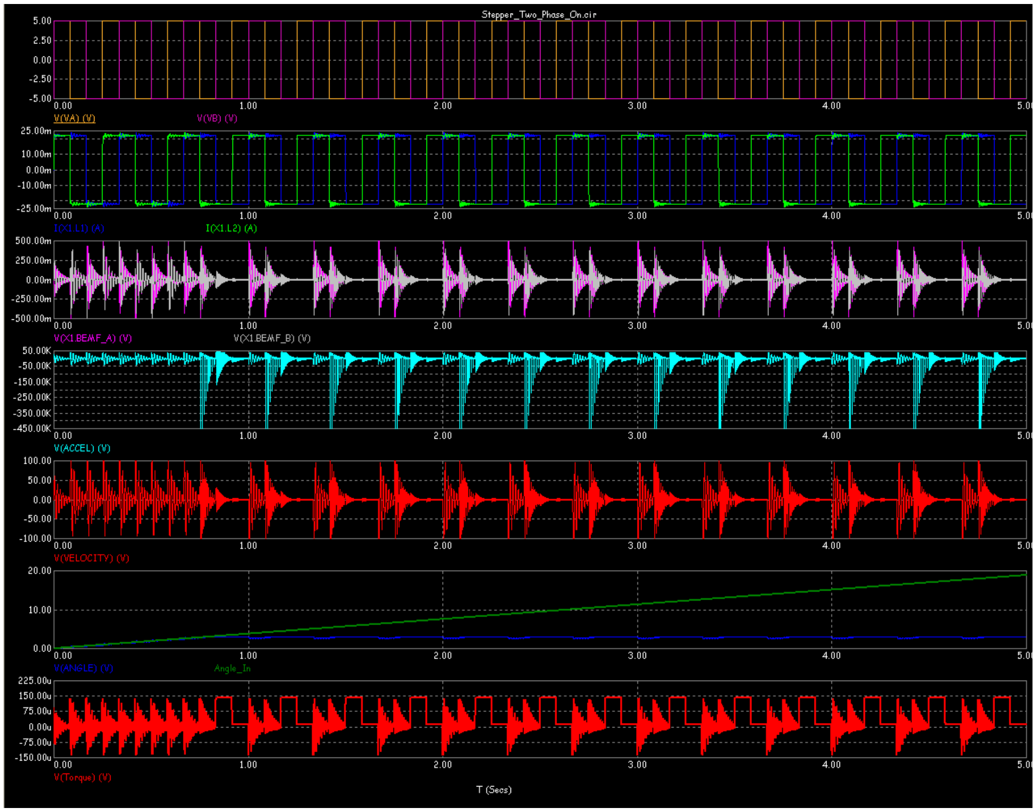


Fig. 13 - Transient analysis with a two phases on drive of the stepper motor

Here we've plotted the voltage at VA and VB, which consist of two overlapping pulses. Next we've plotted the armature currents flowing from the generators. As in the last circuit, the current values are not brought out to pins, so we must plot them by referring to the motor like this:

I(X1.L1)
I(X1.L2)

Similarly, we've plotted the back emf of the A and B coils this way:

V(X1.BEMF_A)
V(X1.BEMF_B)

The last four plots show the acceleration (radians/sec/sec), the velocity (in radians/sec), the angle (in radians) and the Torque (in Newton-meters). The angle increases until it hits the LIMIT parameter value, which in this case is 3 radians.

One of the most efficient ways to drive a stepper motor is called micro-stepping. The next figure shows a micro-stepped motor.

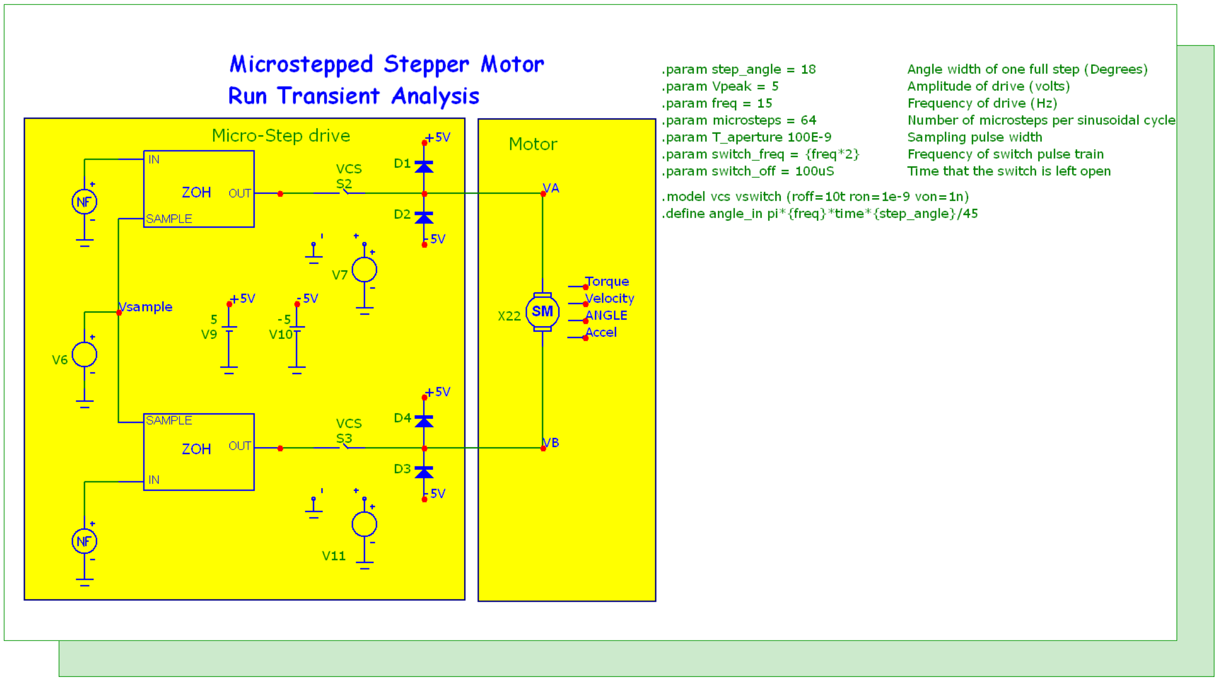


Fig. 14 - A micro-stepped stepper motor

Here is its transient analysis. Note the stepped sine drive waveforms generated by the sine wave NFV sources, the ZOH macros, and the VCS switches.

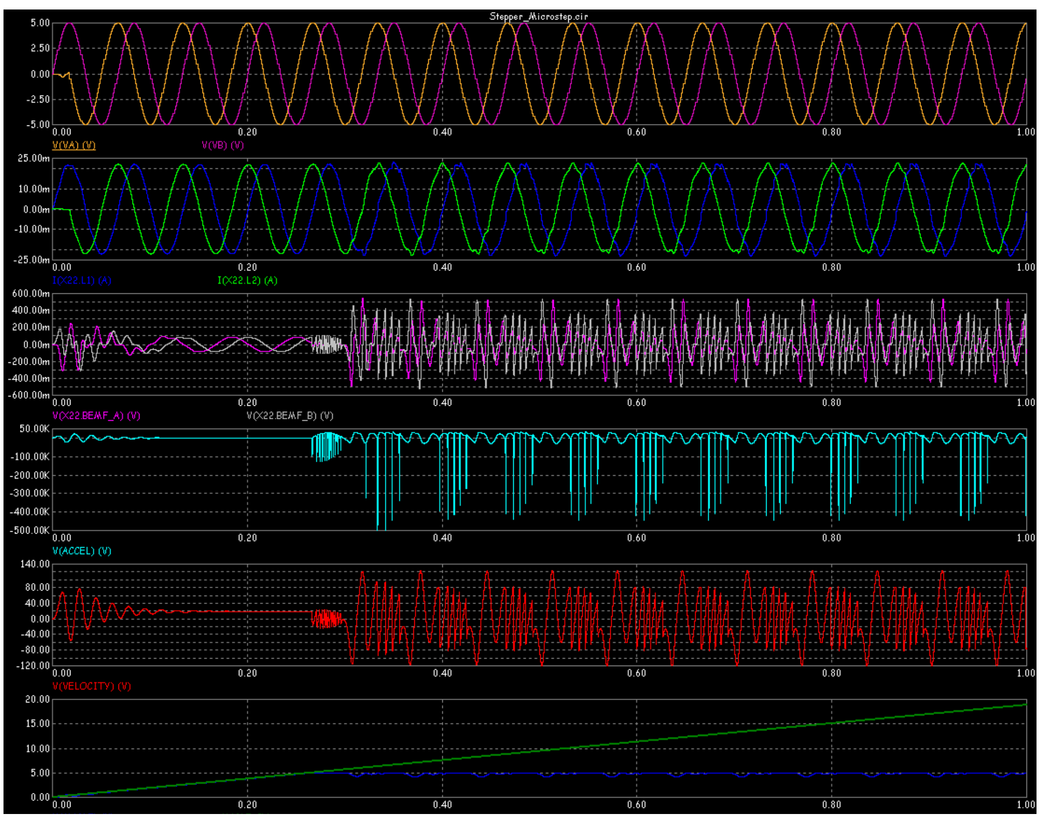


Fig. 15 - Transient analysis of the microstepped drive

AC Induction Motor Model

Here is a new AC induction motor model for Micro-Cap. It is based on a model created by Sohor and Kubov. For more information, see http://valvolodin.narod.ru/articles/Induction3phMotor1.pdf. The signs of BX and BY have been reversed from those in the article.

Here is what the motor model looks like:

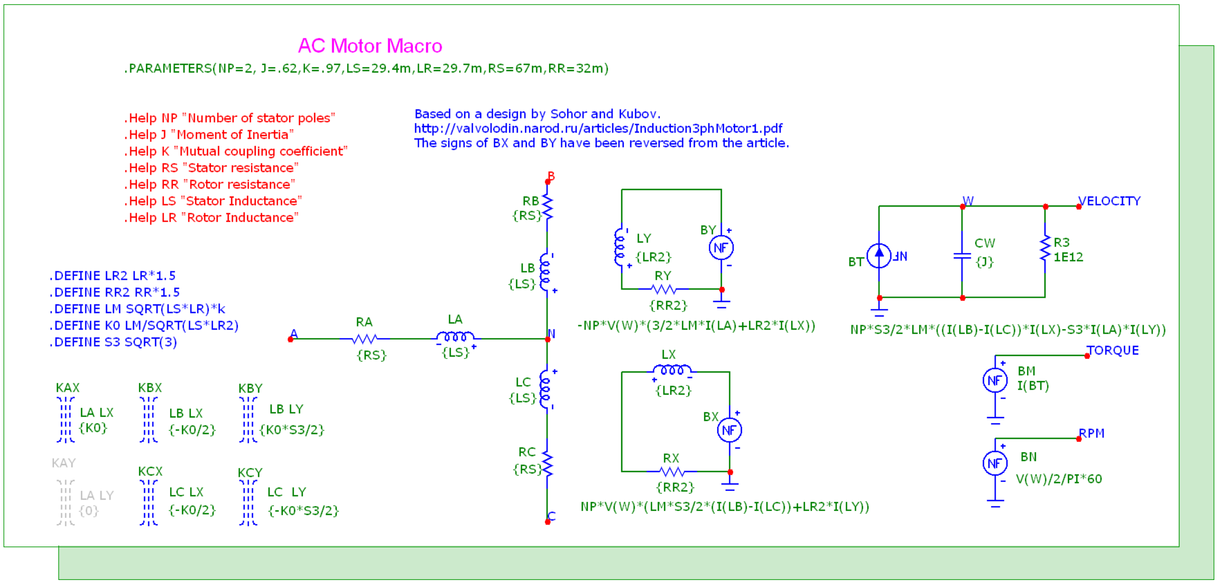


Fig. 16 - AC Induction motor model

The model provides three pins for the input AC drive: A, B, and C. It provides three pins for output: Velocity, Torque, and RPM. The load is attached separately between the Velocity node and ground.

Three types of load are provided: no load, viscous friction, and square law friction. Each of these load types may be attached to the Velocity pin to see how the motor responds. The model currently has no provision for eddy current losses.

The next figure shows a typical test setup.

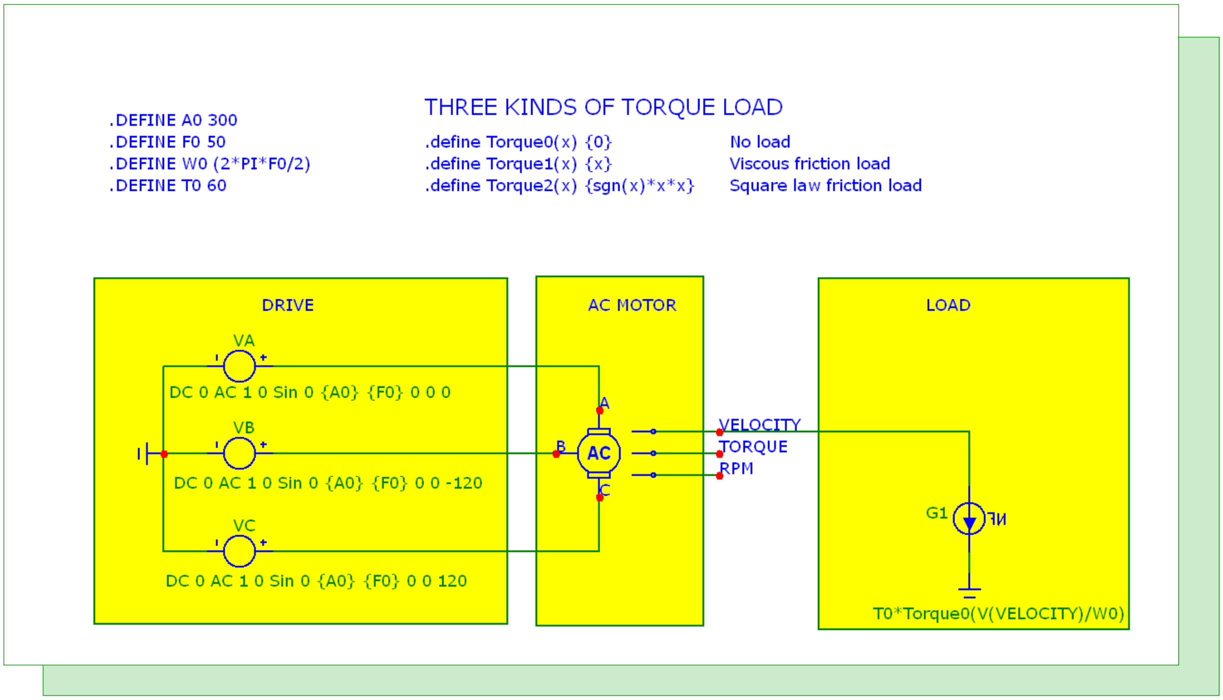


Fig. 17 - AC Induction test circuit

The next figure shows the motor armature current, torque, and RPM waveforms for the Torque0 (no load) condition.

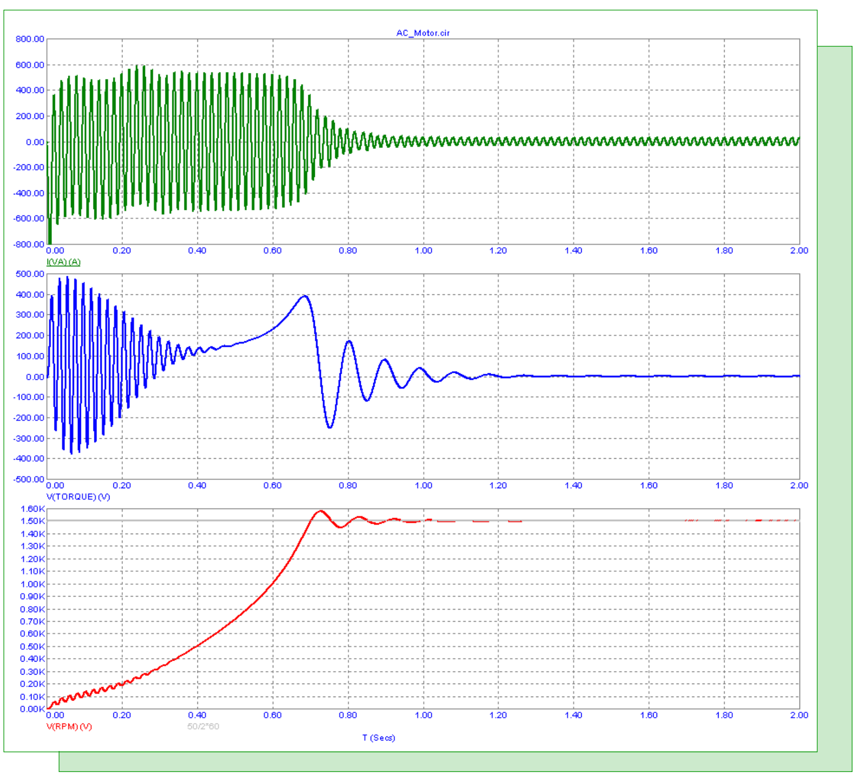


Fig. 18 - AC Induction test circuit waveforms

Here are the response waveforms for the Torque1 (viscous friction) and Torque2 (square law friction) load conditions.

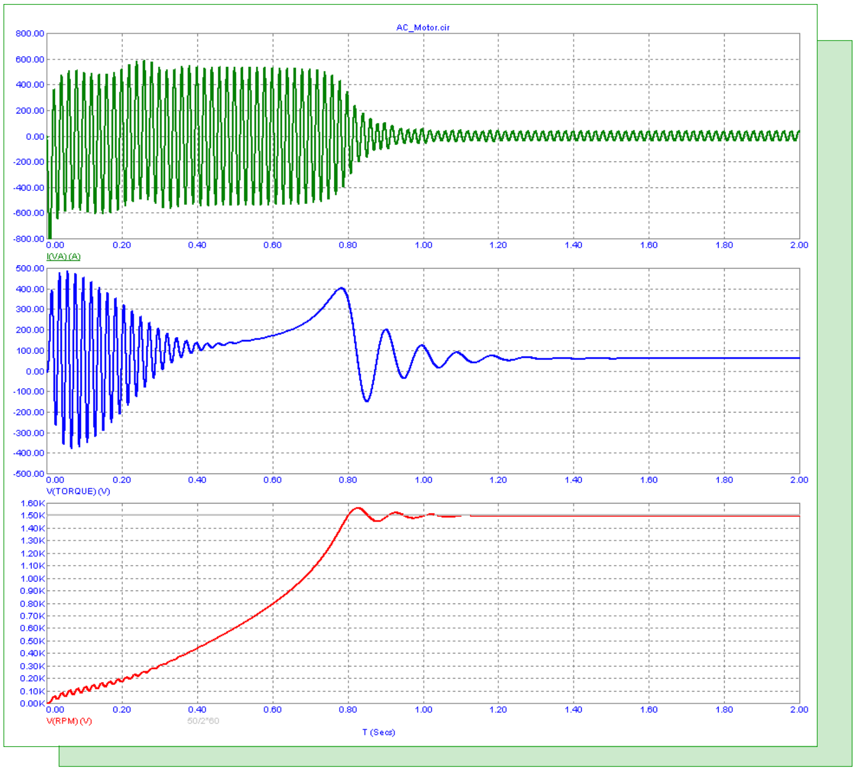


Fig. 19 - AC Induction test circuit waveforms for Torque1

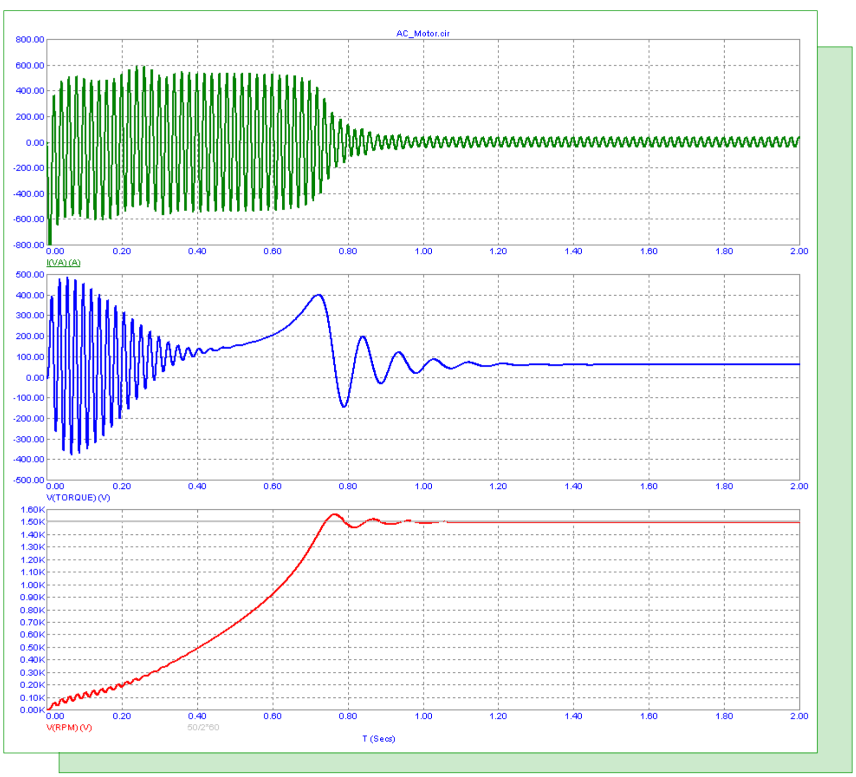


Fig. 20 - AC Induction test circuit waveforms for Torque2

Latest Version numbers

Micro-Cap 11 .... Version 11.0.0.3
Micro-Cap 10 .... Version 10.1.0.2
Micro-Cap 9 .... Version 9.0.9.0
Micro-Cap 8 .... Version 8.1.4.0
Micro-Cap 7 .... Version 7.2.4

Spectrum's numbers

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