KEMET® TECHTOPICS ... THE LEADING EDGE

VOL. 8, NO. 2 • PUBLISHED BY KEMET ELECTRONICS CORP. • P. O. BOX 5928 • GREENVILLE, SC 29606 • (864) 963-6300 • JULY 1998

In the tradition of being the "complete" supplier for our customers, KEMET created a SPICE model available to our customers to help them better decide on the best capacitor solutions for their applications. This model has been modified to make it even more user friendly, and capable of reaching more customers than the old version. The following is a brief description of the added benefits of the new model, and details about its use.

John Moore
Director, Technical Marketing Services

New SPICE© Models

by John Prymak

Mathcad® Models

KEMET's earlier version of the SPICE-like models for surface mount capacitors was introduced in the middle of *1994*. These models are created as computational projections based on many observations and some first-order approximations to simplify the behavior. The bases for these models are explained fully in the earlier Tech Topic (Vol. 4, No. 5, September 1994, "SPICE Models of Capacitors") and in more detail in a CARTS paper published in 1995, "SPICE Modeling of Capacitors."

Because of the complex relationship among temperature, bias voltage, and frequency, we used Mathcad® to perform the mathematics in the computations. It seemed at the time to be the most accessible and available software of this type. The SPICE software available was too varied and too restrictive; we could not create a sub-circuit in one software that would accommodate many.

Invariably, we would run into instances where an engineer did not have access to Mathcad®, and he would have to buy it to have access to our models. Additionally, this software is not easy to get familiar with quickly. We found many instances where the software limited our intended views and the operator interface.

Another limiting feature was the number and size of the models required for each type of tantalum and ceramic capacitor. Creation of multiple models led to an unmanageable library of files.

Windows® Compatible

KEMET has developed a new Windows® version called "KEMET Spice" that eliminates many of these problems. The program, available free of charge, is contained on two diskettes and creates a group in Windows 3.x and a program element in Windows95. By the time this Tech Topic is published, we should have the software available for downloading from our web site (http://www.kemet.com). The diskette version comes with a manual; the web version will require us to mail you a version, or you can access the PDF version of the manual on the Web.

The Models

The ceramic model is still based on the extended RLC model, with allowances for ESR variations with temperature, bias (X7R & Y5V), and frequency. The capacitance dependence on temperature for the X7R and Y5V is also still maintained.

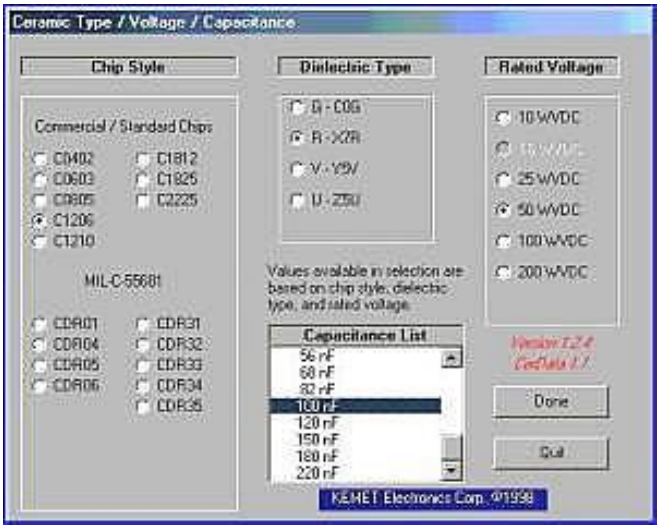
A parallel circuit, composed of a series resistance and capacitance, results in a high frequency parallel resonance. The leakage resistance, another parallel resistance, simulates the insulation resistance effects within the capacitor. For the purpose of these frequency responses, this parallel resistance has a negligible effect.

The tantalum capacitor model is represented as an open ended RC-Ladder, with the total capacitance achieved in five capacitance elements, increasing in value as they increase in the depth of the ladder.

With the tantalum RC-Ladder, the capacitance of each is not affected by voltage or temperature; but, since each ladder element of resistance is affected by temperature, the RC effects vary with temperature. As such, the resultant or summary capacitance and resistance response over frequency, at different temperatures, does also vary.

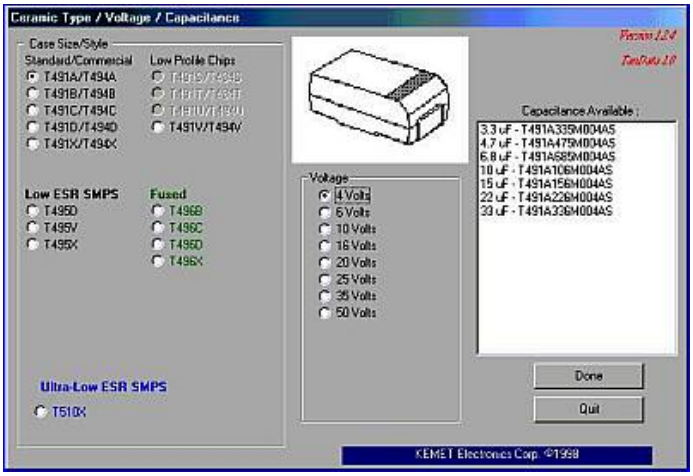
New Models

The new version offers the operator an easy-to-build capacitor entry for both the ceramic and tantalum capacitors. In the case of the ceramic, the user selects the chip size, then the dielectric type, followed by the desired voltage rating. After these basic elements are selected, the program offers a scrollable list of available capacitance values. The user then selects the desired capacitance, and the program continues.



The tantalum types have fewer selection criteria because there is no need to select a dielectric. The user selects, in any order: the style, the voltage, and the capacitance. Once this is done, the program continues.

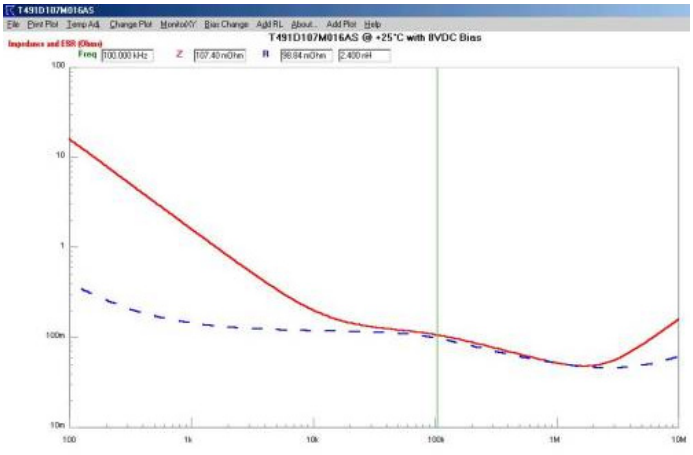
The program proceeds from the part type build screens to a display of the proper KEMET part number. The part number allows the operator to change the tolerance for both ceramic and tantalum. With the ceramic, there is an option to create the part type as a military, and when doing so, the part number screen allows for variations in tolerance, reliability, and terminations.



Graph Results

After the part number display, the program proceeds to the graphical display of the impedance and ESR versus frequency. The graph appears with a vertical line and arrows that move left or right over the graph and allow a display of the frequency, impedance, and ESR at any single frequency step.

From this screen, the operator can choose from many additional options:



File Menu

From this pulldown menu, the offerings include a menu to save the plotted data in an ASCII format, to run another **(^A),** or to quit the program **(^X).** The control-key **(^)** functions allow quick keypad access to certain functions.

Print Plot

This menu offers the choice of printing the impedance and ESR versus frequency (F2), the capacitance and ESL versus frequency (F3), the maximum current and voltage versus frequency (F4), or all three of these possible graph variations **(^P).** The function keys also activate the single type graphical printouts.

Temp Adjust

This offers standard temperature variations as well as any custom temperature entry. For the X7R and C0G ceramics, the standard high temperature **(^H)** is +125°C, room temperature **(^R)** of +25°C, and a low temperature of -55°C. The extreme temperatures vary for the Y5V dielectric as well as the tantalum capacitors. Temperatures outside the "normal" range will warn the operator of this or warn of required derating (tantalum).

Change Plot

Here the operator selects the graph type among impedance and ESR **(^Z),** capacitance and inductance **(^C),** and current and voltage **(^I).** Also available here is the frequency range option **(^F).** The range can be changed to any decade steps between 10 Hz and 100 GHz. Data verification beyond 10 GHz is heavily theoretical.

Monitor XY

Allows the frequency and data monitor function to toggled on and off.

Bias Change

The magnitude of the DC bias voltage can be varied here. The offerings include 95%, 75%, 50% and 25% of the rated voltage, as well as 0 VDC and a custom **(^B)** entry.

Add RL

Here the model can include an external series resistance and inductance entry to simulate circuit effects of the trace wiring and vias.

ESL*. Bias*. About...

These two menu items are associated with explanations of certain elements of the program. They may or may not appear, depending on the settings and the type of capacitor.

KEMET SPICE© Model

KEMET is striving to offer to our customers the most universal and accurate models of the capacitor's behavior. The Windows® version has been expanded to include all the ceramic chip offerings from 0402 up to 2225 chip sizes, and the COG, X7R, Z5U, and Y5V dielectrics. The tantalum group now includes the ultra-low ESR T510 chips. KEMET will continue to expand and develop this software as new products are made available. This software is just another way that KEMET is helping our customers make the correct choice for component selection as the electronic industry moves forward into the next millennium.

Mathcad® is registered trademark of MathSoft, Inc.
Windows® is registered trademark of Microsoft Corp.

© KEMET Electronics Corporation