"HOW TO BUILD YOUR OWN TRIODE SPICE MODEL"

by Alex Kenis

This will walk you step-by-step through how to build up tour own triode spice model from the data sheets, and how to test it. There are other methods, but this is how I do it using the resources that I have.

Here is a list of what you need to set up before we can get started:

- A data sheet of a tube with the characteristic curves and capacitances

  http://tdsl.duncanamps.com/tubesearch.php
  http://www.mif.pg.gda.pl/homepages/frank/vs.html

- An image capture program (screenshots are built into XP and OSX)

- A simple, decent image editing program with layers (Photoshop, Graphic, Converter, etc)

- Circuitmaker or some other SPICE simulator

- Andrei Frolov's CurveCaptor program (free... XP, OSX or source code that you can compile on any other OS)

  http://sourceforge.net/project/showfiles.php?group_id=138442

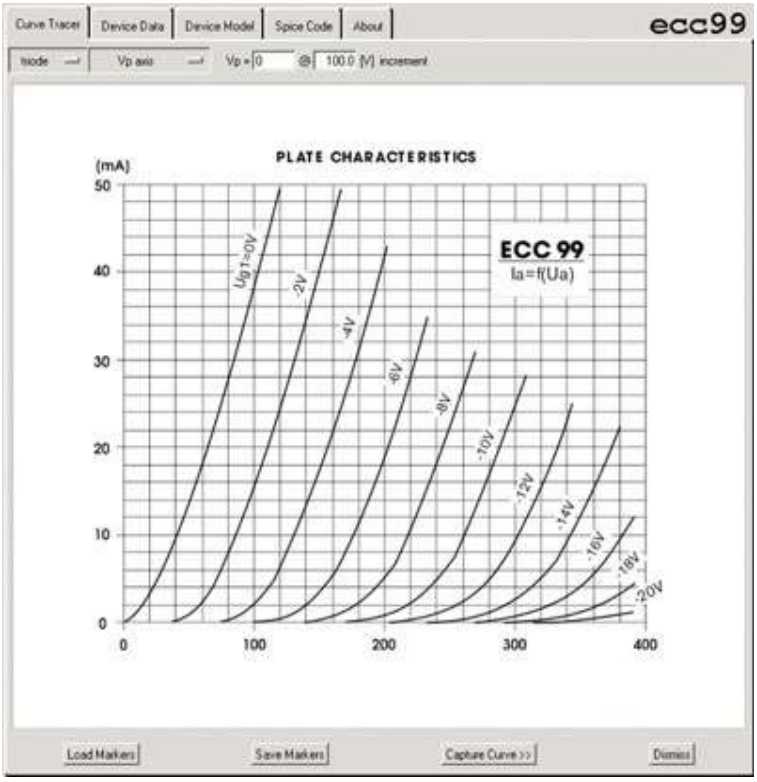
- ActiveState Tcl/Tk (free: OSX, XP, Linux) or another Tcl

  http://www.activestate.com/store/productdetail.aspx?prdGuid= f0cd6399-fefb-466e-ba17-220dcd6f4078

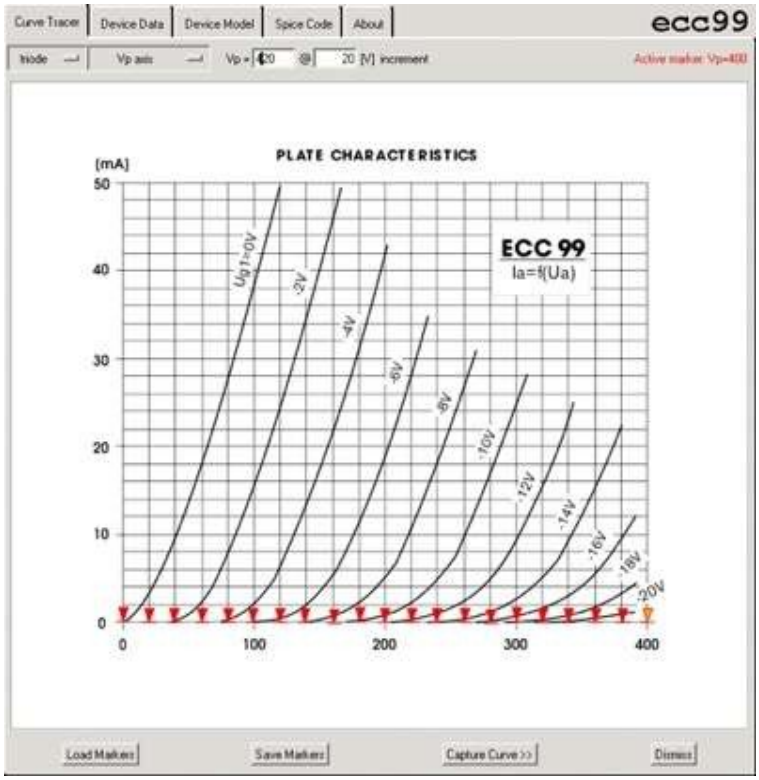
OK, you need to pull up the data sheet and take a screen shot of the characteristic curves.

Take a screenshot of the curves (use GRAB in OSX and push 'cntrl-apple-A' and highlight the area you want to copy) and edit the image to about 800x600 size or so. Or copy the data sheet to an image editor and crop the selection to the curves. I am not going to walk through how to use image editors, but if you are running OSX, Imagewell (http://xtralean.com/download/imagewell.dmg) will let you paste the image from your clipboard and save it in whatever size and image format you want.

Save the image as a gif to your desktop somewhere. Now, open up Curvecaptor. IF you installed Tcl correctly, the icon should look like a little black frog. When you open it, it will ask you to open an image file. Choose the gif that you just made and it should load up in the window.



Now we have to calibrate CruveCaptor to the grid. The program will default to "Vp Axis" first, so set "[V] Incriment" to the small grid lines and place a marker on each. The program will automatically advance data point, but you should look up at the window and make sure you are in the right spot.



Now you click and scroll down on the "Vp Axis" button, and scroll down to "Plate Charactaristics: Ip Axis" and do the same.

index-2.jpg

Congratulations! You have calibrated the chart!

Now go to that same pulldown menu and start on the curves. It will default to the "0" curve, and set the incriament to the spacing. Now put little X's all over the curve. Change the "Vg" box to the next bias point and do the same.

index-3.jpg

Repeat this for every curve. Then click "save markers" and then "Capture Curve". This will bring up a window full of data points. Stare at it for a minute and be happy that you don't have to do any of that by hand, and then click "build model". Now you wil see a set of the curves that you just made over top of the data sheet. If they are not perfect... DON"T WORRY. THey will only be about 1% off and the original curves were traced out from about a dozen data points and a set of french curves... so they are not any more accurate.

Now you pick your flavor of SPICE data... you can pick the Rydel equations, or the Koren equations, or just the simple plain old Child's law equations. Try each and see which ones your sim will support. You can click "redraw" to see how the different equations will fit the data. The Koren equations will fit the curves best, but might freak out your simulator. The Rydel models are close enough under normal operating points, and run very quickly. The Child's law equations are the ones used by the default Circuitmaker stock models... you can see how bad they are.

Now click "See Spice Code" and then pick your flavor of Spice. You can choose 3f4, OrCad, LTSpice, or Circuitmaker formats.

I say this: if you are going to go through all this trouble, copy ALL the different models into a text editor and save them for posterity.

Now we have to put in the interelectrode capacitances. So pull that data sheet back up and find 'em.

index-4.jpg

So we add those into our model:

```
* ecc99 Koren 4-Parameter model

.subckt ecc99 P G K

Bp P K I=(0.04317713444/1.0e3)*uramp(V(P,K)*ln(1.0+exp((7.471978922 )+
(7.471978922)*(23.20455827)*V(G,K)/V(P,K)))/(7.471978922)) ^(1.470223663)

CGK G K 5.8p

CGP G P 5.1p

CPK P K 0.91p

.ends ecc99
```

Now we have to change the model a bit to get Circuitmaker to be happy tieh it. Delete that space between the * and the ecc99, delete the space before the plate equation, and add an "X" before the subcircuit name...and I like to capitalize all the letters as well. I do this with Text Wrangler... one of the best free text editors out there.

```
*JJ-TESLA ECC99 KOREN 4-PARAMETER MODEL

.SUBCKT XECC99-KOREN P G K

BP P K I=(0.04317713444/1.0E3)*URAMP(V(P,K)*LN(1.0+EXP((7.471978922 )+
(7.471978922)*(23.20455827)*V(G,K)/V(P,K)))/(7.471978922)) ^(1.470223663)

CGK G K 5.8P

CGP G P 5.1P

CPK P K 0.91P

.ENDS XECC99-KOREN
```

THERE IT IS! You have a working model... now to test it.

Now we need to see if it works.

Se up Circuitmaker as a virtual curve tracer like this:

index-5.jpg

Match the values with the data sheet, except the "step value" for the primary. That is just the resolution of the test, so set it to whatever you want.

The Vs3 needs to be set to 0 volts. That is just there to flip the curves the right way up when you test it... it took me a while to figure that trick out! Yo will have to screw with the X and Y scaling to get the image to fit properly, but if the model works... you will get this:

index-6.jpg

Test point "A" is a current test point, so move the probe around until it has a little "I" in it, and then click there to produce the curve.

This is optional. The model should be fine, and I won't get too in depth here, but you can take a screen shot of those Circuitmaker curves, and import it into a layer in Photoshop, then delete all the white spaces and lay it over the JJ curves from the data sheet, scaling the images so that the grids are aligned with each other:

index-7.jpg

As you can see, this model is perfect right off the bat. This is the 4-parameter Koren equation model, which is dead-on, but sometimes freaks out Circuitmaker, so I usually build up an identical Rydal 4-parameter model to use when the Koren model fails in a simulation. The raw Rydel models are not usually as accurate, so they will sometimes have to have the parameters tweaked by hand. The Koren model should work the majority of the time though.

So there it is! See... not so bad. It was a royal pain in my butt figuring all this stuff out because I couldn't find any information about it ANYWHERE! But now I pass the info on you you all so that you don't have to go through the agony that I did figuring out Curve Captor, the equations and the test setup in Circuitmaker. I have also tested this out in LTSpice and a few others and you can do it similarly.

I feel that this is a much more accurate method then the old style of copy/pasting excel spreadsheet data points into a generic dummy triode model... and much easier than plotting it all out yourself through trial and error.

I have also tried Curve Captor under XP, OSX and WINE. I can't get the TCL to work properly under WINE, but it works fine in OSX and XP using the pre-compiled binaries. I even compiled Curve Captor from scratch to work under X11 and recompiled it for my computer under OSX and they both worked just fine. I compiled and installed also in OSX under FINK and that worked fine too.

For the purposes of this tutorial, I deleted all of my Curve Captor and TCL software and downloaded, re-installed and started from scratch just to see if there would be any problems, and I had none. If you can't get it to work... um... it is user error (no offense).