Using MMICAD to Compute Cj(0)

by Dennis Mitchell

Often when looking for a varactor diode to do a certain job, the circuit designer turns to the semiconductor manufacturers' catalog of parts. This catalog describes every possible semiconductor that they have made over the years of doing business. As circuit designers, we all hope that they actually make them. But what one quickly finds when looking through the catalogs for varactor diodes is that the junction capacitance is measured at various bias voltages for the different types of diodes. Some lower capacitance diodes are routinely measured at -1.25 volts of bias. Some other abrupt junction diodes are measured at -4 volts.

The question is --- How do you tell one diode from another? Which one will give the best performance when used in MY circuit?

Here MMICAD can help answer some of these questions. By use of MMICAD's **PROC**essor block, one can find Cj(0), the junction capacitance at zero reverse bias voltage which is not usually available in the catalog. By using MMICAD's **PARAM** sweep function, the junction capacitance at any reverse bias can be found; Cj(v). These parameters can also be plotted on MMICAD's graphs by defining them properly within the **OUT** and **GRID** block.

Normalizing all varactor diodes of interest from a manufacturer's catalog so that they all compute Cj(0) or Cj(v) at the same voltage is very useful. This ability has been utilized in MMICAD Application Note 1 to design a linear varactor diode and simulate the results of VCOs.

To compute Cj(v) we solve the following equations which describes a varactor diode.

$$Cj(v) = \frac{Cj(0)}{(1+V/Vb)^{\Gamma}}$$

The complete MMICAD program is shown below:

```
MODE PARAM
VAR
  Gamma=.47          !abrupt junction silicon
  Vb=.7              !built in potential for Si
  V=4                !reverse bias voltage
  Cvar=1.0           !cap at bias voltage

PROC
  CjO=Cvar*(1+V/Vb)^Gamma
  Cjv=CjO/(1+param/Vb)^Gamma

PARAM
  Sweep 0 20 .2

OUT
  OUTVAR MAG[CJO] gr1
  OUTVAR MAG[Cjv] gr1
GRID
  gr1 0 16 0 4
LABEL
  Cj4=1.0 C1=Si C2=GaAs w/ gam=1.0
```

When this program is run it will compute Cj(O) for any given Cj and V input variables and plot Cj(v) over 0 to 20 volts in 2 volt steps. Two different varactor diodes can be compared by comparing individual plots of each or any, adding the appropriate code to plot both curves at once on the same grid. This would allow a direct comparison of a Silicon and GaAs constant gamma varactor of a similar capacitance. Figure 1 shows such a comparison.

This data can then be used in a USER DEFINED MODEL describing a varactor diode.

CKT

```
  MODVAR V=4 CjO=1.0
  LOCVAR Vb=.7
  LOCVAR Gamma=.47
  CAP 1 2 C={CjO/(1+Vb)^Gamma}
  DEF2P 1 2 VARAC (V CjO )
```

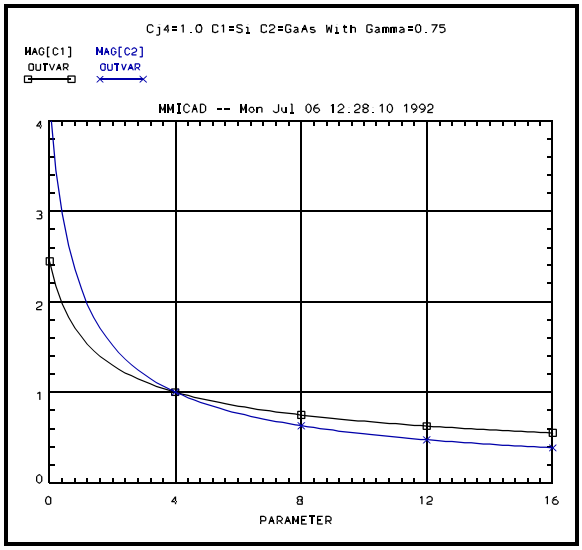

Figure 1

And this model can be saved whenever needed by the **INCLUDE** command.

CKT

```
INCLUDE \MMICAD\MODELS\VARAC.MDL
VARAC 2 0 0 V=PARAM CJO=1.0
```

The MODE PARAM automatically does a parameter sweep from 0 to 20 in steps of .2 volts. This same action could be invoked by using the pull down menu and then doing an 'analyze'. Use of the MODE PARAM is more self-contained and efficient. The use of the PARAM block and **PROC**essor block features of MMICAD makes this a powerful utility.