Reverse bias parameter extraction for the nonlinear diode capacitance.

Reverse bias diode capacitance (Cd) as function of the diode reverse voltage (Vd) is described in SPICE by the following equation.

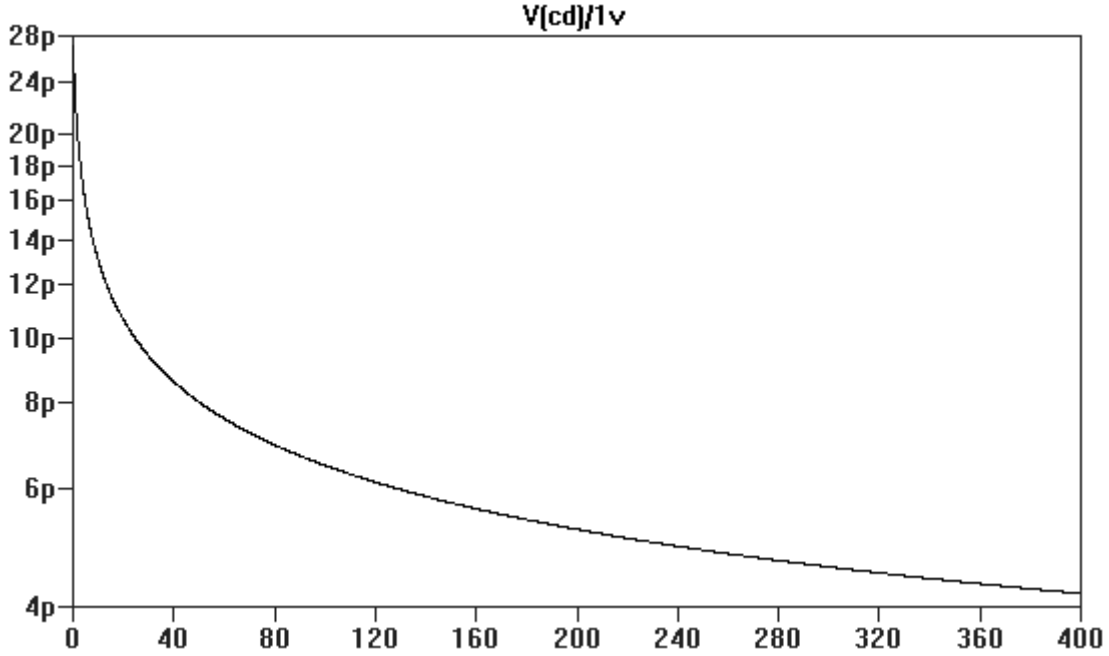
$$Cd = Cjo \times \left(\frac{Vd}{Vj} + 1 \right)^{-m}$$

The parameters that must be found are:

Cjo Diode capacitance at 0V.
Vj Junction potential. Typical value between 0.2 and 1.
m Grading coefficient Typical value between 0.3 and 0.5.

To calculate these parameters analytically we need several capacitance values from the diode capacitance graph.

Typical graph of a diode capacitance:



The parameter Cjo should be easy to find. This is the capacitance value for Vd=0V. Measuring this capacitance accurately (or reading it from a graph) at 0V is not always easy. In practice it's more accurate to measure the diode capacitance at 1V. We also need two more values from the diode's capacitance. One at about 10 or 25V and the lowest value at the highest diode reverse voltage.

Now we have three points that describes the diode capacitance as function of the reverse voltage:

Vd0	->	Cd0	Vd0 = 0-1V
Vd1	->	Cd1	Vd1 = 10-25V
Vd2	->	Cd2	Vd2 = maximum reverse voltage

Now we can at least make two functions but it has three unknown parameters. For one parameter we hopefully can neglect it. For instance, Vj with very high diode voltage, leaving only two unknown parameters: m and Cjo.
So to calculate the m parameter we use Vd1 and Vd2:

$$Cd1 = Cjo \times \left(\frac{Vd1}{Vj} + 1 \right)^{-m} \qquad Cd2 = Cjo \times \left(\frac{Vd2}{Vj} + 1 \right)^{-m}$$

Rewrite the two equations to Cjo=.. and put the two together:

$$\frac{Cd1}{\left(\frac{Vd1}{Vj} + 1 \right)^{-m}} = \frac{Cd2}{\left(\frac{Vd2}{Vj} + 1 \right)^{-m}} \quad \text{->} \quad \left(\frac{Vd2 + Vj}{Vd1 + Vj} \right)^{m} = \frac{Cd1}{Cd2} \qquad (1)$$

Now we can calculate m using Vj=0 since Vj<<Vd:

$$m = \frac{\log(Cd1/Cd2)}{\log(Vd2/Vd1)} \qquad (2)$$

For the parameter Vj we re-use equation (1) and use the first two value pairs so Vd1 becomes Vd0 and Cd1 becomes Cd0. Same for Vd2 and Cd2

$$Vj = \frac{Vd0\left(\frac{Cd0}{Cd1} \right)^{1/m} - Vd1}{1 - \left(\frac{Cd0}{Cd1} \right)^{1/m}} \qquad (3)$$

Now for Cjo it's easy. In case Vd0=0V Cjo = Cd0 else use:

$$Cjo = \frac{Cd0}{\left(\frac{Vd0}{Vj} + 1 \right)^{-m}} \qquad (4)$$

Practical example BYV29

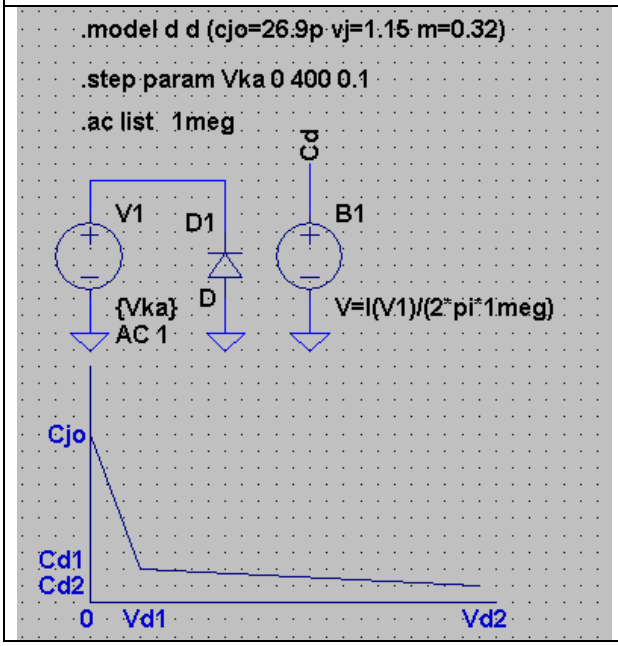
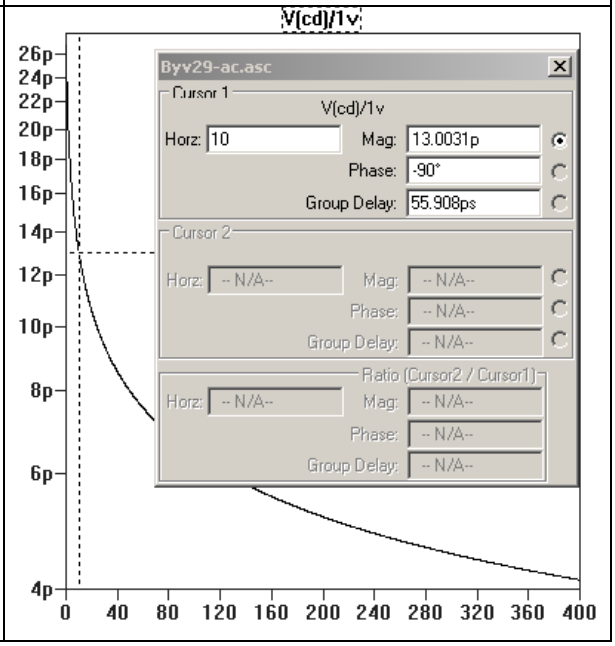
Measure at three reverse diode voltages the diode capacitance:

Reverse bias junction capacitance

Vd (ka)	Cd	
1	22	p
10	13	p
400	4	p

Calculate m, Vj and Cjo using the equations (2), (3) and (4)

m = 0.32
Vj = 1.15
Cjo = 26.9pF

LTSPICE test circuit	Simulation results
	

The simulated diode capacitance matches the three values we have used to calculate the SPICE parameters nicely.

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