

**EXTRACTION OF DEVICE MODEL PARAMETERS via EXCEL and using HEURISTIC CURVE FITS (Ref: Experiment #3x )**

**Measured data from experiment:**  $f_0$  (resonant frequency) vs  $V_{bias}$ .

Measurements (data)			
Vbias	fpeak	fpeak	fpeak
(volts)	(kHz)	(kHz)	(kHz)
	2diodes	3diodes	4diodes
1	35.8	29.5	25.1
2	38.3	31.9	27.4
3	39.9	33.5	29.0
4	41.1	34.8	30.3
5	42.0	35.8	31.3
6	42.8	36.6	32.1
7	43.4	37.4	32.8
8	44.0	38.0	33.5

**Figure 3X-1** Measured data, parts A+B, C and D, respectively

Use the formula  $f_0 = \frac{1}{2\pi} \times \frac{\sqrt{2}}{C_J \sqrt{R_1 R_2}}$  to find Cmeas.

R1		33 k-ohm	
R2		4.7 M-ohm	
sqrt(R1R2/2)		278.5 k-ohm	
1/2pi		0.1592	
Extracted capacitances from DF formula			
Vbias	Cmeas		
	2diodes	3diodes	4diodes
(volts)	(pF)	(pF)	(pF)
1.0	16.24	19.84	23.33
2.0	14.94	17.92	20.85
3.0	14.29	17.11	19.71
4.0	13.92	16.42	18.89
5.0	13.61	16.33	18.44
6.0	13.36	15.60	17.80
7.0	13.16	15.30	17.41
8.0	12.99	15.05	17.21

**Figure 3X-2:** Extraction of Cmeas from data: Parts A&B uses a 2-diode pair, parts C uses a 3-diode pair, and part D uses a 4-diode pair.

Subtract one column from another. Parasitic capacitance  $C_p$  is eliminated and  $C_J$  is left. This gives us  $C_J$  vs  $V_{bias}$ . Listed as M3-M2 (3-diode data – 2-diode data) and M4-M3 (4-diode data – 3-diode data)

CJmeas	
M3-M2	M4-M3
(pF)	(pF)
3.61	3.48
2.98	2.94
2.82	2.60
2.50	2.47
2.72	2.11
2.24	2.20
2.14	2.11
2.06	2.17

**Figure 3X-3:** Extraction of  $C_J$  from data

We now have extracted measured values of  $C_J$  vs  $V_{bias}$ . Compare the data to the formula

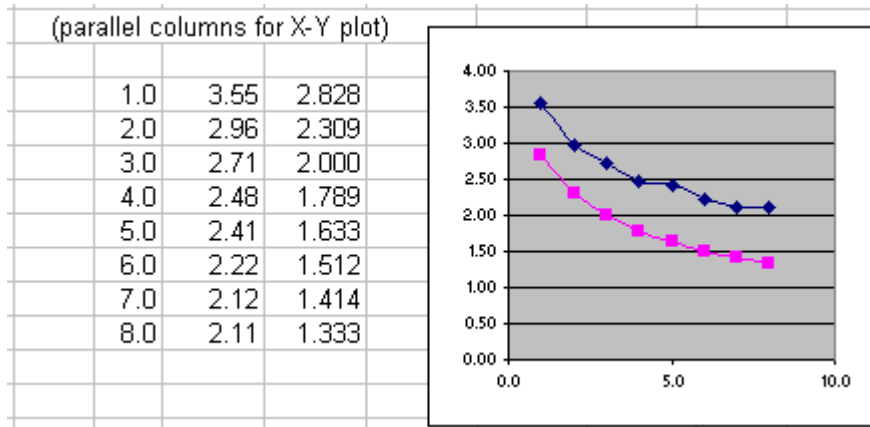
$$C_J = C_{J0} / (1 + V_{Rev} / \phi_0)^{MJ}$$

Of course we have no idea what  $C_{J0}$ ,  $\phi_0$ , and  $MJ$  might be. So we just make some guesses and accordingly plot  $C_J(\text{theory})$  vs  $V_{rev} = V_{bias}$ .

		curvefit guesses	
		Cjo	4 (pF)
		phi0	1 (V)
		MJ	0.5
CJmeas		CJtheory	
M3-M2	M4-M3	Vrev	(pF)
(pF)	(pF)		
3.61	3.48	1.0	2.83
2.98	2.94	2.0	2.31
2.82	2.60	3.0	2
2.50	2.47	4.0	1.79
2.72	2.11	5.0	1.63
2.24	2.20	6.0	1.51
2.14	2.11	7.0	1.41
2.06	2.17	8.0	1.33

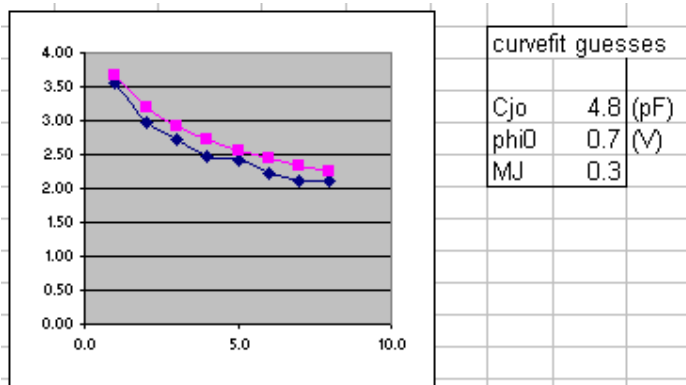
**Figure 3X-4:** Same as figure 3X-3 except columns for theoretical values added. Makes use of educated guesses for the parameters  $C_{J0}$ ,  $\phi_0$ , and  $MJ$ .

Copy data and theory into parallel columns. Necessary for the make of an X-Y plot in Excel.

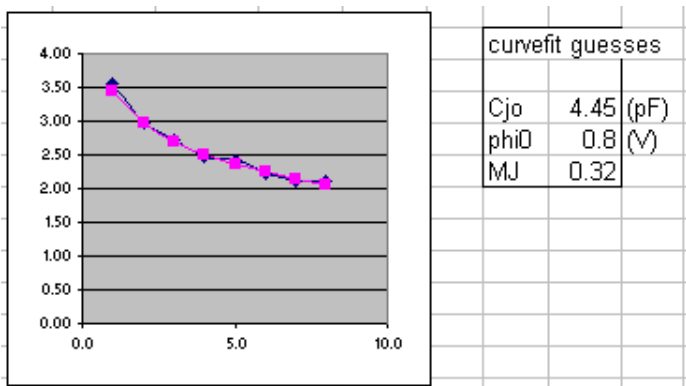


**Figure 3X-5:** Data and theory copied into parallel columns for graphical comparison. The data in this case is the column of averaged value of the two columns of figure #X-3 But not a very good fit.

So we try some new guesses.

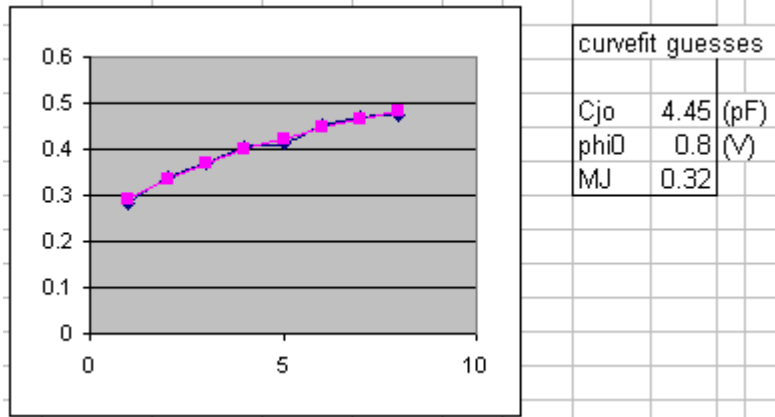


**Figure 3X-6:** Looks better. Still not a very good fit.



**Figure 3X-7a:** Much better. These are reasonably good parameters for defining the diode in reverse bias.

Of course if we had been a little more clever we might have plotted  $1/CJ$ , for which it is much easier to make estimates and decisions.



**Figure 3X-7b:** Plot of  $1/CJ$  (using same parameter values as those used for figure 3X-7a).