Appendix D

Derivation of Approximate Equations for the Clapp Oscillator

The impedance Z_L, can be written as

$$Z_L = \frac{(R_e + jX_e)\left[jX_2 + \dfrac{(1/g_m)(jX_1)}{(1/g_m) + jX_1}\right]}{R_e + jX_e + jX_2 + \dfrac{(1/g_m)(jX_1)}{(1/g_m) + jX_1}}.$$

This can be simplified to

$$Z_L = \frac{(R_e + jX_e)\,[jX_2(1 + jX_1 g_m) + jX_1]}{(R_e + jX_e + jX_2)(1 + jX_1 g_m) + jX_1}.$$

It can be further rearranged to the form

$$Z_L = \frac{(R_e + jX_e)\,[j(X_1 + X_2) - X_1 X_2 g_m]}{R_e - X_e X_1 g_m - X_1 X_2 g_m + j(X_1 + X_2 + X_e) + jR_e X_1 g_m}.$$

If we now assume that

$$g_m X_1 X_2 << X_e, \quad X_1 + X_2 + X_e = 0, \quad \text{and} \quad R_e << X_e,$$

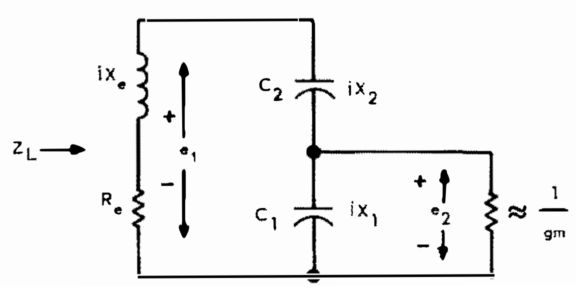

Figure D-1. Clapp oscillator tank circuit: simplified diagram.

then the expression may be simplified to

$$Z_L = \frac{-X_e(X_1 + X_2)}{R_e - g_m X_1 (X_e + X_2)};$$

but since $X_1 + X_2 + X_e = 0$,

$$Z_L = \frac{(X_1 + X_2)^2}{R_e + g_m X_1^2}.$$

The voltage ratio e_2/e_1 may be found to be

$$\frac{e_2}{e_1} = \frac{\dfrac{(1/g_m)(jX_1)}{(1/g_m) + jX_1}}{jX_2 + \dfrac{(1/g_m) jX_1}{(1/g_m) + jX_1}}.$$

This simplifies to

$$\frac{e_2}{e_1} = \frac{X_1}{X_1 + X_2 + jX_1 X_2 g_m}.$$

If we assume that $X_1 + X_2 >> X_1 X_2 g_m$, then the expression simplifies to

$$\frac{e_2}{e_1} \doteq \frac{X_1}{X_1 + X_2}.$$