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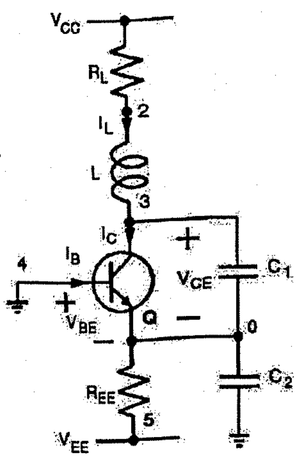
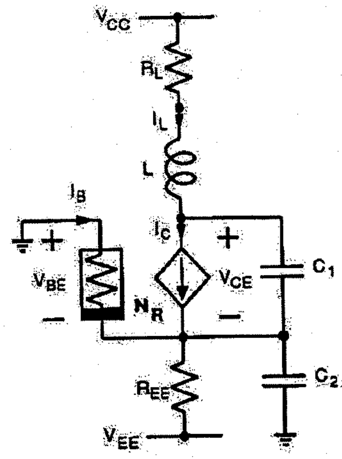
Chaos in the Colpitts Oscillator

Michael Peter Kennedy -- Presented By Aamer Jaleel

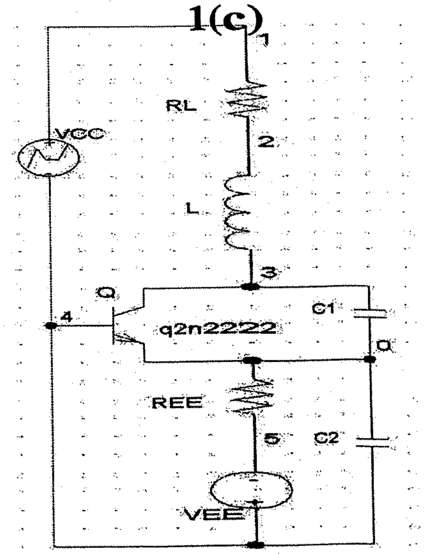
1(a)



1(b)



1(c)



1 Objective:

- Colpitts Oscillator can exhibit chaos
- Chaos is NOT a parasitic effect
- Present a 3rd order autonomous circuit model using a two-segment piecewise-linear resistor

2 Colpitts Oscillator

BJT Circuit 1(a) , Pspice Schematic 1(c)

- BJT biased in active region via V_{EE}, R_{EE}, and V_{CC}.
- Feedback network consists of inductor L with resies resistance R_L, and capacitive divider C_1 and C_2.

Equivalent Circuit

- Assume BJT operates as a purely resistive element
- BJT operates in two regions: forward active and cutoff, oscillator can be modeled using **Figure** 1(b) where **BJT** is modeled as a linear current-controlled current source I_C, and a single voltage-controlled **nonlinear** resistor N_R.

$$I_B = \begin{cases} 0 & \text{if } V_{BE} < V_{TH} \\ \dfrac{V_{BE} - V_{TH}}{R_{ON}} & \text{if } V_{BE} > V_{TH} \end{cases} \qquad I_C = \beta_F \cdot I_B$$

3 Circuit Equations

- Three state variables: $V_{C1}(x_1) = V_{CE}$, $V_{C2}(x_2) = -V_{BE}$, $I_L(x_3)$

$$C_1 \cdot \dot{x}_1 = x_3 - I_C \qquad C_2 \cdot \dot{x}_2 = \frac{V_{EE} + V_{BE}}{R_{EE}} + x_3 - I_B \qquad L \cdot \dot{x}_3 = V_{CC} - x_1 + x_2 - x_3 R_L$$

- Third order circuit model in terms of V_{BE}:

$$A \cdot \dddot{x}_2 + B \cdot \ddot{x}_2 + C \cdot \dot{x}_2 - (\alpha \cdot f(x_2)) = 0$$