Solution 1

- $\omega_{osc} = \frac{\sqrt{6}}{RC} = 2\pi f_0$

  $R = 0.9746 \text{ k}\Omega$

- $K = 29 \frac{R_2}{R_1}$
  $\therefore R_1 > 10 \Omega$

  Let $R_1 = 9.746 \text{ k}\Omega$

  $R_2 = 29 \times R_1$
  $\therefore R_2 = 282.634$
Solution 2

Given $L = 0.33$ H, $C_s = 0.065$ pF, $C_p = 1$ pF, $r = 5.5$ kΩ.

(a) Series resonance frequency:

$$\omega_s = \frac{1}{\sqrt{LC_s}} = 6.83 \text{ Mrads}^{-1}$$

(b) Parallel resonance frequency:

$$\omega_p = \frac{1}{\sqrt{\frac{C_s C_p}{C_s + C_p}}} = 7.05 \text{ Mrads}^{-1}$$

(c) Diagram:

$$\omega_{35C} \cong \omega_s = 6.83 \text{ Mrads}^{-1}$$

$$K = \frac{C_1}{C_2}$$
Solution 3

Note: Analysis available in the oscillators notes, resulting in:

\[
\omega_{\text{osc}} = \frac{1}{\sqrt{L \frac{C_1 C_2}{C_1 + C_2}}}
\]

\[
K = \frac{C_1}{C_2} \Rightarrow \frac{R_2}{R_1}
\]

Given \(f_{\text{osc}} = 1 \text{ MHz}\) and \(C_1 = 4\text{nF}\) & \(C_2 = 1\text{nF}\):

\[
2\pi \times 1\text{MHz} = \frac{1}{\sqrt{L \frac{1\text{n} \times 4\text{n}}{5\text{n}}}}
\]

\[
\therefore L = 31.66 \mu\text{H}
\]

\[
K = \frac{4\text{n}}{1\text{n}} = 4
\]

\[
\therefore R_2 = 4\text{k}\Omega \quad \& \quad R_1 = 1\text{k}\Omega
\]
(a) Given $R = 1\, \text{k}\Omega$ & $C = 1\, \text{pF}$:

For single stage ring oscillator:

$$\frac{V_o}{V_i} = \frac{g_m R}{sRC + 1}$$

Phase shift = $\tan^{-1}(\omega_{osc} RC)$

Since this is a 3 stages ring oscillator:

$$\frac{V_o}{V_i} = \left( \frac{g_m R}{sRC + 1} \right)^3$$

phase shift = $-3 \tan^{-1}(\omega_{osc} RC)$

From the condition of oscillation, phase shift around the closed loop = $2\pi$

$\therefore -3 \tan^{-1}(\omega_{osc} RC) = 2\pi$

$\therefore f_{osc} = \frac{\tan\left(\frac{2\pi}{3}\right)}{2\pi RC} = 275.67 \, \text{MHz}$

(b) To get $g_m$, we can use the loop gain condition:

Loop gain = 1

$$\left| \frac{V_o}{V_i} \right| = \left( \frac{g_m R}{\sqrt{1 + (\omega_{osc} RC)}} \right)^3 = 1$$

$\therefore g_m = 2 \, \text{ms}$
(c)

- $V_{\text{max}}$ is when both transistors of a differential pair are ON:
  
  \[ V_{\text{max}} = V_{\text{DD}} = 2 \, \text{V}. \]

- $V_{\text{min}}$ is when only one MOS transistor is ON and the other is OFF, leading to the total drain current flowing through only one MOS, hence, output voltage would be:

  \[ V_{\text{min}} = V_{\text{DD}} - I_s R = 1 \, \text{V} \]

Solution 5

(see oscillators lecture (2) or oscillators notes pages 27 – 28)