DEVELOPING SMALL ac SIGNAL MODEL

Total voltage and current can be expanded around the Q point as

\[
v_D(t) = V_{DQ} + v_d(t) \\
i_d(t) = I_{DQ} + i_d(t)
\]

We expand \(i_d(t)\) in terms of \(v_d(t)\) around the Q point (Taylor Series Expansion):

\[
i_d(t) = q_1 v_d(t) + q_2 v_d^2(t) + q_3 v_d^3(t) + \ldots
\]

where \(q_n = \frac{1}{n!} \frac{\partial^n}{\partial v_D^n} \bigg|_{V_{DQ}} i_d(t)\). So \(q_1 = \frac{\partial i_d}{\partial v_D} \bigg|_{V_{DQ}}\). 

For sufficiently small peak-to-peak value of \(v_d(t)\):

\[
i_d(t) \approx q_1 v_d(t) \Rightarrow v_d(t) \approx \frac{1}{q_1} i_d(t)
\]

We define \(r_{\delta Q} \Delta \frac{1}{q_1}\). Therefore \(v_d(t) = r_{\delta Q} i_d(t)\).