

Referencing the schematic in post 1160, we can write

$$\frac{v_e - v_o}{R_f} + \frac{v_e}{r_o} + \frac{v_e}{R_g} - g_m \cdot (v_b - v_e) = 0$$

$$i_c = g_m \cdot (v_b - v_e) - \frac{v_e}{r_o}$$

$$v_o = i_c \cdot Z$$

$$\frac{v_e - v_o}{R_f} + \frac{v_e}{r_o} + \frac{v_e}{R_g} - g_m \cdot (v_b - v_e) = 0 \quad \text{implies} \quad v_o = R_f \cdot \left[\frac{v_e}{R_f} - g_m \cdot (v_b - v_e) + \frac{v_e}{R_g} + \frac{v_e}{r_o} \right]$$

$$i_c = g_m \cdot (v_b - v_e) - \frac{v_e}{r_o} \quad \text{and} \quad v_o = i_c \cdot Z \quad \text{implies} \quad v_o = Z \cdot \left[g_m \cdot (v_b - v_e) - \frac{v_e}{r_o} \right]$$

equating the right hand sides of the two expressions for v_o :

$$Z \cdot \left[g_m \cdot (v_b - v_e) - \frac{v_e}{r_o} \right] = R_f \cdot \left[\frac{v_e}{R_f} - g_m \cdot (v_b - v_e) + \frac{v_e}{R_g} + \frac{v_e}{r_o} \right]$$

solving for v_e :

$$v_e = \frac{R_f \cdot g_m \cdot v_b + Z \cdot g_m \cdot v_b}{Z \cdot \left(g_m + \frac{1}{r_o} \right) + R_f \cdot \left(g_m + \frac{1}{R_f} + \frac{1}{R_g} + \frac{1}{r_o} \right)}$$

simplifying:

$$v_e = \frac{1}{1 + \left(\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z} \right) \cdot \frac{1}{g_m}} \cdot v_b$$

current due to transconductance:

$$gm \cdot (v_b - v_e) = gm \cdot \left[v_b - \frac{1}{1 + \left(\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z} \right) \cdot \frac{1}{gm}} \cdot v_b \right] = \frac{\left(\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z} \right)}{1 + \left(\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z} \right) \cdot \frac{1}{gm}} \cdot v_b$$

current due to the Early effect:

$$\frac{v_e}{r_o} = \frac{1}{1 + \left(\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z} \right) \cdot \frac{1}{gm}} \cdot v_b \cdot \frac{1}{r_o}$$

the ratio of these two currents is:

$$\frac{gm \cdot (v_b - v_e)}{\frac{v_e}{r_o}} = \frac{\frac{1}{r_o} + \frac{1 + \frac{R_f}{R_g}}{R_f + Z}}{\frac{1}{r_o}} = 1 + \left(1 + \frac{R_f}{R_g} \right) \cdot \frac{r_o}{R_f + Z}$$

Assume similar transistors produce r_o and Z . At frequencies where Z is resistive, which includes audio frequencies in many CFAs, it is not unreasonable to estimate that $r_o = Z$. Of course, $Z \gg R_f$. And so, the ratio of the two currents is approximately

$$\text{current_ratio} = 2 + \frac{R_f}{R_g}$$

With R_g equal to infinity in the sim from post 1028, this is just about exactly the result I got.

Therefore, especially at low closed loop gains and at frequencies below those at which Z looks at least partially capacitive, current due to the Early effect is a significant portion of the CFA input transistor collector current.

Therefore, the transistor is not acting as a simple transconductor.