Thevenin Eq.

Bias Circuit

\[ I_E = \frac{V_{BB} - V_{BE}}{R_0 + \frac{R_S}{\beta+1}} = \frac{3.33V - 0.7V}{2.1k + \frac{66.7k}{151}} = 1.03mA \]

\[ I_E = \frac{I_E}{\beta+1} = \frac{1.03mA}{151} = 6.85\mu A \]

\[ I_C = \beta I_E = 150(6.85\mu A) = 1.027mA \]

\[ V_E = I_E R_E = 1.03mA(2.1k\Omega) = 2.16V \]

\[ V_B = V_E + 0.7V = 2.16V + 0.7V = 2.86V \]

\[ V_C = V_{CC} - I_C R_C = 10V - 1.027mA(3k) = 6.92V \]

\[ g_m = \frac{I_{CQ}}{V_{TH}} = \frac{1.027mA}{25.9mV} = 39.7 \text{ mS/V} \]

\[ V_{TH} = \frac{V_{TH}}{I_{EQ}} = 3.78k\Omega \quad \left( \frac{V_{TH}}{I_{EQ}} = 25.0 \text{ k} \right) \]
3. DC Operating Points
2. Common Emitter Amplifier

\[ A_V = - \frac{g_m (R_C || R_L)}{1 + \frac{g_m R_E}{k}} = - \frac{(39.7 \text{ mhos}) (3 \text{ kohm} || 20 \text{ kohm})}{1 + \frac{(89.7 \text{ mhos}) (100 \text{ ohm})}{0.993}} \]

\[ A_V = -20.7 \text{ V/V} = 26.3 \text{ dB} \]

\[ R_{in} = R_B \ || (r_i + (\beta_1)R_E) \]

\[ = 66.7 \text{ kohm} || [3.78 \text{ kohm} + 151/100] \]

\[ R_{in} = 14.7 \text{ kohm} = 83.3 \text{ dB} \]

\[ R_{out} = R_C = 3 \text{ kohm} = 69.5 \text{ dB} \]

\[ G_V = \frac{R_{in}}{R_{in} + R_s} \]

\[ A_V = \frac{14.7 \text{ kohm}}{14.7 \text{ kohm} + 50} \]

\[ G_V = -20.6 \text{ V/V} = 26.3 \text{ dB} \]
2. Common Emitter Amplifier

**$A_V$ and $G_V$**

The simulated value of 26.2dB closely matches the hand calculation of 26.3dB for both $A_V$ and $G_V$.

**$R_{in}$**

The simulated $R_{in}$ value of 83.6dBΩ closely matches the hand calculation of 83.3dBΩ.

**$R_{out}$**

The simulated $R_{out}$ value of 69.5dBΩ closely matches the hand calculation of 69.5dBΩ.
3. **Common Collector Amplifier**

\[ A_v = \frac{R_E \| R_L}{\frac{R_E}{R_L}} = \frac{2.1k\Omega/20k\Omega}{25.0\Omega + 2.1k\Omega/20k\Omega} \]

\[ A_v = 0.987 \implies -0.114 \text{ dB} \]

\[ R_{in} = R_E \| \left[ r_e + (B+1) \left( R_E \| R_L \right) \right] \]

\[ = 66.7k\Omega \| \left[ 3.78k\Omega + (151) \left( 2.1k\Omega/20k\Omega \right) \right] \]

\[ R_{in} = 54.3k\Omega = 14.7 \text{ dB} \]

\[ R_{out} = R_E \| \left[ r_e + \frac{R_S \| R_L}{B+1} \right] \]

\[ = 2.1k\Omega \| \left[ 25.0\Omega + \frac{50/66.7k\Omega}{151} \right] \]

\[ R_{out} = 25.0\Omega = 28.0 \text{ dB} \]

\[ G_v = \frac{R_{in}}{R_{in} + R_S} A_v = \frac{54.3k\Omega}{54.3k\Omega + 50} (0.987) = 0.986 \]

\[ G_v = 0.986 \implies -0.121 \text{ dB} \]
3. Common Collector Amplifier

**A\_V and G\_V**

The simulated A\_v value of -0.117dB matches closely the hand calculation of -0.114dB. The simulated G\_v value of -0.125dB matches closely the hand calculation of -0.121dB.

**R\_in**

The simulated R\_in value of 94.8dBΩ closely matches the hand calculation of 94.7dBΩ.

**R\_out**

The simulated R\_out value of 28.0dBΩ closely matches the hand calculation of 28.0dBΩ.
4. Common Base Amplifier

\[ A_v = \ImaginaryPart(R_c \parallel R_L) = 39.7 \text{ mV} / (3k \Omega \parallel 20k \Omega) \]

\[ A_v = 10^4 \text{ V/V} = 40.3 \text{ dB} \]

\[ R_{in} = R_E \parallel r_e = (2.1k \Omega \parallel 25 \Omega) \]

\[ R_{in} = 24.7 \Omega = 27.9 \text{ dB} \]

\[ R_{out} = R_c = 3k \Omega = 69.5 \text{ dB} \]

\[ G_v = \frac{R_{in}}{R_{in} + R_s} = \frac{24.7}{24.7 + 50} \approx 0.344 \]

\[ G_v = 34.4 \text{ V/V} = 30.7 \text{ dB} \]
4. Common Base Amplifier

**A\text{v} and G\text{v}**

The simulated $A_v$ value of 39.9dB matches closely the hand calculation of 40.3dB. The simulated $G_v$ value of 30.6dB matches closely the hand calculation of 30.7dB.

**R\text{in}**

The simulated $R_{in}$ value of 28.3dBΩ closely matches the hand calculation of 27.9dBΩ.

**R\text{out}**

The simulated $R_{out}$ value of 69.4dBΩ closely matches the hand calculation of 69.5dBΩ.