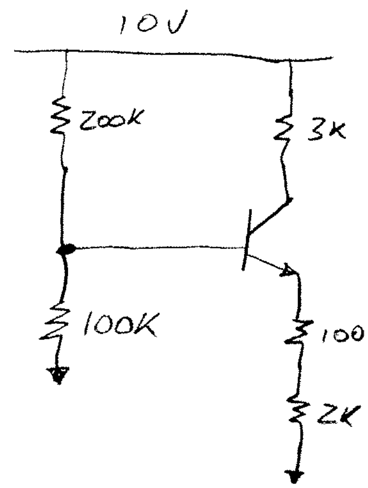
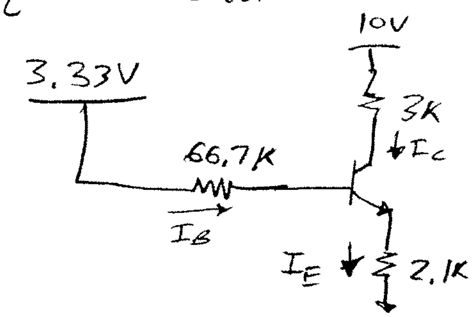
Homework # 5 Solutions – SAM PALERMO

1.



$\beta = 150$

Thevenin Eq Bias Circuit



$$I_E = \frac{V_{BB} - V_{BE}}{R_E + \frac{R_B}{\beta+1}} = \frac{3.33V - 0.7V}{2.1K + \frac{66.7K}{151}} = 1.03mA$$

$$I_B = \frac{I_E}{\beta+1} = \frac{1.03mA}{151} = 6.85\mu A$$

$$I_c = \beta I_B = 150(6.85\mu A) = 1.027mA$$

$$V_E = I_E R_E = 1.03mA(2.1K\Omega) = 2.16V$$

$$V_B = V_E + 0.7V = 2.16V + 0.7V = 2.86V$$

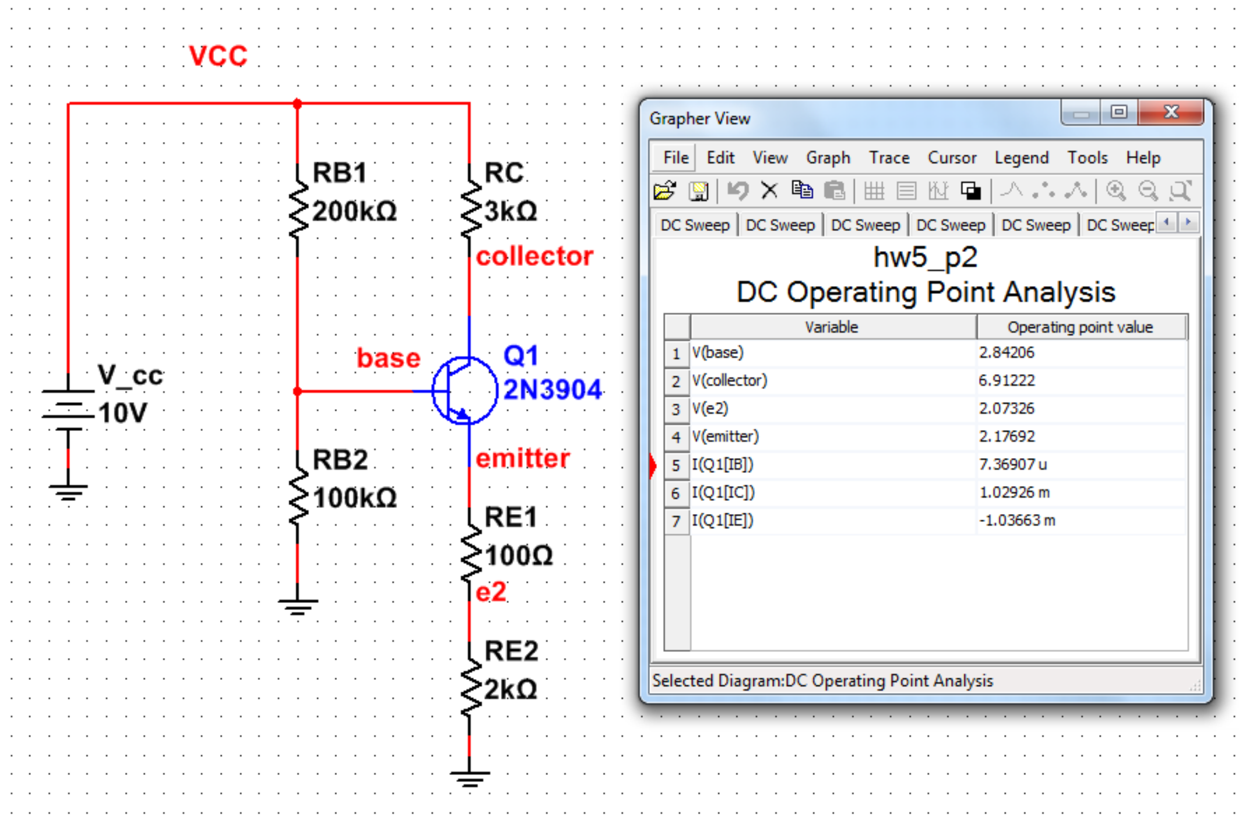
$$V_c = V_{cc} - I_c R_c = 10V - 1.027mA(3k) = 6.92V$$

$$g_m = \frac{I_{CQ}}{V_{th}} = \frac{1.027mA}{25.9mV} = 39.7\ mA/V$$

$$r_\pi = \frac{V_{th}}{I_{BQ}} = 3.78k\Omega \qquad r_e = \frac{V_{th}}{I_{EQ}} = 25.0\Omega$$

3.

DC Operating Points



	Variable	Operating point value
1	V(base)	2.84206
2	V(collector)	6.91222
3	V(e2)	2.07326
4	V(emitter)	2.17692
5	I(Q1[IB])	7.36907 u
6	I(Q1[IC])	1.02926 m
7	I(Q1[IE])	-1.03663 m

2. Common Emitter Amplifier

$$A_V = -\frac{g_m (R_C \| R_L)}{1 + \frac{g_m R_{E1}}{\alpha}} = -\frac{(39.7\,\text{mA/V})(3\,k\Omega \| 20\,k\Omega)}{1 + \frac{(39.7\,\text{mA/V})(100\,\Omega)}{0.993}}$$

$$\boxed{A_V = -20.7\ \text{V/V} = 26.3\,\text{dB}}$$

$$R_{in} = R_B \| (r_\pi + (\beta+1)R_{E1})$$

$$= 66.7\,k\Omega \| [3.78\,k\Omega + 151(100)]$$

$$\boxed{R_{in} = 14.7\,k\Omega = 83.3\,\text{dB}\Omega}$$

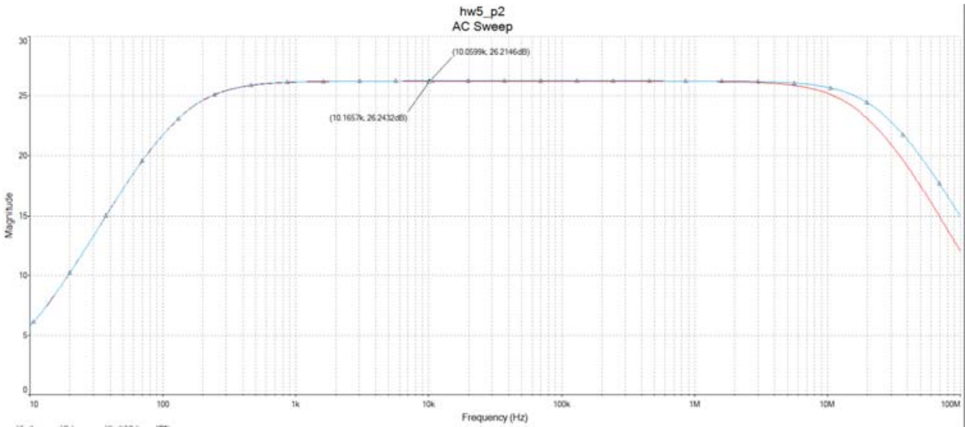
$$\boxed{R_{OUT} = R_C = 3\,k\Omega = 69.5\,\text{dB}\Omega}$$

$$G_V = \frac{R_{in}}{R_{in} + R_S} A_V = \frac{14.7\,k\Omega}{14.7\,k\Omega + 50}(-20.7)$$

$$\boxed{G_V = -20.6\ \text{V/V} = 26.3\,\text{dB}}$$

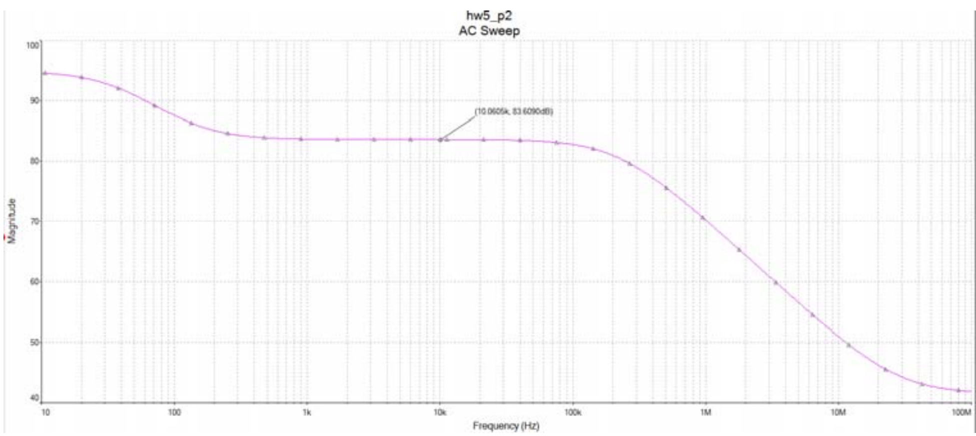
2. Common Emitter Amplifier

A_V and G_v



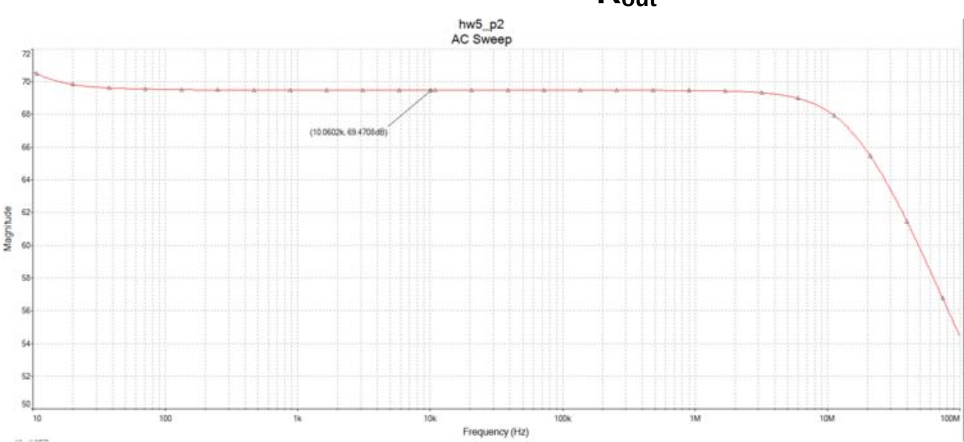
The simulated value of 26.2dB closely matches the hand calculation of 26.3dB for both A_v and G_v.

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

$$A_V = \frac{R_E \| R_L}{r_e + R_E \| R_L} = \frac{2.1k\Omega \| 20k\Omega}{25.0\Omega + 2.1k\Omega \| 20k\Omega}$$

$$\boxed{A_V = 0.987\, V/V = -0.114\, dB}$$

$$R_{in} = R_B \| \left[r_\pi + (\beta+1)(R_E \| R_L) \right]$$

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

$$\boxed{R_{in} = 54.3k\Omega = 94.7 dB\Omega}$$

$$R_{out} = R_E \| \left[r_e + \frac{R_S \| R_B}{\beta+1} \right]$$

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

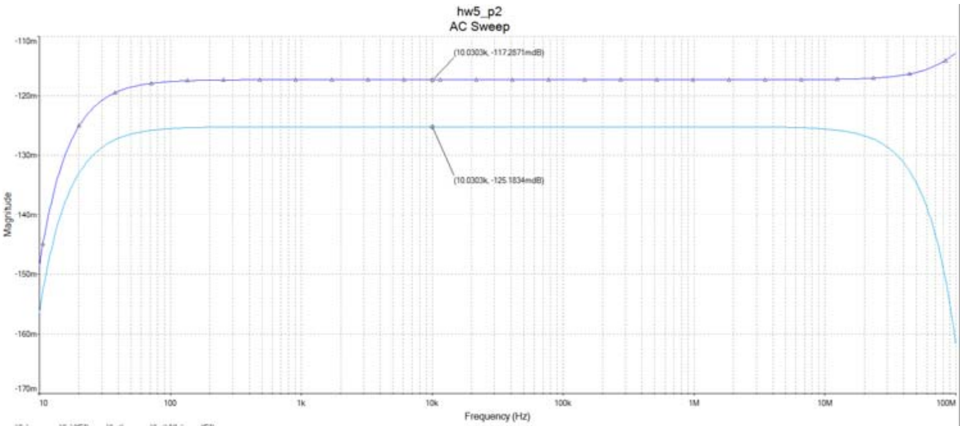
$$\boxed{R_{out} = 25.0\Omega = 28.0 dB\Omega}$$

$$G_V = \frac{R_{in}}{R_{in} + R_S} A_V = \frac{54.3k\Omega}{54.3k\Omega + 50}(0.987) = 0.986$$

$$\boxed{G_V = 0.986\, V/V = -0.121\, dB}$$

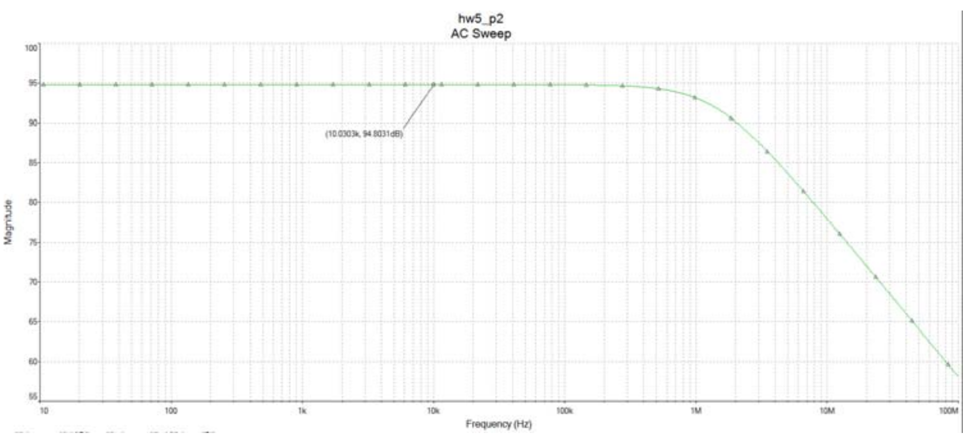
3. Common Collector Amplifier

A_V and G_v



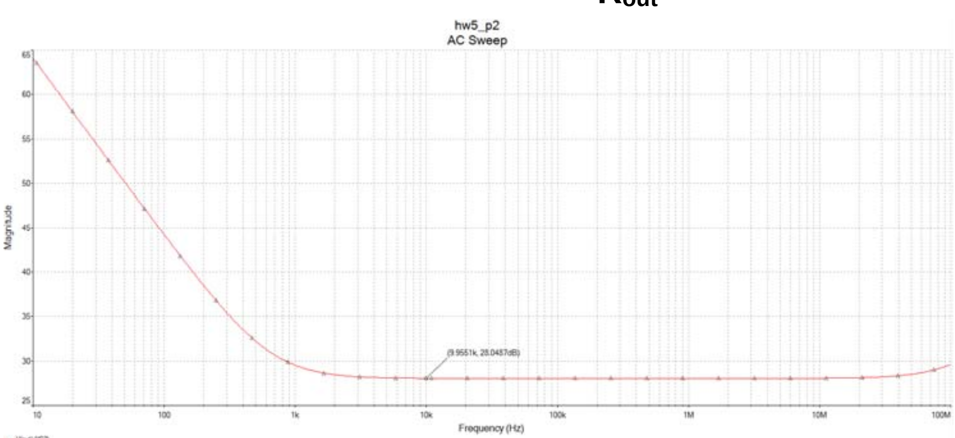
The simulated A_v value of -0.117dB matches closely the hand calculation of -0.114dB. The simulated G_v value of -0.125dB matches closely the hand calculation of -0.121dB.

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

$$A_V = g_m(R_C \| R_L) = 39.7\,\text{mA/V}\,(3\,k\Omega \| 20\,k\Omega)$$

$$\boxed{A_V = 104\ \text{V/V} = 40.3\,\text{dB}}$$

$$R_{in} = R_E \| r_e = 2.1\,k\Omega \| 25.0\,\Omega$$

$$\boxed{R_{in} = 24.7\,\Omega = 27.9\,\text{dB}\Omega}$$

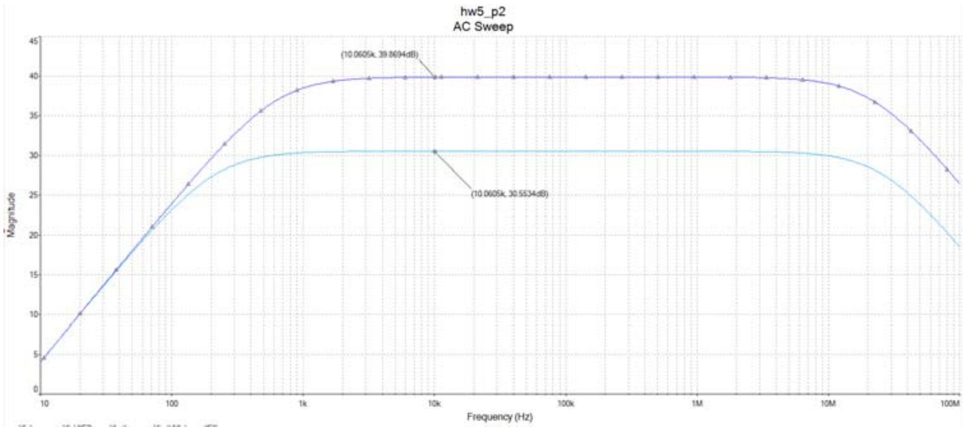
$$\boxed{R_{OUT} = R_C = 3\,k\Omega = 69.5\,\text{dB}\Omega}$$

$$G_V = \frac{R_{in}}{R_{in} + R_S} = \frac{24.7}{24.7 + 50}(104) = 34.4\ \text{V/V}$$

$$\boxed{G_V = 34.4\ \text{V/V} = 30.7\,\text{dB}}$$

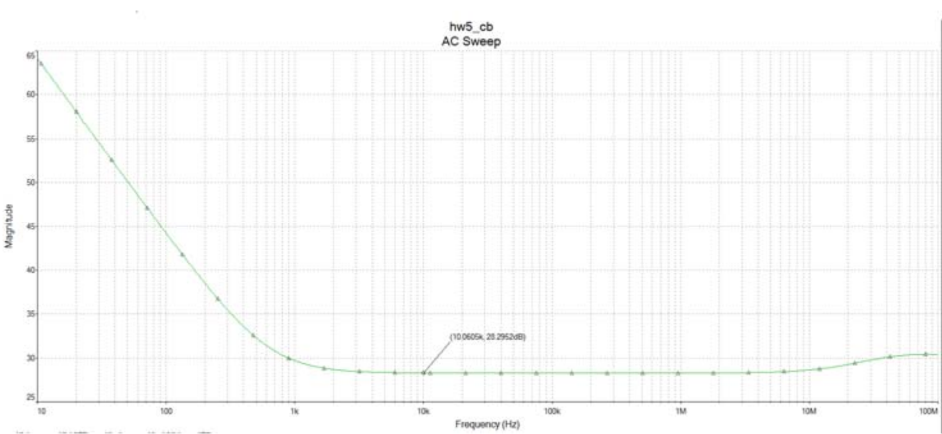
4. Common Base Amplifier

A_V and G_v



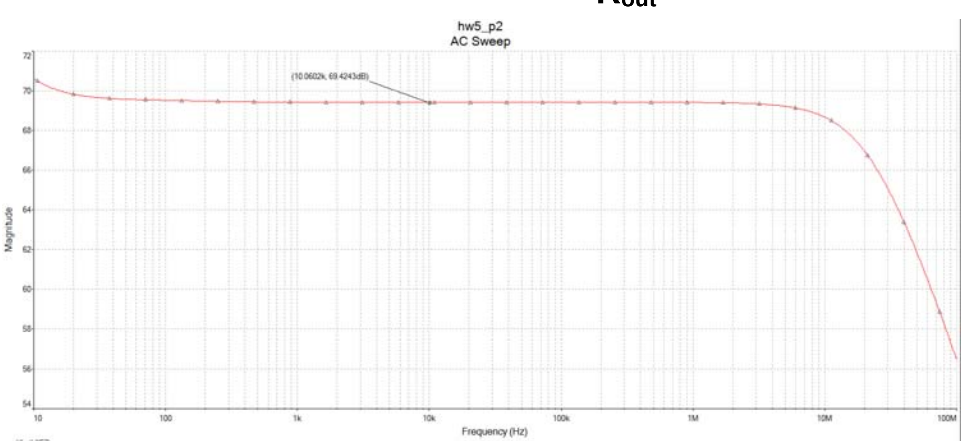
The simulated A_v value of 39.9dB matches closely the hand calculation of 40.3dB. The simulated G_v value of 30.6dB matches closely the hand calculation of 30.7dB.

R_{in}



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

R_{out}



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