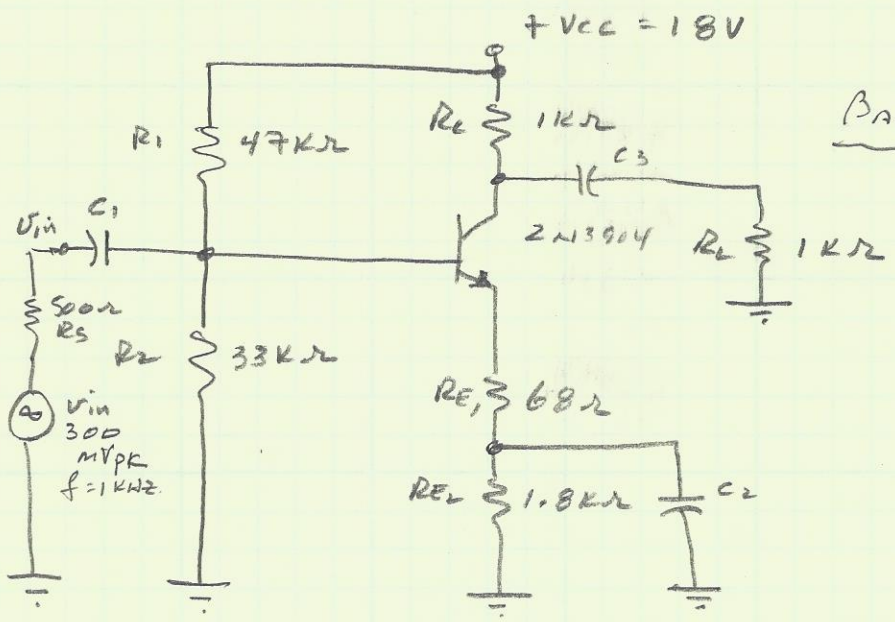
BJT C-E AMPLIFIER ANALYSIS EXAMPLE – dc + AC (w/ SWAMPING)



$\beta_{AC} = \beta_{dc} = 150$

$C_1 = C_3 = 100\,nf$

$C_2 = 47\,nf$ to.

dc (BIAS + Q-POINT) ANALYSIS FIRST: [V-DIVIDER BIAS]

$$V_B = \left(\frac{R_2}{R_1 + R_2}\right) V_{CC} \;;\quad V_B = \left(\frac{33K\Omega}{80K\Omega}\right) 18V \qquad \boxed{V_B = 7.425V}$$

$$V_E = V_B - V_{BE} \quad (-0.7V) \;;\quad \boxed{V_E = 6.725V}$$

$$I_E = \frac{V_E}{R_{E1} + R_{E2}} \;;\quad \frac{6.725V}{68 + 1.8K\Omega} \;;\quad \boxed{I_E = 3.6mA}$$

$$\boxed{I_E \cong I_C = 3.6mA} \leftarrow I_{CQ}$$

$$r'_e = \frac{25mV}{I_E} = \frac{25mV}{3.6mA} \;;\quad \boxed{r'_e = 6.944\,\Omega}$$

$$V_{RC} = I_C \cdot R_C = (3.6mA)\,1K\Omega \;;\quad V_{RC} = 3.6V$$

$$V_C = V_{CC} - V_{RC} \quad (-I_C \cdot R_L) = 18 - 3.6V \;;\quad \boxed{V_C = 14.4V}$$

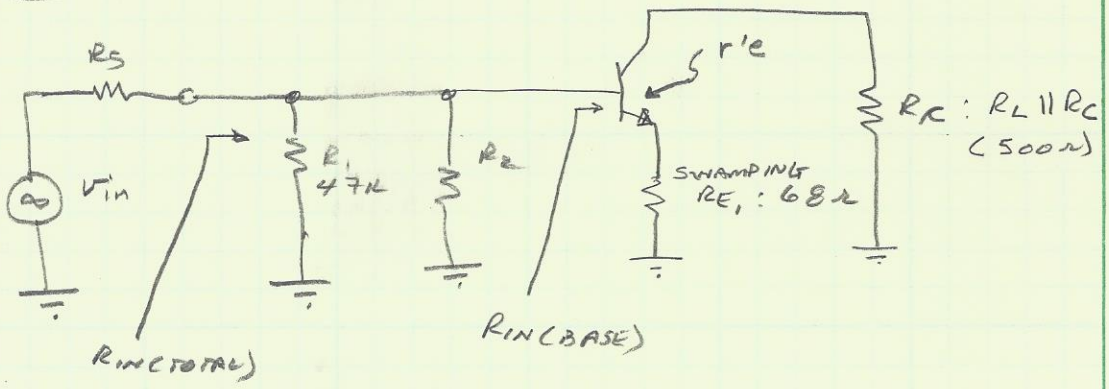
$$V_{CE} = V_C - V_E = 14.4 - 6.725V \;;\quad \boxed{V_{CE} = 7.675\,V_{dc}} \leftarrow V_{CEQ}$$

$$I_{C(SAT)} = \frac{V_{CC} - 0.7}{R_C + R_{E1} + R_{E2}} = \frac{17.3V}{2.868K\Omega} \;;\quad \boxed{I_{C(SAT)} = 6.032\,mA}$$

AC ANALYSIS

AC EQUIVALENT CIRCUIT :

(WITH INPUT SOURCE):



$$R_{IN(BASE)} = \beta_{AC}(r'_e + R_{E_1})$$

(w/o SWAMPING, i.e. R_E COMPLETELY BYPASSED): $R_{IN(BASE)} = \beta_{AC} \cdot r'_e$

$$R_{IN(BASE)} = 150(6.944 + 68\Omega)$$

$$\boxed{R_{IN(BASE)} = 11.242\ K\Omega}$$

$$R_{IN(TOTAL)} = R_1 \| R_2 \| R_{IN(BASE)}$$

$$= 47K\Omega \| 33K\Omega \| 11.242\ K\Omega$$

$$\boxed{R_{IN(TOTAL)} = 7.116\ K\Omega}$$

$$R_{OUT} = R_{LOAD(AC)} = R_C = R_L \| R_C$$

$$R_C = 1K\Omega \| 1K\Omega \; ; \quad \boxed{R_C = 500\Omega}$$

AC ANALYSIS (CONTINUED):

VOLTAGE GAIN: A_V (RAW; W/O ATTENUATION)

$$A_V = \frac{R_C}{r'_e + R_{e_1}}$$

$$= \frac{500\,\Omega}{6.9 + 68} \; ; \quad \boxed{A_V = 6.68}$$

note: SCALER QTY NO DIMENSIONS

ATTENUATION:

$$\text{ATTENUATION} = \frac{V_s}{V_b} = \frac{R_s + R_{in\,(TOTAL)}}{R_{in\,(TOTAL)}}$$

$$= \frac{500\,\Omega + 7.116\,K\Omega}{7.116\,K\Omega} \; ; \quad \boxed{ATTN = 1.07}$$

REAL VOLTAGE GAIN (ACTUAL CONSIDERING ATTENUATION)

ATTN IS 1.07. REAL GAIN IS RAW GAIN TIMES THE RECIPROCAL OF THE ATTENUATION.

$$\therefore A'_V = A_V \cdot \frac{1}{ATTN}$$

$$A'_V = (6.68)0.934 \; ; \quad \boxed{A'_V = 6.235}$$

SO: $V_{OUT} = A'_V \cdot V_{in}$

$= 6.235 \cdot 300\,mV_{PK}$ → $\boxed{V_{OUT_{PK}} = 1.875\,V_{PK}}$

OR: in rms values → $\boxed{V_{OUT_{RMS}} = 1.322\,V_{RMS}}$

AC ANALYSIS (CONTINUED):

$$I_A = \frac{V_s}{R_s + R_{in\,(TOTAL)}} = \frac{1.322\ V_{rms}}{500\Omega + 7.116k\Omega}$$

$$I_b = 174\mu A$$

CURRENT GAIN:

$$A_i = \frac{I_c}{I_s} = \frac{(1.322\ V_{rms}/500\Omega)}{174\mu A}$$

$$= \frac{2.644mA}{0.174mA}$$

$$\boxed{A_i \cong 15.2}$$

POWER GAIN

$$A_p = A'_v A_i$$

$$= (6.235)(15.2)$$

$$\boxed{A_p = 94.74}$$