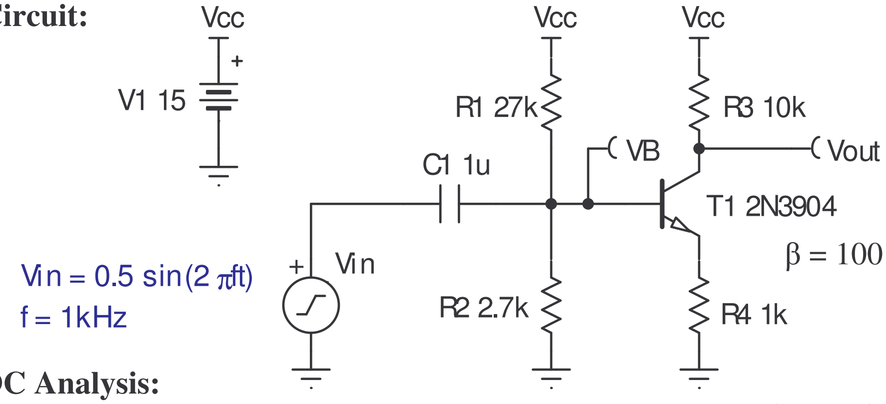
Common Emitter (CE) Amplifier
w/ Voltage Divider Bias & Emitter Resistance

1. Circuit:



2. DC Analysis:

(1) Treat the capacitor as an open-circuit since its reactance $(1/j\omega C) = \infty$ for DC (ω = 0).

(2) Determine the Open-Circuit (Thevenin) Voltage of the divider:

$$Vth = \left(\frac{R2}{R1 + R2}\right) \cdot Vcc = \left(\frac{2.7k}{27k + 2.7k}\right) \cdot 15V = 1.36V$$

(3) Determine the Thevenin Resistance of the divider:

$$Rth = R1 || R2 = 2.7k\Omega \; || \; 27k\Omega = 2.45k\Omega$$

(4) Check to see if $(\beta+1)R_E >> Rth$. If so, $V_B \approx Vth$:

$101k >> 2.45k$? YES, by a factor of 40+. $\therefore V_B \approx 1.36V$

(5) Determine V_E: $V_E = V_B - V_{BE} = 1.36V - 0.7V = 0.66V$

(6) Determine I_E: $I_E = V_E/R_E = 0.66V/1k\Omega = 0.66mA$

(7) Determine I_C: $I_C = \left(\frac{\beta}{\beta+1}\right) \cdot I_E = \left(\frac{100}{101}\right) \cdot 0.66mA = 0.65mA$

* Notice that $I_C \approx I_E$!

(8) Find voltage across R_C: $V_{RC} = I_C \cdot R_C = 0.65mA \cdot 10k = 6.5V$

(9) Find $V_{OUT(DC)}$: $V_{OUT(DC)} = (V_{CC} - V_{RC}) = (15V - 6.5V) = 8.5V$

(10) Verify *ACTIVE Region,* is $V_{SAT} < V_{OUT(DC)} < V_{CC}$?

$$0.2V < 8.5V < 15V? \text{ YES! } \therefore V_{OUT(DC)} = 8.5V$$

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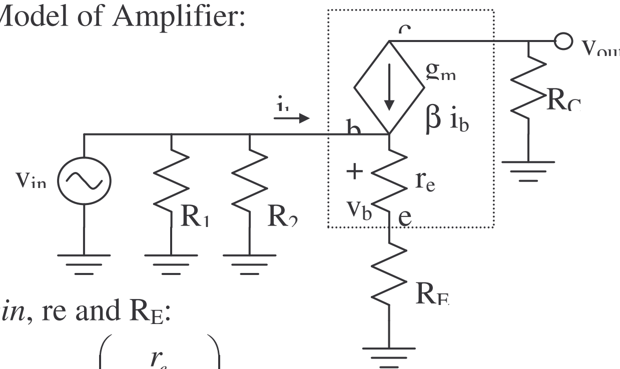
3. Small-Signal (ac) Analysis *(using T-model of BJT)*:

(1) Determine Small-Signal Parameters g_m and r_e for T-model using DC bias:

$$g_m = \frac{I_{C(Bias)}}{nV_T} = \frac{0.65mA}{1\cdot(26mV)} = 25mA/V$$

$$r_e = \left(\frac{\beta}{\beta+1}\right)\frac{1}{g_m} \approx \frac{1}{g_m} = \frac{1}{25mA/V} = 40\Omega$$

(2) Draw Small-Signal Model of Amplifier:



(3) Find v_{be} in terms of vin, re and R_E:

$$v_{be} = v_{in}\left(\frac{r_e}{r_e+R_E}\right)$$

(4) Solve for i_c: $$i_c = g_m\cdot v_{be} = v_{in}\left(\frac{g_m\cdot r_e}{r_e+R_E}\right) \approx v_{in}\left(\frac{1}{r_e+R_E}\right)$$

(5) Solve for v_{out}: $$v_{out} = -R_C\cdot i_C = -v_{in}\left(\frac{R_C}{r_e+R_E}\right)$$

(6) Solve for A_v (Voltage Gain):

$$A_v \equiv \frac{v_{out}}{v_{in}} = -\left(\frac{R_C}{r_e+R_E}\right) = -\frac{10k\Omega}{40\Omega+1k\Omega} = -9.62$$

(7) Compare to Approximation:

$$A_v \cong -\frac{R_C}{R_E} = -\frac{10k\Omega}{1k\Omega} = -10 \text{ (within 5\%)}$$

(8) Solve for v_{out}: $$v_{out} = A_v\cdot v_{in} = -9.62(0.5Vpk) = -4.81Vpk$$

4. Determine Net Output Response:

(1) $v_{OUT(NET)} = V_{OUT(DC)} + v_{out(ac)}$

(2) $\boldsymbol{v_{OUT} = 8.5 - 4.81\sin(2\pi ft)}$ **Volts** , *where f = 1kHz*

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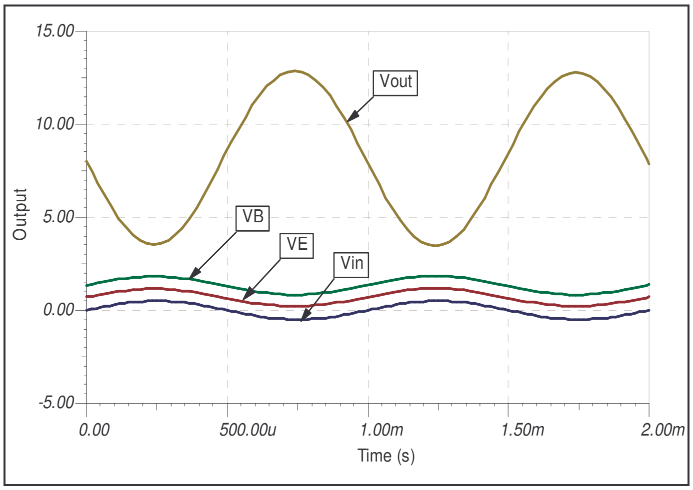
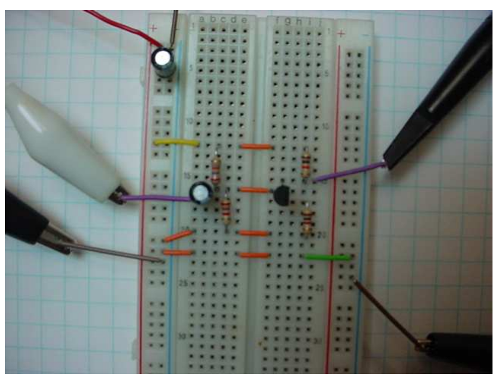
5. Simulation:



6. Lab Circuit:



7. Lab Measurement: