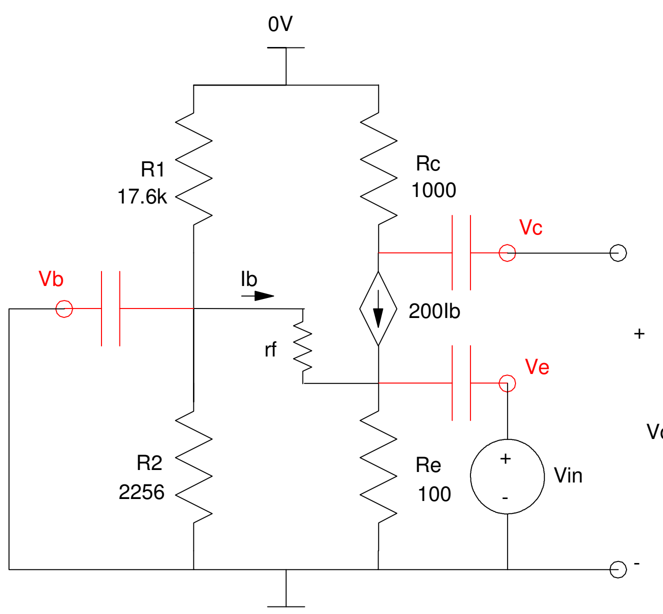
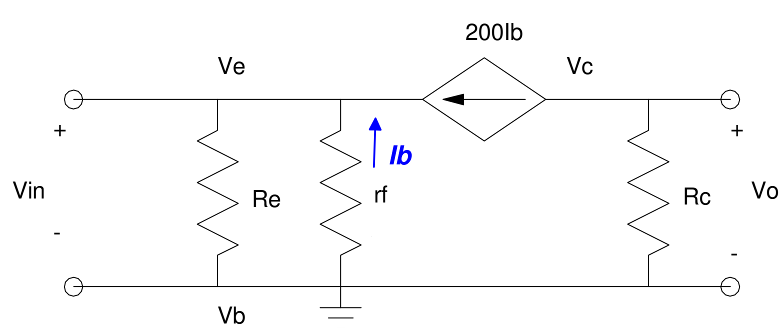
Common Base, Common Collector Amplifiers.

Common Base Amplifier:

- Connect the base to ground
- Connect the input to Ve
- Connect the output to Vc:



Now find the 2-port model. To do this, let's first redraw the circuit:



Now let's find the 2-port parameters:

Rin: Set Vo = 0V and measure the input resistance. In this case, it's not that obvious what the answer is. So, let's apply 1V to Vin and see how much current is draws, 1/Iin is the input resistance.

$$I_{in} = \frac{1V}{R_e} + \frac{1V}{r_f} + \beta I_b$$

$$I_{in} = \frac{1V}{R_e} + \frac{1V}{r_f} + \frac{\beta}{r_f}$$

so

$$R_{in} = \left(\frac{1}{R_e} + \frac{1}{r_f} + \frac{\beta}{r_f}\right)^{-1}$$

Note that this is also

$$R_{in} = R_e || r_f || \frac{r_f}{\beta}$$

$$R_{in} = 8\Omega$$

Ain: Set Vo = 1V and measure the voltage at the input. Again, this isn't obvious, but 0V works. If Vin = 0V, Ib = 0, βI_b=0. So Ain = 0.

Ain = 0.

Rout: Set Vin = 0V and measure the resistance at the output. If Vin = 0V, Ib = 0, βI_b=0 and everything is turned off. The only thing you see at the output is Rc.

Rout = Rc.

Ao: Set Vin = 1V and measure the voltage at the output.

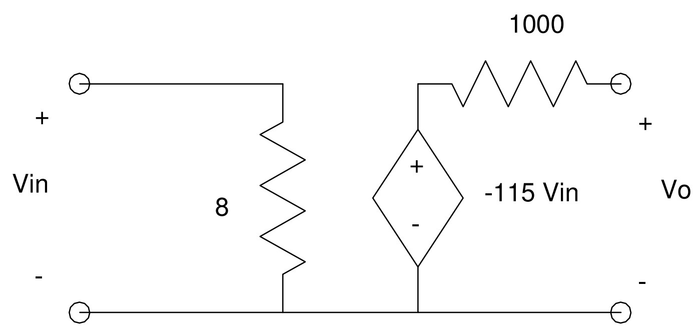
$$I_b = \frac{1}{r_f}$$

$$I_c = \beta I_b$$

$$A_o = V_o = -\frac{\beta R_c}{r_f}$$

$$A_o = -115$$

So, the 2-port model is then

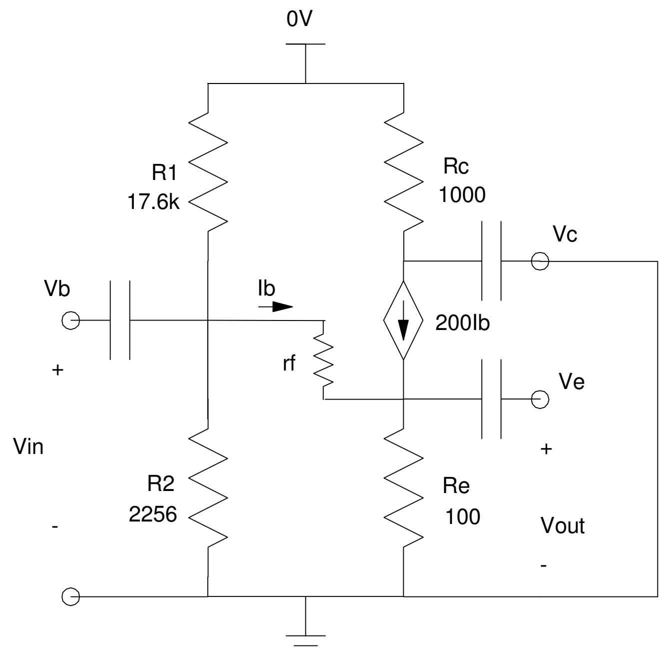


Note that the common-base amplifier has a low input impedance. It's used as the first stage in an amplifier where the sensor needs a low-impedance load, such as a phonograph (the current carries the signal.)

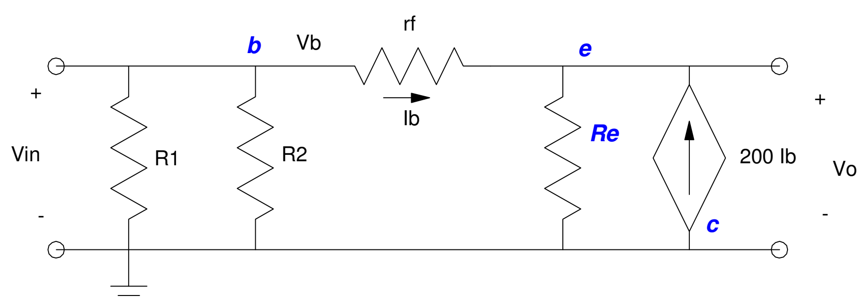
Common Collector Amplifier:

- Short the collector to ground
- Connect the input to the base

- Connect the output to the collector



To find the 2-port parameters, redraw the circuit:



Now, find the 2-port parameters:

Rin: Set Vo = 0V and measure the resisance at the input.

$$R_{in} = R_1 || R_2 || r_f$$

$$R_{in} = 928\Omega$$

Ain: Set Vo = 1V and measure the voltage at the input. By voltage division

$$A_{in} = \left(\frac{R_1||R_2}{R_1||R_2 + r_f} \right)$$

$$A_{in} = 0.5357$$

Rout: Set Vin = 0V and measure the resistance across Vo. Again, this isn't obvious, so let's apply a 1V source to Vo and measure the current drawn:

$$I = \frac{1}{r_f} + \frac{1}{R_e} - \beta(-I_b)$$

$$I = \frac{1}{r_f} + \frac{1}{R_e} + \frac{\beta}{r_f}$$

so

$$R_{out} = \left(\frac{1}{r_f} + \frac{1}{R_e} + \frac{\beta}{r_f} \right)^{-1}$$

which is also

$$R_{out} = r_f || R_e || \frac{r_f}{\beta}$$

$$R_{out} = 7.9\Omega$$

Ao: Set Vin = 1V and measure the voltage across the output. Using voltage node analysis:

$$\left(\frac{V_o - 1}{r_f} \right) + \left(\frac{V_o}{R_c} \right) - \beta I_b = 0$$

$$\left(\frac{V_o - 1}{r_f} \right) + \left(\frac{V_o}{R_c} \right) - \beta \left(\frac{1 - V_o}{r_f} \right) = 0$$

$$\left(\frac{1}{r_f} + \frac{1}{R_c} + \frac{\beta}{r_f} \right) V_o = -\left(\frac{\beta}{r_f} \right)$$

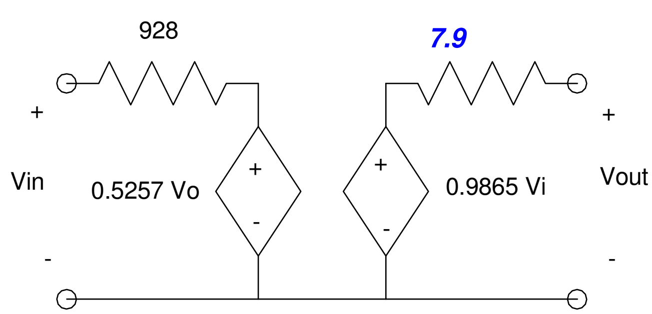
$$V_o = -\left(\frac{\beta}{r_f} \right) \left(\frac{1}{r_f} + \frac{1}{R_c} + \frac{\beta}{r_f} \right)^{-1}$$

or

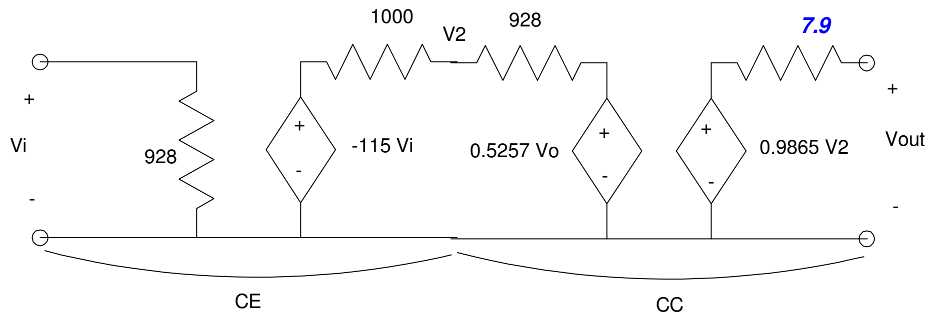
$$A_o = \left(\frac{R_c || r_f || \frac{r_f}{\beta}}{r_f} \right) \beta$$

$$A_o = 0.9865$$

So the 2-port model is:



It isn't really obvious what this is useful for. Typically, CC amplifiers are preceeded by a CE amplifier:

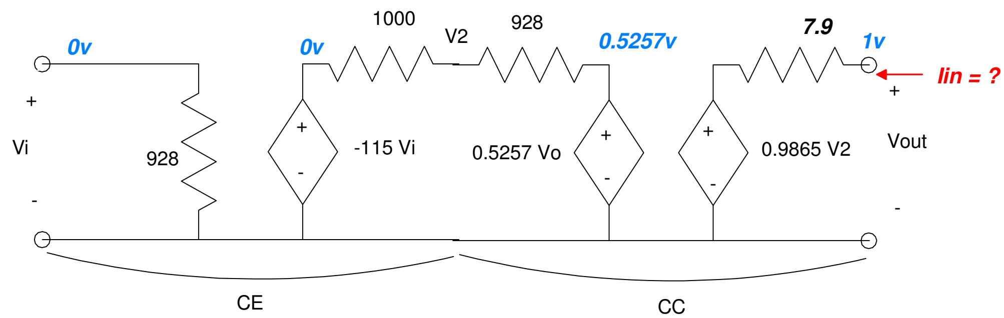


Now the 2-port model becomes:

Rin = 928 Ohms by inspection

Ai = 0 by inspection

Rout: Set Vi = 0V and measure the resistance at the output. Apply a 1V source to Vout and see how much current you draw

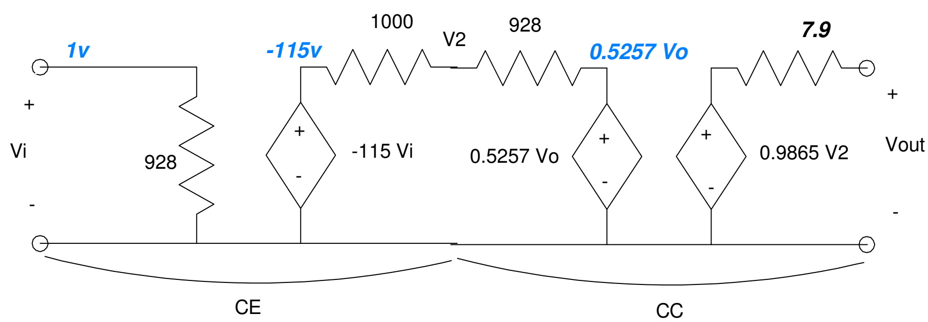


$$V_2 = \left(\frac{1000}{1000+928}\right)(0.5257V) = 0.2727V$$

$$I = \left(\frac{1V-0.2727V}{7.9\Omega}\right) = 92.1mA$$

$$R_{out} = \frac{1V}{92.1mA} = 10.8\Omega$$

Aout: Set Vi = 1V and measure the voltage at the output. Using voltage nodes, at V2:



Solve for the voltage at V2. Using voltage nodes:

$$\left(\frac{V_2-0}{1000}\right)+\left(\frac{V_2-0.5257V_o}{928}\right)=0$$

$$V_o=0.9865V_2$$

$$\left(\frac{V_2-(-115)}{1000}\right)+\left(\frac{V_2-0.5257\cdot 0.9865\cdot V_2}{928}\right)=0$$

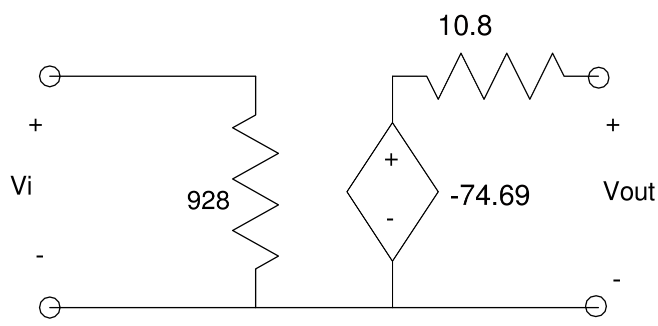
$$\left(\left(\frac{1}{1000}\right)+\left(\frac{1-0.5257\cdot 0.9865}{928}\right)\right)V_2=-\left(\frac{115}{1000}\right)$$

$$V_2=-75.72V$$

$$V_o=0.9865V_2$$

$$V_o=-74.69$$

So the 2-port model of a CE:CC amplifier is



CE:CC

Common collector amplifiers are used as the last stage for an amplifier when you need to drive a low-impedance load, such as an 8-Ohm speaker.