Multi-Stage Amplifiers.

As a recap, the shopping list of amplifiers you have to play with are as follows:



A multi-stage amplifier cascades several amplifiers together to get a new amplifier. In general,

- CE amplifiers are good for increasing the gain.
- CB amplifiers are good for te first stage if you need a low input impedance.
- CC amplifiers are good for the last stage if you are driving a low-impedance load, such as an 8-Ohm speaker.

CE : CC Amplifier

For example, determine the 2-port model for a CE amplifier cascaded with a CC amplifier



By inspection

- Rin = 928
- Ain = 0

The other two paraters take a little more work to compute.

Rin: 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 Vout

• Solve for the voltage at V2. Using voltage nodes:

$$\left(\frac{V_2-0}{1000}\right) + \left(\frac{V_2-0.5257V_o}{928}\right) = 0$$
$$V_o = 0.9865V_2$$
$$\left(\frac{V_2-(-115)}{1000}\right) + \left(\frac{V_2-0.5257\cdot0.9865\cdot V_2}{928}\right) = 0$$
$$V_2 = -75.72V$$
$$V_o = -74.69$$



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



With this, you now have the following three building blocks:



Example 2: Phonograph Amplifier

Design an amplifier to connect a phonograph to an 8-Ohm speaker. Assume the phonograph is a current source with

 $I_{in} = 1 \mu A$ ground to peak

 $R_{N} = 100 \text{ Ohms}$

Assume the load is an 8-Ohm speaker, which should be driven with Vout = 10.0V

Since the input is a current source, use a CB amplifier for the first stage. The 8 Ohm input impedance allows the current to flow without too much resistance.

Since the output is an 8-Ohm speaker, make the last stage a CE:CC amplifier. The 11.7 Ohm output impedance isn't desirable (you'd rather have it be zero ohms), but it's the best we have for now.

NDSU

Add in a bunch of CE amplifiers in the middle until you get enough gain.

Assume for a start you have a single CE amplifier in the muiddle. The 2-port model is then:



The voltages are then:

$$V_{1} = (100||8)1\mu A = 7.41\mu V$$

-115 $V_{1} = -851.8\mu V$
$$V_{2} = \left(\frac{928\Omega}{928\Omega + 1000\Omega}\right)(-851.8\mu V) = -410.0\mu V$$

-115 $V_{2} = 47.15mV$
$$V_{3} = \left(\frac{928\Omega}{928\Omega + 1000\Omega}\right)(47.15mV) = 22.69mV$$

-77.4 $V_{3} = -1.756V$
$$V_{4} = \left(\frac{8\Omega}{8\Omega + 11.7\Omega}\right)(-1.756V) = -0.713V$$



To increase the output to 10V

• Add another CE amplifier

This results in the output being too large (-39.49V). To reduce the output voltage to 10.0V, add a resistor in series to drop the gain



The resulting amplifier thus consists of five stages:

• CB : CE : CE : CE : CC