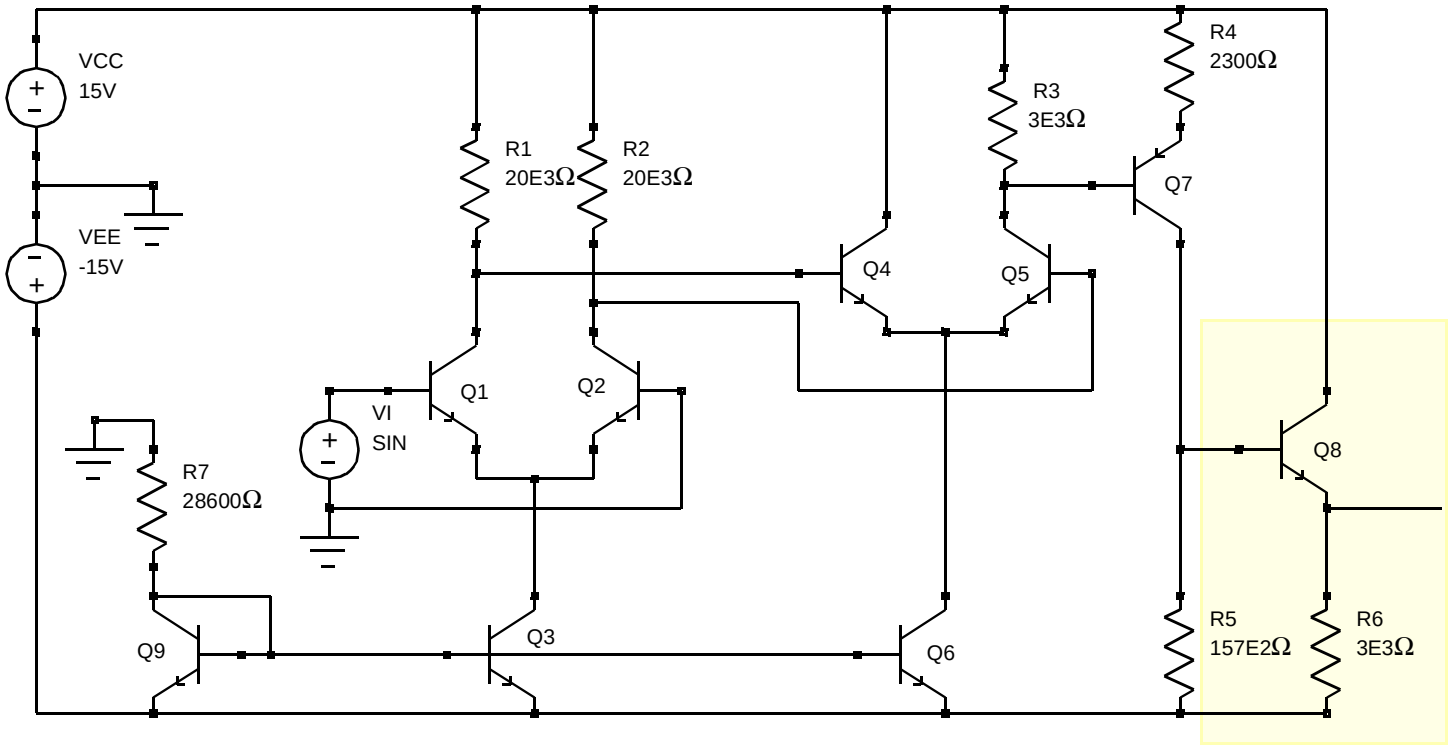
Output Stages

- Output stage must deal with large signal swings
- Small signal model assumption is not valid, but emitter follower behaves *somewhat linearly*
- Emitter follower is not power efficient



Output Stages

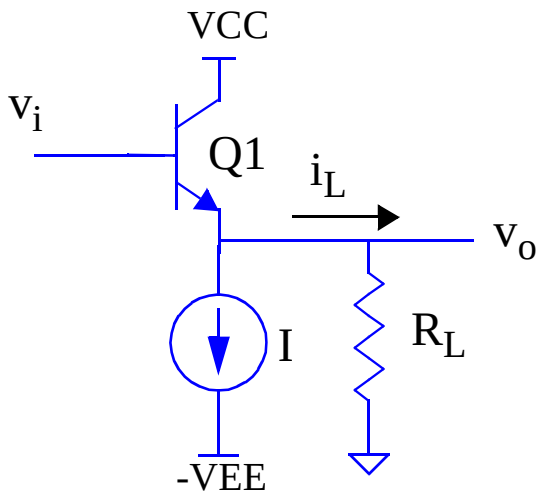
- The linearity of the output stage is of primary importance
- Minimize output signal distortion
- Design goodness is measured in terms of total harmonic distortion (THD)

$$\frac{\text{RMS of output signal harmonics}}{\text{RMS of output signal fundamental frequency}}$$

- THD should be much less than 1% for a good stereo receiver
- Other concern is with delivering a lot of power without wasting power on the output transistors
- Output stages are classified into various types
- We'll look briefly at class A, class B and class AB

Class A

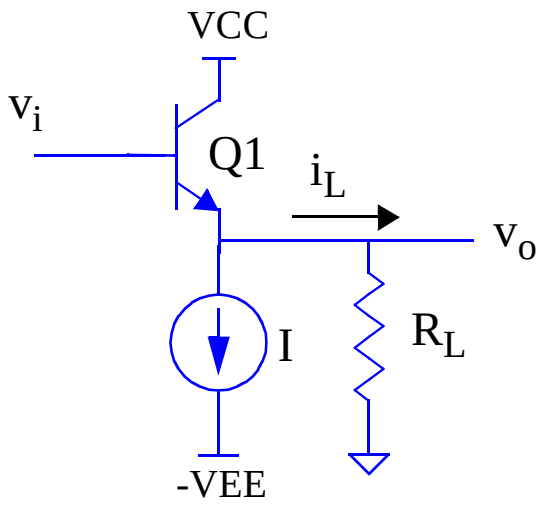
- Large signal emitter follower with a current source bias



- "I" must be greater than the largest negative load current

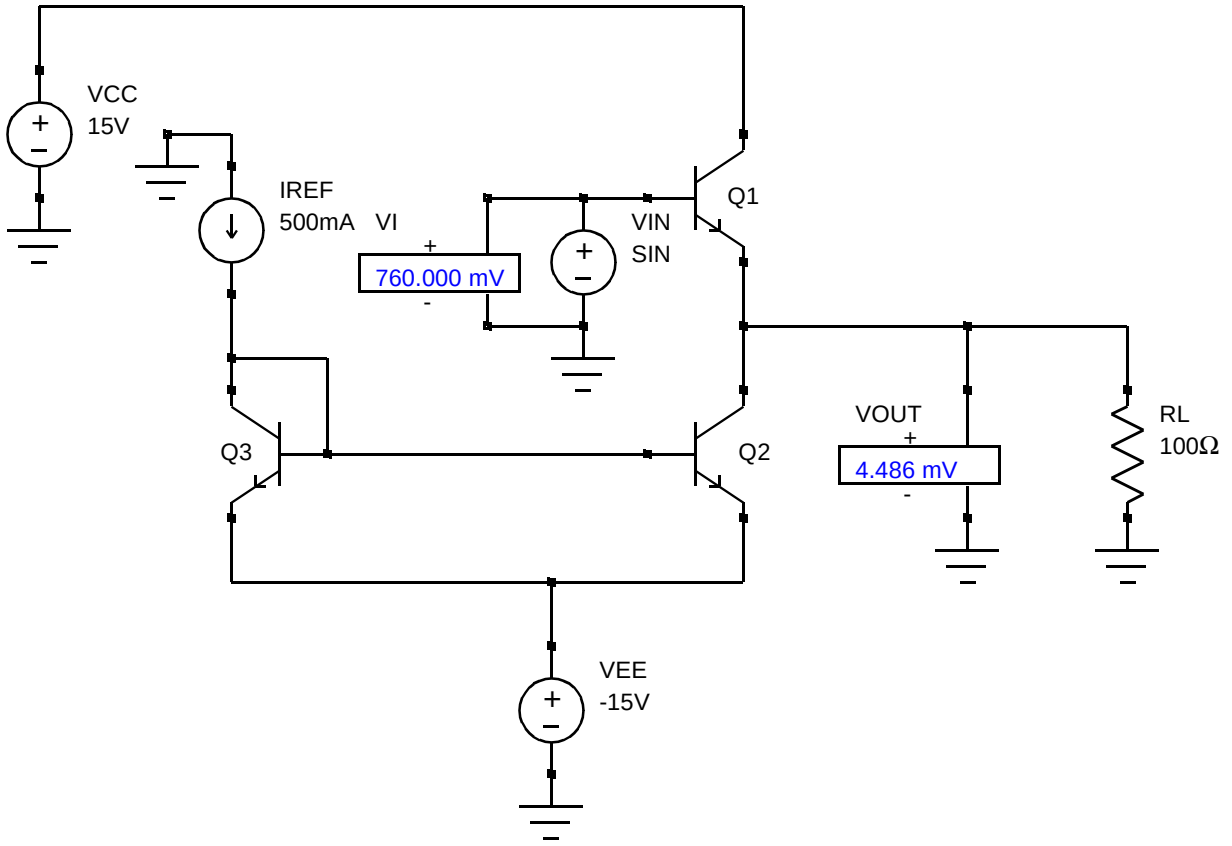
Class A

- Assuming v_{BE} is small, it behaves somewhat linearly:



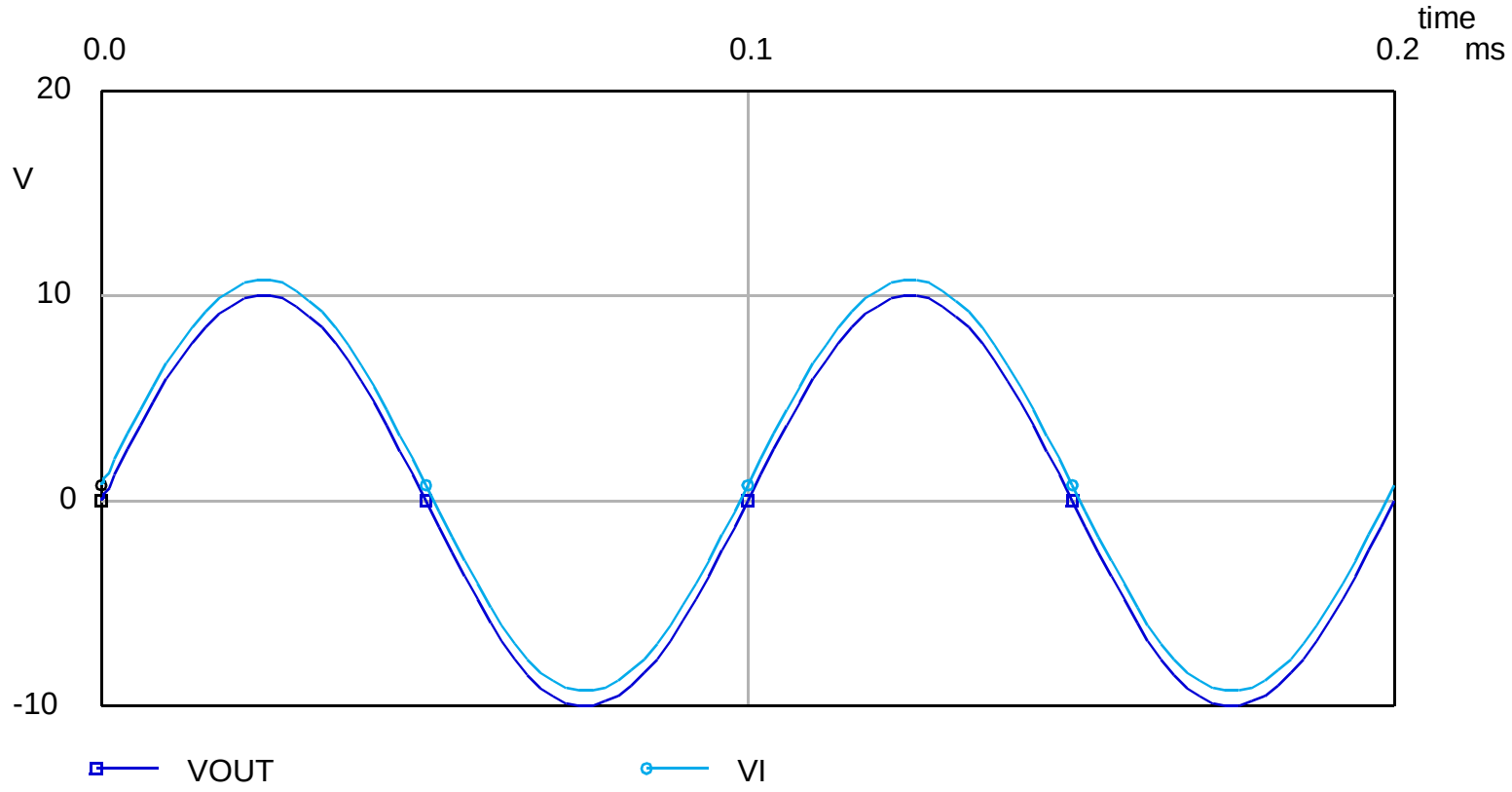
Class A

- Offset is added to V_{IN} so that output is zero for zero ac input



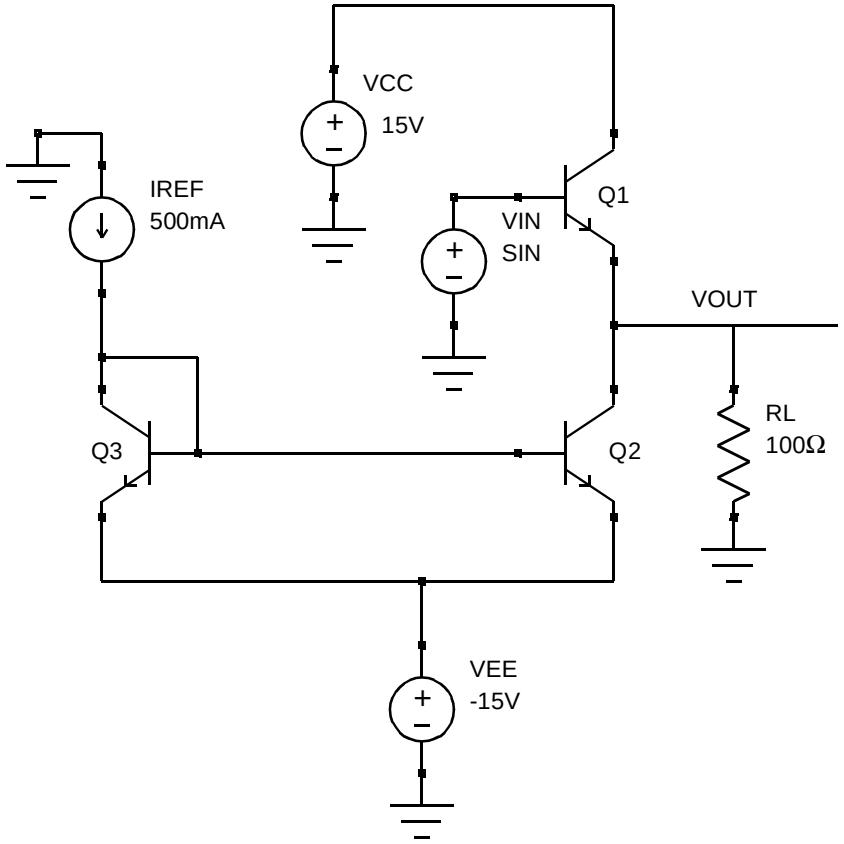
Class A

- Large signal response is fairly linear, even with large load currents



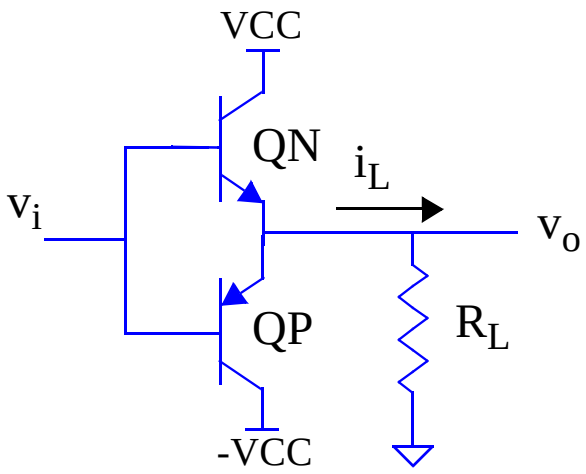
Class A Power Dissipation

- Power dissipation can be excessive, even with no ac input signal
- For example, when v_o=0, what is the power dissipation on the transistor?



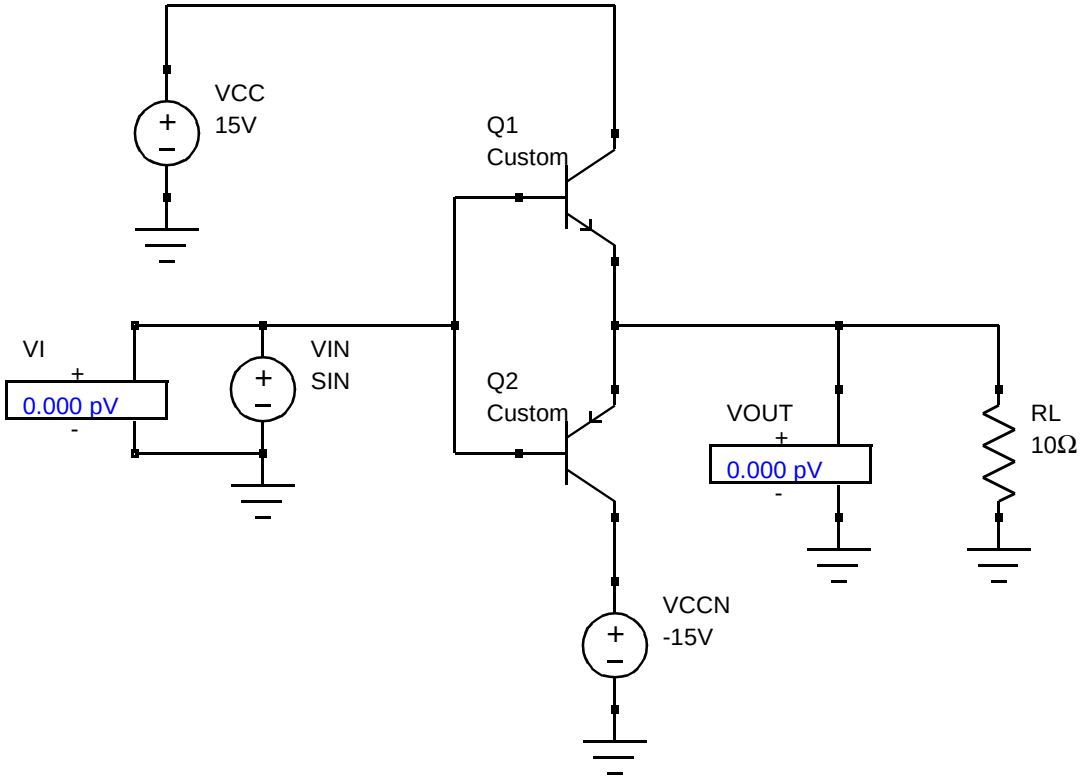
Class B -- Push-Pull Output Stage

- Designed so that both transistors cannot be conducting at the same time using a pair of emitter followers



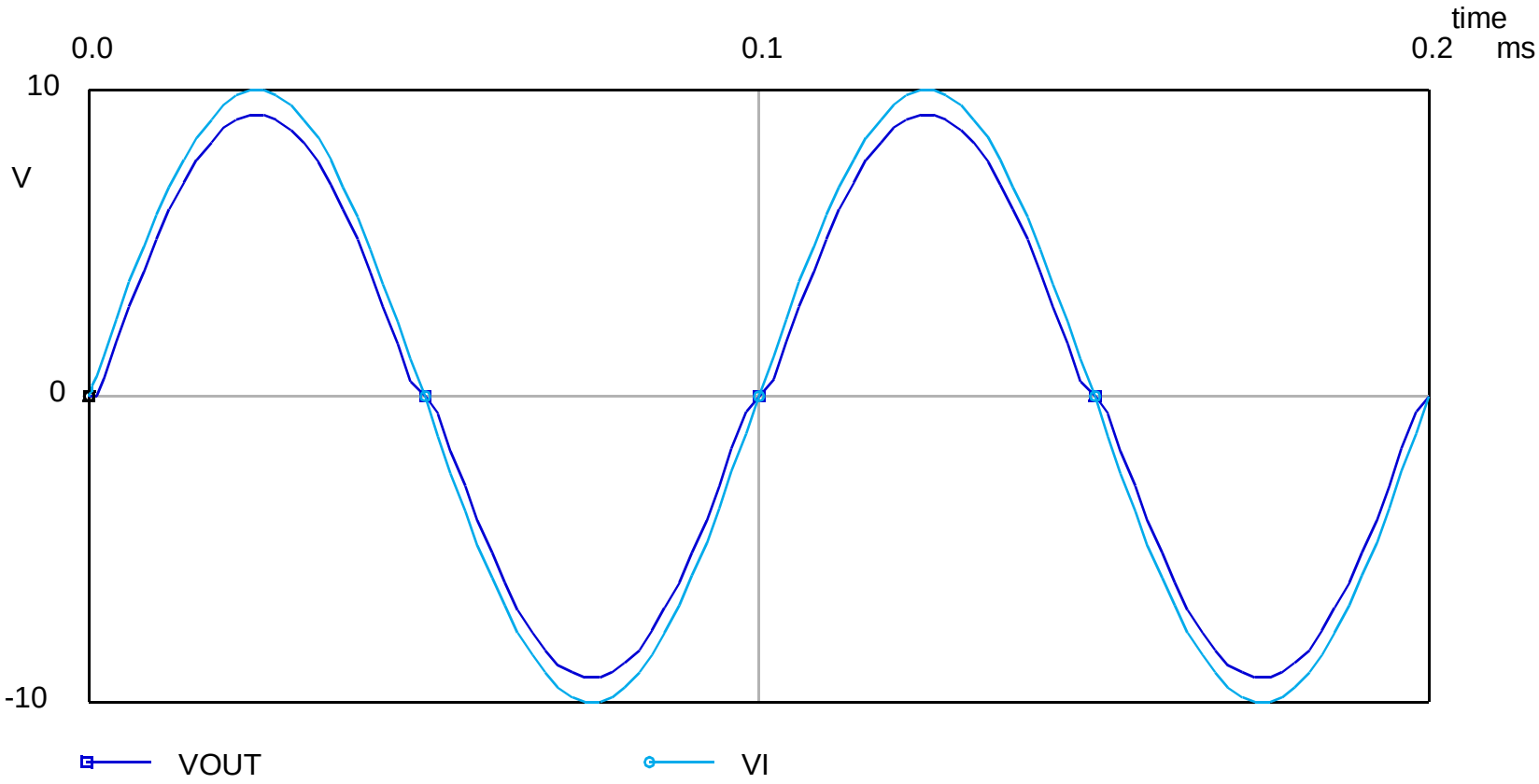
Class B

- The class B is simpler to design, and no offset is required for V_{IN}



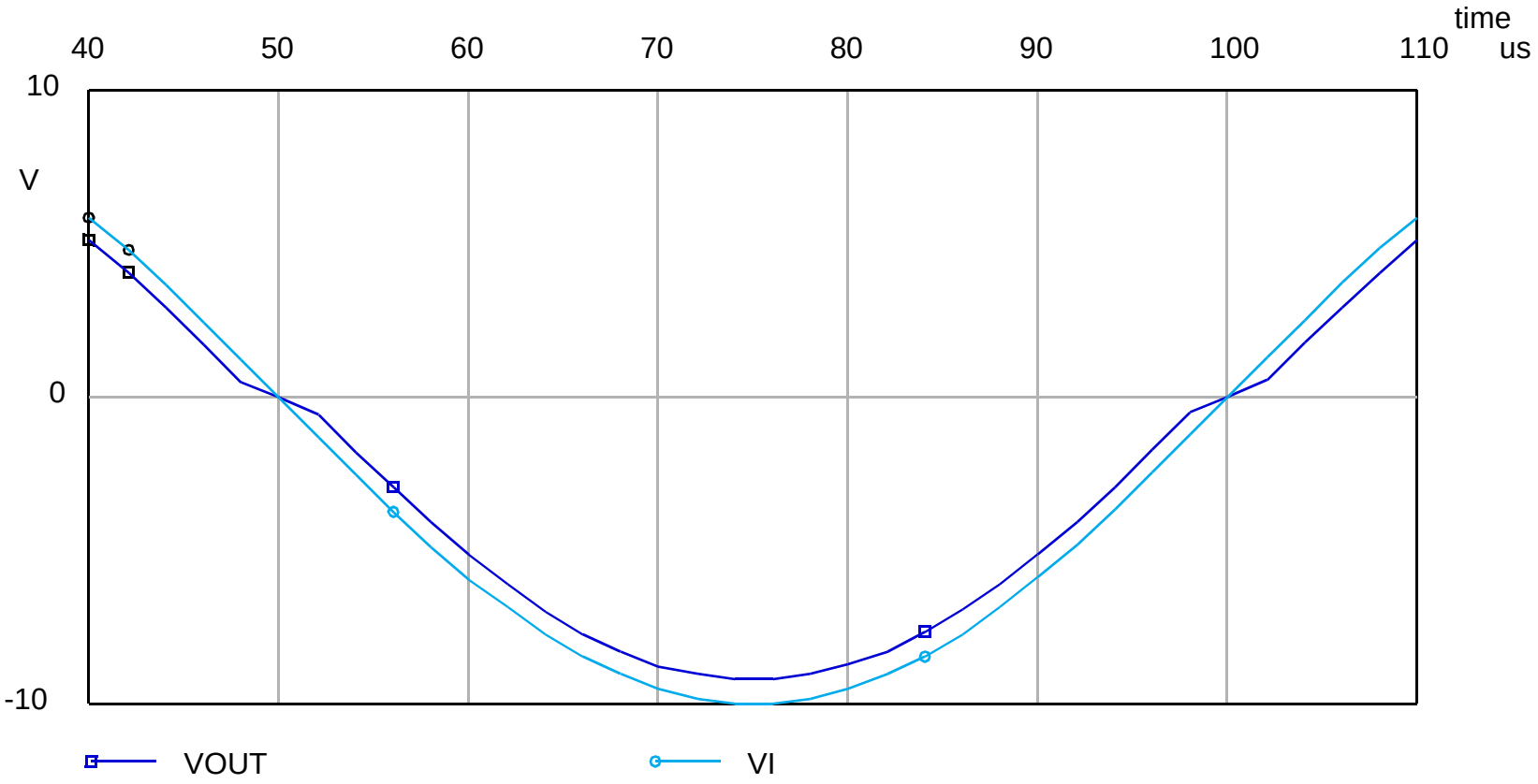
Class B

- Large signal response is still fairly linear, even with larger load current



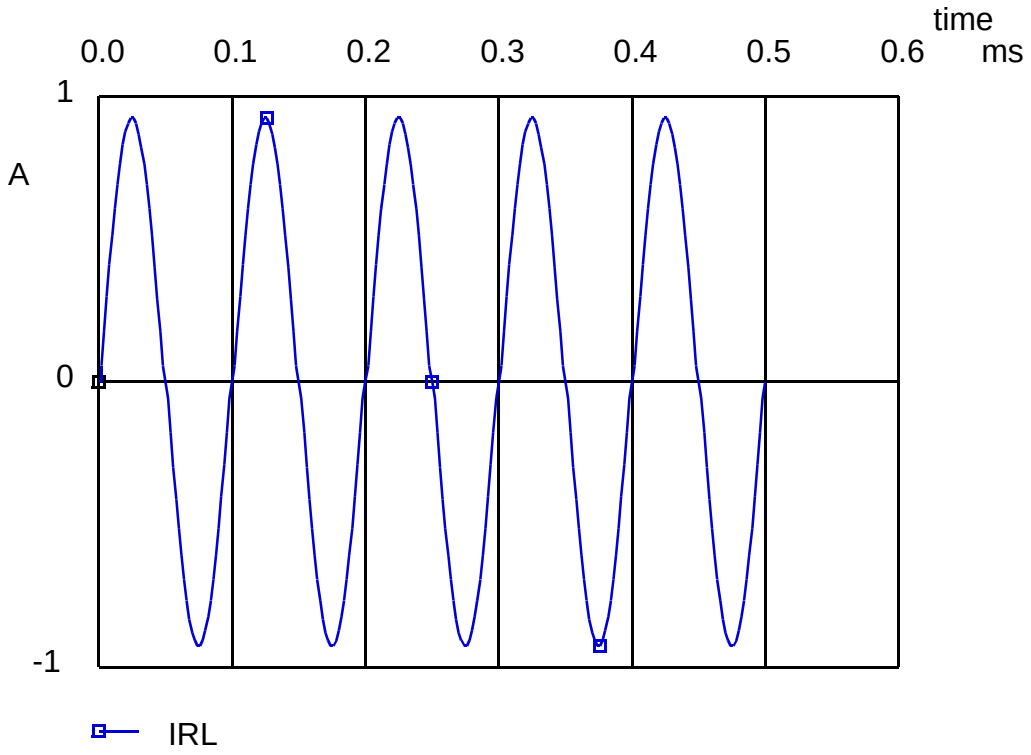
Class B Crossover Distortion

- The problem is the deadband region for which both QP and QN are off
- Produces unwanted noise for an audio signal



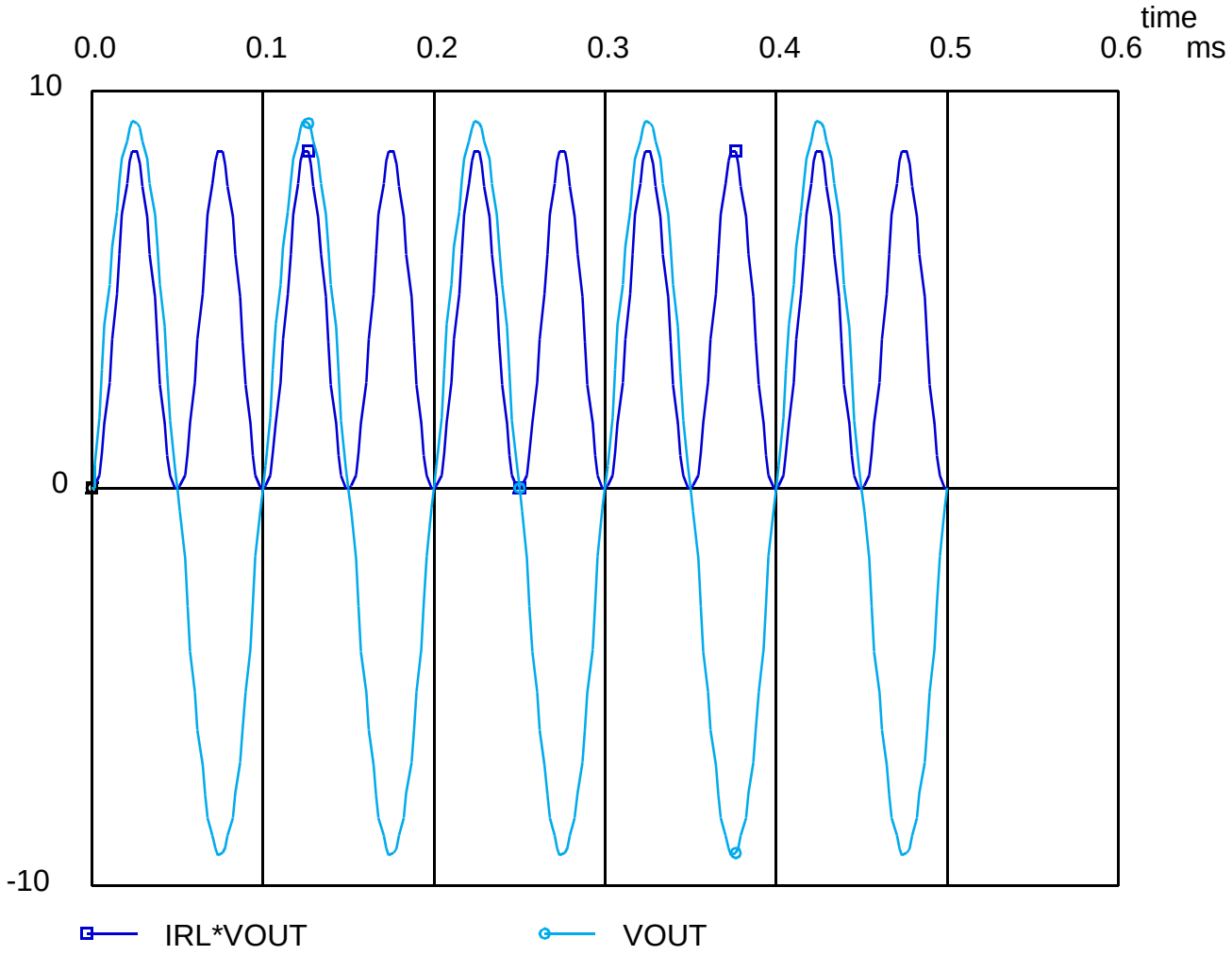
Class B Power Dissipation

- dc power dissipation is zero
- Avg. power can be calculated for each transistor
- The postive load current is supplied by QN, and the negative is supplied by QP



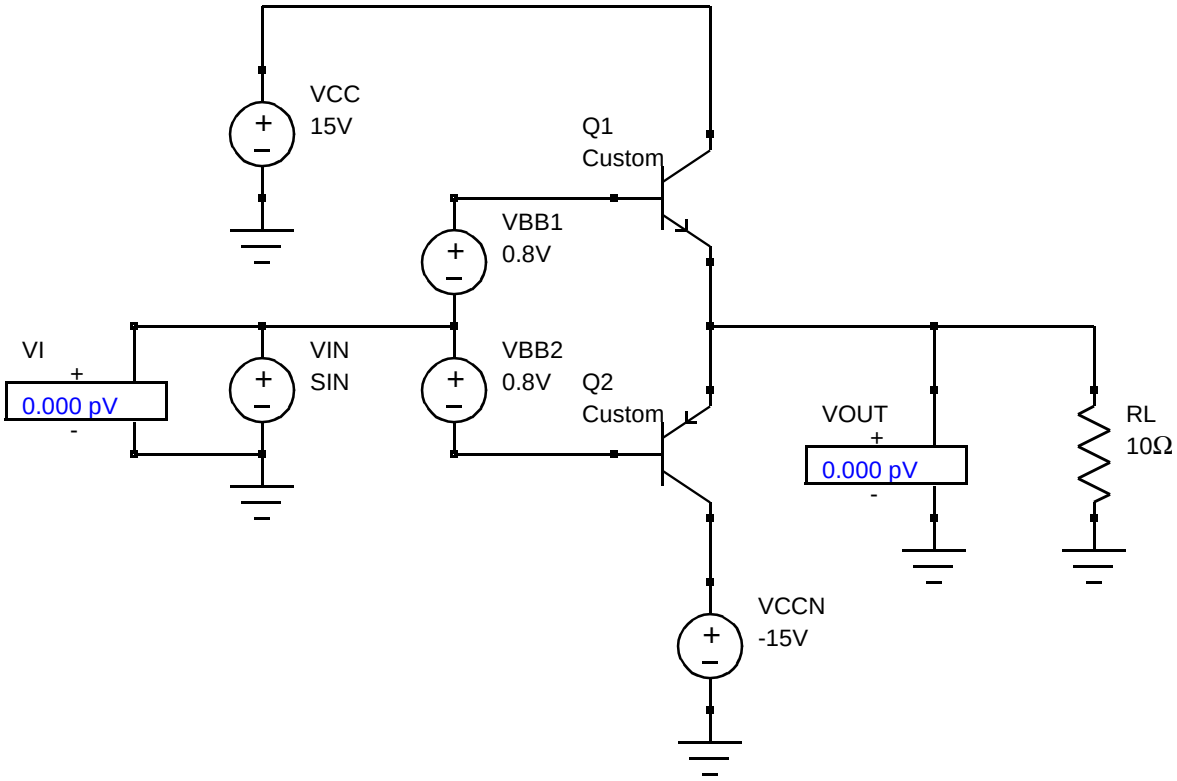
Class B Power Dissipation

- The instantaneous power is the same for both the push and the pull



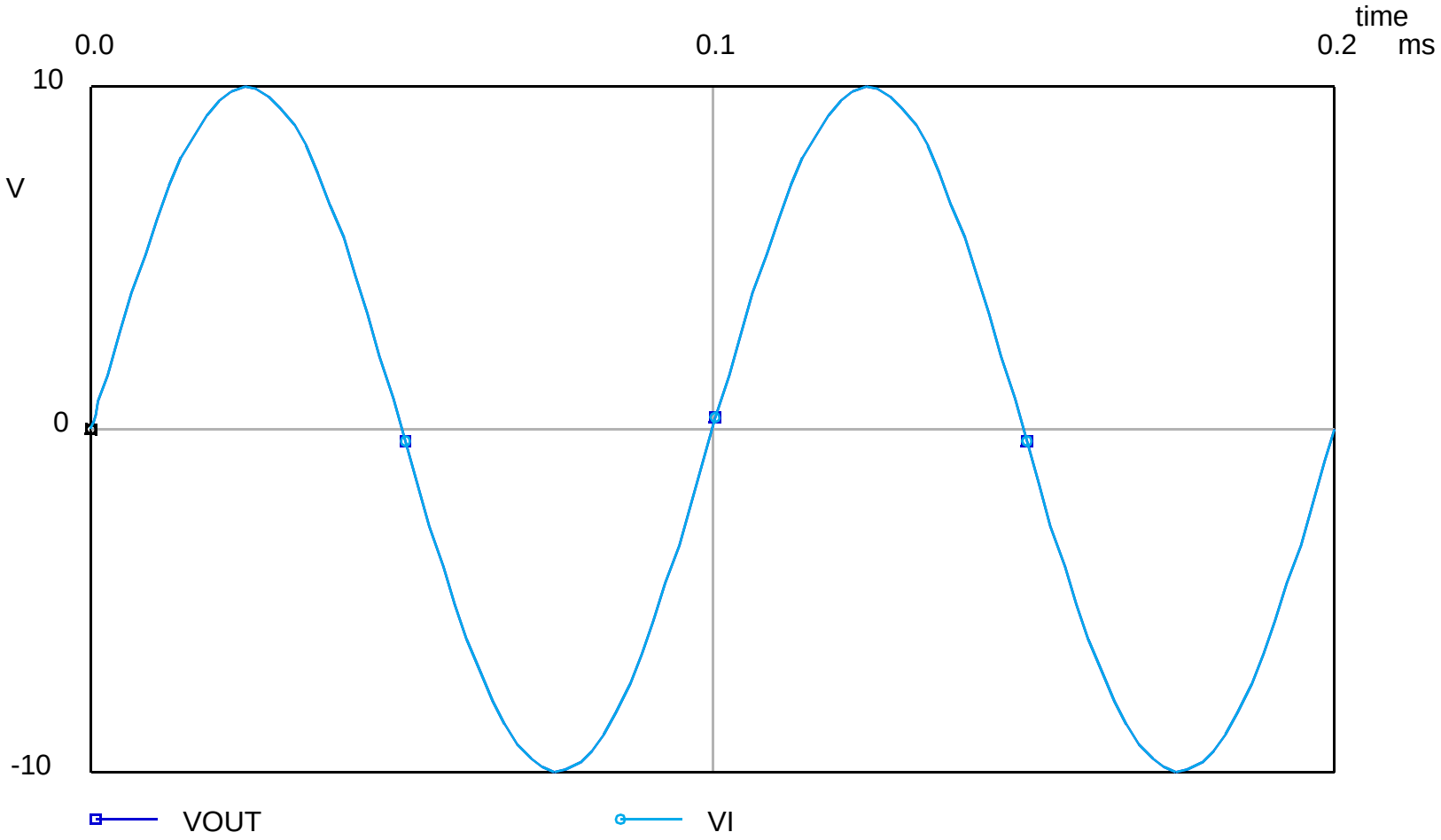
Class AB

- The most difficult aspect of the class AB design is creating the VBB bias voltages



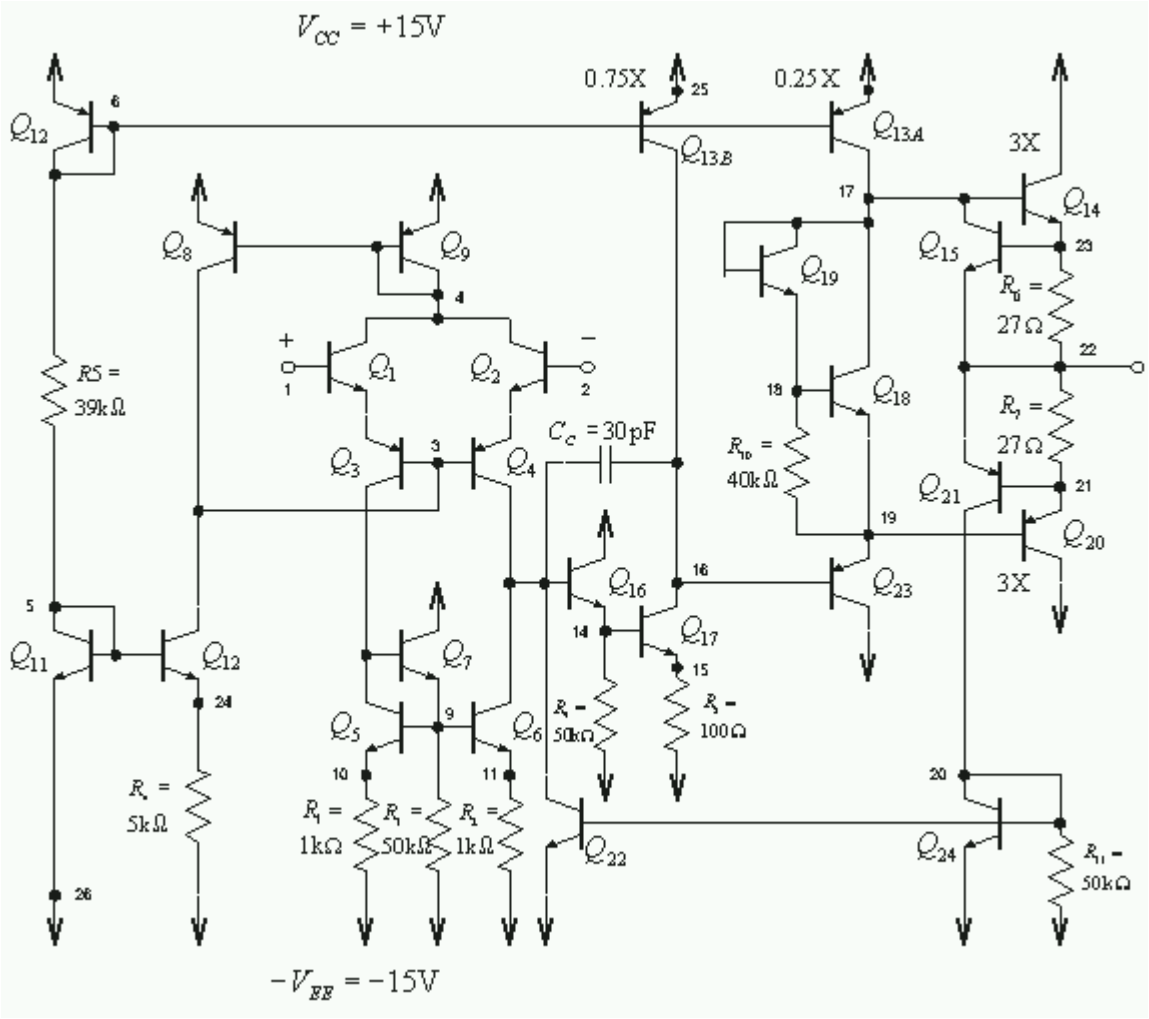
Class AB

- Input and output are now overlapping, with no cross-over distortion



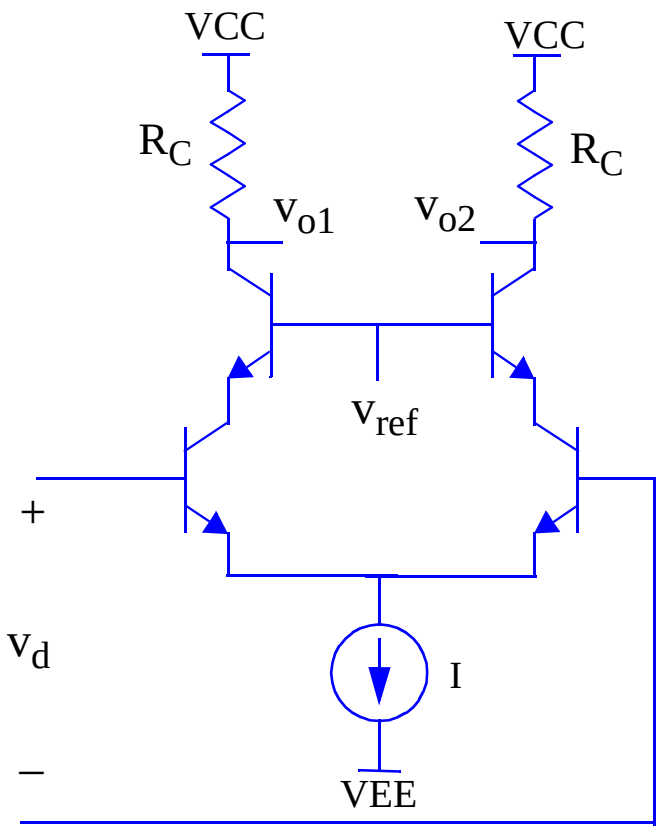
More Elaborate Multi-Stage Amplifiers

- Now you can "sort of" recognize all of the major portions of a 741 opamp



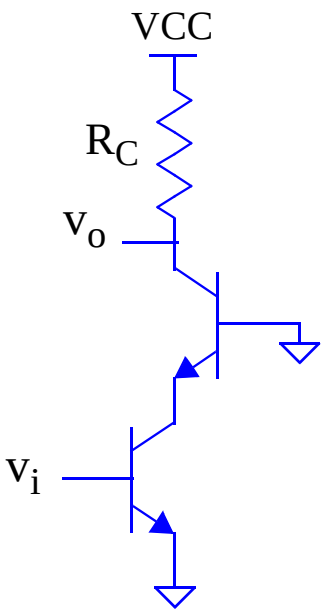
Cascode Amplifier

- Most differential IC stages will use a cascode stage or something similar to one



Cascode Amplifier

- Cascode amplifiers are often used for generating high output impedance and/or high frequency operation



Cascode Amplifier