Project:

Design a transimpedance amplifier. Minimum specifications include:

- Open-loop transimpedance at d-c with a 1kΩ load: $> 200kΩ$
- Input common mode and output range: ±10V
- Output current: ±10mA
- Power supply voltages: ±15V
- Quiescent power consumption: <250mW
- Transistors: see SPICE models below

Use the topology below, with the bias current $I \geq 1mA$. Bias all transistors used in the buffer amplifiers at $I_C \approx 1mA$.

You may have to use a mirror that has an output resistance greater than $r_o$ and an output buffer with a current gain of $\beta^2$ to meet specifications. You may use ideal current sources for biasing. Work out a preliminary design based upon typical numbers from the transistor models. Analyze the circuit by hand, making reasonable approximations. In your report, convince us that you understand this topology.
Show that your design meets the specifications listed above. Then connect your design as shown below.

![Circuit Diagram](image)

The transfer function \( \frac{v_o}{v_i}(j\omega) \) has an angle of \(-180^\circ\) at low frequencies, and the angle becomes more negative as frequency increases. Determine a value for \( R \) that results in an angle of \(-225^\circ\) when the \(|\frac{v_o}{v_i}(j\omega)| = 1\) (that is, results in a phase margin of 45°).

Then connect your amplifier as shown to get a nominal closed loop gain of 11.

![Amplifier Diagram](image)

What is the bandwidth of your amplifier in this connection? What is the actual closed-loop gain at low frequencies?

Your report should be short and informal. Include appropriate plots to support that your design meets all specifications.

**Transistor models:**

* Q[name] Nc Nb Ne [model name]
  .model npn1 npn is=15fA bf=200 vaf=50 cje=10p tf=750p cjc=1p
  .model pnp1 pnp is=15fA bf=50 vaf=25 cje=10p tf=750p cjc=1p