The amplifier shown below is termed a bridge amplifier. The amplifier symbol with the -1 inside is an inverting amplifier with unity gain. The BJT characteristics are shown next to the circuit diagram.

![Bridge Amplifier Diagram](image)

Q1 = Q2 = Q3 = Q4
Beta = 100
V_A = 100 V
V_{CE,sat} = 0 V
Max. junction temp. T_{j,max} = 125 °C
Max. ambient temp. T_{a,max} = 50 °C
Junction-to-case thermal resistance R_{θ,jc} = 1 °C/W

1. (0.5 points)
   Estimate the maximum average power the circuit can deliver to the 8 ohm load.

2. (1 point)
   What is the efficiency (<P_{load}>/<P_{supplies}>) at maximum output signal swing?

3. (0.5 points)
   What should be the peak voltage rating and current rating of the transistors. Include a 50% factor of safety.

4. (1 point)
   What is the maximum average power dissipated in a transistor?

5. (1 point)
   The transistors are mounted next to each other on a common heat sink. Specify the required heat sink thermal resistance so that T_{j,max} is not exceeded when the ambient is at 50°C.
1. \[ \langle P_{\text{Load}} \rangle = \frac{V_0^2}{2R_L} \quad V_{0\text{max}} = 40 \text{ V b}-\text{p} \]

\[ \langle P_{\text{Load}} \rangle_{\text{max}} = \frac{(40)^2}{(2)/(8)} = \frac{1600}{16} = 100 \text{ watts} \]

2. \[
\begin{align*}
\langle P_{\text{Supply}} \rangle &= 2 \frac{1}{\pi} \int_0^\pi \frac{V_{cc}V_0 \sin \theta}{R_L} \\
&= \frac{2}{\pi} \frac{V_{cc}V_0}{R_L} \left[-\cos \theta \right]_0^\pi \\
&= \frac{2}{\pi R_L} \left[ (-1)-(-1) \right] \\
&= \frac{4V_{cc}V_0}{\pi R_L}
\end{align*}
\]
At max signal swing $V_o = 2V_{CC}$ base-to-
peak

Efficiency $\eta_{max} = \frac{(2V_{CC})^2}{2R_L \left( \frac{4V_{CC}}{2R_L} \right) \frac{2V_{CC}}{\pi R_L}}$

$= \frac{4\pi}{16} = \frac{4\pi}{4} = 79\%$

\(\text{Max. } V_{CE} \text{ imposed by circuit} = 40V\)

Voltage rating $= 40 \times 1.5 = 60V$

Max. collector current $= \frac{40V}{85} = 0.5A$

Current rating $= (5)(1.5) = 7.5A$

\(\text{4) } <P_{\text{trans}}> = <P_{\text{supplies}} > - <P_{\text{load}} >$

$= \text{power dissipated in each transistor}$
\[ \angle P_{\text{trans}} \rangle = \frac{4V_{cc}V_o}{4RL/\pi} - \frac{V_o^2}{(4)(2RL)} \]

\[ \frac{d \angle P_{\text{trans}}}{d V_o} = 0 = \frac{V_{cc}}{HR_L} - \frac{V_o}{4RL} \]

\[ V_o = \frac{4}{\pi} V_{cc} = \text{value of } V_o \text{ at max power dissipation in BJTs} \]

\[ \angle P_{\text{trans}} \rangle \bigg|_{\text{max}} = \frac{4V_{cc} \times 4V_{cc}}{4\pi R_L} - \left( \frac{4V_{cc}}{\pi} \right)^2 \]

\[ = \frac{16V_{cc}^2}{4\pi^2 R_L} \left[ 1 - \frac{1}{2} \right] \]

\[ = \frac{2}{\pi^2} \frac{V_{cc}^2}{R_L} = 2 \left( \frac{400}{8} \right) \]

\[ \angle P_{\text{trans}} \rangle \bigg|_{\text{max}} = 10 \text{ watts} \]

\[ T_{j,\text{max}} = 4 \angle P_{\text{trans}} \bigg|_{\text{max}} \left[ R_{\theta_{jc}} + R_{\theta_{s}} \right] + T_{q,\text{max}} \]

\[ R_{\theta_{s}} = \frac{[1.25-50]}{(4)(10)} - 1 = 0.88 \degree \text{C/W} \]