More information on lab project 3.

First: this is a hard project, and it will take several days of active work in the lab for success. The specifications, again: 100 Ohms ≪ Rin ≪ 10 kOhm

You’ll need 1 Vpp for 10 mA input current. RL≈8 Ohms…a physical speaker you should solder to the circuit.

Operation: Lab 1 was a circuit roughly as below. The LED had 10 mA bias current, upon which you could superimpose an AC current.

\[
\begin{align*}
V_{cc} & \quad \text{20 mA} \\
\text{LED} & \quad \text{PINKI I} \\
K & = \frac{1}{1000} \\
\text{The resistor converts this current back into a voltage, and then the signal can be amplified.}
\end{align*}
\]

This illuminates a PIN photodiode. If there were no optical losses, then the photocurrent would be exactly the same as the current in the LED. Instead, with optical losses,

\[
I_{\text{PIN}} = K I_{\text{LED}}, \quad \text{were } K \text{ might be about } 1/1000 \text{ for an LED-PIN separation of a few inches.}
\]

The resistor converts this current back into a voltage, and then the signal can be amplified.

For the first part of the lab check-off, you will test the amplifier using a Signal generator to emulate the PIN. The input current is

\[
I_{\text{PIN}} = V_{\text{PIN}} / (R_{\text{PIN}} + R_{\text{in}}). \quad \text{Make } R_{\text{gen}} \approx 200 \text{ kOhm. Use this configuration for most of your testing.}
\]

When it comes time to test with your LED transmitter (last part of the check-off), you put the LED near to the PIN. Keep both dark (cover with something) to prevent picking up room lights. Because there is a DC current in the LED which is bigger than the AC current, the light picked up by the PIN diode will have both the AC signal you want and a big DC current you don’t.

This will upset the DC output voltage of your amplifier. So, add Roffset, as shown (make it removable, a switch or something) and adjustable… the shop has been warned you will need these. Adjust Roffset so as to cancel the DC current in the PIN, making the DC output of the amplifier again zero volts. Then turn on the AC signal generator, set at 4 kHz, and see if you can pick up and amplify the signal. You should be able to hear it on the speaker.

How to reduce suffering in the lab:

Keep wires short. The whole project can fit on a circuit board the size of a playing card.

Use power supply bypasses. 10 uF in parallel with 0.1 uF.

Make a single FAT ground wire on the board. Connect scope, signal generator, supply, etc., grounds directly to the ground on the board, not to each other. Keep input and output wires away from each other. Keep them short.

Put 1 kOhm in series with the scope probe.

Obey the thermal runaway equation:

\[
(2mV / C)(1 / R_1) (\theta_{\text{junction-case}} + \theta_{\text{case-to-skink}} + \theta_{\text{skink-to-room}} < 1)
\]

PICK BIG (several square inch heat skinks (sheet metal) to make the last thermal resistance less than ~20 C/W. There is a similar equation for R6.

Do the preliminary design report on time. Get it right.

Draw the circuit diagram on a big piece of paper, with bias currents and voltages indicated. Build the circuit on a proto-board, and point-by-point, measure the bias conditions. This will help you find wiring and design errors quickly.

On my web page, I will put a several documents which just show lots of amplifier configurations.