Calculations

Beacon IR detector circuit

Transresistive Circuit

When the phototransistor was off, V_{out} = 2.5V, since no current went through R_1.
When the phototransistor was on, the current through R_1 forced the op amp to rail to 0V:
$Vout = 2.5 - i_{R1}R_1 = 0$, since R_1 was so large (33K).
V_{out} ranged from 2.5V (off) to 0V (on).

AC coupling

The corner frequency was chosen to be very small so that the 50Hz signal would still be seen as high/low on the output instead of being filtered out to 2.5V.

$$\omega_c = \frac{1}{R_2 C_1} = 8.3Hz$$

Amplification

After solving for V_{out} using the op-amp golden rules, the following relationship is derived:

$$V_{out} = \left(1 + \frac{R_4}{R_3}\right) V_{in} - 2.5\frac{R_4}{R_3} = 11V_{in} - 25$$

Any input voltage less than 2.27V saturates to 0V and any voltage greater than 2.72 saturates to 5V. In between these two values, the signal is amplified by 11 and centered around 2.5V. Since the signal in is on the order of 0.1V amplitude, this would have been sufficient to feed into the comparator circuit. Just to be safe, and since we had 4 op-amps in an LM324 package, we fed the signal through an identical amplifier to get an amplification of 121. This resulted in a 0 to 5V square wave oscillating at the frequency of the beacon.

Comparator

Since the signal reliably went over 2.5 when HIGH and under 2.5 when LOW (very rapidly and without any jitter in the signal that would cause false triggers) we decided to forgo hysteresis in our comparator circuit. The output gave us a very crisp and reliable 0-5V square wave to the E128.