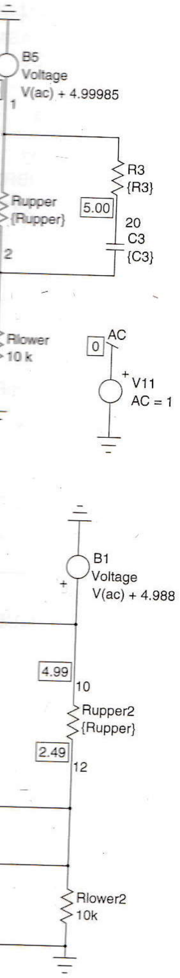

amplifier!

ng (complicated)

pullup (3-73)

ula simplifies to

(3-74)

gain needed at
can compute a

value for C_{pz}, as this capacitor plays a role for the zero (but also for the pole position). From Eq. (3-68a), we can extract R_{pz}:

$$R_{pz} = \frac{1}{2\pi f_{p1} C_{pz}} \tag{3-75}$$

Inserting this result into Eq. (3-69) gives

$$f_{z2} = \frac{1}{2\pi\left(R_{LED} + \frac{1}{2\pi f_{p1} C_{pz}}\right) C_{pz}} \tag{3-76}$$

Solving for C_{pz} leads us to the final result:

$$C_{pz} = \frac{f_{p1} - f_{z1}}{2\pi f_{z1} f_{p1} R_{LED}} \tag{3-77}$$

As we did for the type 2 amplifier, let us imagine that R_{upper} equals 10 kΩ. Then, for the sake of the example, we will create a type 3 amplifier offering the following parameters:

- Crossover frequency = 1 kHz
- Needed phase margin = 100°
- Gain needed at crossover = +20 dB (hence $G = 10$)
- Phase observed at crossover = –55°
- $k = 3.32$ given by the k factor tool

First, the k factor for the type 3 amplifier computes the following coincident pole and zero locations [Eq. (3-42)]. Of course, nothing prevents you from placing individual poles and zeros as discussed above. In that case, use Eq. (3-73) instead.

$$f_z = \frac{f_c}{\sqrt{k}} = 549\ \text{Hz}$$

$$f_p = f_c\sqrt{k} = 1.8\ \text{kHz}$$

Via Eq. (3-74), we obtain the value for R_{LED}: 3.6 kΩ with $R_{pullup} = 20$ kΩ and CTR = 1.

From Eq. (3-77), $C_{pz} = 55.6$ nF. The rest of the elements are easily calculated via Eqs. (3-67), (3-68a), and (3-70):

$$C_{zero1} = \frac{1}{2\pi R_{upper} f_{z1}} = 29\ \text{nF} \tag{3-78}$$

$$R_{pz} = \frac{1}{2\pi f_{p1} C_{pz}} = 1.57\ \text{k}\Omega \tag{3-79}$$

$$C_{pole2} = \frac{1}{2\pi R_{pullup} f_{p2}} = 4.37\ \text{nF} \tag{3-80}$$

Figure 3-43 portrays the test circuitry where all elements are automatically computed. This also works in *OrCAD*. Once the simulation has finished, Fig. 3-44 shows the results: the TL431 plots perfectly match those coming from the type 3 op amp–based circuit!

As we will see in some of the examples, the TL431 does not lend itself well to the type 3 implementation. This is so because the LED resistor acts in the gain definition and the pole-zero position. Depending on the pull-up resistor, an R_{LED} value ensuring the right gain at the crossover frequency and enough bias in light-load conditions can sometimes lead to an impossible solution. In that case, the solution might require the use of an operational amplifier. The implementation of one of the solution depicted by Fig. 3-41 or Fig. 3-42 is also possible.