- CTR = 1
- $R_{pullup} = 20\ \text{k}\Omega$
- $R_{upper} = 10\ \text{k}\Omega$

From Eqs. (3-59) through (3-61),

$$C_{zero} = \frac{1}{2\pi R_{upper} f_z} = 71.8\ \text{nF} \tag{3-62}$$

$$C_{pole} = \frac{1}{2\pi R_{pullup} f_p} = 1.76\ \text{nF} \tag{3-63}$$

$$R_{LED} = \frac{\text{CTR} \cdot R_{pullup}}{G} = 2\ \text{k}\Omega \tag{3-64}$$

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where G is the midband gain (or attenuation) wanted at the crossover frequency [Eqs. (3-27a) and (3-61)].

Figure 3-39 gathers all solutions to compare their ac responses. At the top of the picture, you can recognize the traditional op amp–based type 2 amplifier, tailored to deliver +20 dB at 1 kHz. This is the reference. On the right side, this is the equivalent internal arrangement of the TL431, featuring the various electrical paths. Finally, on the left side, appears the complete chain, implementing a simplified optocoupler network (a current-controlled current source F_2) without a pole. When the simulator runs, it delivers Bode plots, all assembled in Fig. 3-40, which shows perfect agreement between all graphical representations. This terminates the type 2 configuration built around a TL431. It is now time to explore the type 3 version.

here

but there is no small inductor

or (1)

3.7.2 A Type 3 Amplifier with the TL431

The type 3 version is a bit more complicated, again because of the fast lane presence. We could get rid of this input by inserting a zener diode or a bipolar device to avoid any interference with the output voltage. This is shown in Figs. 3-41 and 3-42 [4]. However, it requires external components and it slightly complicates the design. How do we place a zero in the TL431 chain? In parallel with R_{upper} as on the traditional op amp–based solution? No, because of the fast lane, the solution does not work. The only solution is to place an RC network in parallel with R_{LED}. This is what Fig. 3-43 portrays. Fortunately, the transfer function of this new arrangement does not differ too much from Eq. (3-58). The only difference lies in the R_{LED} expression since an RC network now comes in parallel. The equivalent arrangement features the following impedance:

$$Z_{eq} = \frac{R_{LED}(sR_{pz}C_{pz} + 1)}{sC_{pz}(R_{LED} + R_{pz}) + 1} \tag{3-65}$$

Once Eq. (3-65) is inserted into Eq. (3-58) in place of R_{LED}, the complete transfer function becomes

$$G(s) = \frac{V_{FB}(s)}{V_{out}(s)} = -\underbrace{\left(\frac{sR_{upper}C_{zero1}+1}{sR_{upper}C_{zero1}}\right)}_{1}\underbrace{\left(\frac{1}{1+sR_{pullup}C_{pole2}}\right)}_{2}\underbrace{\frac{[sC_{pz}(R_{LED}+R_{pz})+1]}{(sR_{pz}C_{pz}+1)}}_{3}\underbrace{\frac{R_{pullup}}{R_{LED}}\text{CTR}}_{4} \tag{3-66}$$

As usual, we can calculate the poles and zeros from the following definitions:

$$f_{z1} = \frac{1}{2\pi R_{upper}C_{zero1}} \tag{3-67}$$

Cpole 2 – remember to include the opto pole.