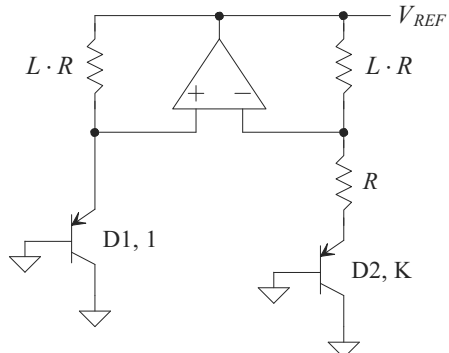
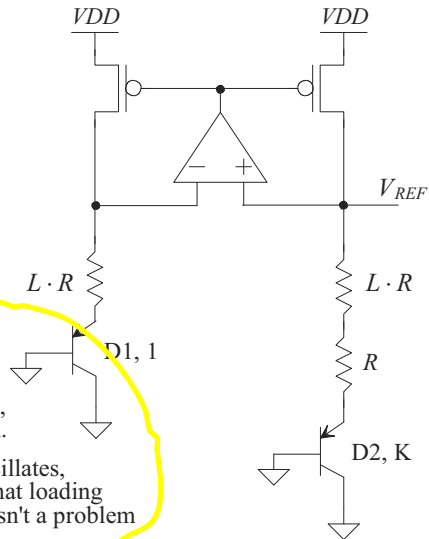


(a) Alternative BGR using cascodes.



(b) Using an amplifier to force the same current through each branch of the reference, see Fig. 23.16.



(c) Using PMOS devices to isolate the amplifier from the resistive loading.

Start-up circuits (required) are not shown. Compensation capacitors for stability are also not shown. See the bottom of pages 625, 630, and Fig. 23.7 for additional information.

In simple terms, to avoid a reference that oscillates, minimize the capacitive load on  $V_{REF}$ . Note that loading the reference voltage with a large capacitor isn't a problem in the BGR seen in Fig. 23.27.

**Figure 23.29** Alternative BGR topologies.

amplifier's output from the resistors. This makes using a diff-amp for the added amplifier possible. The currents are equal in (c) because the source-gate voltages of the PMOS devices are equal. Note how the branch containing D2 is a higher resistance (than the branch containing D1) and so it (the D2 branch) is always connected to an inverting point in the feedback loop. As seen in (c) the addition of the PMOS devices (which are inverting) means that we need to switch the inverting and noninverting amplifier inputs from (b). Finally, note that a start-up circuit is required for all three of these references.