

**Figure 23.29** Alternative BGR topologies.

In (c) PMOS devices are added to isolate the 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.