2
Operational Transconductance Amplifier-C Filters

In this chapter, Active filters using only OTAs and capacitors are described. Cascade design of OTA-C filters needs high input impedance for each block, as well as first-order and second-order blocks. Various structures that can be used to implement these will be discussed in detail. The subject of ladder filter simulation using component simulation as well as operational simulation also will be discussed in detail. Finally, the multiple loop feedback technique for attaining high-order filters will be considered.

2.1. First-order OTA-C filters

The OTA-C circuit of figure 2.1 (a) realizes a lossless differential integrator and can be used as an inverting or non-inverting integrator. A lossy integrator can be obtained by two techniques, one based on figure 2.1 (a) by shunting a resistor across the capacitor (see figure 2.1 (b)). The resistor is simulated by an OTA. Alternatively, the circuit of figure 2.1 (c) can be employed where both the input feeding as well as the introduction of the loss can be done by one OTA. The advantage of the circuit of figure 2.1 (b) is to obtain a variable gain as well as a differential input gain function. The transfer functions of the various circuits are as shown in figure 2.1. Note that the output resistance and capacitance of the OTAs affect the transfer functions.

First-order high-pass filters can be derived [2.1] as shown in figure 2.2 (a). The transfer function of this circuit is given by

$$\frac{V_o}{V_i} = \frac{sC}{sC + g_m} \tag{2.1}$$

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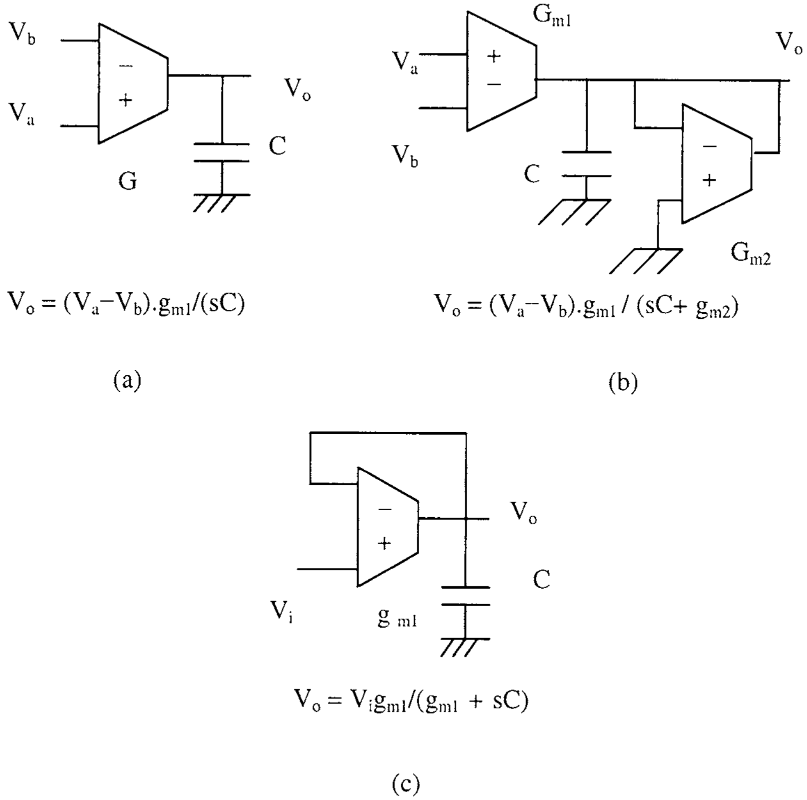

FIGURE 2.1. (a) Lossless differential integrator and (b) and (c) lossy integrators (adapted from [2.1] ©1985 IEEE)

Note that the circuit needs a floating capacitor. Mead [2.2] has suggested a circuit using grounded capacitors shown in Figure 2.2 (b), which uses the fact that

$$\frac{sCR}{1+sCR} = 1 - \frac{1}{1+sCR} \tag{2.2}$$

Thus the first-order low-pass filter of figure 2.1 (c) cascaded by an amplifier realized by OTAs g_{m2} and g_{m3} achieves the first-order high-pass filter shown in figure 2.2 (b) whose transfer function is given by

$$\frac{V_o}{V_i} = \frac{sC}{sC + g_{m1}} \cdot \frac{g_{m2}}{g_{m3}} \tag{2.3}$$