dual slope A/D converters fall in this category.

13.9.1 Simultaneous Type (Flash type) A/D Converter

The simultaneous type A/D converter is based on comparing an unknown analog input voltage with a set of reference voltages. To convert an analog signal into a digital signal of n output bits $(2^n - 1)$ number of comparators are required. For example, a 2-bit A/D converter requires 3 or $(2^2 - 1)$ comparators, while a 3-bit converter needs 7 or $(2^3 - 1)$ comparators. The block diagram of a 2-bit simultaneous type A/D converter is shown in Fig. 13.16.

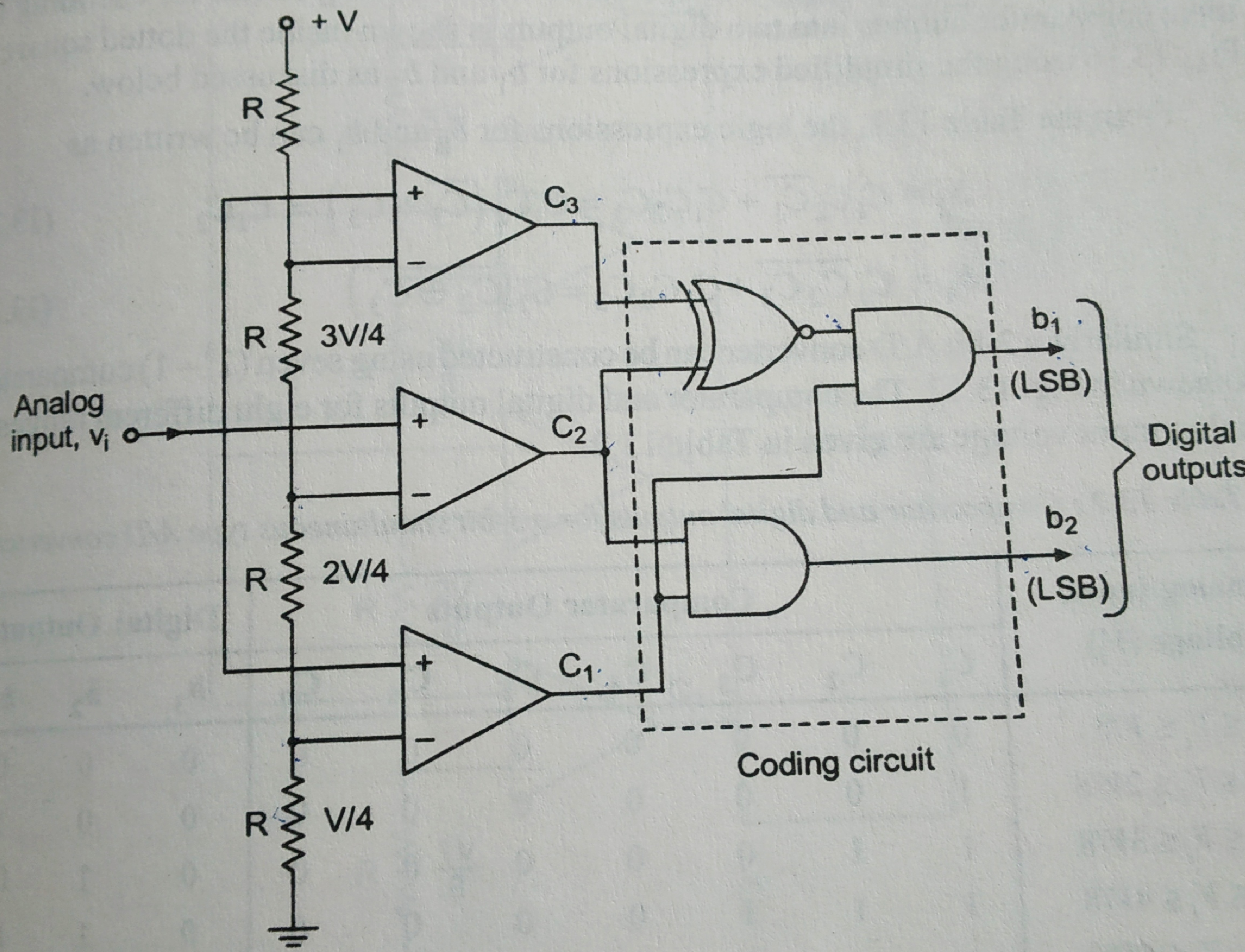

Fig. 13.16 Block diagram of a 2-bit simultaneous type A/D converter

As shown in Fig. 13.16, the three op-amps are used as comparators. The noninverting inputs of all the three comparators are connected to the analog input voltage. The inverting input terminal of the op-amps are connected to a set of reference voltages V/4, 2V/4 and 3V/4 respectively, which are obtained using a resistive divider network and power supply +V.

The output of a comparator is in *positive* saturation state when the voltage at the noninverting input terminal is more than the voltage at the inverting terminal and it is in *negative* saturation state otherwise. When the analog input voltage is less than $V/4$, the voltage at the noninverting terminals of the three comparators is less than their respective inverting input voltages, and hence, the comparator outputs are $C_1C_2C_3 = 000$. When the analog input is between $V/4$ and $V/2$, the comparator outputs are $C_1C_2C_3 = 100$. Table 13.1 shows the comparator outputs for different ranges of analog voltage and their corresponding digital outputs.

***Table 13.1** : Comparator and digital outputs for a 2-bit simultaneous type A/D converter*

Analog input voltage (V_i)	Comparator Outputs			Digital Outputs	
	C_1	C_2	C_3	b_2	b_1
$0 \leq V_i \leq V/4$	0	0	0	0	0
$V/4 \leq V_i \leq V/2$	1	0	0	0	1
$V/2 \leq V_i \leq 3V/4$	1	1	0	1	0
$3V/4 \leq V_i \leq V$	1	1	1	1	1

Since there are four ranges of analog input voltages, this can be coded using a 2 bit digital output (b_2, b_1) as shown in Table 13.1. The coding circuit for encoding the three comparator outputs into two digital outputs is shown inside the dotted square of Fig. 13.16 using the simplified expressions for b_1 and b_2 as discussed below.

From the Table 13.1, the logic expressions for b_2 and b_1 can be written as

$$b_2 = C_1C_2\overline{C_3} + C_1C_2C_3 = C_1C_2\left(\overline{C_3} + C_3\right) = C_1C_2 \qquad (13.20)$$

$$b_1 = C_1\overline{C_2\,C_3} + C_1C_2C_3 = C_1\left(\overline{C_2 \oplus C_3}\right) \qquad (13.21)$$

Advantages

(i) Simultaneous type A/D converter is the fastest because A/D conversion is performed simultaneously through a set of comparators. Hence, it is also called *flash type* A/D converter. Typical conversion time is 100ns or less.

(ii) The construction is simple and easier to design.

Disadvantages

The simultaneous type A/D converter is not suitable for A/D conversion with more than 3 or 4 digital output bits. Then $(2^n - 1)$ comparators are required for an n-bit A/D converter and the number of comparators required doubles for each added bit.