Flash type (simultaneous type) A/D converter (for 2-bit digital o/p)

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Flash type A/D converter is open-loop and direct type analog-to-digital converter which is based on the technique of comparision of unknown input analog voltage with a set of reference voltages. To convert a range of input analog voltage into n-bit digital output, we need (2^n-1) comparators. Here we design 2-bit flash type Analog-to-digital converter. For this we need $(2^2-1)=3$ comparators. The fig-1 shows a block diagram of 2-bit flash type A/D converter. since we have to convert analog input into 2-bit digital output, hence we need $2^2-1=3$ discrete level of reference voltages as $\frac{V}{4}, \frac{2V}{4}, \frac{3V}{4}$ as shown in fig-1.

As illustrated in fig-1, three op-amp are used here as comparators. The inverting terminal of op-amp-1, 2, 3 are connected with reference voltages as $V/4, 2V/4, 3V/4$ respectively, which are

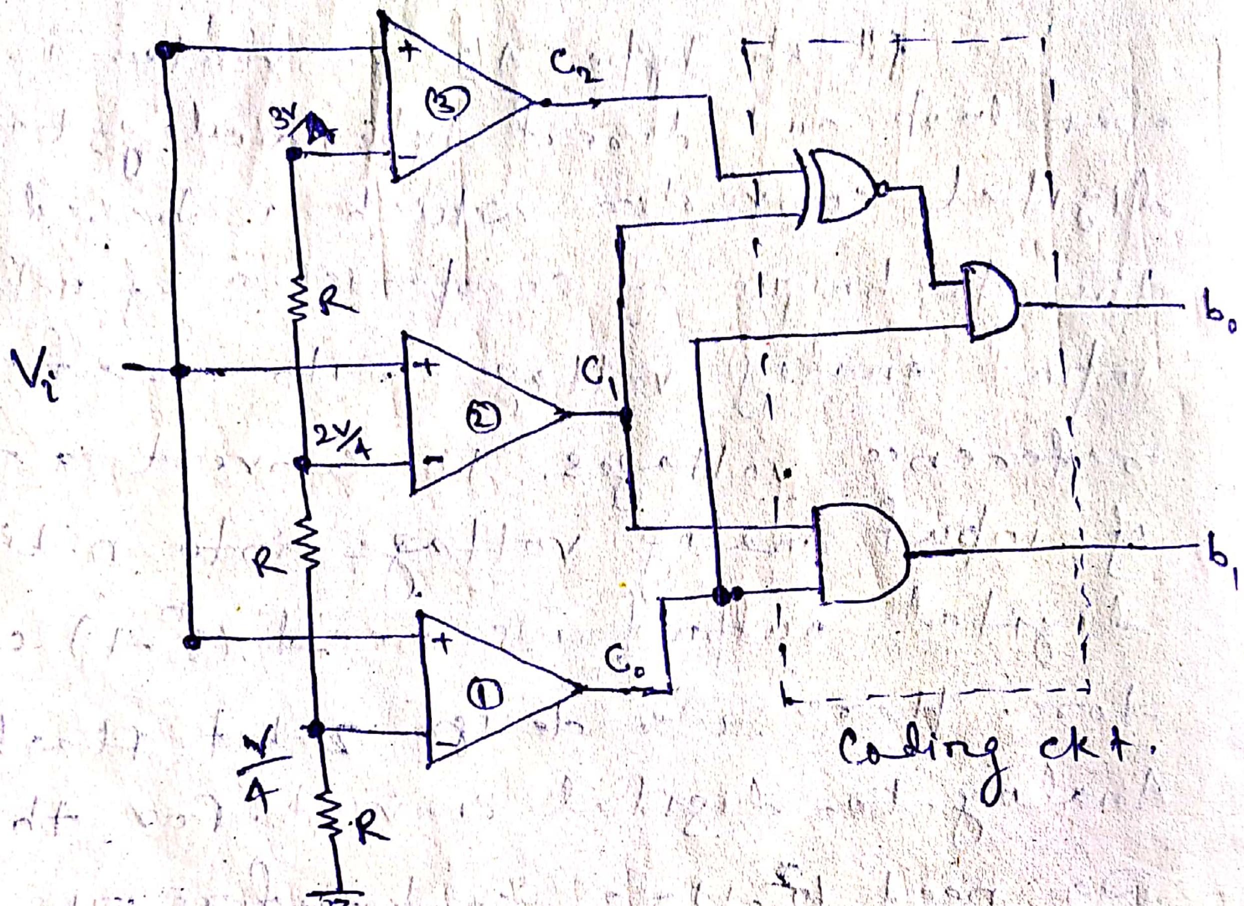

Fig-1

obtained by voltage divider ckt. The analog input voltage that is to be converted into digital signal, is supplied to non-inverting terminal of all three op-amp.

Working:- When input voltage V_i is less than the reference voltage $\frac{V}{4}$ (at inverting terminal), all the op-amp (which are used as comparators), gives output as negative saturated voltage and assumed as LOW. Thus, in this case, $C_2C_1C_0 = 000$. Again, when unknown applied analog input voltage V_i is greater that $\frac{V}{4}$ but less than $\frac{2V}{4}$ then only op-amp-1 goes to +ve saturated output voltage which treated as HIGH, but op-amp-2 & 3 gives as -ve saturated voltage which are treated as LOW. Thus, comparators output is $C_2C_1C_0 = 001$. Thus obtained comparator ~~is~~ are encoded by using digital coding ckt which are shown in fig-4 by dotted box. The entire working function and comparators output can be listed as below in table-

Analog input(V_i)	Comparator o/p C_2	C_1	C_0	Digital o/p b_1	b_0
$0 \le V_i \le V/4$	0 (LOW)	0 (LOW)	0 (LOW)	0	0
$V/4 \le V_i \le \frac{2V}{4}$	0	0	1 High	0	1
$\frac{2V}{4} \le V_i \le \frac{3V}{4}$	0	1	1	1	0
$\frac{3V}{4} \le V_i \le V$	1	1	1	1	1

By using K-map, we can design the coding digital ckt as below —

b_0:

c_1c_0 \ c_2	0	1
00		
01	1	
11		1
10		

$\bar{c}_2\bar{c}_1c_0$ $c_2c_1c_0$

b_1:

c_1c_0 \ c_2	0	1
00		
01		
11	1	1
10		

c_1c_0

$$b_0 = c_2c_1c_0 + \bar{c}_2\bar{c}_1c_0$$
$$= (c_2c_1 + \bar{c}_2\bar{c}_1)c_0$$
$$= c_0(\overline{c_2 \oplus c_1})$$

$$b_1 = c_1c_0$$

3-bit flash type (or simultaneous type) A/D converter

3-bit simultaneous type A/D converter, convertes the entire analog input voltage into 3-bit digital word by comparision of input analog voltage with $\frac{V}{2^3}$, $\frac{2V}{8}$, $\frac{3V}{8}$, $\frac{4V}{8}$, $\frac{5V}{8}$, $\frac{6V}{8}$, $\frac{7V}{8}$. For designing 3-bit flash type A/D converter, we need $2^3-1=7$ comparators.

The reference voltages to which input analog voltage is to be compared and comparates output as $c_0, c_1, c_2, c_3, c_4, c_5, c_6, c_7$ are listed in table-1. Fig-Ⓐ shows 3-bit flash type A/D converter.

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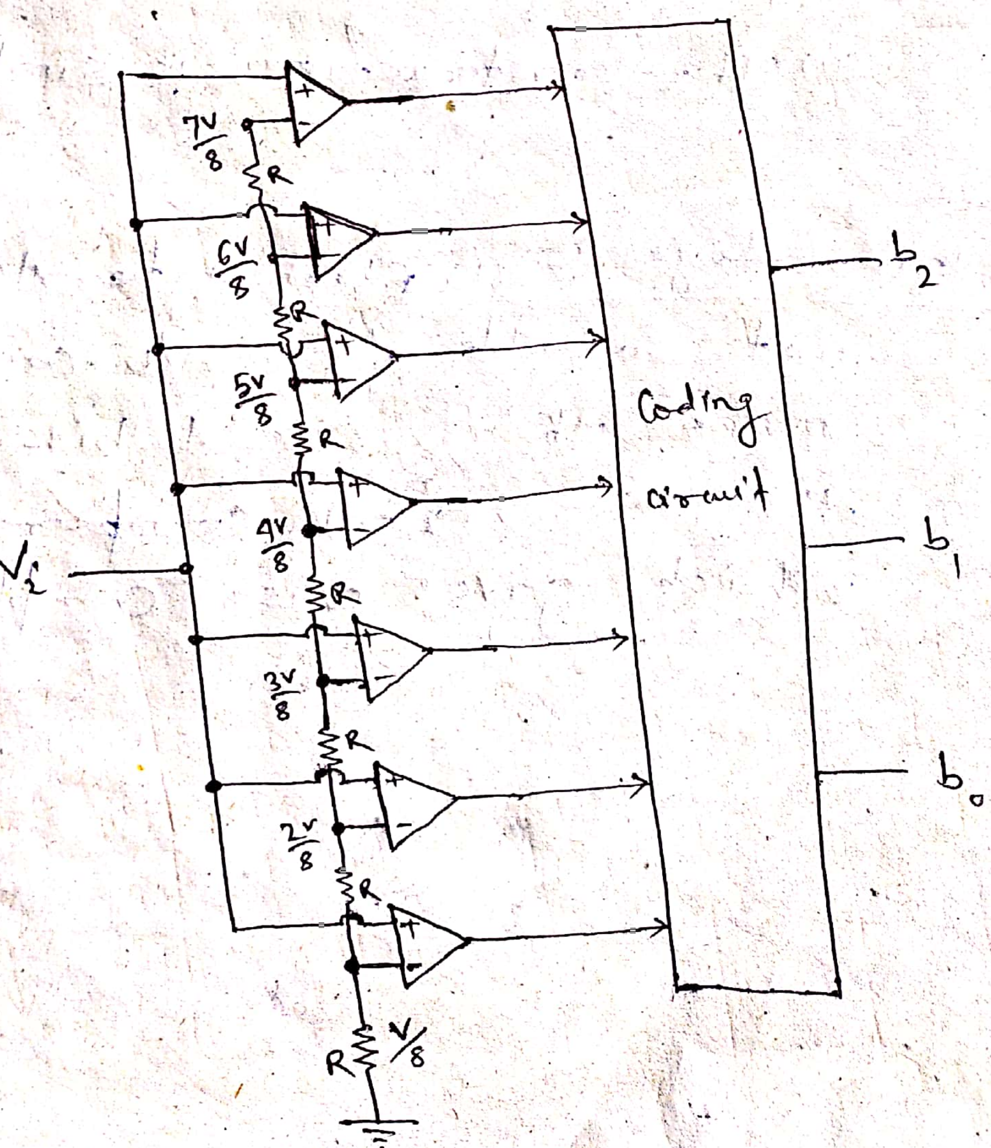
Input voltage	Comparator output							Digital o/p		
	c_6	c_5	c_4	c_3	c_2	c_1	c_0	b_2	b_1	b_0
$0 \le V_i < V/8$	0	0	0	0	0	0	0	0	0	0
$V/8 \le V_i < \frac{2V}{8}$	0	0	0	0	0	0	1	0	0	1
$2V/8 \le V_i < \frac{3V}{8}$	0	0	0	0	0	1	1	0	1	0
$3V/8 \le V_i < \frac{4V}{8}$	0	0	0	0	1	1	1	0	1	1
$4V/8 \le V_i < \frac{5V}{8}$	0	0	0	1	1	1	1	1	0	0
$5V/8 \le V_i < 6V/8$	0	0	1	1	1	1	1	1	0	1
$6V/8 \le V_i < 7V/8$	0	1	1	1	1	1	1	1	1	0
$7V/8 \le V_i \le V$	1	1	1	1	1	1	1	1	1	1



[Fig-4]

Fig-4 represents the logic ckt diagram of a 3-bit simultaneous type A/D (or Flash type A/D) converter.

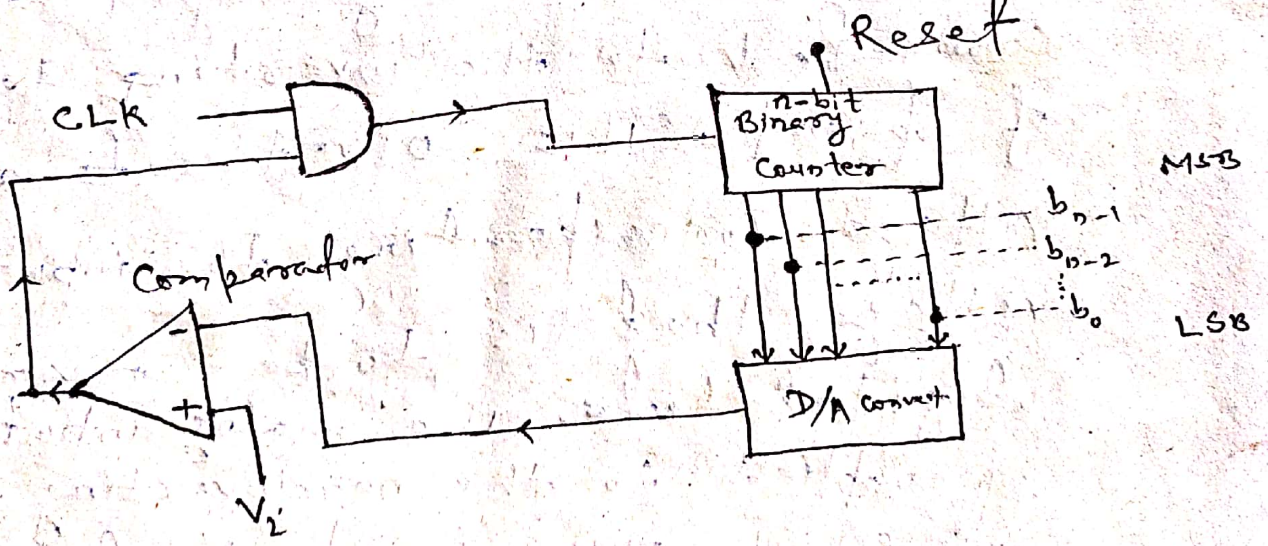
Advantages :- (i) Flash type A/D converter is the fastest because in this converter, the conversion is performed simultaneously through a set of comparators. A typical conversion time is 100ns or less.

(ii) The construction is simple and easier.

Disadvantages :- (i) Flash type A/D converter is not suitable for A/D conversion with more than 3 or 4 bits. Because we need (2^n-1) comparators to design which gives rise complexity.

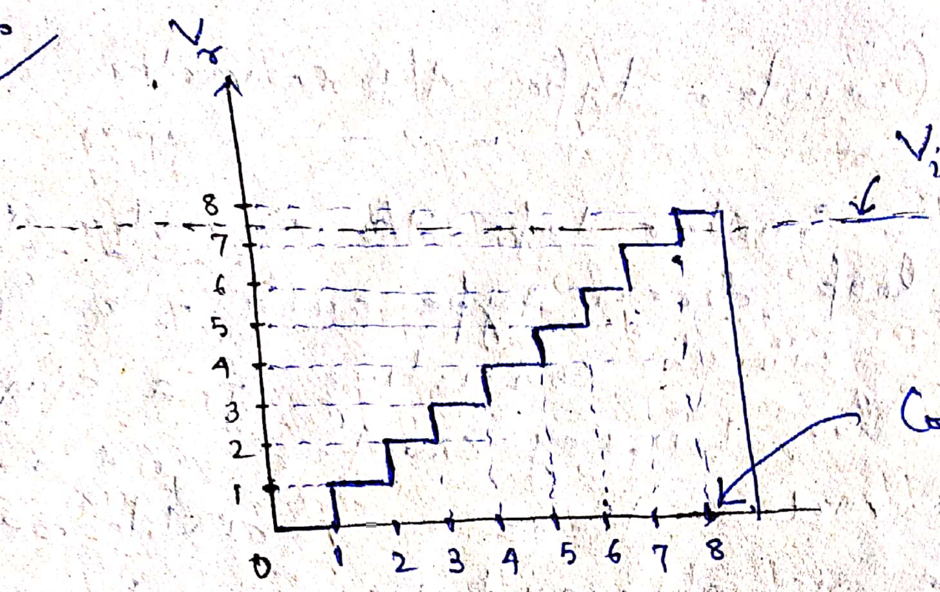
Counter type A/D converter

Counter type A/D converter is a closed-loop direct type analog-to-digital converter which consisting of a single comparator, binary counter and a D/A converter. Here a variable reference voltage is obtained by using binary counter and input analog signal is compared with this variable reference voltage and then digital data is produced correspondingly. The fig-① shows a basic block diagram of a counter type A/D converter.



Counter type A/D converter.

Fig-1.



Operation :- The n-bit binary counter is initially Reset or set to zero by switch RESET. RESET switch is active LOW And, hence Counter output is LOW which is given to D/A converter which produces 0 volt analog output and is connected to the inverting terminal of op-amp. This 0 volt acts as refer voltage corresponding to input analog voltage that is to be converted into digital data. The analog input voltage is applied to the non-inverting terminal of op-amp, this op-amp functions as a comparator and output of it, is given to AND gate as shown in fig. A clock pulse is also applied to another terminal of AND gate.

NOTE (for n-bit A/D converter)

Maximum Conversion for n-bit A/D —

i) Successive type — n-clock cycle

ii) Parallel comparator or Flash type A/D — 1 clock cycle

iii) Dual-slope A/D — 2^n clock cycle

iv) Max^m counts to reach full scale conversion for counter type A/D converter — 2^n counts.

v) Average conversion time for counter type A/D converter — 2^{n-1} time clock period.

- **Digital output corresponding to analog input** —

$$\boxed{\sum_{i=0}^{n} 2^i b_i = \frac{V_{in}}{\text{Resolut}^n}}\ , \quad \text{Resolution} = \frac{V_R}{2^n}.$$

- 1 LSB = Resolution
weigth

- Accuracy = $T_{coeff.} \times (T_{max} - T_{calibration})$

$\pm \frac{1}{2}$ LSB = $T_{coeff} (T_{max} - T_{calib})$

where, T_{coeff} = Temp. coeff. of A/D converter in V/°C
T_{max} = Max^m temp of operating range
$T_{calib.}$ = Calibrated temp. of A/D converter.