GE1354 Tutorial Sheet

Analog to Digital Conversion

1. Convert the following binary numbers to decimal numbers and hexadecimal numbers
   a) 10100011
   b) 101101
   c) 110100101010

Ans.

	From binary to decimal	From binary to hexadecimal
a)	163	A3
b)	45	2D
c)	3370	D2A

2. Convert the following decimal numbers to binary numbers and hexadecimal numbers
   a) 112
   b) 25673
   c) 1000

	From decimal to binary	From decimal to hexadecimal
a)	01110000	70
b)	0110010001001001	6449
c)	0000001111101000	3E8

3. Consider a 3-bit ADC. The conversion from analog voltage to digits is shown in Fig. Q3. The full-scale is 10V.
   a) How much voltage does one LSB represent?
   b) What is the possible range of voltage if the output is 010?
   c) What is the maximum quantization error?
   d) Derive an equation to convert an analog input to the output code in decimal and binary. Illustrate the results if the ADC value is 6 (in decimal).

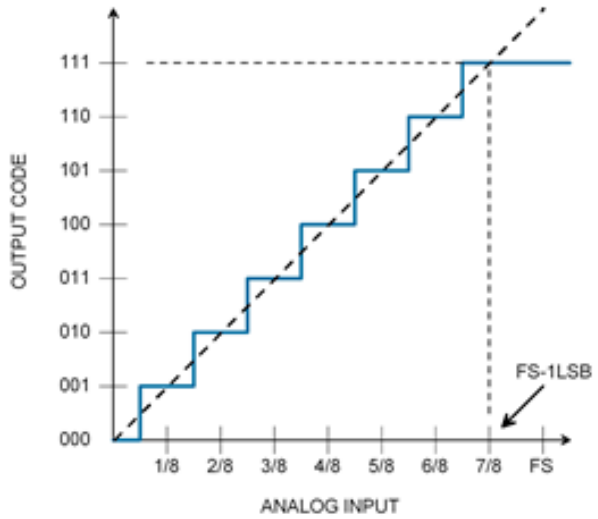


Fig. Q3

Ans.

a) 1 LSB = 1 / (2^3) × 10 V = 1.25V

b) If the output is 010, the possible range of analog input is:

$[10 \times \frac{3}{16},\ 10 \times \frac{5}{16}]$ = [1.875V, 3.125V], including 1.875V, excluding 3.125V

c) Quantization error is ± 0.5 LSB. Therefore, the maximum error is 1.25V / 2 = 0.625V.

d) The ADC output in decimal can be expressed as

$$\text{ADC value} = \text{Round}\left(\frac{8}{10} v_{in}\right)$$

The ADC value (in decimal) can be converted into a binary representation as follows:

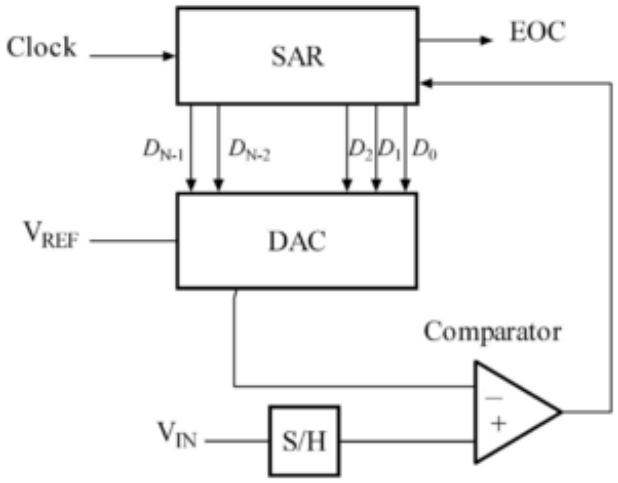
3^{rd} bit	2^{nd} bit	1^{st} bit
floor (ADC / 4)	rem (floor (ADC / 2) / 2)	rem (ADC / 2)

Note: rem (x/y) returns the reminder of the division, floor(x) returns the largest integer less than or equal to x.

For example, if ADC =6,
3^{rd} bit : floor(6/4) = 1
2^{nd} bit : rem(floor(6/2)/2) = rem(3/2)=1
1^{st} bit : rem(6/2)=0

The answer is equal to 110

4*. Discuss how an ADC converter is implemented by a digital-to-analog (DAC) converter.


Clock
SAR
EOC
D_{N-1}
D_{N-2}
D_2
D_1
D_0
V_{REF}
DAC
Comparator
V_{IN}
S/H
−
+