Chapter 4

Textbook questions

Question 4-1

- Convert each of the following decimal numbers to its binary equivalent.

(a) 37 (b) 93 (c) 129 (d) 355

(a) $2^5=32$ 37-32=5

$2^2=4$ 5-4=1

$2^0=1$

□100101

(b) $2^6=64$ 93-64=29

$2^4=16$ 29-16=13

$2^3=8$ 13-8=5

$2^2=4$ 5-4=1

$2^0=1$ 1-1=0

 1011101

(c) $2^7=128$ 129-128=1

$2^0=1$ 1-1=0

 10000001

(d) $2^8=256$ $355-256=99$

$2^6=64$ $99-64=35$

$2^5=32$ $35-32=3$

$2^1=2$ $3-2=1$

$2^0=1$ $1-1=0$

 101100011

Question 4-2

Convert each of the following decimal numbers into binary-coded-decimal (BCD) numbers.

(a) 37

(b) 93

(c) 129

(d) 355

(a) 3 = 0011
7 = 0111

37 in BCD = 0011 0111

(b) 1001 0011

(b) 0001 0010 1001

(b) 0011 0101 0101

Question 4-3

Based on your answer in 4-1 and 4-2, which is more efficient in expressing decimal numbers in the fewest number of bits, binary or BCD? Why is the less efficient coding scheme still very useful?

Comparing 4-1c with 4-2c we see that in binary we need 8 bit to express 129_{10}, while in BCD we need12 bits. Likewise in 4-1d, we need 9 bits to express 355_{10} while in BCD, we need 12 bits. Hence, binary is more efficient. BCD is still very useful because it is much easier for humans to read and translate since it is closer to decimal.

Question 4-8

Three ADCs all have a range of 0 to 12V and a digitization uncertainty of ±1 LSB. What is the maximum uncertainty in the digitization of a 10-V signal if the converters have

(a) 8 bits?

(b) 12 bits?

(c) 16 bits?

(a) $2^8 = 256$ so 12 V/256 = 0.047V

(b) $2^{12} = 4096$ so 12 V/4096 = 0.0029V

(c) $2^{16} = 65536$ so 12V/65536 = 0.00018V

Question 4-11

ADCs digitalize at different rates. What conversion rate is required if a chromatographic peak is to be sampled and digitized 25 times between the first positive deflection from the baseline until the peak returns to the baseline? The total baseline-to-baseline time is (a) 20s and (b) 1s.

(a) 20 s/25 points = 0.8 s/point

$$\frac{1}{0.8 \text{ s/point}} = 1.25 \text{ point/s or } 1.25 \text{ Hz}$$

(b) 1 s/25 points = 0.04 s/point or 25 points/s = 25 Hz.

Question 4-12

According to the Nyquist sampling criterion, a signal must be digitized at a rate at least twice that of the highest frequency in the signal to avoid a sampling error. If a particular 12-bit ADC has a conversion time of 5μs, what is the highest frequency that can be accurately digitized while satisfying the Nyquist criterion.

Conversion frequency = 1/5 μs = 200 kHz

According to the Nyquist criterion, the maximum signal frequency should be half the conversion frequency or 200 kHz/2 = 100 kHz.