Embedded Systems (Tutorial_02)

Chamika Bandara
BEng(Hons)Digital Communication & Electronics ,
MSc in Information Security,
MIET(London),AMIIESL.
0714446072

Ex_01

In a microcomputer, the *addresses* of memory locations are binary numbers that identify each memory circuit where a byte is stored. The number of bits that make up an address depends on how many memory locations there are. Since the number of bits can be very large, the addresses are often specified in hex instead of binary.

(a) If a microcomputer uses a 20-bit address, how many different memory locations are there?

(b) How many hex digits are needed to represent the address of a memory location?

(c) What is the hex address of the 256th memory location? (*Note:* The first address is always 0.)

Ex_1 _Solution

(a) A 20-bit address will allow 1,048,576 (2^{20}) different memory locations to exist.
(b) Since a hex digit requires 4 bits to represent, it will take 5 hex digits to represent the 20-bit address of a memory location.
(c) $000FF_{16}$

Ex_02

In an audio CD, the audio voltage signal is typically sampled about 44,000 times per second, and the value of each sample is recorded on the CD surface as a binary number. In other words, each recorded binary number represents a single voltage point on the audio signal waveform.

(a) If the binary numbers are six bits in length, how many different voltage values can be represented by a single binary number? Repeat for eight bits and ten bits.

(b) If ten-bit numbers are used, how many bits will be recorded on the CD in 1 second?

(c) If a CD can typically store 5 billion bits, how many seconds of audio can be recorded when ten-bit numbers are used?

Ex_02_ Solution

(a) 2^6=64 different voltage values; 2^8=256 different voltage values; 2^{10}=1,024 different voltage values.
(b) In 1s there are about 44,000 samples of 10-bits each recorded on the CD surface. Thus, there are about 440,000 bits recorded on the CD disk during 1s of sampling.

(c) There are about 440,000 bits recorded on the CD disk in 1 second of audio. Therefore, 5 billion bits of audio stored on the CD disk will be equivalent to approximately 11,363.63 seconds (5×10^9/440,000).

Ex_03

A black-and-white digital camera lays a fine grid over an image and then measures and records a binary number representing the level of gray it sees in each cell of the grid. For example, if four-bit numbers are used, the value of black is set to 0000 and the value of white to 1111, and any level of gray is somewhere between 0000 and 1111. If six-bit numbers are used, black is 000000, white is 111111, and all grays are between the two.

Suppose we wanted to distinguish among 254 different levels of gray within each cell of the grid. How many bits would we need to use to represent these levels?

Ex_03_ Solution

$254=2^{x}$. Therefore $x=7.98$˜8-bits

Ex_04

A 3-Megapixel digital camera stores an eight-bit number for the brightness of each of the primary colors (red, green, blue) found in each picture element (pixel). If every bit is stored (no data compression), how many pictures can be stored on a 128-Megabyte memory card? (Note: In digital systems, Mega means 2^{20}.)

Ex_04 Solution

Mega = 2^{20} =1,048,576
3 Bytes/pixel (1 byte per primary color)
(3 Bytes/pixel) x 3 x 1,048,576 = 9,437,184 Bytes/photo
Memory card capacity = 128 x 1,048,576 = 134,217,728 Bytes/card
Thus, (134,217,728 Bytes/card) / (9,437,184 Bytes/photo) = 14.2 photos/card or ***14 Pictures.***