Design Engineering – EA1.3 Electronics

Problem Sheet 5 Solutions (Topics 12 - 13)

1. Using 2^n where n = 4 gives 16 different possible symbols.

2. Total number of different symbols = 26 + 26 + 3 = 55. If we choose n = 5 we can represent 32 symbols which is too few. If we choose n = 6 we can represent 64 symbols which is OK. We can only choose integers for n. Thus we need 6 bits.

3. Total number of symbols used in the message is 17. (Don't forget to include the space between the words and the full-stop at the end). From Question 2 above we know that we need 6 bits per symbol. Therefore, the total number of bits in the message is 6 x 17 = 102. At a rate of 9600 bits per second, 102 bits would take 102/9600 = 10.625 ms.

4. a) $(5)_{10} \equiv (101)_2$ b) $(99)_{10} \equiv (1100011)_2$ c) $(1024)_{10} \equiv (10000000000)_2$

5. a) $(1010)_2 \equiv (10)_{10}$ b) $(10000000)_2 \equiv (128)_{10}$ c) $(11111111)_2 \equiv (255)_{10}$

6. a) $(64)_{10} \equiv (40)_{16}$ b) $(98)_{10} \equiv (62)_{16}$

7. Converting between binary and octal or hex is quite straight-forward because the bases are related by integer powers. This means that each group of binary digits is directly related to a hex or octal digit. The octal base is the 3rd power of the binary base hence a group of 3 binary digits is equivalent to 1 octal digit. The hex base is the 4th power of the binary base and hence a group of 4 binary digits is equivalent to one hex digit. It is easy to see why writing in binary is not popular when considering problem 4c) for example. Hex and octal are much more compact and, hence, more popular.

   a) $(F8)_{16} \equiv (1111\ 1000)_2$ b) $(144)_{16} \equiv (1\ 0100\ 0100)_2$

   Note that each hex digit is equivalent to four binary digits and that these groups of four bits have been separated by spaces. The use of such spaces aids clarity but is optional.

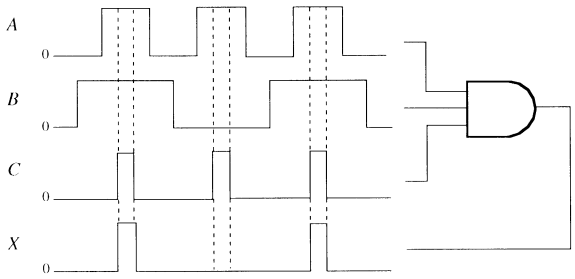
8. a) 01101001 b) 0000 with a carry-out of 1 c) 00101010 d) 1011

   In b), the addition has overflowed the size of the input numbers (given as 4 bits). The extra 1 generated from adding the MSBs is called a carry. If this carry is not handled correctly, it will cause an error in the calculation.

   In d), the answer wants to be negative - except you may not yet have studied how to represent negative numbers. The answer given here turns out to be correct in 2's complement form - more on that later in the course

9. Using binary representations, U is coded as 1010101, k is coded as 1101011. Converting these to hex gives U as 55 and k as 6B.

10.



11. $Z = A \cdot B + C \cdot D$

A	B	C	D	A B	C D	Z
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	0	1	1	0	1	1
0	1	0	0	0	0	0
0	1	0	1	0	0	0
0	1	1	0	0	0	0
0	1	1	1	0	1	1
1	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	0	0	0
1	0	1	1	0	1	1
1	1	0	0	1	0	1
1	1	0	1	1	0	1
1	1	1	0	1	0	1
1	1	1	1	1	1	1

12. There are 13 address pins (i.e. address bus is 13 bits wide) and 8 data pins (i.e. data is 8 bits wide).

13. Program Counter is a register that contains the address in memory of the next instruction to be executed by the CPU. Once the instruction is fetched, the register is incremented – hence the name Program Counter.

14. A microprocessor is part of a microcontroller. A microcontroller contains one or more microprocessors (called cores) and many other hardware modules to aid interfacing to the outside world.