Digital Electronics

Answer Sheet 7

1.

Bit Pattern	Unsigned	Signed
0101	5	5
1101	13	13-16=-3
1111	16-1=15	-1
00100000	32	32
11011111	255-32=223	-1-3 =-33
01111110	128-2=126	126
10000000	128	-128

2. The basic reason is that the range of numbers is asymmetrically distributed about zero. For an 8 bit system, say, the range is -128 to +127. It is therefore impossible to represent (-1 x -128).

3. & 4. You can find the answers in any textbook.

5. The answer to this question will not be presented here since 7 segment display decoders will be studied further in the Electrical Laboratory.

6. a) -2^N to $2^N - 2$ which needs N+1 bits.

   b) $-(2^{2N-2} - 2^{N-1})$ to 2^{2N-2} which needs 2N bits. Note that it nearly fits into 2N-1 bits whose range extends to $2^{2N-2} - 1$.

7. To invert the number, we must interchange segments a and d, b and e, and c and f. We need a standard 7-segment decoder followed by multiplexers to do the switching. See figure 1.

   When $\overline{\text{ENABLE}}$ is high, the display will be turned off; if it is connected to a square wave, the duty cycle will control the brightness of the display. This method of brightness control is more cost effective than controlling the display currents with analogue circuits.

   Connect $\overline{\text{ENABLE}}$ to 0 to make the display permanently on. In this case, segment g need not be passed through the multiplexer.

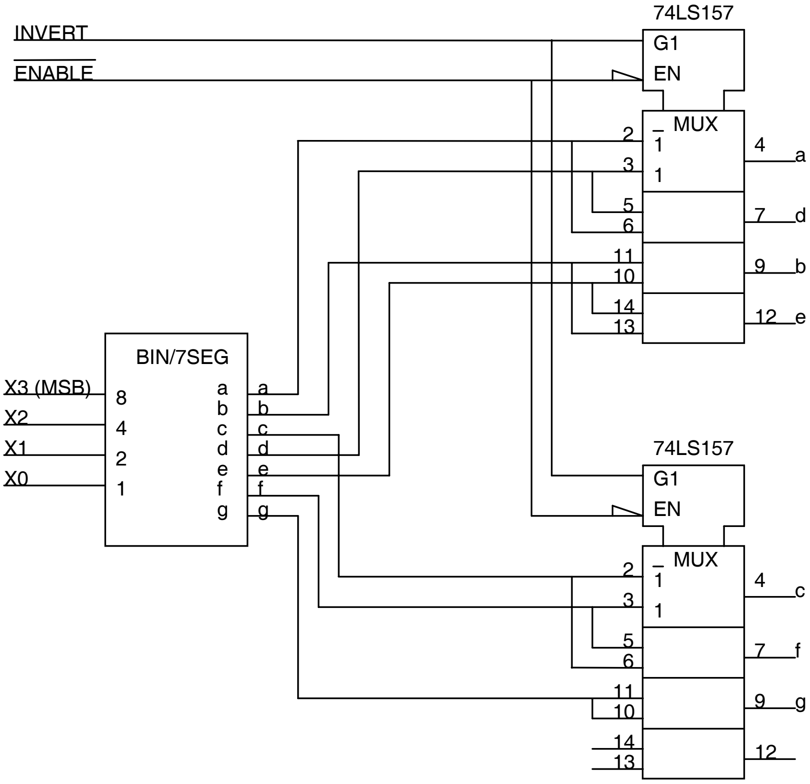

Figure 1

8. This can be achieved by adding 3 left-shifted versions of the binary number to the unshifted number since 45 = 32 x 8 x 4 x 1. The x32 corresponds to a shift of 5 bits, the x8 corresponds to a shift of 3 bits, the x4 corresponds to a shift of 2 bits and the x1 corresponds to no shift.

9. The brute force method would use 4 inverters and an adder to multiply by -1 and then use a multiplexer to select between X and -X.

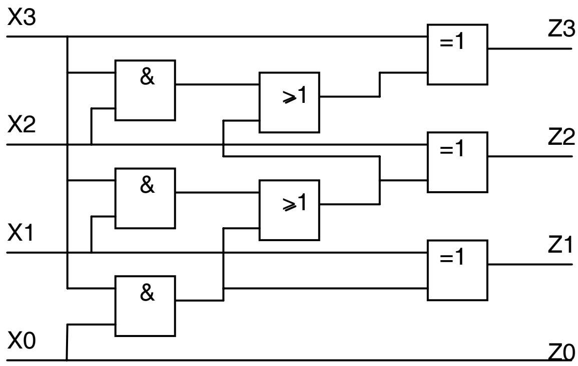

Figure 2

A better way (see figure 2) is to notice that -X and X have the same LSBs up to and including the least significant bit that equals 1. All the more significant bits than this are inverted: eg. 0110 : -6, 1010 : +6. Thus to form the absolute value, we need to invert a particular bit if (a) the number is negative (i.e. X3=1) and (b) one or more of the less significant bits are 1. In the circuit above, the AND gate outputs are always zero if the number is positive; the OR gates are arranged to check if any less significant bits are high.