25.11. ONE'S COMPLEMENT NOTATION

The 1's complement of a binary number is found by subtracting each bit from 1. For example, if the number is 1000, the 1's complement of the number is

$$\begin{array}{rl} & 1111 \\ - & 1000 \quad \longrightarrow \text{Binary number} \\ \hline & 0111 \quad \longrightarrow \text{1's complement} \end{array}$$

It is seen from the above example that 1's complement of a binary number is formed by simply changing every 0 to 1 and every 1 to 0. Thus, we see that the 1's complement of 1101.011 is 0010.100. It means that we need not carry out subtraction operations. Changing a bit to its opposite is called ***complementing*** the bit.

1's complement addition is very much similar to binary addition. The sign bit must also be added during the addition operation. When all bits are added, if a carry bit is produced in the most significant position, it is to be added to the least significant bit of the sum. It is called ***end-around*** carry.

Example 25.25:

```
   +14        0 1 1 1 0
 +(−7)         +1 1 0 0 0
 -----
   +7       [1] 0 0 1 1 0
              └────────→ 1   ←──── end-around carry
            ─────────────
               0 0 1 1 1
```

The chief advantage of 1's complement numbers is that subtraction is never required. When subtraction is to be done, we obtain complement of the number to be subtracted and add it to the other number.

Addition in place of subtraction is a great convenience.

The steps in subtraction by 1's complement method may be summarized as follows

(*i*) Find 1's complement of the number to be subtracted.

(*ii*) Add it to the number from which the subtraction is to be made.

(*iii*) When there is a carry in the last position of the result in step(ii), remove this carry and add it to the remaining number.

The procedure is illustrated in the following example.

Example 25.26: Subtract 10001 from 10011

```
                          1 0 0 1 1
                          0 1 1 1 0  (1's complement of 10001)
                        ───────────
1 carry           ───→  [1] 0 0 0 0 1
1 carry is removed          0 0 0 0 1
1 carry is added                    1
                        ───────────
                            0 0 0 1 0
```

(*iv*) If carry 1 is not obtained in the last position of the step (ii), then the result is a negative number and it is in its 1's complement form. Therefore, to express the final answer 1's complement of the result with a minus sign is to be written.

Example 25.27: Subtract 10011 from 10001

```
                      1 0 0 0 1
                      0 1 1 0 0
                    ───────────
no carry ───→ [ ]     1 1 1 0 1
```

Final answer is −00010 (1's complement of 11101 with a negative sign).

25.12. TWO'S COMPLEMENT NOTATION

The 2's complement is the binary number that is generated when we add 1 to the least significant bit of complement. Two's complement is a little more difficult to form but it simplifies addition and subtraction.

2's complement = 1's complement + 1

Example 25.28: Find 2's complement of 1010.

```
1010  ───→  0101 (1's complement)
          +    1
          ──────
            0110 (2's complement)
```

The addition of 2's complement numbers is carried in much the same way as is done in 1's complement addition, except that the end-around carry is ignored.

Example 25.29:

+ 14	01110	
+(–7)	+11000	→ 1's complement
+7	[1]00110	→ carry discarded
	+1	
	00111	2's complement

If there is no carry of 1 in the last position, the answer of subtraction is negative and remains in the 2's complement of the magnitude of the actual answer. Therefore, the 2's complement of the result is determined and a minus is added before it for obtaining the final answer. The procedure is illustrated in the following example.

Example 25.30: Subtract 10011 from 10001

	10001
	01101
No carry → [ ]	11110

The 2's complement 11110 is 00001 + 1 = 00010. Hence the actual answer is –00010.

Table 4 lists 1's complements and 2's complements of binary numbers.

Table 4. 1's and 2's complements of some binary numbers

Binary Number	1's complement	2's complement
1010	0101	0101 + 1 = 0110
1011	0100	0100 + 1 = 0101
10001	01110	01110 +1 = 01111
10100	01011	01011 +1 = 01100