Decimal Arithmetic unit

Decimal Arithmetic unit

- To perform arithmetic operation with decimal data, it is necessary to convert the i/p decimal number to binary to perform all calculation and convert the result into decimal.
- A decimal arithmetic unit is a digital function that performs decimal microoperations.
- A single stage decimal arithmetic unit consist of nine binary i/p variables and five binary o/p variables, since a minimum of four bits is required to represent each coded decimal digit.

BCD ADDER

- In BCD, each i/p digit does not exceed 9, the o/p sum cannot be greater than 19 (9+9+1=19), the 1 in the sum being an i/p carry.
- The binary number are shown in the below table and are labeled by symbols K,Z8,Z6,Z4 and Z2, where K is the carry.
- The first column is the binary sum as they appear in the o/p of the 4 bit binary adder.
- In the second column, values are converted to the correct BCD digits.

BCD ADDER

TABLE 10-4 Derivation of BCD Adder

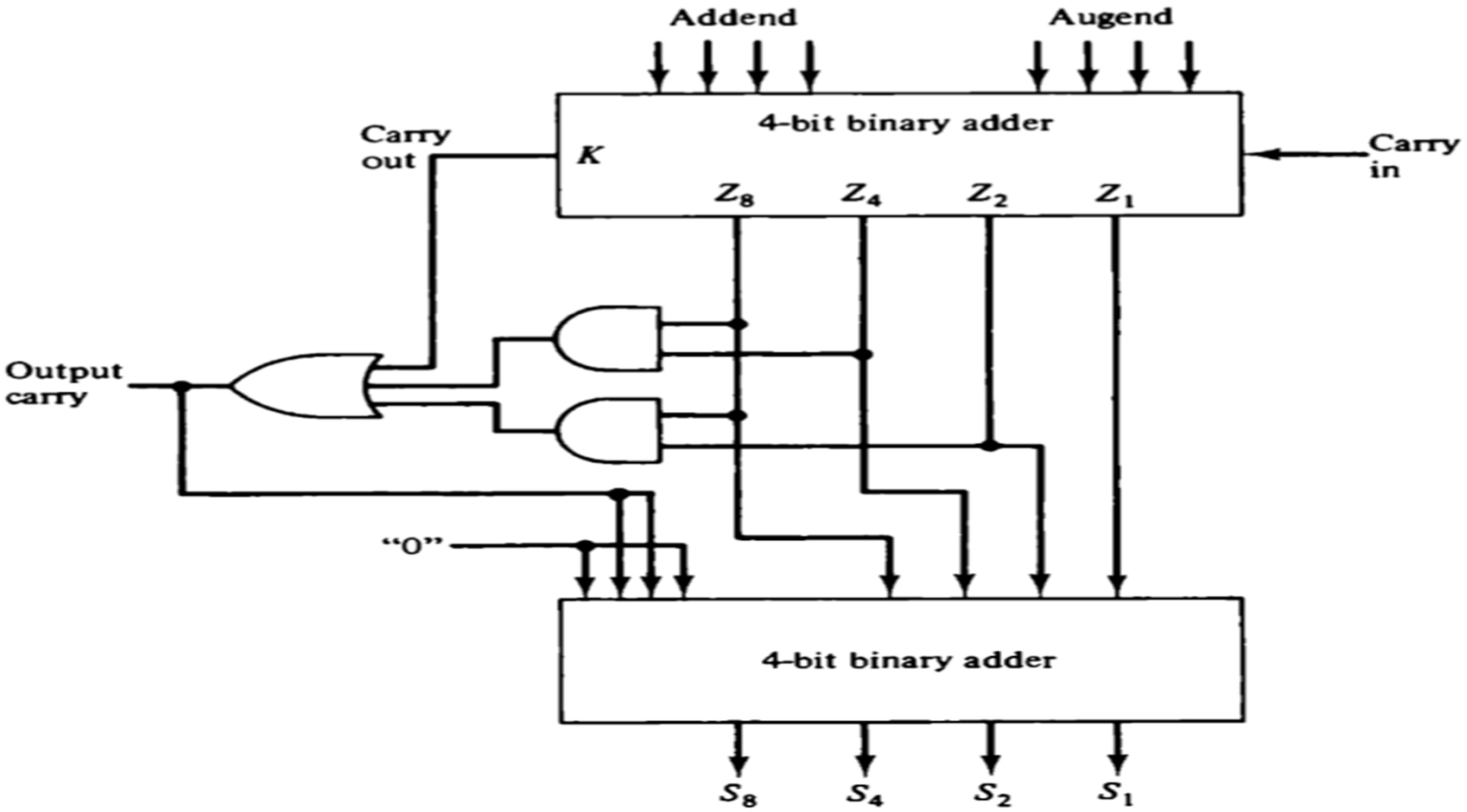
Binary Sum					BCD Sum					
K	Z_8	Z_4	Z_2	Z_1	C	S_8	S_4	S_2	S_1	Decimal
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	2
0	0	0	1	1	0	0	0	1	1	3
0	0	1	0	0	0	0	1	0	0	4
0	0	1	0	1	0	0	1	0	1	5
0	0	1	1	0	0	0	1	1	0	6
0	0	1	1	1	0	0	1	1	1	7
0	1	0	0	0	0	1	0	0	0	8
0	1	0	0	1	0	1	0	0	1	9
0	1	0	1	0	1	0	0	0	0	10
0	1	0	1	1	1	0	0	0	1	11
0	1	1	0	0	1	0	0	1	0	12
0	1	1	0	1	1	0	0	1	1	13
0	1	1	1	0	1	0	1	0	0	14
0	1	1	1	1	1	0	1	0	1	15
1	0	0	0	0	1	0	1	1	0	16
1	0	0	0	1	1	0	1	1	1	17
1	0	0	1	0	1	1	0	0	0	18
1	0	0	1	1	1	1	0	0	1	19

BCD ADDER

- In the table, when the binary sum is equal to or less than 1001, the corresponding BCD number is identical and there is no conversion is needed.
- When the binary number is greater than 1001, the BCD number is differed.
- The method for adding decimal number in BCD can be done by performing the arithmetic operation one digit at a time with 4 bit binary adder.
- If the result is ≥ 1010, it is corrected by adding 0110 to the binary sum.

BCD ADDER

Figure 10-18 Block diagram of BCD adder.



BCD ADDER

- The two decimal digits together with i/p carry are added first in the top 4 bit binary adder to produce the binary sum.
- When the o/p carry is equal to 1, binary 0110 is added to the binary sum through bottom 4 bit binary adder to produce BCD result value.
- The second operation will automatically produce an o/p carry for next pair of significant digits.
- The procedure is repeated until all decimal digits are added.
- The condition for a correction and o/p carry can be expressed by a Boolean function as follows

  $C = K + Z8\,Z4 + Z8\,Z2$

- The decimal parallel adder that adds n decimal digits needs n BCD adder stages with the o/p carry connected from one stage to the i/p carry of the next higher order stage.

BCD Subtraction

- BCD is not a self complementing code, the 9's complement cannot be obtained by complementing each bit in the code.
- The 9's complement of a decimal digit represented in BCD may be obtained by complementing the bits provided a correction is included.
- There are two possible correction method
  1. Binary 1010(decimal 10) is added to each complemented digit and the carry is discarded after each addition.
  2. Binary 0110(decimal 6) is added before the digit is complemented.

BCD Subtraction

- Example:

9's Complement of 0111(decimal 7) can be obtained as follows:

1. 0111
   After Complementing
   1000
+ 1010

   0010
---

2. 0111
+ 0110

   1101

After Complementing
   0010

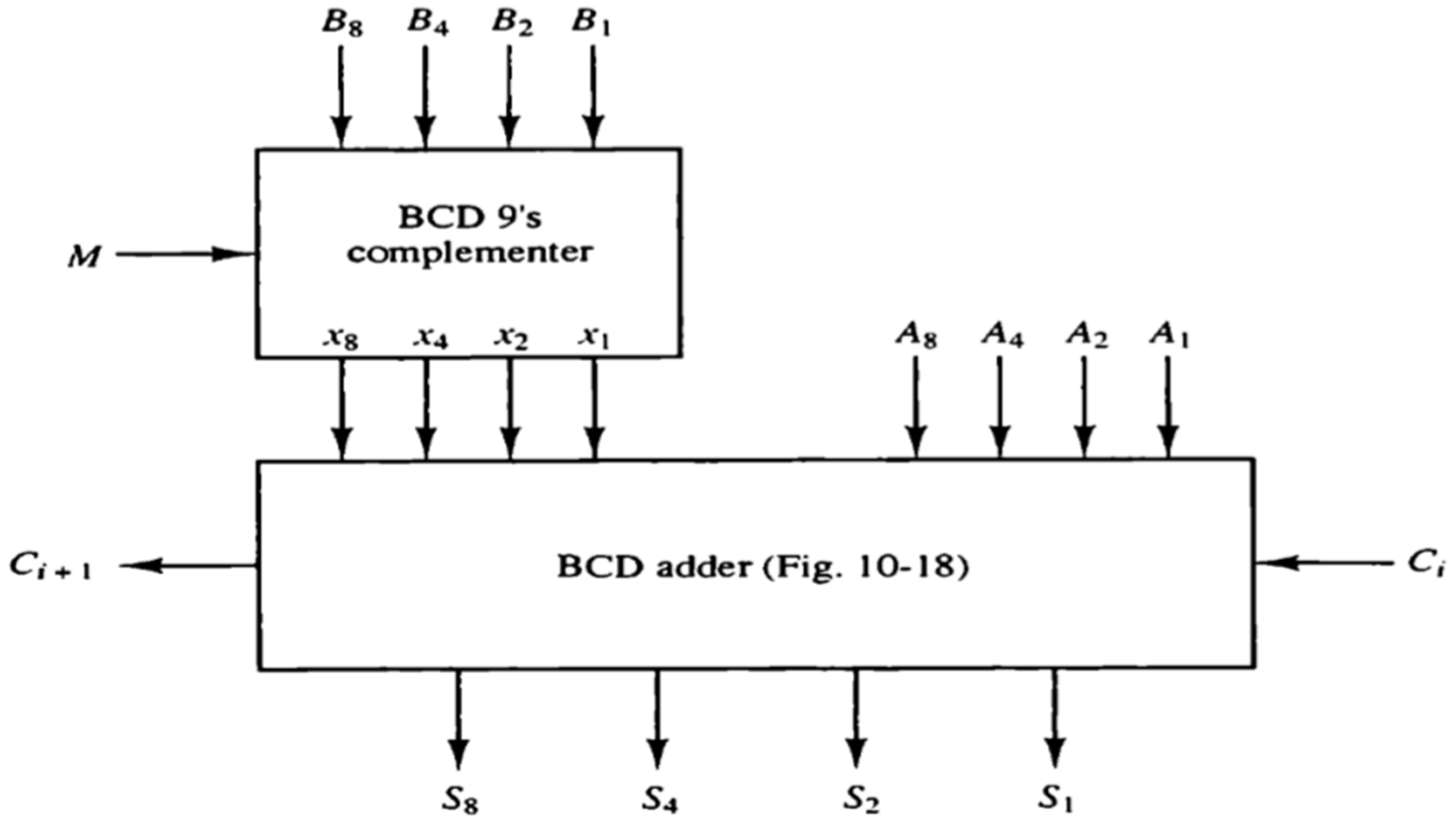
Finally 9's complement of 0111 is 0010

In decimal, 9's complement can be obtained by $(10^n-1)-N$

$(10^1-1)-7 = 2$

BCD Subtraction

Figure 10-19 One stage of a decimal arithmetic unit.



BCD Subtraction

- The 9's Complement of a BCD digit can also be obtained through the combinational circuit.
- When this circuit is attached to the BCD adder, the result is BCD adder/subtractor.
- Let the subtrahend/addend digit be denoted by the 4 binary variables B8,B4,B2 and B1. Let M be the mode bit that controls the add/subtract operation.
- Let the binary variables X8,X4,X2 and X1 be the o/p's of the 9's complementor circuit.

BCD Subtraction

- The mode M controls the operation of the unit, with M=0 the S o/p's form the sum of A and B.
- With M=1 the S o/p's form the sum of A and 9'scomplement of B.
- The o/p carry C_{i+1} from one stage must be connected to the i/p carry C_i of the next higher order stage.
- The o/p will for the sum of A plus 10's Complement of B which is equivalent to subtraction when the Mode bit M=1