Arithmetic Micro-operations

Definitions:-

A micro-operation is an elementary operation performed with the data stored in registers. Arithmetic Micro-operations perform arithmetic operation on numeric data stored in registers.

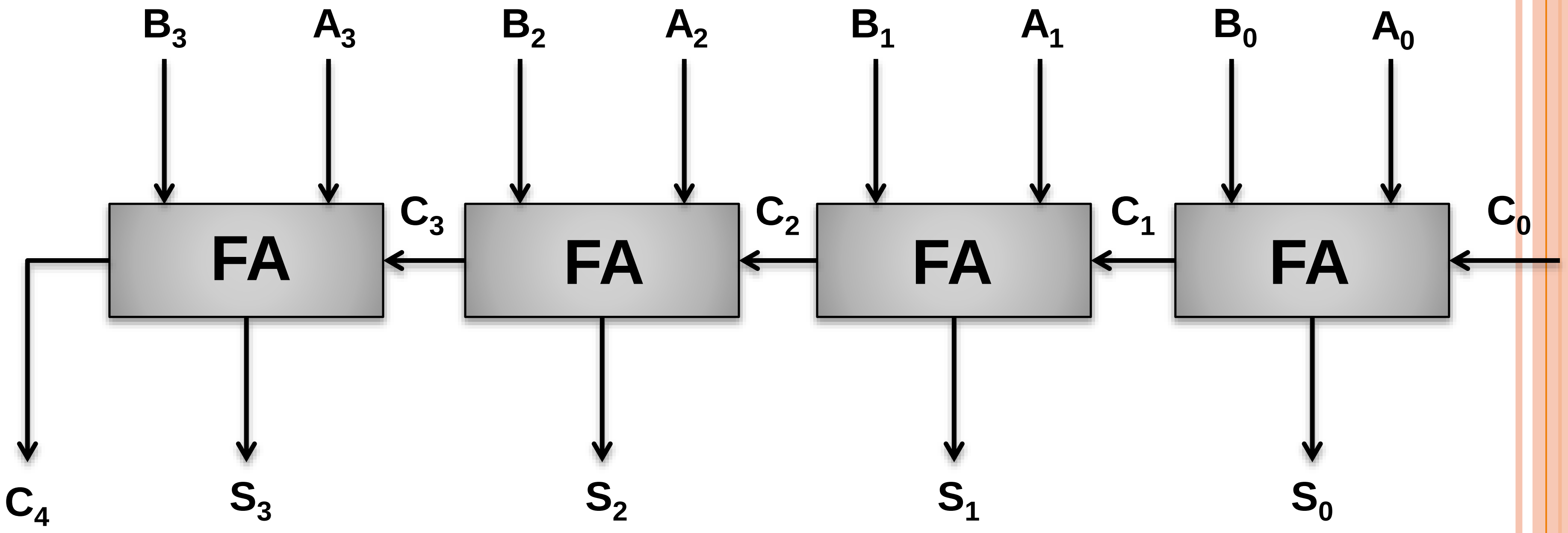
The basic arithmetic micro operations are:-

- Addition
- Subtraction
- Increment
- Decrement

Addition Micro-operation

- The arithmetic add micro operation is given by the statement.
- **R3 ← R1+ R2**
- It states that the contents of register R1 are added with the contents of register R2 and the result will be transferred to register R3.

4 - bit Binary Adder



Working

Add Micro operation can be implemented using Full adders. Each full adder takes 2 inputs from 2 numbers and a third input as a previous carry.

All the carries are connected in serial fashion to the next full adder.

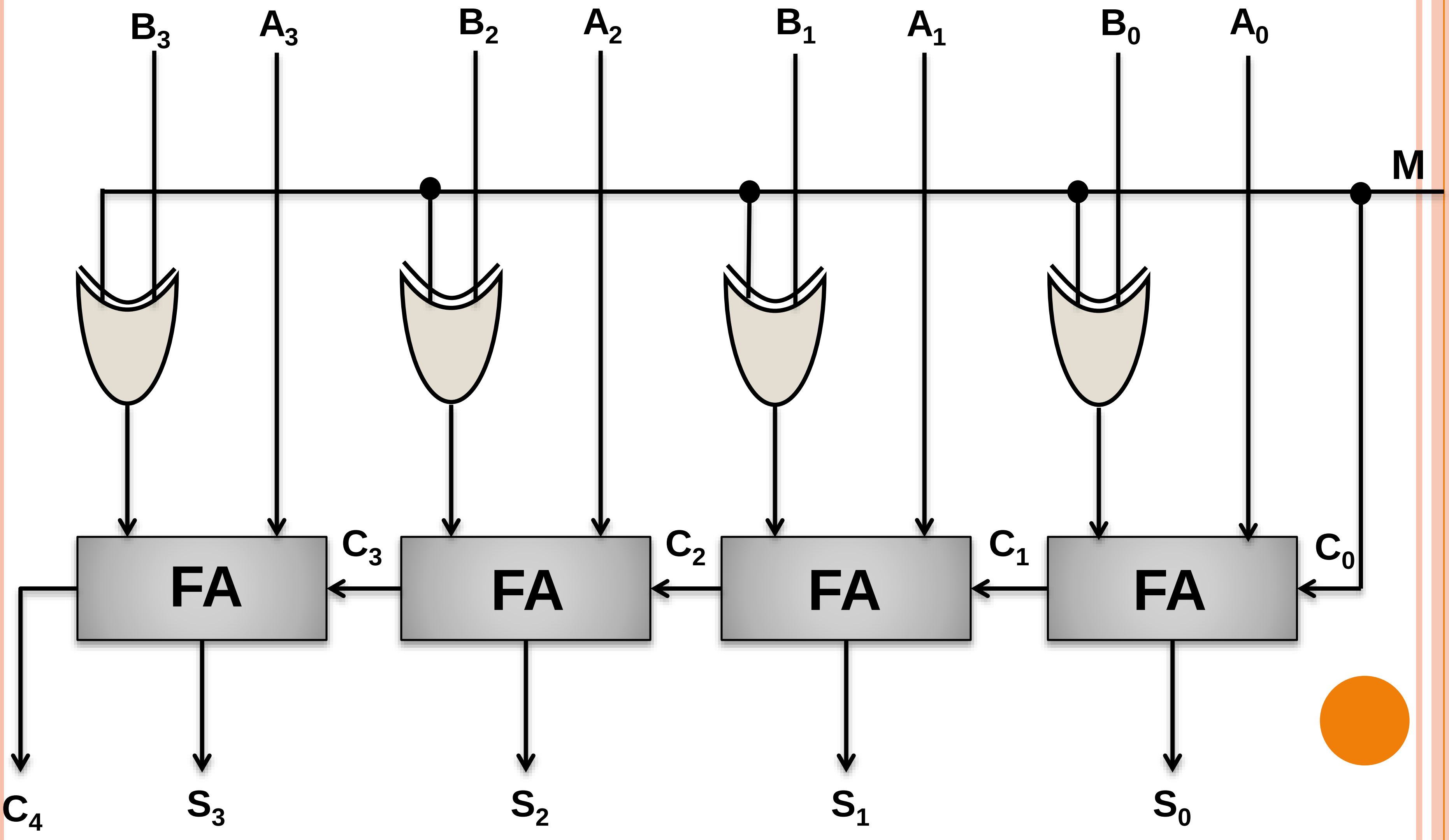
Number of full adders depends upon number of bits of data.

When $\mathbf{A_0}$ $\mathbf{B_0}$ are added and initially $\mathbf{C_0}$ is 0 then as a result $\mathbf{S_0}$ gives the sum of $\mathbf{A_0}$ and $\mathbf{B_0}$ and so on.

ADDITION / SUBTRACTION MICRO-OPERATION

- The arithmetic addition / subtract micro operation is given by the statements,
- **$R3 \leftarrow R1 + \overline{R2} + 1$**
- **$R3 \leftarrow R1 + R2$**
- The addition and subtraction operations are performed in one common circuit by including an exclusive-OR gate with each full adder.

4 – bit Adder - Subtractor



Working

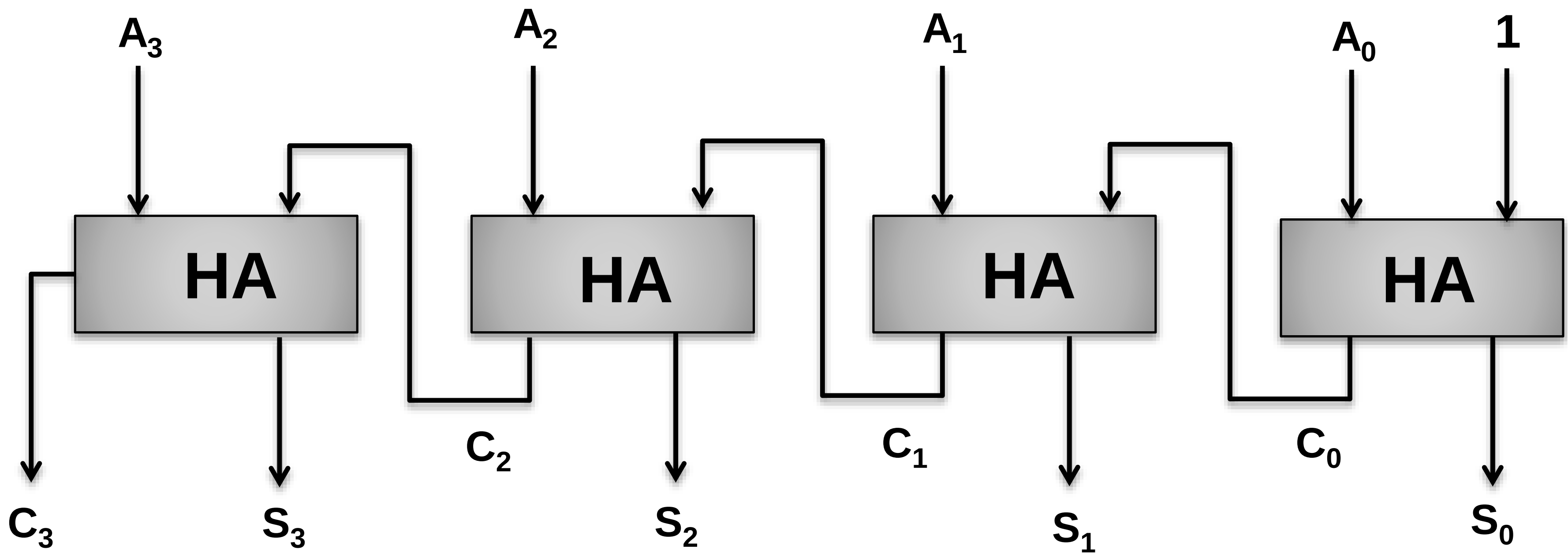
The addition and subtraction operations can be combined into one common circuit by including an XOR gate with each full-adder.
With the help of a mode bit we can add or subtract.

- **M = 0**
  When M is 0 then $\mathbf{C_{in}}$ will be 0 and $0 \oplus B_0$ gives $\mathbf{B_0}$ then $\mathbf{S_0}$ will be the sum of $\mathbf{A_0}$ and $\mathbf{B_0}$. hence by M = 0 will perform addition.
- **M = 1**
  When M is 1 then $\mathbf{C_{in}}$ will be 1 and $1 \oplus B_0$ gives $\mathbf{B_0}$ then $\mathbf{A_0} + \mathbf{B_0} + 1 = \mathbf{A_0} - \mathbf{B_0}$ hence M = 1 will perform subtraction.

Increment Micro-operation

- The increment micro operation is given by the statement,
- **R1 ← R1 + 1**
- The contents of register R1 are incremented by one.

4 - bit Binary Incrementer



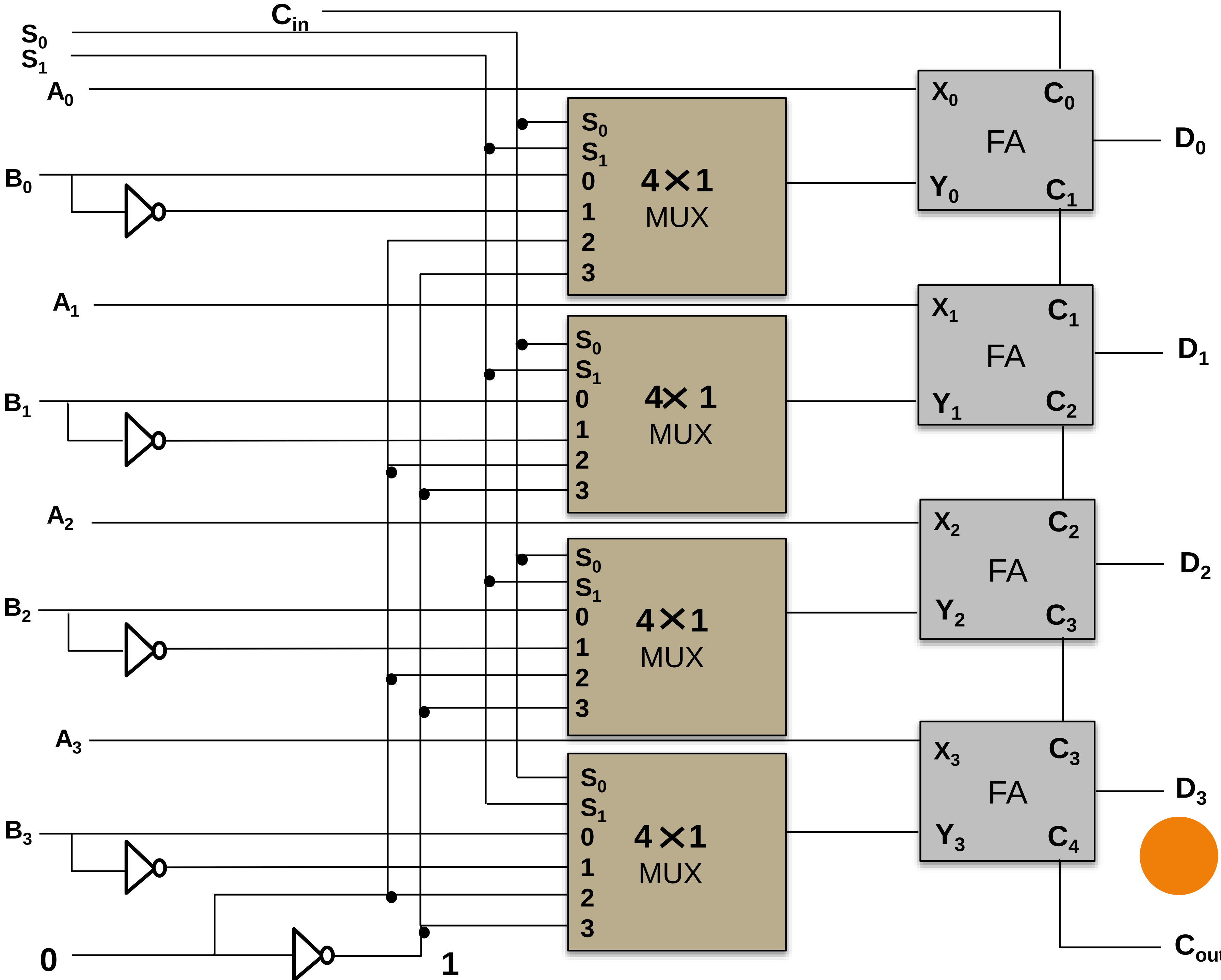
Working

The increment Micro operation adds 1 to a number in a register.
This Micro operation easily carried out using half adders as described in previous slide.
Each half adder needs 1 input and 1 carry. In the very first half adder the carry is 1.
As this is the increment micro operation hence the carry is forward to the next half adder if generated and as a result sum bits $\mathbf{S_3}$, $\mathbf{S_2}$, $\mathbf{S_1}$, $\mathbf{S_0}$ are generated along with a possible carry out.

ARITHMETIC CIRCUIT

The basic arithmetic micro operations (addition, subtraction, increment and decrement) can be performed in one composite arithmetic circuit.

Select			Input	Output	Micro operation
S_1	S_0	C_{in}	Y	$D = A + Y + C_{in}$	
0	0	0	B	$D = A + B$	Add
0	0	1	B	$D = A + B + 1$	Add with Carry
0	1	0	$\overline{B}$	$D = A + \overline{B}$	Subtract with Borrow
0	1	1	$\overline{B}$	$D = A + \overline{B} + 1$	Subtract
1	0	0	0	$D = A$	Transfer A
1	0	1	0	$D = A + 1$	Increment A
1	1	0	1	$D = A – 1$	Decrement A
1	1	1	1	$D = A$	Transfer A



Cin
S0
S1
A0
B0
A1
B1
A2
B2
A3
B3
0
1
S0
S1
0
1
2
3
4×1
MUX
X0
C0
FA
Y0
C1
D0
X1
C1
FA
Y1
C2
D1
X2
C2
FA
Y2
C3
D2
X3
C3
FA
Y3
C4
D3
Cout

Working

This arithmetic circuit can perform 8 operations among them some are :-

Addition:-

When S_1 S_0 = 0 0, the value of B is applied to the Y inputs of the adder. If C_{in} = 0, the output D = A + B. if C_{in} =1, output D = A + B + 1. Both cases perform the add microoperation with or without adding the input carry.

Subtraction:-

When S_1 S_0 = 0 1, the value of B is applied to the Y inputs of the adder. If C_{in} = 1, then D = A + B + 1. this produces A plus the 2’s complement of B, which is equivalent to a subtraction of A – B. when C_{in} = 0, then D = A + B. this is equivalent to a subtract with borrow, that is , A – B – 1.

Increment:-

When S_1 S_0 = 1 0, the inputs from B are neglected , and instead, all 0's are inserted into the y inputs. The output becomes $D = A + 0 + C_{in}$. This gives $D = A$ when $C_{in} = 0$ and $D = A + 1$ when $C_{in} = 1$. in the first case we have a direct transfer from the input A to output D. in the second case, the value of A is incremented by 1.

Decrement:-

When S_1 S_0 = 1 1, all 1's are inserted into the Y inputs of the adder to produce the decrement operation D = A – 1 when C_{in} = 0. this is because a number with all 1's is equal to the 2's complement of 1 (the 2's complement of binary 0001 is 1111). Adding number A to the 2'complement of 1 produces F = A + 2's complement of 1 = A – 1 when C_{in} = 1, then D = A – 1 + 1 = A, which causes a direct transfer from input A to output D.

NOTE :-

Microoperation D = A is generated twice , so there are only 7 distinct Microoperations in the arithmetic circuit.