

## Unit - 1 - Register Transfer and Micro-Operations

1 Explain Register Transfer Language.

=> A Digital computer system is interconnection of digital modules.

A Digital module is interconnection of some register and some control path.

Digital modules are defined by the register and the operations that are performed on the data stored in them.

The operation performed on store data in register is called Micro-operation.

The sequence of Micro-operation performed on the store data in register.

The Register Transfer Language is the symbolic representation of notation used to specify the sequence of Micro-operation.

RTL is used to describe the sequence of micro-operation.

Micro-operation performed between two registers, between memory and register or between two memory.

RTL is an algebraic notation used to define machine level operation.

RTL is not executed by a computer.

Ex. Add 3 into Register  $R_2$ .

So, RTL defined as,

$$[R_2] \leftarrow [R_2] + 3$$

2 Explain the Register Transfer in detail with block Diagram and Timing Diagram.

=> Register Transfer stands for performed micro-operation on register and store result from same or another register.

This are the common Compute Register.

- MAR - Memory Address Register  
Store the address for a memory unit.
- IR - Instruction Register -  
Store the instruction to be executed.
- PC - Program Counter -  
Store the next line instruction of the program.
- R<sub>1</sub> : Processor Register
- SR : Status Register -  
Store the Flags data.

Ex. Information Transfer From Register  $R_1$  to  $R_2$ .

$$R_2 \leftarrow R_1$$

Here, Information  $R_1$  Transfer into register  $R_2$ .

$R_1$  is called source location and  $R_2$  is called destination location.

Content of  $R_1$  does not change but content of  $R_2$  is overwritten to content of  $R_1$ .

Content of  $R_2$  is change.

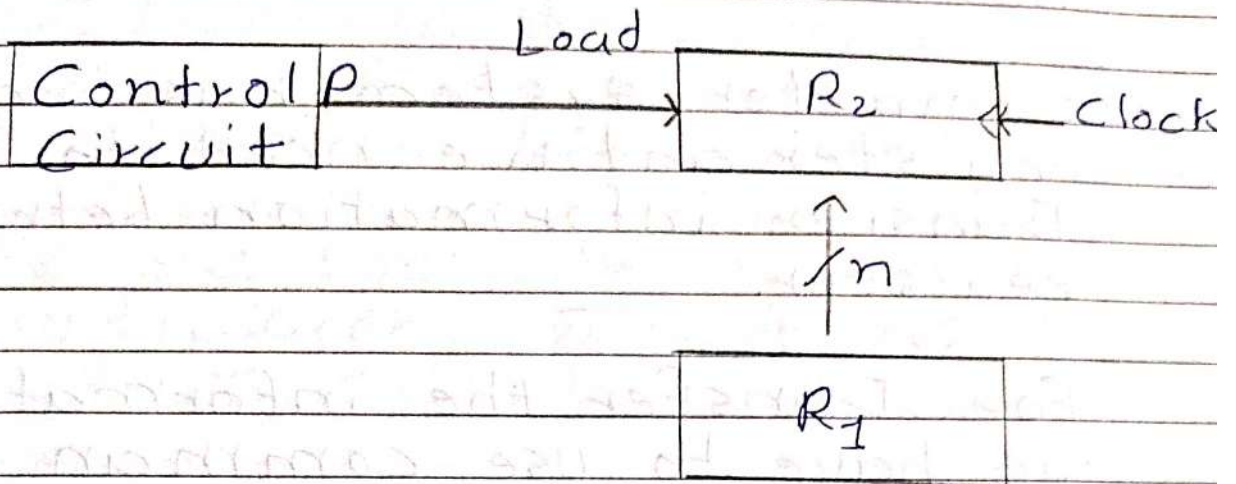
For Transfer the data from  $R_1$  to  $R_2$ , we have to follow control condition.

$$P: R_2 \leftarrow R_1$$

Here,  $P$  is equal to 1 or 0.

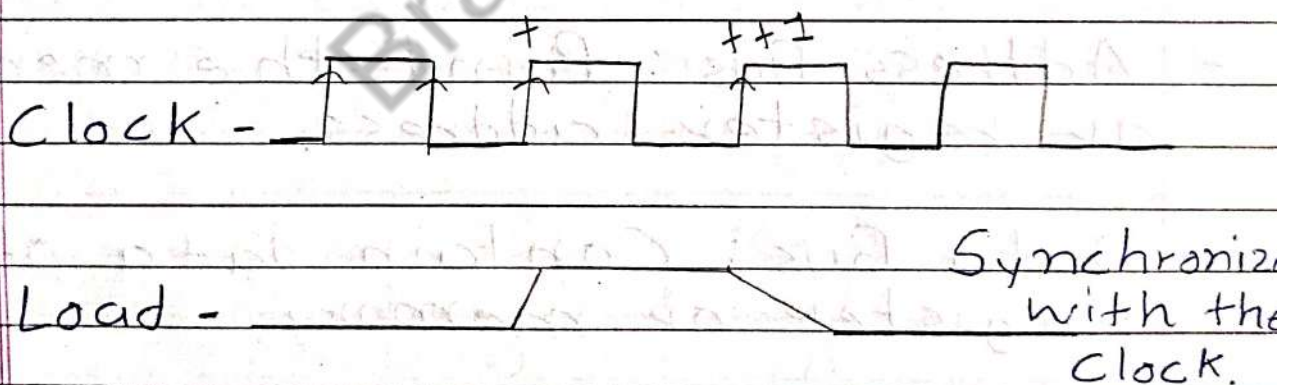
IF  $P = 1$ , then Transfer data From  $R_1$  to  $R_2$

=> Block Diagram:



Here, the  $n$  indicates the  $n$ -bit connect with  $R_1$  and  $R_2$  Register.

=> Timing Diagram:



3 Design and explain a common Bus System for four register.

=> Computer system has many register and we need to transfer information between register.

For transfer the information we have to use common Bus system.

For transfer the different information, common system bus contain different buses.

- Address Bus: Point the memory or register address.
- Data Bus: Contain data of Register or memory.
- Control Bus: Contain control signal for performed the particular operation.

=> System Bus For Four Register.

For transfer the information using system bus for register we have to use Multiplexers.

The bus consists of  $4 \times 1$  multiplexers with 4 input and 1 output.

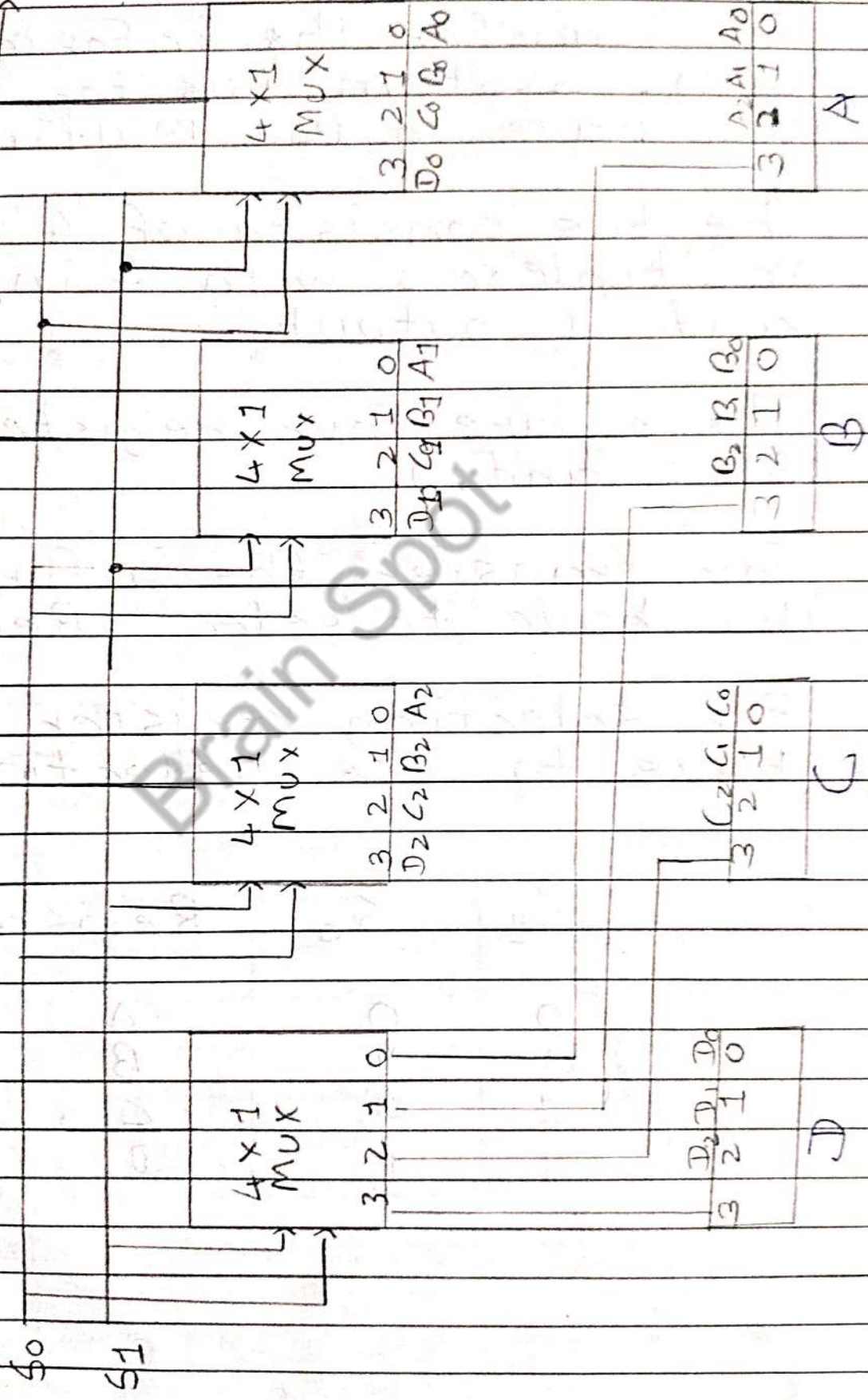
There are Four register, A, B, C and D.

For transfer the information, we have to select Register.

For selecting register we have to use selection line.

$S_1$	$S_0$	Register
0	0	A
0	1	B
1	0	C
1	1	D

4-line  
 Common  
 Bus





#### 4 Explain Memory Transfer.

The transfer of information from a memory is called Read operation.

The transfer of new information and store in memory is called write operation.

A memory word is defined by  $M$ .

#### => Read Operation:

Assume that the address of a memory unit stored in Address register AR, and the data register by DR.

$$DR \leftarrow M[AR]$$

Transfer of information into the data register from selected by the address register AR.

Here, Address register AR Transfer information in Data Register.

=> Write operation:

Assume that address of memory unit stored in Address register AR and Process Register is  $R_1$

$$R_1 \leftarrow M[AR]$$

Here, Address register AR information Transfer and Overwrite from  $R_1$  register.

$R_1$  register get new information using Address register.

5 Explain Arithmetic Micro-operation

Arithmetic Micro-operation deals with the operation performed on numeric data and stored in register.

This are the Basic Arithmetic Micro-operation

① Addition:  $R_3 \leftarrow R_1 + R_2$

Here, Register  $R_1$  and Register

$R_2$  data Performed addition and stored in  $R_3$  register.

② Subtraction:  $R_3 \leftarrow R_1 - R_2$

Here, Register  $R_1$  and  $R_2$  Data Performed subtraction and stored in  $R_3$  register.

③ 1's Complement:  $R_1 \leftarrow R_1'$

Here,  $R_1$  Register data performe complement operation and stored in  $R_1$  register.

④ 2's Complement:  $R_1 \leftarrow R_1' + 1$

Here,  $R_1$  register data Performed complement operation and add with 1 and store in  $R_1$  register.

⑤ Increment:  $R_1 \leftarrow R_1 + 1$

Here,  $R_1$  register data Performed addition with 1 and store in  $R_1$  register.

⑥ Decrement Operation:  $R_1 \leftarrow R_1 - 1$

Here,  $R_1$  register Data performed subtraction with 1 and store in  $R_2$  register.

6 Explain Binary Adder :

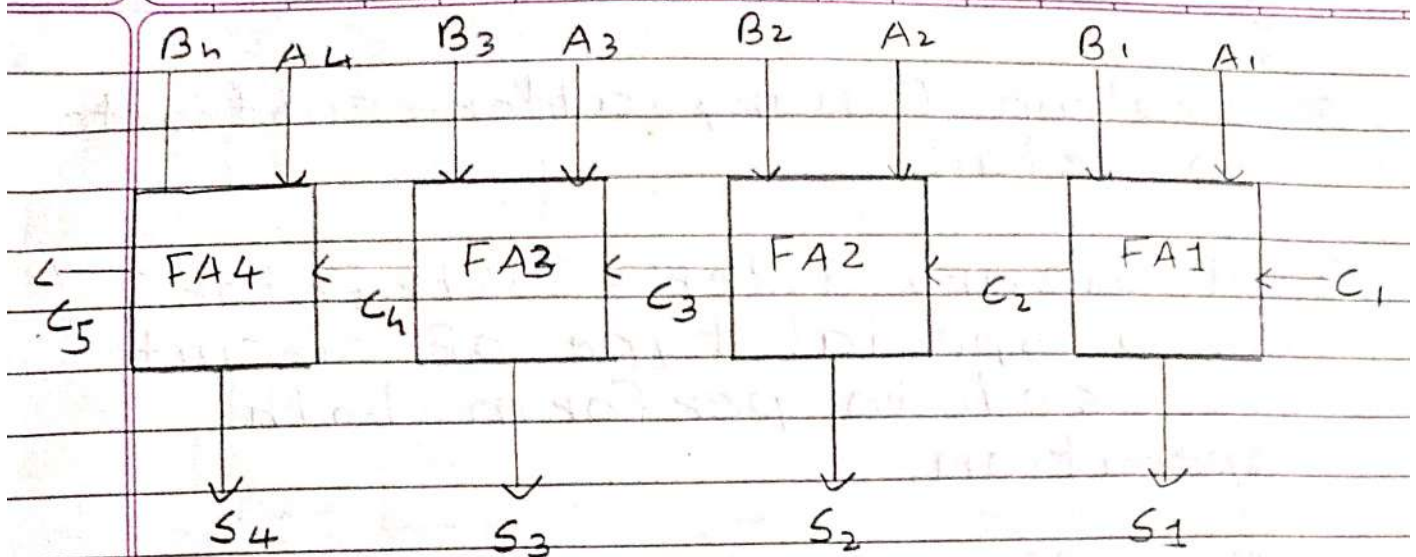
Binary adder is a digital circuit that produces the sum of two binary number.

In Binary adder, Full adders are connected in a chain.

First adder output carry is connected with each Full adder to the input carry of next adder.

$n$ -bit binary adder requires a  $n$ -bit Full adder to perform operation.

Binary adder performed the addition operation faster than single adder.



→ Advantages:

The Binary adder perform addition operation faster as compared to single adder.

→ Disadvantages:

The Binary adder, each Full adder has to wait for the carry which is generated by previous full adder in chain.

→ Application:

Binary adder is use to finding the sum of two binary number.

7 Explain Binary adder-subtractor in detail.

=> A Binary Adder-Subtractor is a special type of circuit is used to perform both operation.

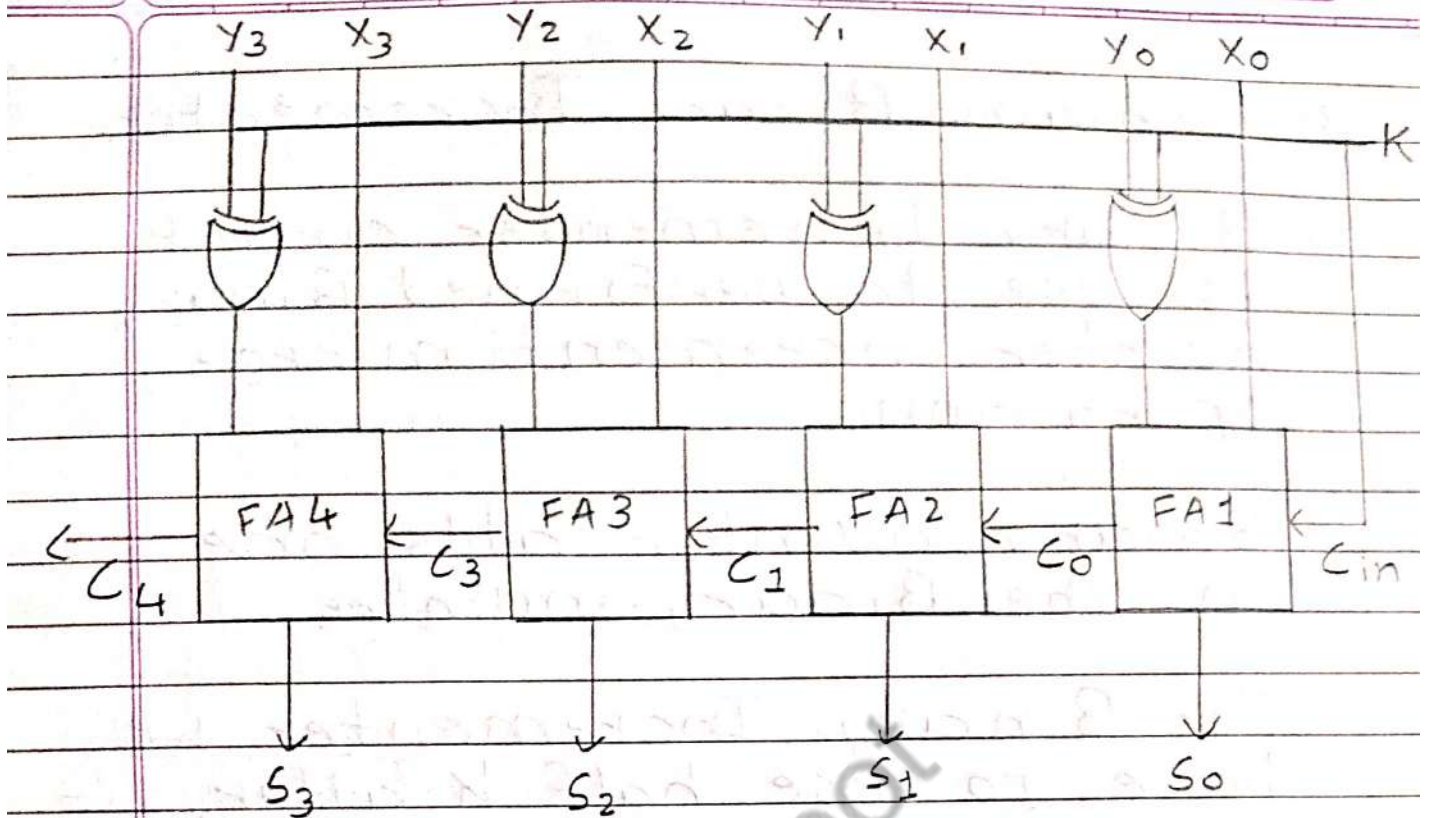
For Binary adder-subtractor required extra XOR gate in the circuit of Full adder.

This circuit is control using the control signal.

The control line determines whether the operation addition or subtractor is performed.

If Control signal value is 0, so, this circuit is performed addition.

If Control signal value is 1, so, this circuit is performed subtraction operation.



For  $n$ -bit Binary adder-subtractor we have to require  $n$  Full adder and  $n$  XOR gate.

→ Advantages:

Using Binary Adder-Subtractor circuit we can performed addition and subtraction together.

→ Disadvantages:

For control the circuit we have to use control single.

8 Explain Binary Incrementer.

=> Binary Incrementer circuit is use to performed Binary number increment micro-operation.

Binary number adds one in the Binary number.

For Binary Incrementer, we have to use half k-adder.

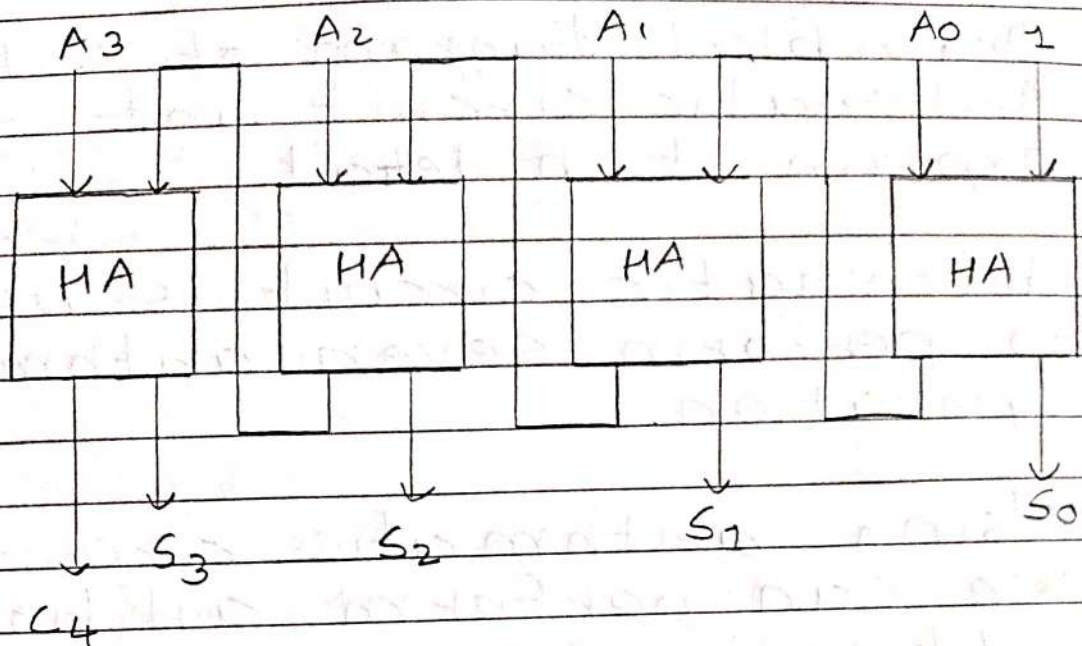
For n-bit Binary Incrementer, we have to use n-bit half adder.

For Binary Incrementer, n half adder are connect with the chain.

The output carry from one half-adder is connected to one of the inputs of next half adder.

Using Binary Incrementer, we can increment any Binary number.





→ advantages:

Binary Incrementer, can performed any binary number incrementer.

→ Disadvantages:

Each Half adder, have to wait for previous carry of half adder circuit.

9 Draw Block diagram of 4-bit Arithmetic circuit and explain it in detail.

=> Arithmetic circuit is used to perform seven arithmetic operations.

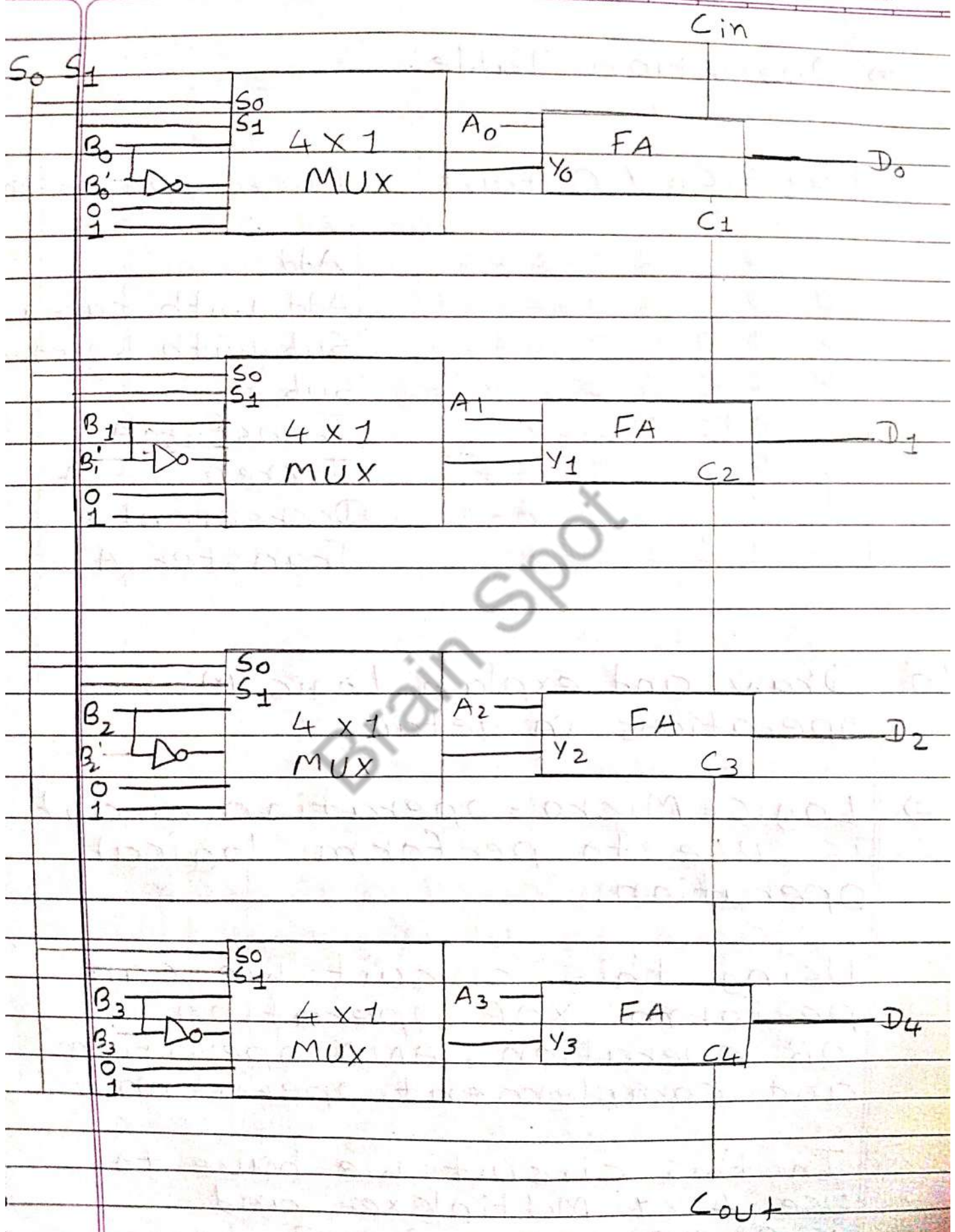
Using arithmetic circuit we can perform addition, subtraction operations.

For Arithmetic circuit we have to use Full adder and  $4 \times 1$  Multiplexer.

For 4-bit Arithmetic circuit we have to use 4 Full adder and 4,  $4 \times 1$  Multiplexer.

The output of Full adder is calculated from the following arithmetic sum:

$$D = A + Y + C_{in}$$



=> Operation Table:

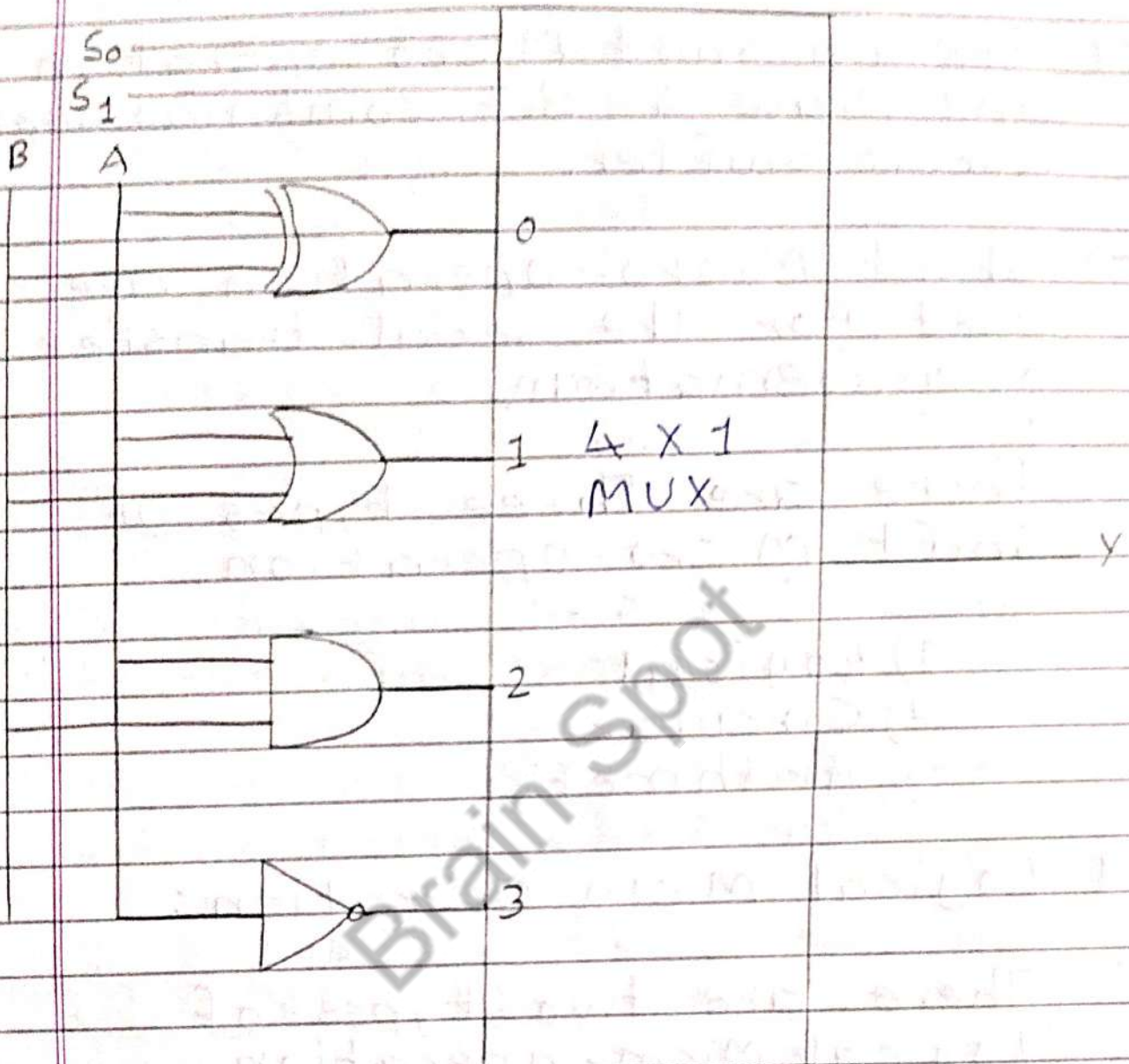
$S_1$	$S_0$	$C_{in}$	$Y$	Output	Micro-operation
0	0	0	B	$D = A + B$	Add
0	0	1	B	$D = A + B + 1$	Add with carry
0	1	0	$B'$	$D = A + B'$	Sub with borrow
0	1	1	$B'$	$D = A + B' + 1$	Sub
1	0	0	0	$D = A$	Transfer A
1	0	1	0	$D = A + 1$	Increment A
1	1	0	1	$D = A - 1$	Decrement A
1	1	1	1	$D = A$	Transfer A

10 Draw and explain Logic Micro-operations in detail.

=> Logic Micro-operation circuit is use to perform logical operation.

Using this circuit we can perform XOR operation, OR operation, AND operation and complement operation.

In this circuit we have to use 4 x 1 Multiplexer and XOR, OR, AND and NOT Logic Gates.



S <sub>0</sub>	S <sub>1</sub>	Output	Operation
0	0	$Y = A \oplus B$	XOR
0	1	$Y = A \vee B$	OR
1	0	$Y = A \wedge B$	AND
1	1	$Y = A'$	Complement

71 Explain Shift Micro-operation and Draw 4-Bit combinational circuit shifter.

=> Shift Micro-operation are used for the serial transfer of information.

There are Three types of Shift Micro-operation.

- 1) Logical
- 2) Circular
- 3) Arithmetic

1 Logical Micro-operation:

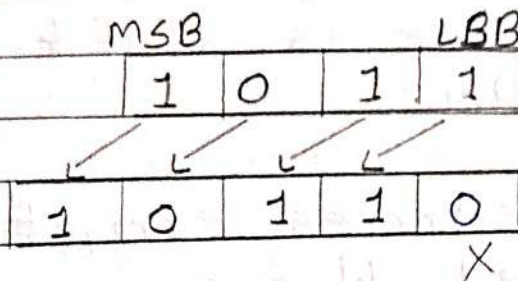
There are two types of Logical Micro-operation.

- (i) Logical Left Shift
- (ii) Logical Right Shift

(i) Logical Left Shift:

In this shift, one position moves each bit to the left one by one.

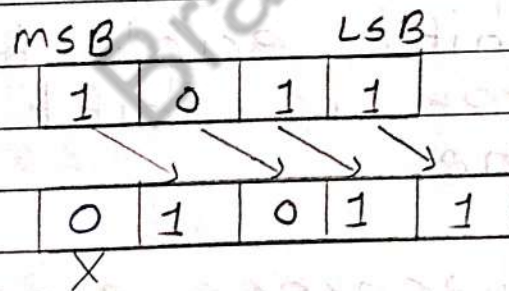
The empty Least significant bit is filled with zero.



(ii) Logical Right Shift:

In this shift, each bit moves to the right one by one, and

The empty Most Significant bit is filled with zero.



2 Circular Micro-operation:

There are two types of circular micro-operation.

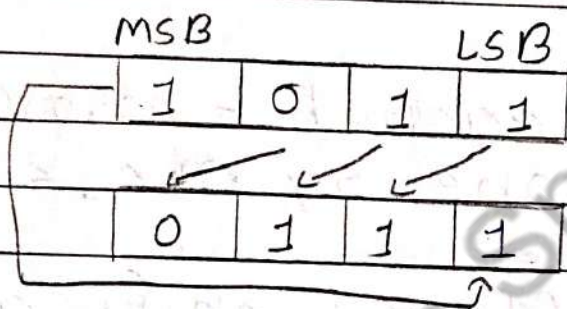
(a) Circular Shift left

(b) Circular Right shift.

c) Circular shift left:

In this shift, each bit in the register is shift left to one by one.

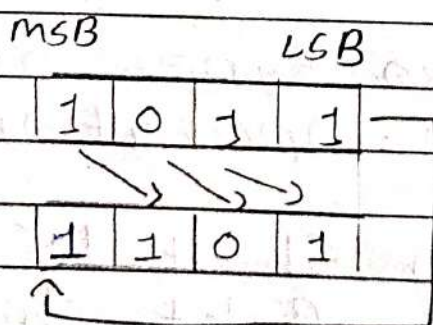
The LSB becomes empty so, MSB is filled there.



b) Circular shift Right:

In this shift, each bit in the register is shift right one by one.

The MSB becomes empty so, LSB is filled there.





### 3 Arithmetic shift:

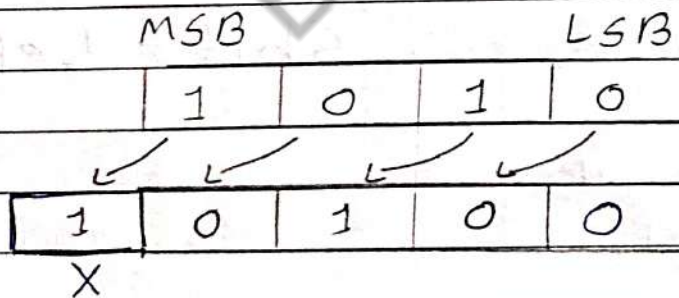
There are two types of Arithmetic shift.

- ci) Arithmetic Left Shift
- cii) Arithmetic Right Shift.

#### ci) Arithmetic Left Shift:

In this shift, each bit is moved to the left side one by one.

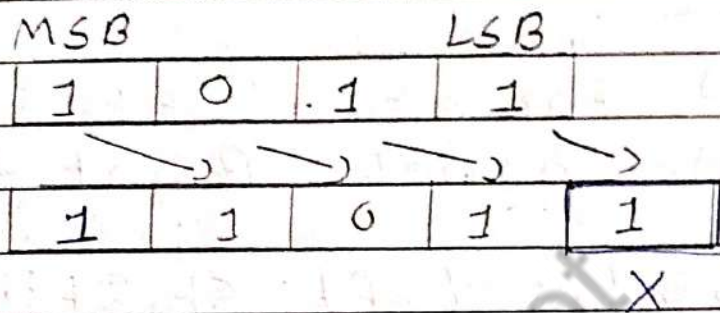
The empty LSB bit is filled with zero and MSB bit is rejected.



#### cii) Arithmetic Right Shift:

In this shift, each bit is moved to the right side one by one.

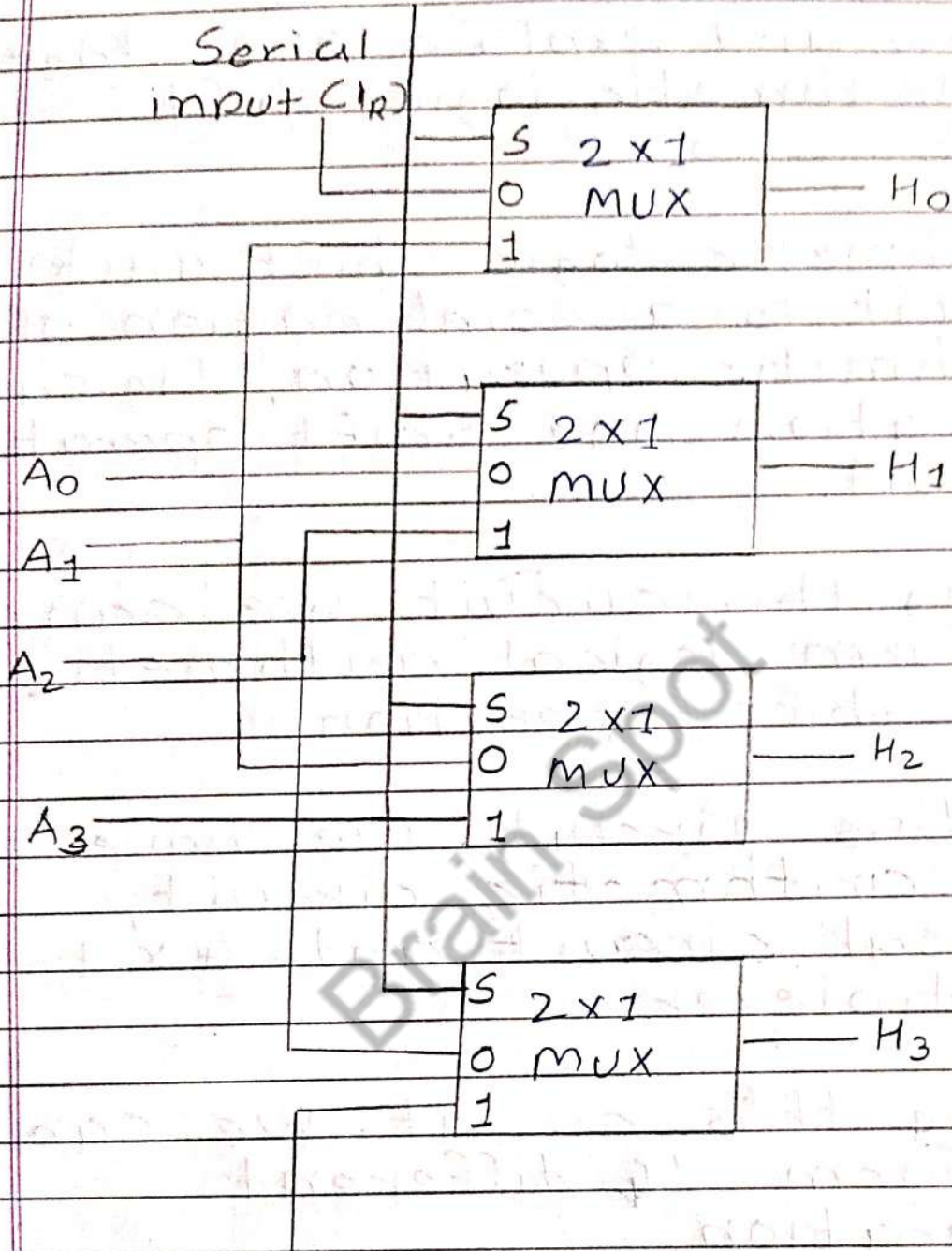
The LSB bit is rejected and empty MSB bit is filled with previous MSB bit.



=> Shift Micro-operation Circuit:

S	H <sub>0</sub>	H <sub>1</sub>	H <sub>2</sub>	H <sub>3</sub>	
0	I <sub>R</sub>	B <sub>0</sub>	B <sub>1</sub>	B <sub>2</sub>	Shift Right
1	B <sub>0</sub>	B <sub>1</sub>	B <sub>2</sub>	I <sub>L</sub>	Shift Left

$S = 0, 1$



Serial input (I<sub>L</sub>)

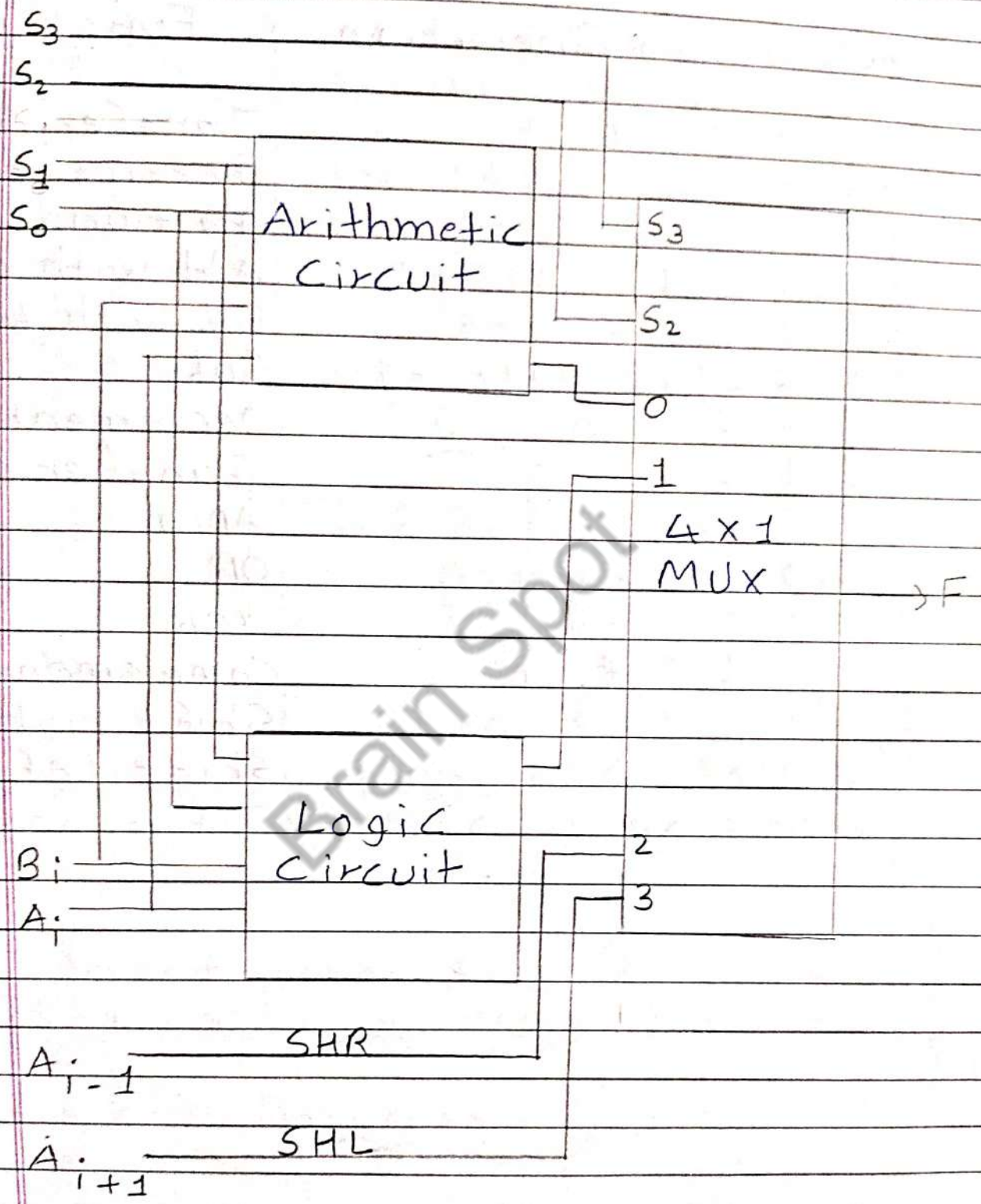
12 Draw and explain one stage of Arithmetic logic shift unit.

=> Arithmetic logic shift unit circuit is a combination of Arithmetic operation, logical operation and Shift operation circuit.

Using this circuit, we can perform logical, arithmetic and shift operation.

In this circuit, we have to use arithmetic circuit, Logical circuit and  $4 \times 1$  Multiplexer.

Using this circuit, we can perform 16 different operation.



$S_3$	$S_2$	$S_1$	$S_0$	$C_{in}$	Operation	Function
0	0	0	0	0	$F = A$	Transfer A
0	0	0	0	1	$F = A + 1$	Increment A
0	0	0	1	0	$F = A + B$	Addition
0	0	0	1	1	$F = A + B + 1$	Add with carry
0	0	1	0	0	$F = A + B'$	Sub with borrow
0	0	1	0	1	$F = A + B' + 1$	Sub
0	0	1	1	0	$F = A - 1$	Decrement A
0	0	1	1	1	$F = A$	Transfer A
0	1	0	0	X	$F = A \wedge B$	AND
0	1	0	1	X	$F = A \vee B$	OR
0	1	1	0	X	$F = A \oplus B$	XOR
0	1	1	1	X	$F = A'$	Complement A
1	0	X	X	X	$F = shr A$	Shift right
1	1	X	X	X	$F = shl A$	Shift Left