University of Engineering & Management

Department of Electronics & Communication Engineering

Laboratory Manual

Embedded Systems Lab

Code: ECEL 703

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University Roll No: 12018009019482

College Roll No: 77

Year: 4th **Semester:** 7th

Session: 2018-2022

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30/07/2021	1B	Write a Traffic Light Controller program using 8051 Assembly Language as given in Problem Statement.		
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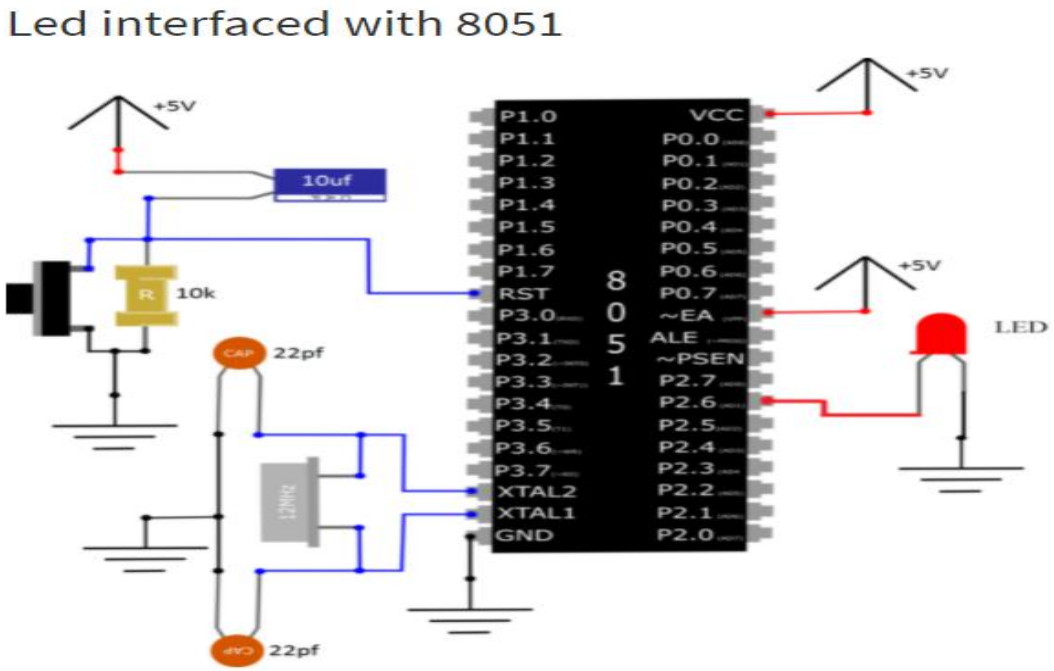
29/10/2021	9	Design and Simulation of Arithmetic Logic Unit and show the different arithmetic operations.		

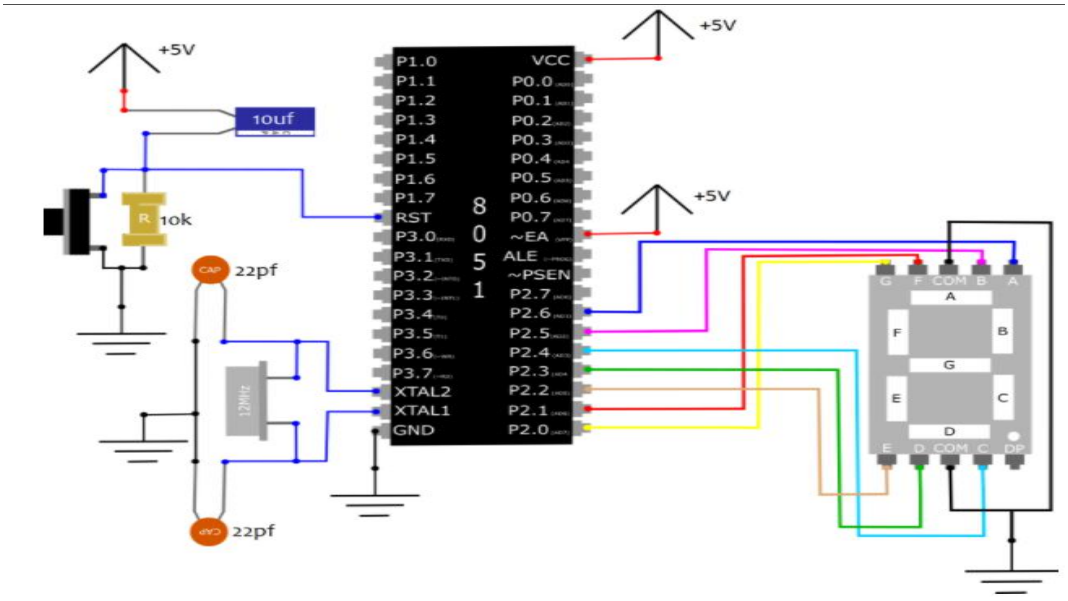
EXPERIMENT NO. 01(A)

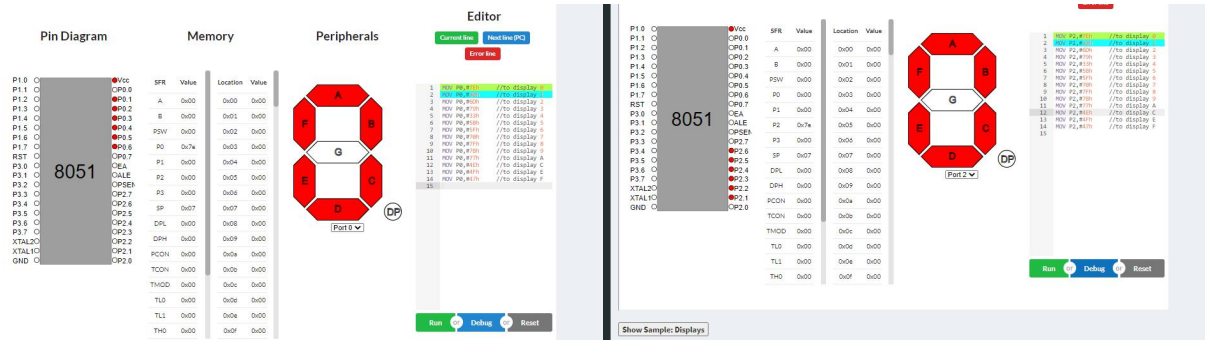
Title: Write a Program to Glow the Traffic Lights.

Objective: Write a Program to Glow the Traffic Lights.

Circuit Diagram:



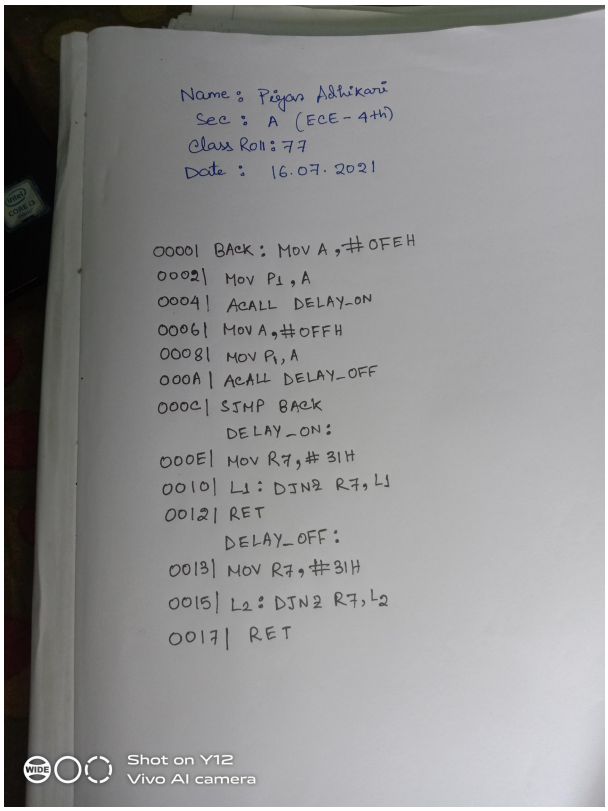




Problem statement:

a) ON the RED LED for 101µs.
b) OFF the RED LED for 101µs.

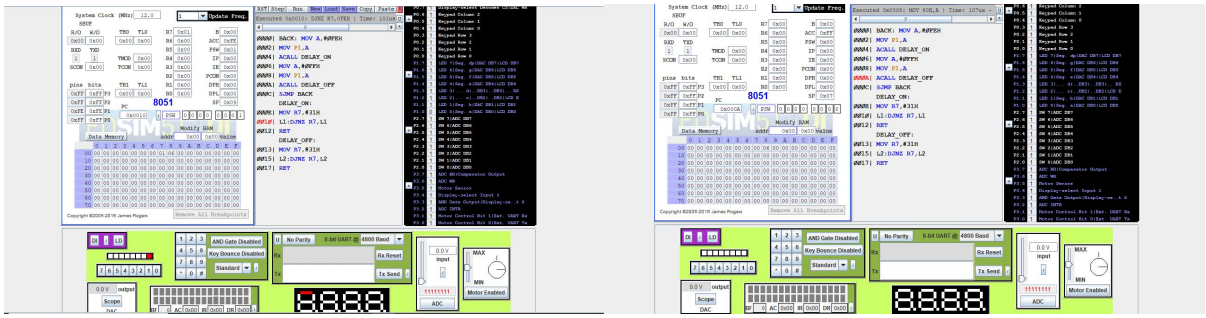
Program Code:



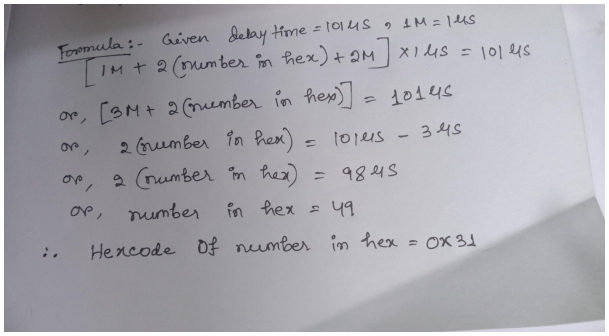
Practical Observations/Output:

a)ON the RED LED for 101µs.

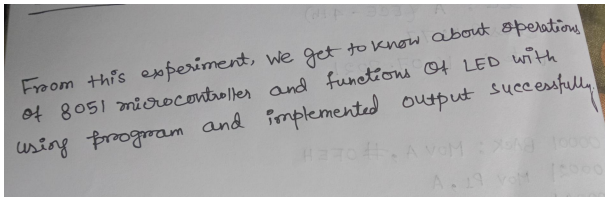
b)OFF the RED LED for 101µs.



Calculation:



Discussions:

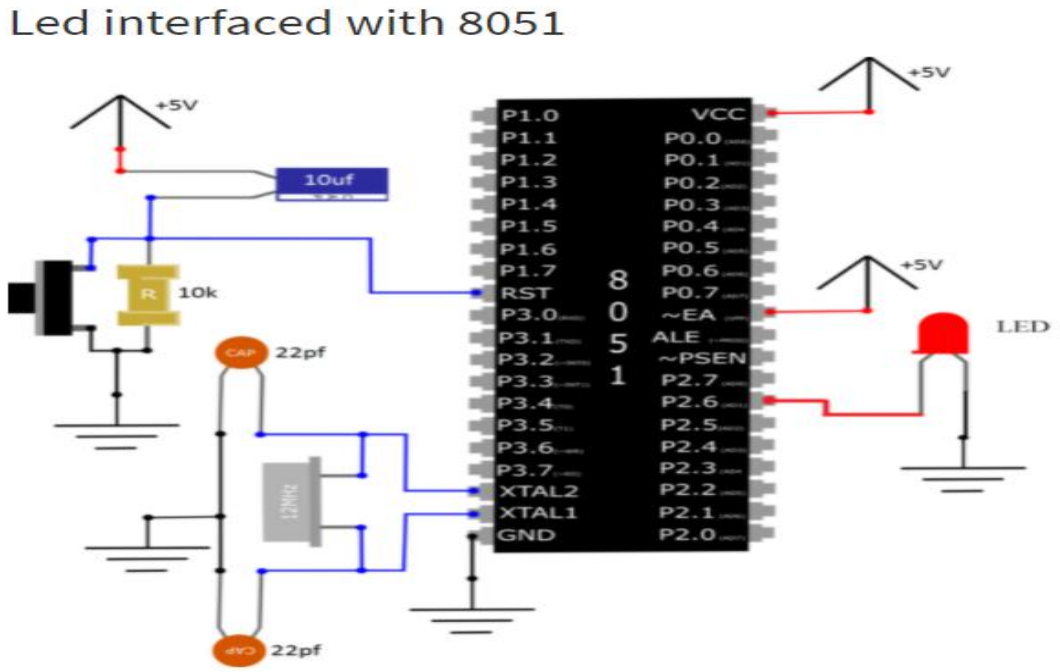


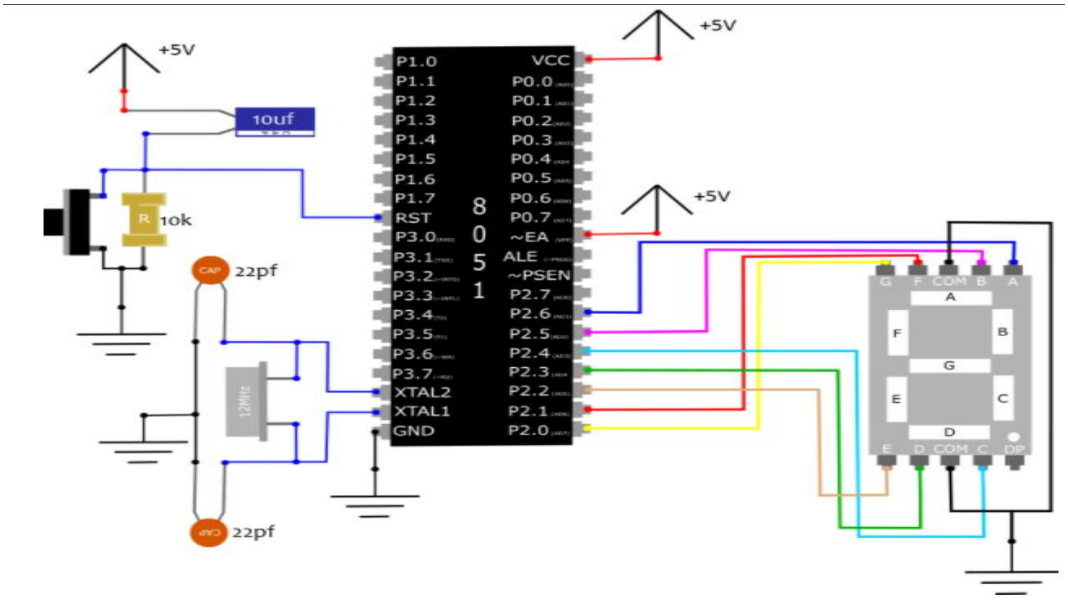
EXPERIMENT NO. 01(B)

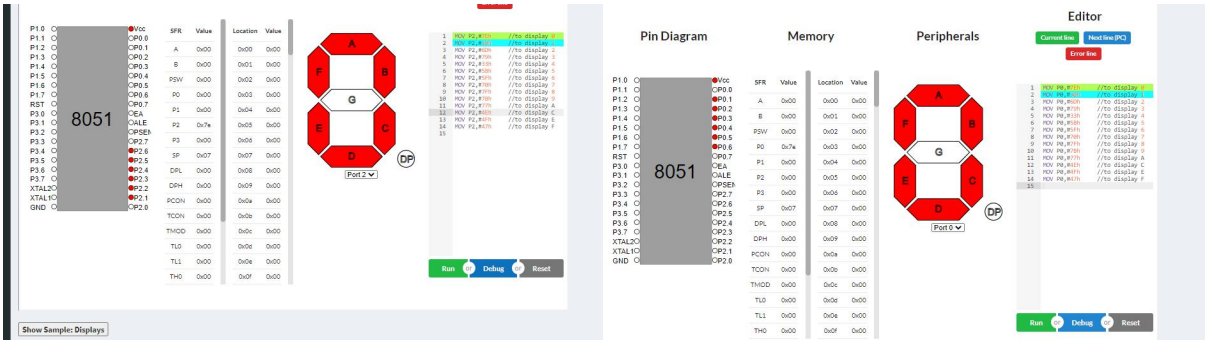
Title: Write a Traffic Light Controller program using 8051 Assembly Language as given in Problem Statement.

Objective: Write a Traffic Light Controller program using 8051 Assembly Language as given in Problem Statement.

Circuit Diagram:







Problem statement:

Suppose in a Road-crossing Traffic Signal has three LED Lights –

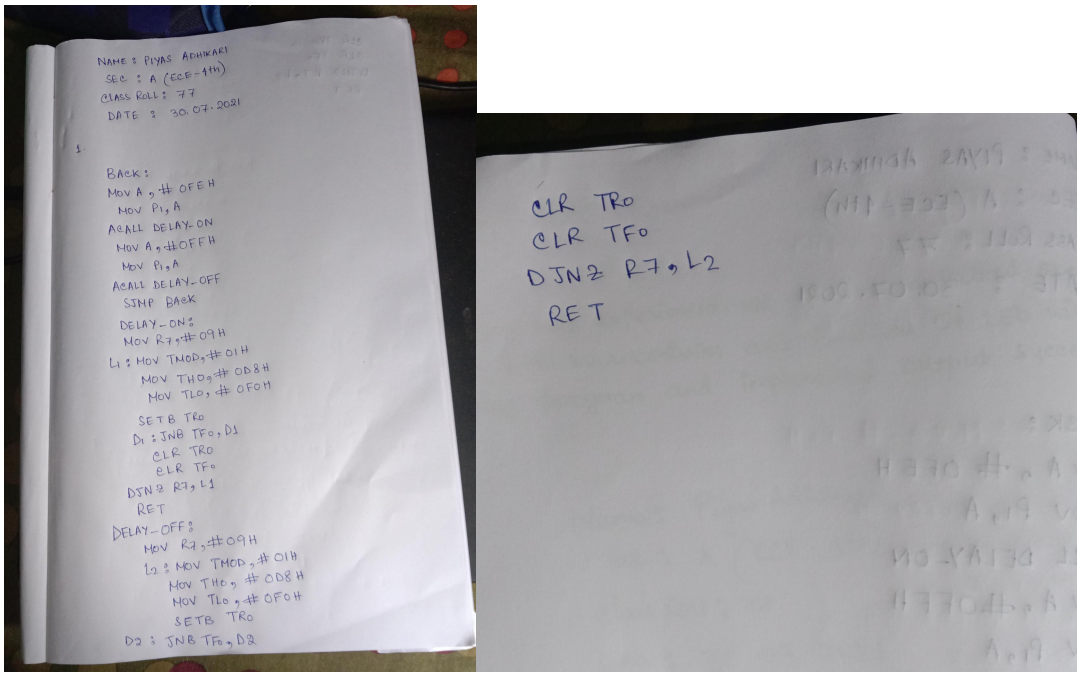
1. **RED:** Cars should not cross the road,
2. **GREEN:** Cars are allowed to cross the road,
3. **Yellow:** A blinking Yellow Light instructs to slow down the car as the RED signal is about to Glow.

Write a Program to Glow the Traffic Lights in the Following way -

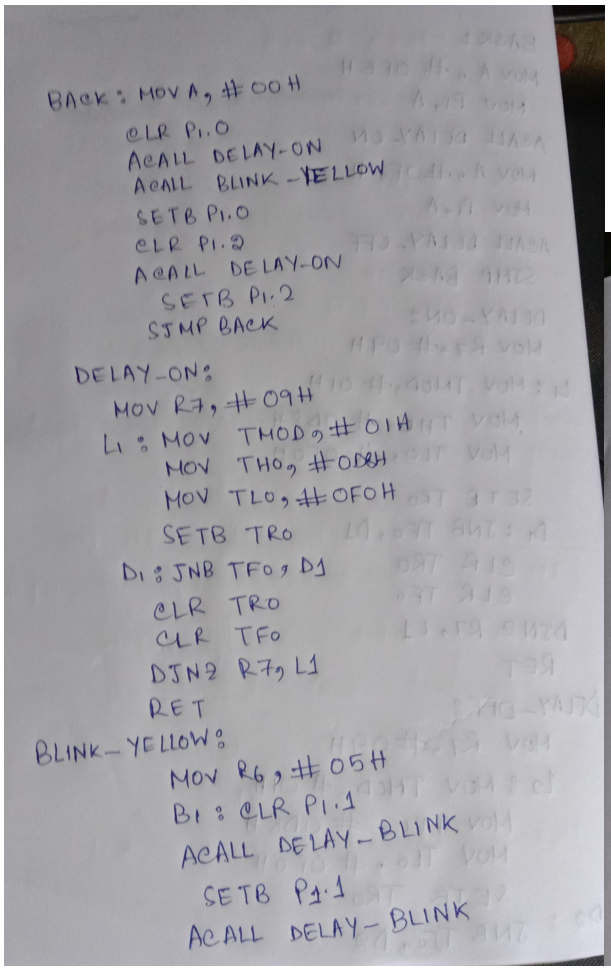
1. ON the RED LED for 90ms.
2. Keep ON the RED LED for 20ms more and during this time simultaneously BLINK the YELLOW LED with a period of 2ms.
3. Turn OFF both RED and YELLOW LEDs and Turn ON the GREEN LED for 90ms.
4. Turn OFF the GREEN LED and Repeat from Step 1.

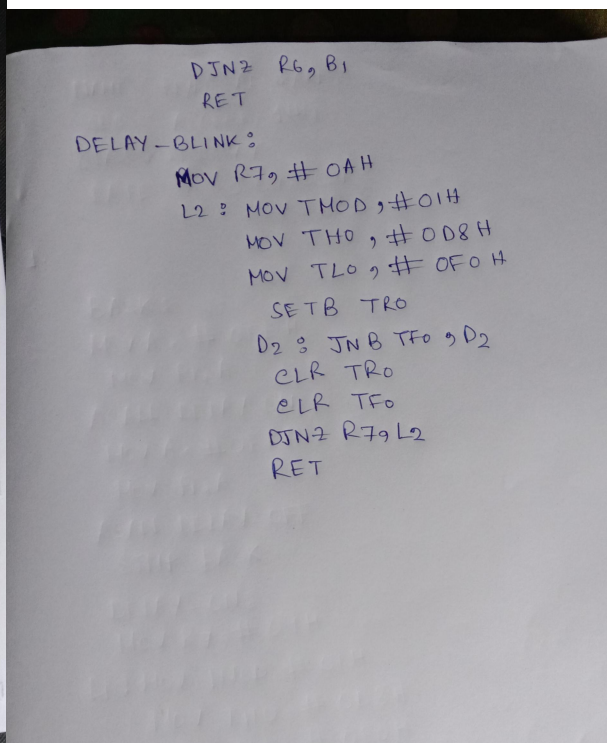
1. Program Code:

ON and OFF the RED LED for 90ms.



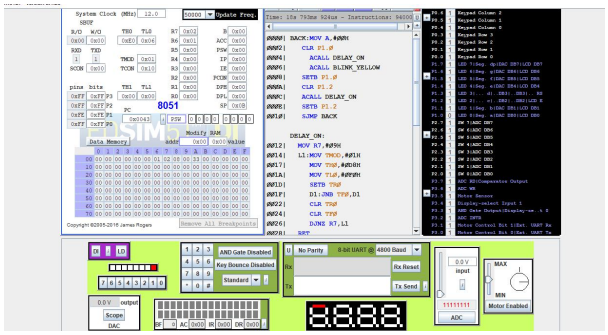
2. Keep ON the RED LED for 20ms more and during this time simultaneously BLINK the YELLOW LED with a period of 2ms.
3. Turn OFF both RED and YELLOW LEDs and Turn ON the GREEN LED for 90ms.
4. Turn OFF the GREEN LED and Repeat from Step 1**.**



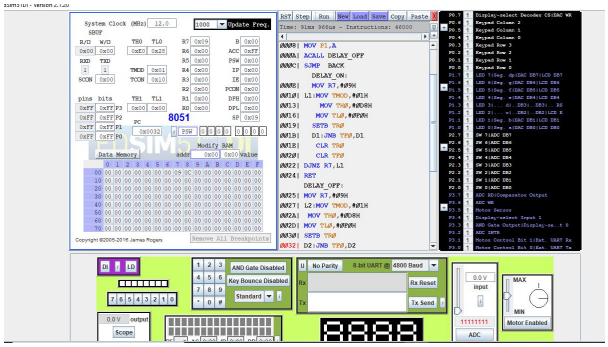


Practical Observations/Output:

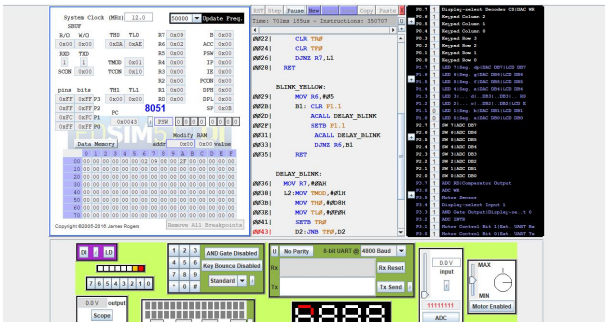
1.ON the RED LED for 90ms



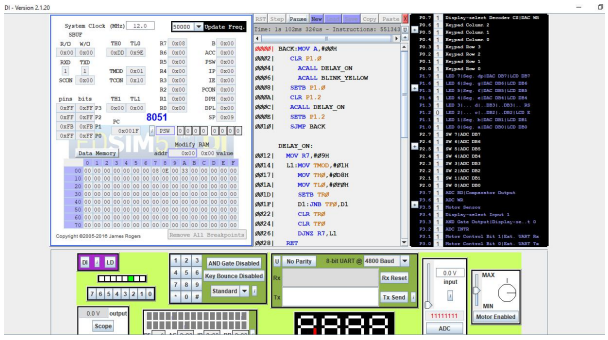
2. OFF the RED LED for 90ms



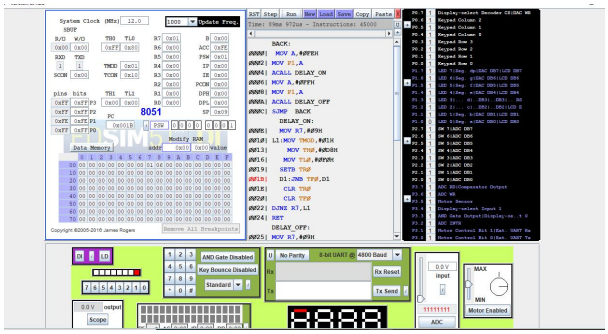
3.Keep ON the RED LED for 20ms more and during this time simultaneously BLINK the YELLOW LED with a period of 2ms.



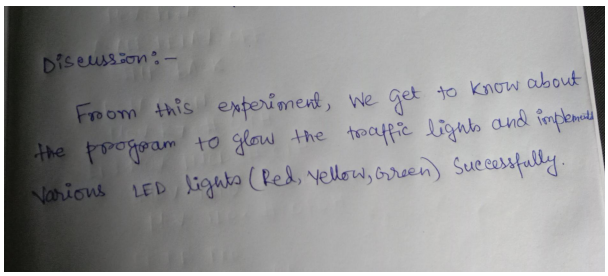
4. Turn OFF both RED and YELLOW LEDs and Turn ON the GREEN LED for 90ms.



5.Turn OFF the GREEN LED and Repeat from Step 1.



Discussions:



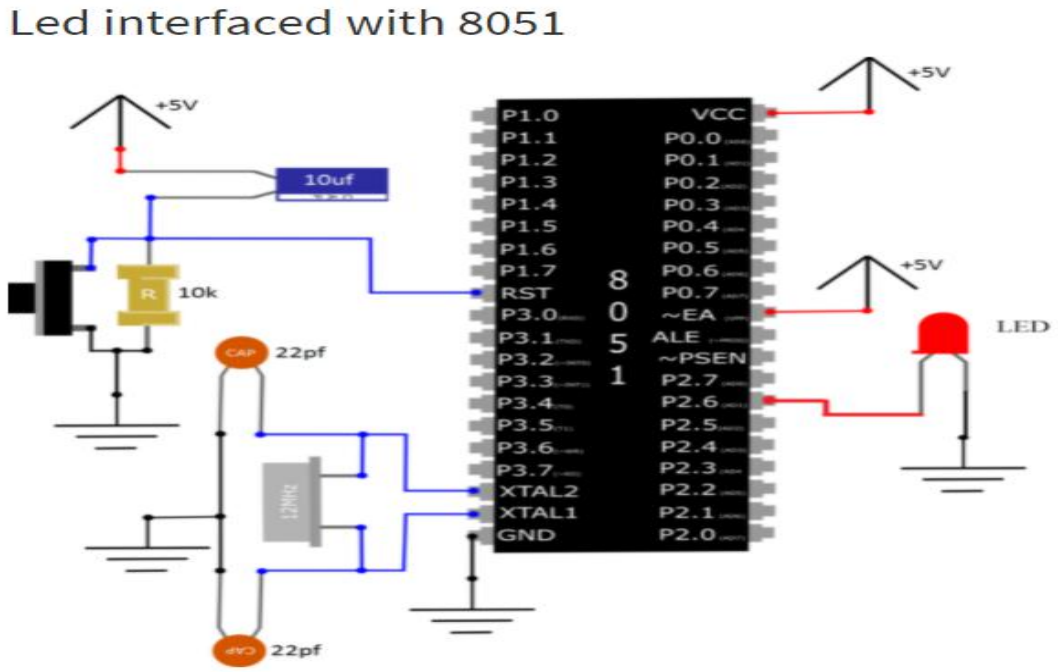
EXPERIMENT NO. 02(A)

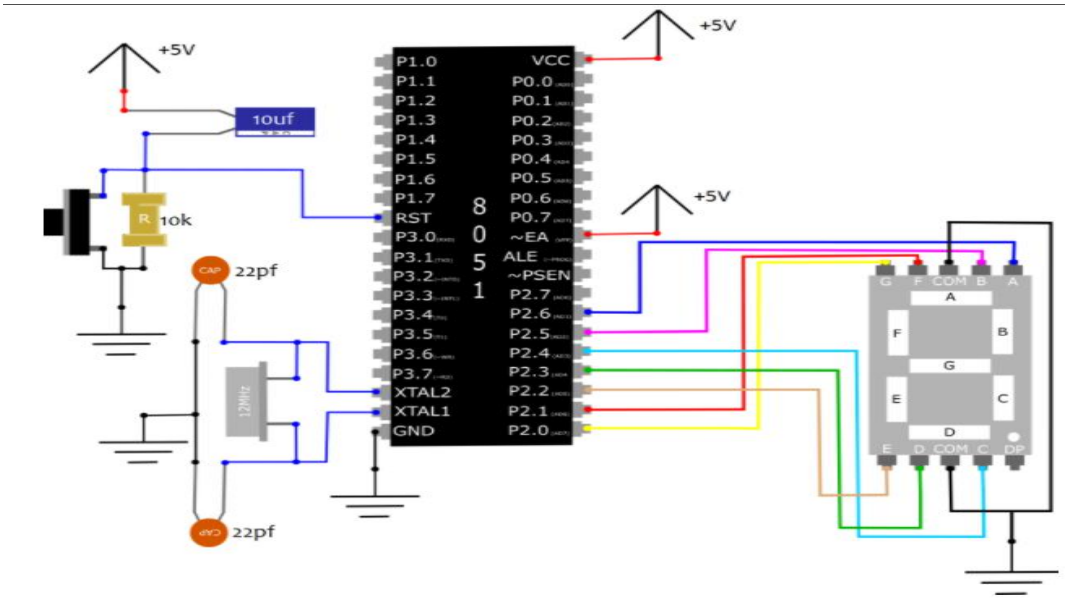
Title: UART: Serial Communication - Transmission

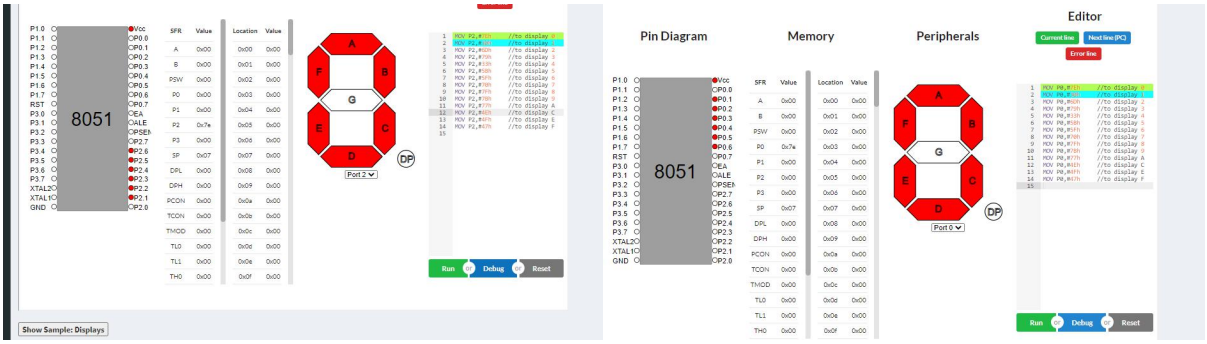
Objective: Write a program for Serial Communication.

1) Transmit your name at Baud Rate 1200.
2) Transmit your name at Baud Rate 2400.
3) Transmit your name at Baud Rate 4800.

Circuit Diagram:







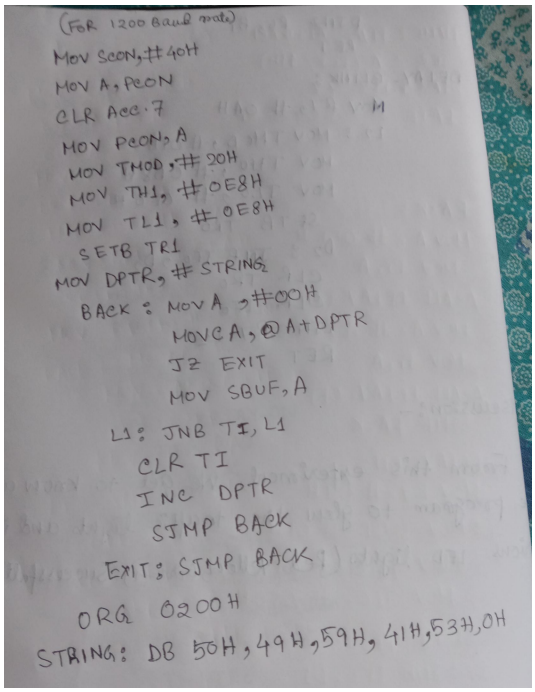
Problem statement:

1) Transmit your name at Baud Rate 1200 :

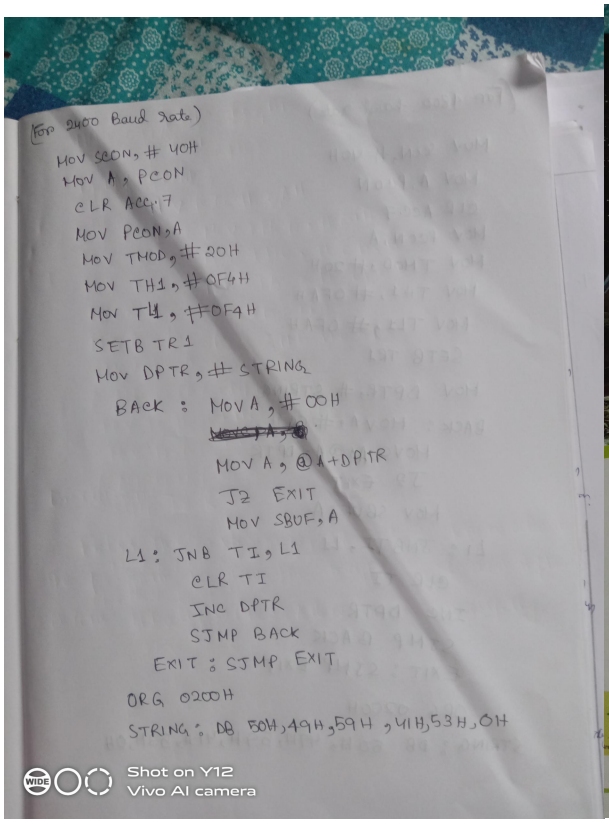
2)Transmit your name at Baud Rate 2400.

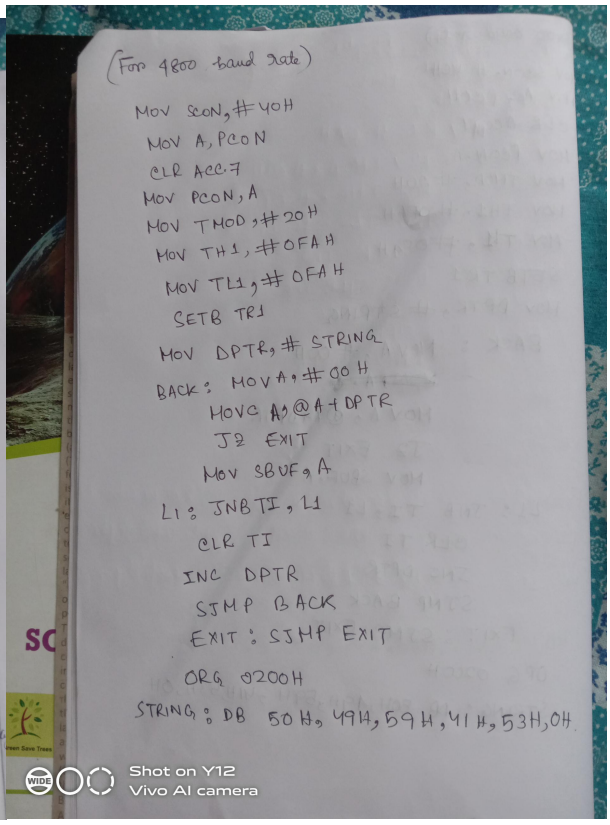
3)Transmit your name at Baud Rate 4800.

Program code:

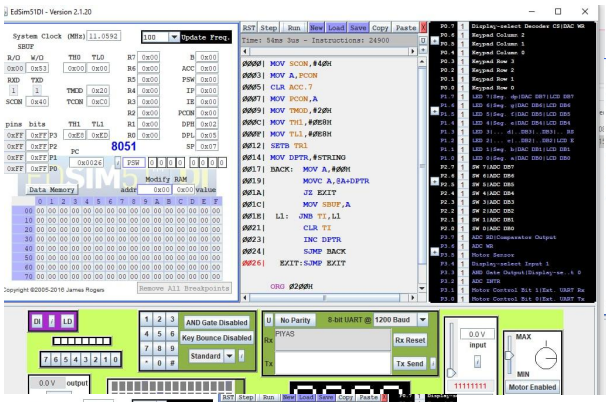


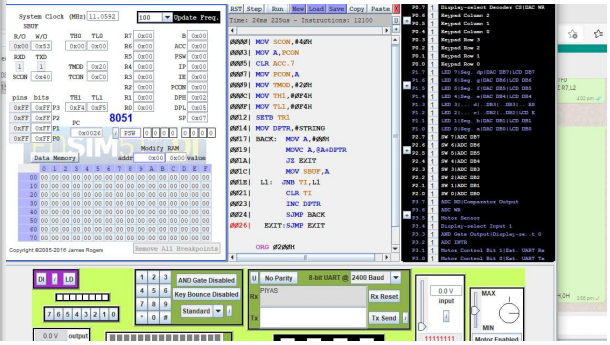
```
(FOR 1200 Baud rate)
MOV SCON,#40H
MOV A,PCON
CLR ACC.7
MOV PCON,A
MOV TMOD,#20H
MOV TH1,#0E8H
MOV TL1,#0E8H
SETB TR1
MOV DPTR,#STRING
BACK: MOV A,#00H
      MOVC A,@A+DPTR
      JZ EXIT
      MOV SBUF,A
L1: JNB TI,L1
    CLR TI
    INC DPTR
    SJMP BACK
EXIT: SJMP BACK
ORG 0200H
STRING: DB 50H,49H,59H,41H,53H,0H
```

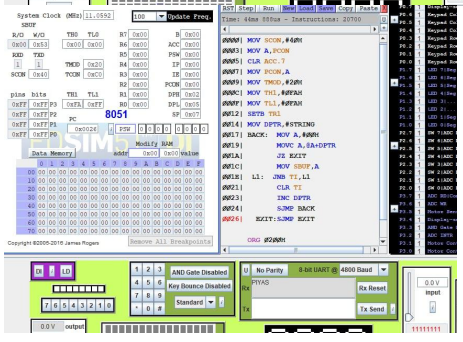




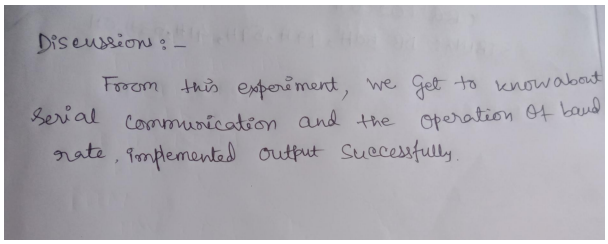
Practical Observations/Output:







Discussions:


Discussions :-

Fooom this experiment, we get to know about Serial Communication and the Operation of baud rate, implemented output successfully.

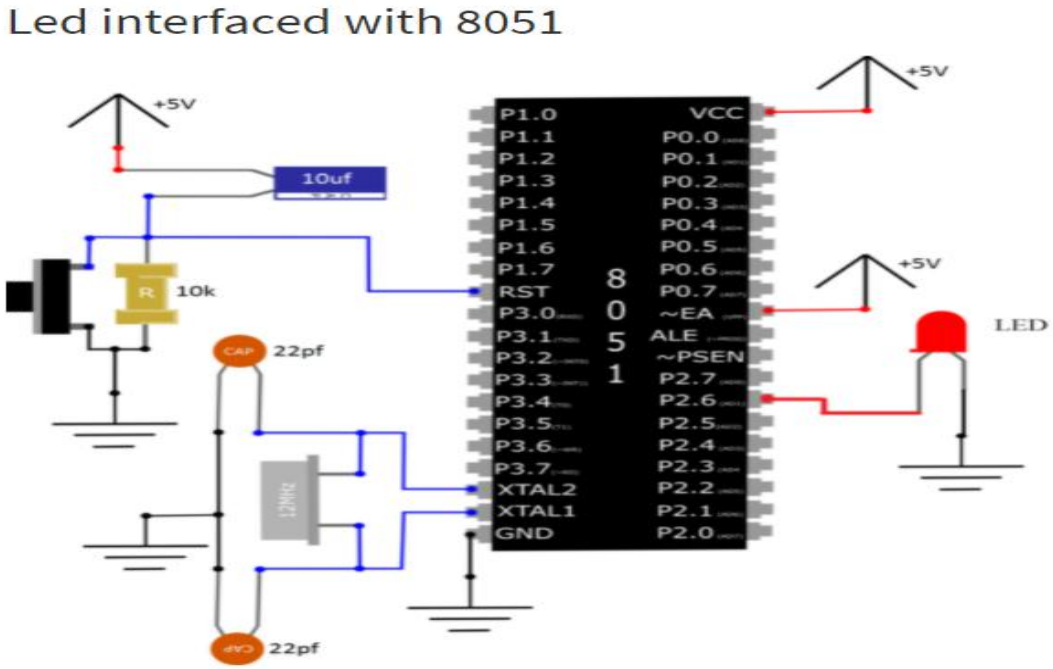
EXPERIMENT NO. 02(B)

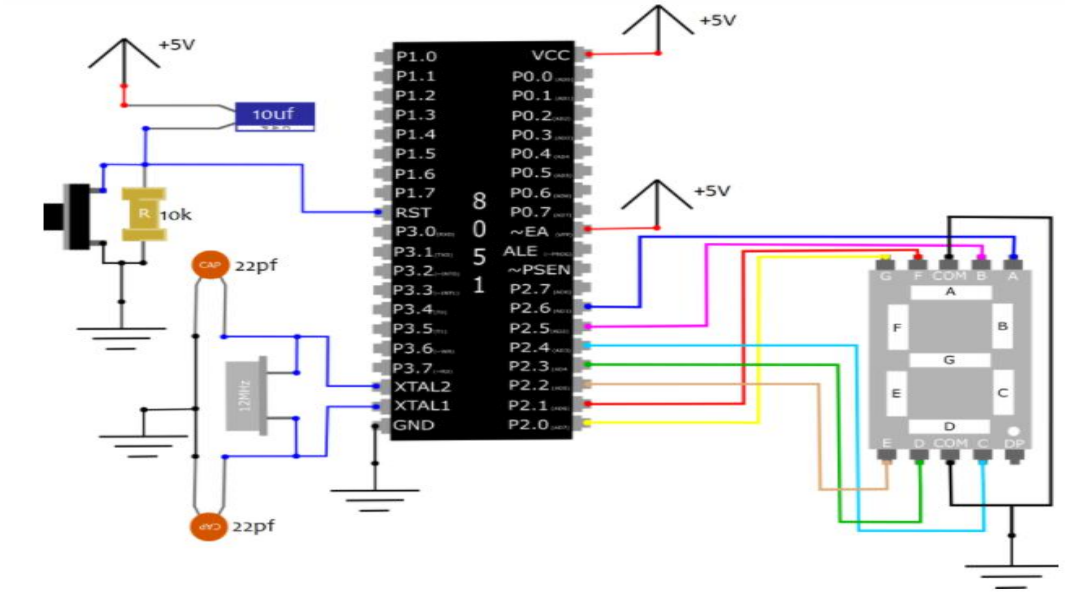
Title: UART: Serial Communication: Receive – Transmit (Send Back)

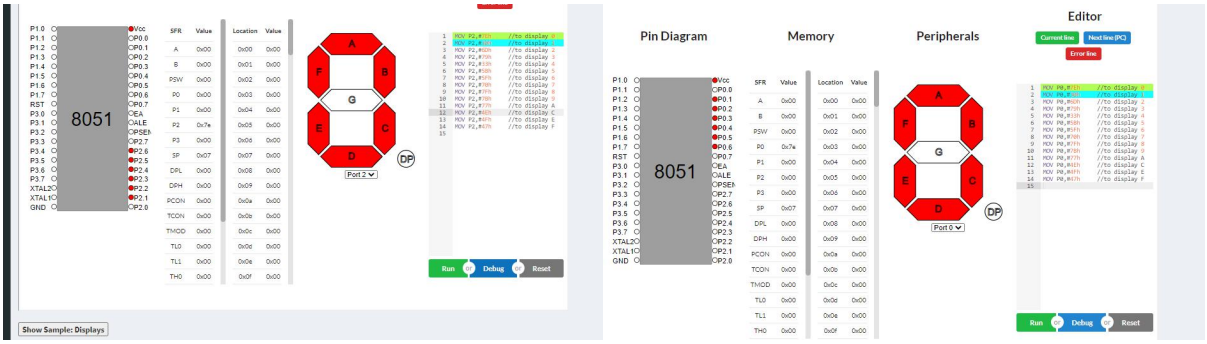
Objective: Write a program for Serial Communication.

1) Send Back your name at Baud Rate 1200 from External UART.
2) Send Back your name at Baud Rate 2400 from External UART.
3) Send Back your name at Baud Rate 4800 from External UART.

Circuit Diagram:



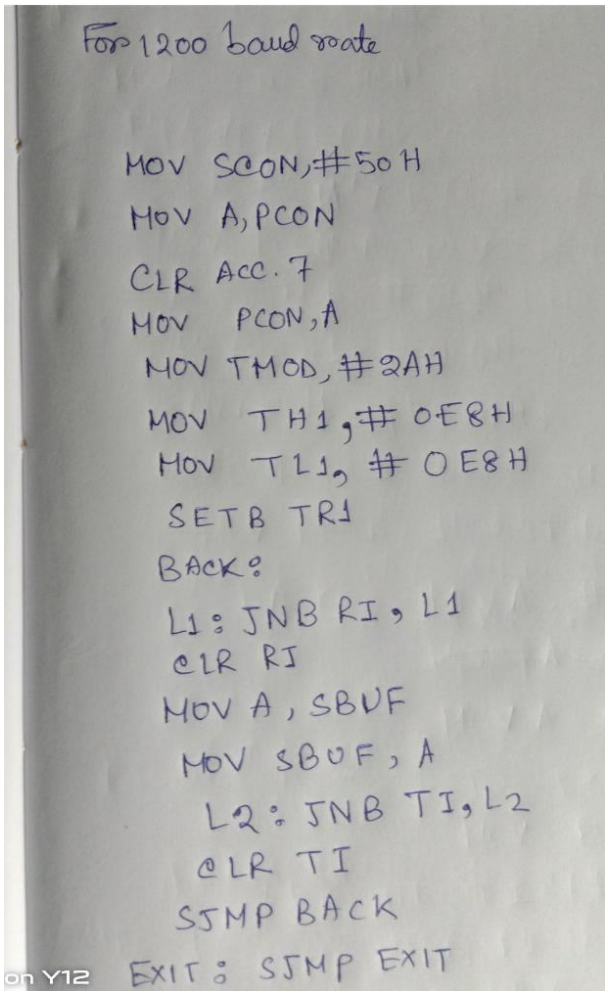




Problem statement:

1) Send Back your name at Baud Rate 1200 from External UART.

Program Code:

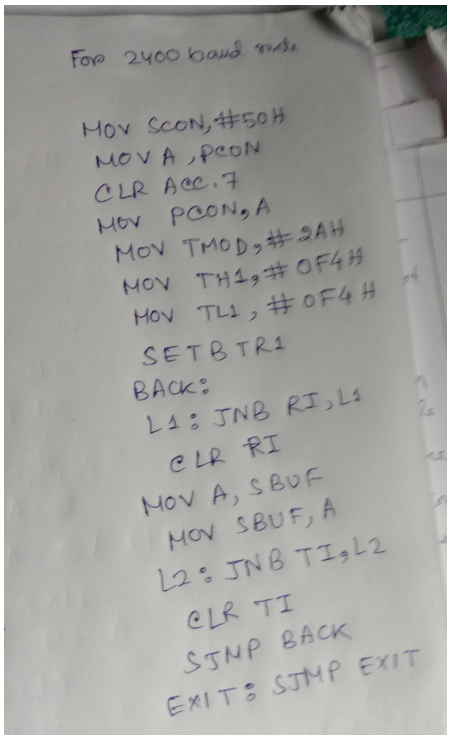


For 1200 baud rate

```
MOV SCON,#50H
MOV A,PCON
CLR ACC.7
MOV PCON,A
MOV TMOD,#2AH
MOV TH1,#0E8H
MOV TL1,#0E8H
SETB TR1
BACK:
L1: JNB RI,L1
CLR RI
MOV A,SBUF
MOV SBUF,A
L2: JNB TI,L2
CLR TI
SJMP BACK
EXIT: SJMP EXIT
```

2) Send Back your name at Baud Rate 2400 from External UART.

Program Code:

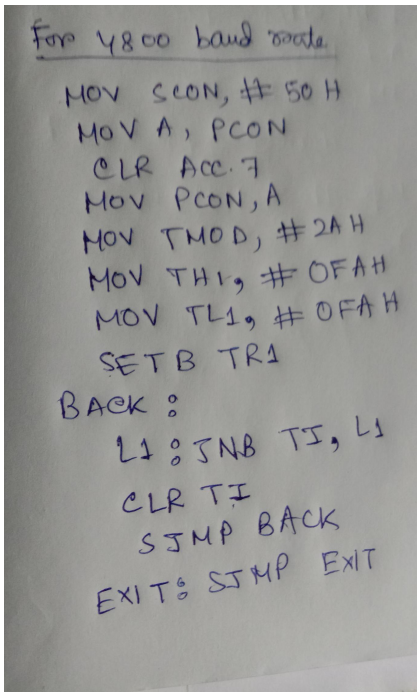


For 2400 baud rate

```
MOV SCON,#50H
MOV A,PCON
CLR ACC.7
MOV PCON,A
MOV TMOD,#2AH
MOV TH1,#0F4H
MOV TL1,#0F4H
SETB TR1
BACK:
L1: JNB RI,L1
CLR RI
MOV A,SBUF
MOV SBUF,A
L2: JNB TI,L2
CLR TI
SJMP BACK
EXIT: SJMP EXIT
```

3) Send Back your name at Baud Rate 4800 from External UART.

Program Code:

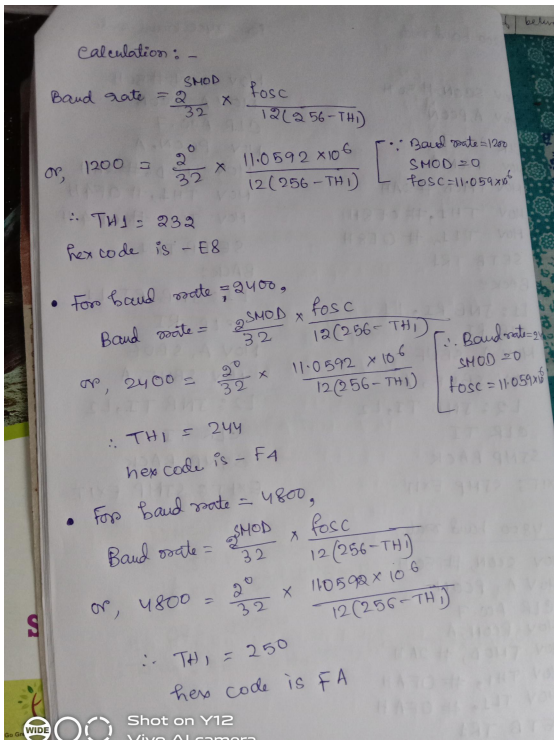


For 4800 baud rate

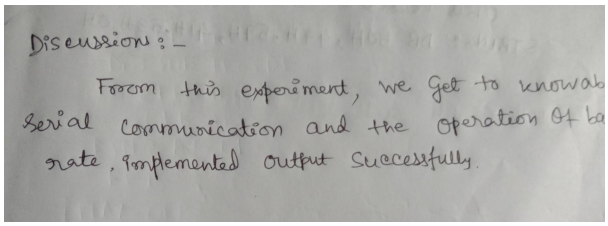
```
MOV SCON,#50H
MOV A,PCON
CLR ACC.7
MOV PCON,A
MOV TMOD,#2AH
MOV TH1,#0FAH
MOV TL1,#0FAH
SETB TR1
BACK:
L1: JNB TI,L1
CLR TI
SJMP BACK
EXIT: SJMP EXIT
```

Practical Observations/Output:

Calculation:



Discussions:


Discussion :-

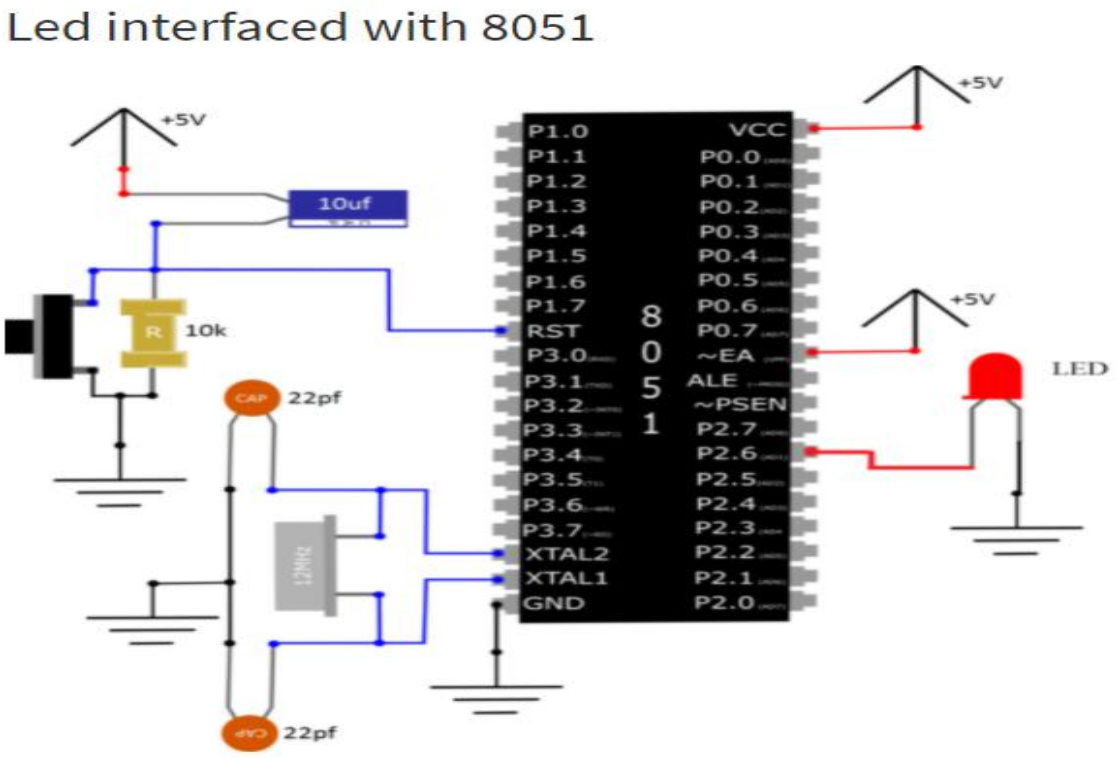
From this experiment, we get to know ab
Serial Communication and the Operation of ba
rate, Implemented output successfully.

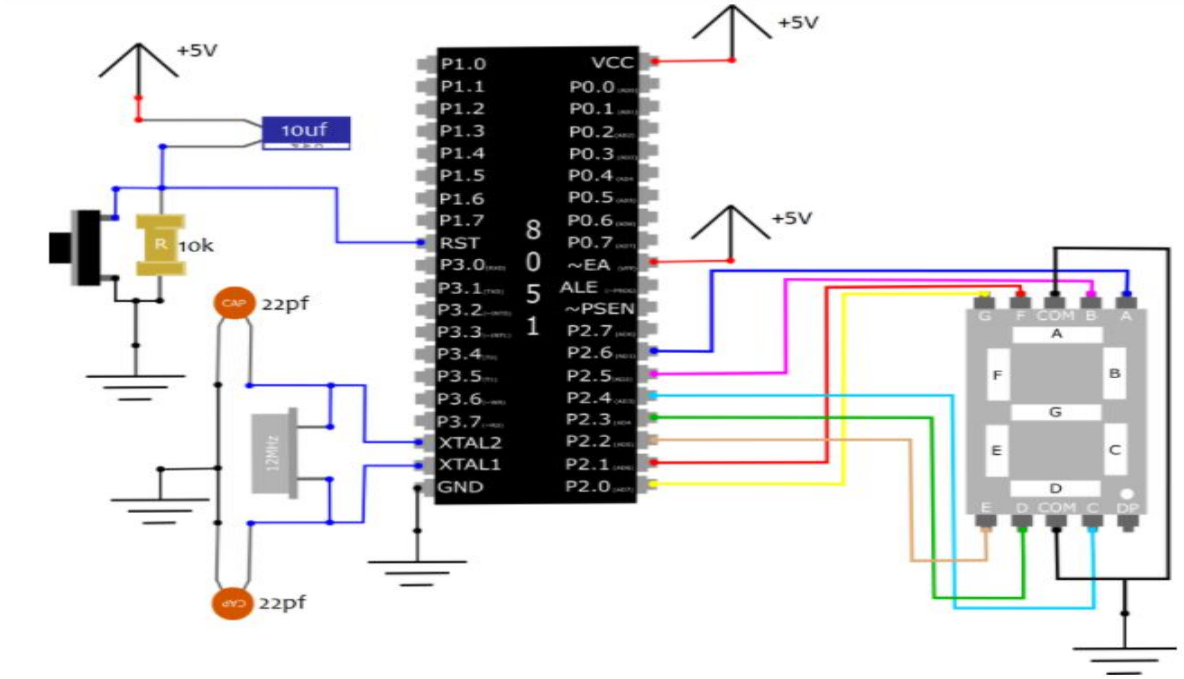
EXPERIMENT NO. 03

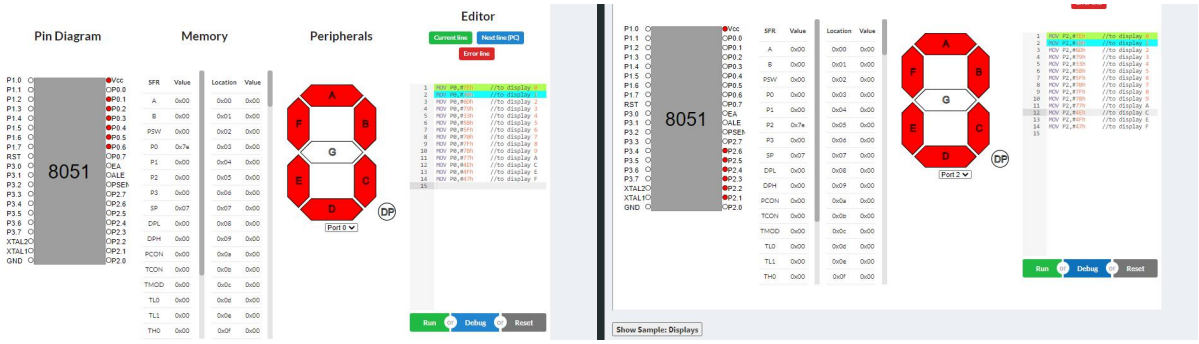
Title: Use seven segment displays to display your class, roll number

Objective: Use seven segment displays to display your class, roll number

Circuit Diagram:





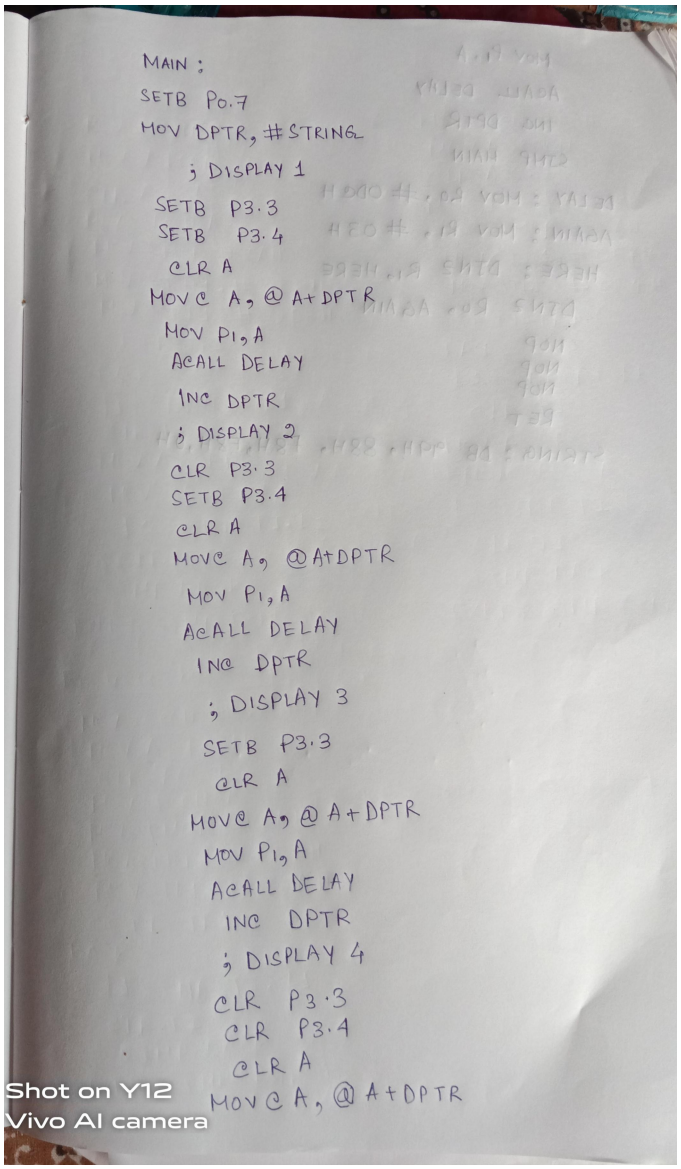


Problem statement:

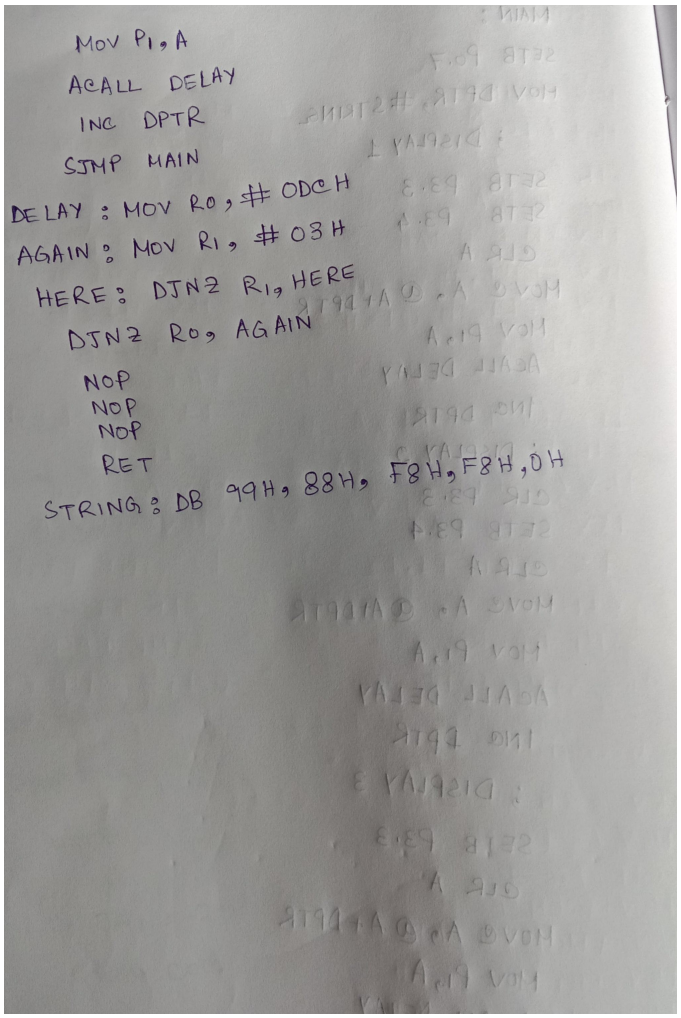
Use seven segment display to display your own class, section and roll number.
(Example: A student of 4B with roll number 01,
Seven segment display 1 = 4
Seven segment display 2 = B
Seven segment display 3 = 0
Seven segment display 4 = 1)

Use **2ms** delay between two displays.

Program Code:



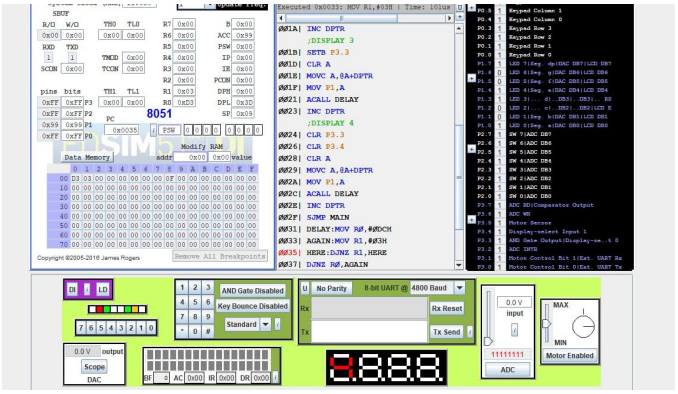
```
MAIN :
SETB P0.7
MOV DPTR, #STRING
    ; DISPLAY 1
 SETB  P3.3
 SETB  P3.4
  CLR A
MOVC  A, @ A+DPTR
 MOV P1, A
 ACALL DELAY
  INC DPTR
 ; DISPLAY 2
 CLR P3.3
 SETB P3.4
 CLR A
 MOVC A, @A+DPTR
  MOV P1, A
  ACALL DELAY
   INC DPTR
    ; DISPLAY 3
    SETB P3.3
     CLR A
    MOVC A, @ A+DPTR
     MOV P1, A
     ACALL DELAY
      INC DPTR
       ; DISPLAY 4
       CLR P3.3
        CLR P3.4
         CLR A
Shot on Y12  MOVC A, @ A+DPTR
Vivo AI camera
```



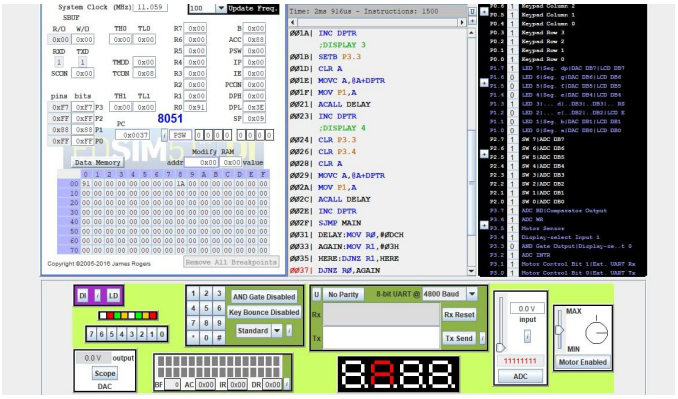
```
MOV P1, A
ACALL DELAY
INC DPTR
SJMP MAIN
DELAY : MOV R0, #0D0H
AGAIN : MOV R1, #03H
HERE : DJNZ R1, HERE
DJNZ R0, AGAIN
NOP
NOP
NOP
RET
STRING : DB 99H, 88H, F8H, F8H, 0H
```

Practical Observations/Output:

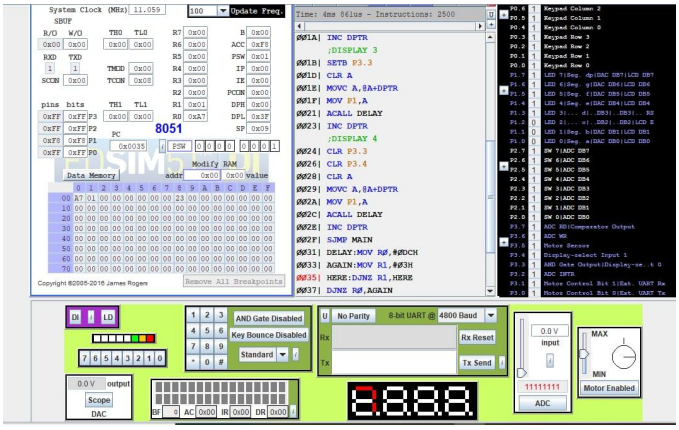
Seven segment display 1= 4



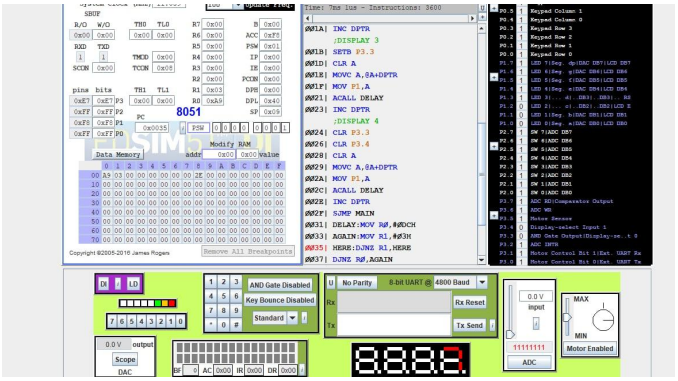
Seven segment display 2=A



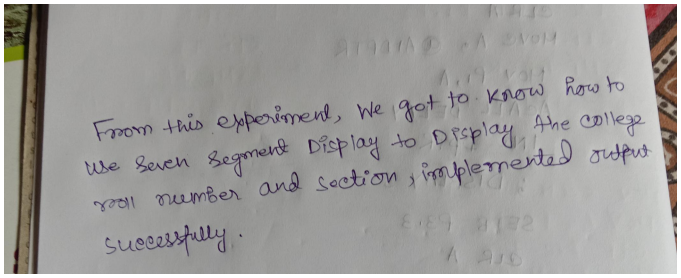
Seven segment display 3=7



Seven segment display 4=7



Discussions:

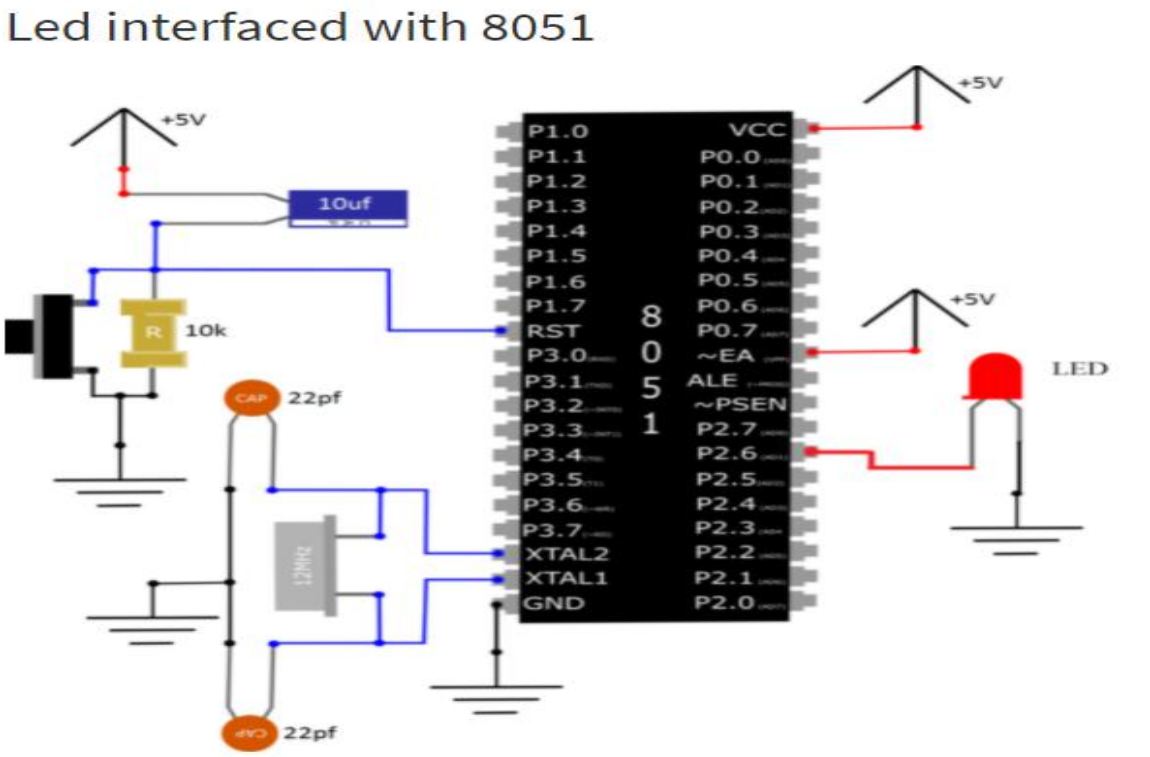


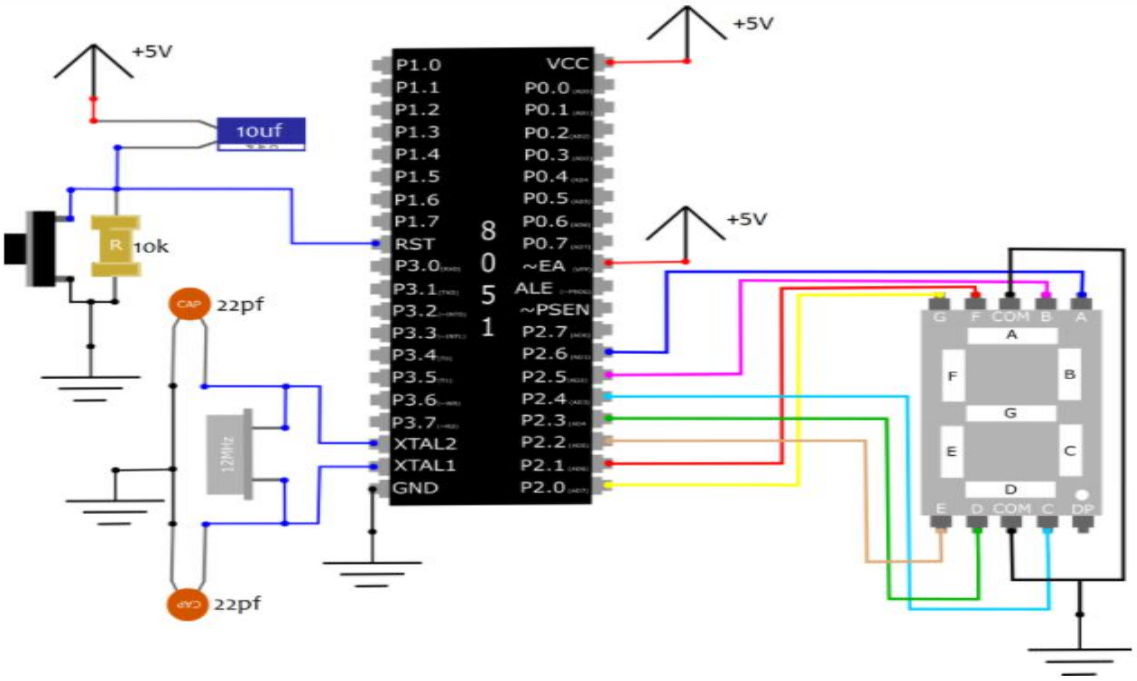
EXPERIMENT NO. 04

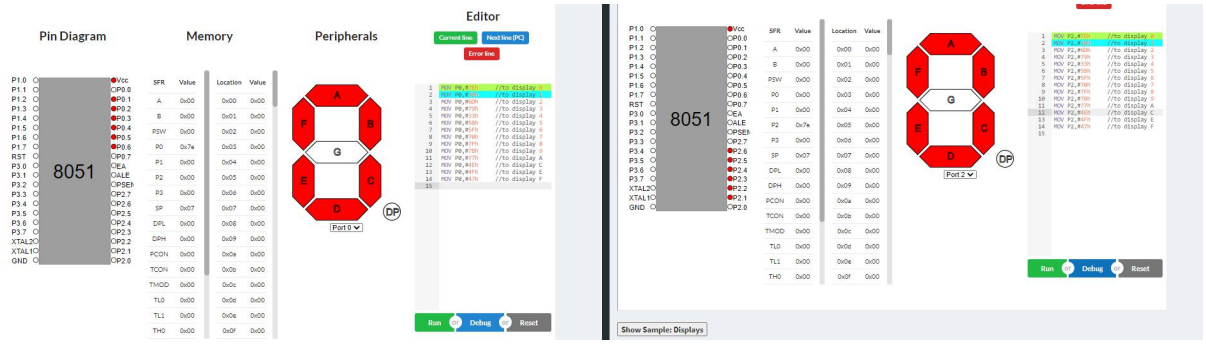
Title: Use the matrix keypad to display your class roll number in seven segment displays

Objective: Use the matrix keypad to display your class roll number in seven segment displays

Circuit Diagram:


Led interfaced with 8051
+5V
10uf
R
10k
CAP
22pf
12MHz
22pf
P1.0
P1.1
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
RST
P3.0
P3.1
P3.2
P3.3
P3.4
P3.5
P3.6
P3.7
XTAL2
XTAL1
GND
8051
VCC
P0.0
P0.1
P0.2
P0.3
P0.4
P0.5
P0.6
P0.7
~EA
ALE
~PSEN
P2.7
P2.6
P2.5
P2.4
P2.3
P2.2
P2.1
P2.0
+5V
+5V
LED

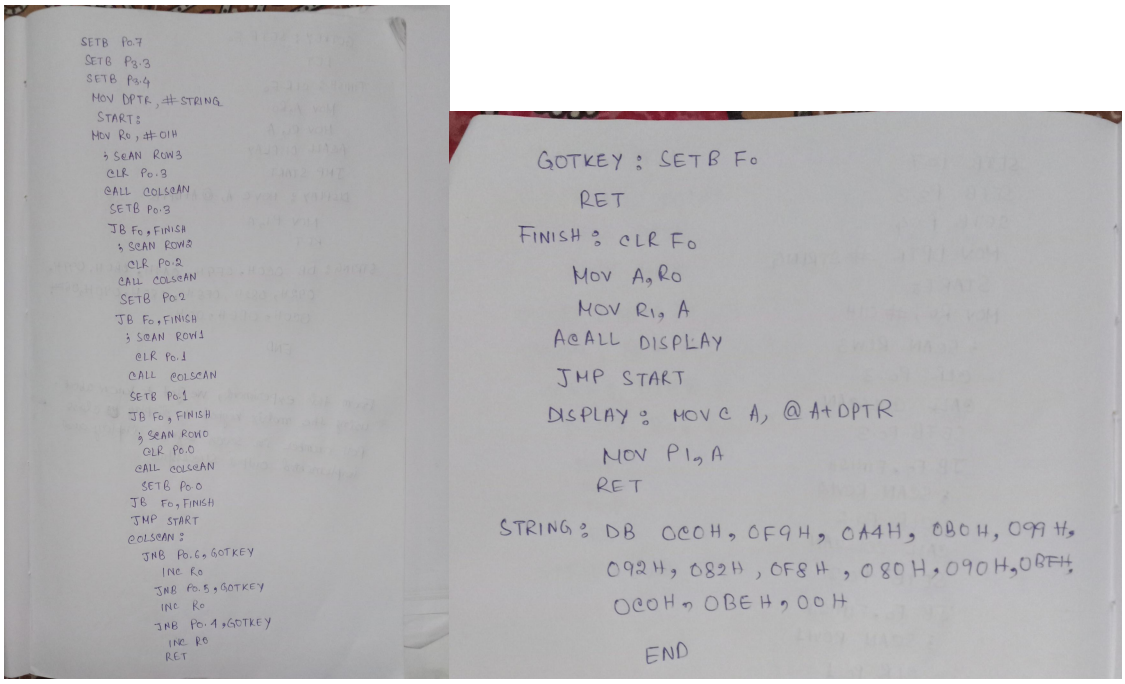

+5V
10uf
R
10k
CAP
22pf
12MHz
22pf
P1.0
P1.1
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
RST
P3.0
P3.1
P3.2
P3.3
P3.4
P3.5
P3.6
P3.7
XTAL2
XTAL1
GND
8051
VCC
P0.0
P0.1
P0.2
P0.3
P0.4
P0.5
P0.6
P0.7
~EA
ALE
~PSEN
P2.7
P2.6
P2.5
P2.4
P2.3
P2.2
P2.1
P2.0
+5V
+5V
G
F
COM
B
A
E
D
C
DP



Problem statement:

Use the matrix keypad to display your class roll number in seven segment displays (Example: A student with roll number 54,
1st key to be pressed and displayed in seven segment display1 = 5
2nd key to be pressed and displayed in seven segment display1 = 4)

Program Code:



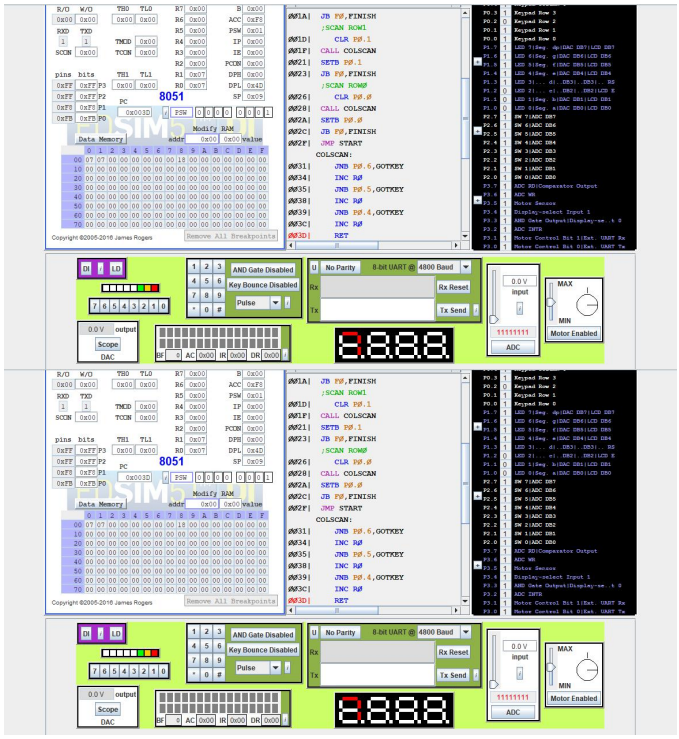
```
SETB P0.7
SETB P3.3
SETB P3.4
MOV DPTR, #STRING
START:
MOV R0, #0FH
; SCAN ROW3
CLR P0.3
CALL COLSCAN
SETB P0.3
JB F0, FINISH
; SCAN ROW2
CLR P0.2
CALL COLSCAN
SETB P0.2
JB F0, FINISH
; SCAN ROW1
CLR P0.1
CALL COLSCAN
SETB P0.1
JB F0, FINISH
; SCAN ROW0
CLR P0.0
CALL COLSCAN
SETB P0.0
JB F0, FINISH
JMP START
COLSCAN:
JNB P0.6, GOTKEY
INC R0
JNB P0.5, GOTKEY
INC R0
JNB P0.4, GOTKEY
INC R0
RET
GOTKEY: SETB F0
RET
FINISH: CLR F0
MOV A, R0
MOV R1, A
ACALL DISPLAY
JMP START
DISPLAY: MOVC A, @A+DPTR
MOV P1, A
RET
STRING: DB 0C0H, 0F9H, 0A4H, 0B0H, 099H,
092H, 082H, 0F8H, 080H, 090H, 0BFH,
0C0H, 0BEH, 00H
END
```

Practical Observations/Output:

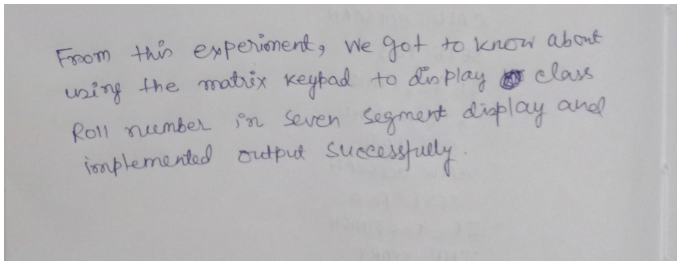
Class roll number=77

1st key to be pressed and displayed in seven segment display1= 7

2nd key to be pressed and displayed in seven segment display1= 7



Discussions:

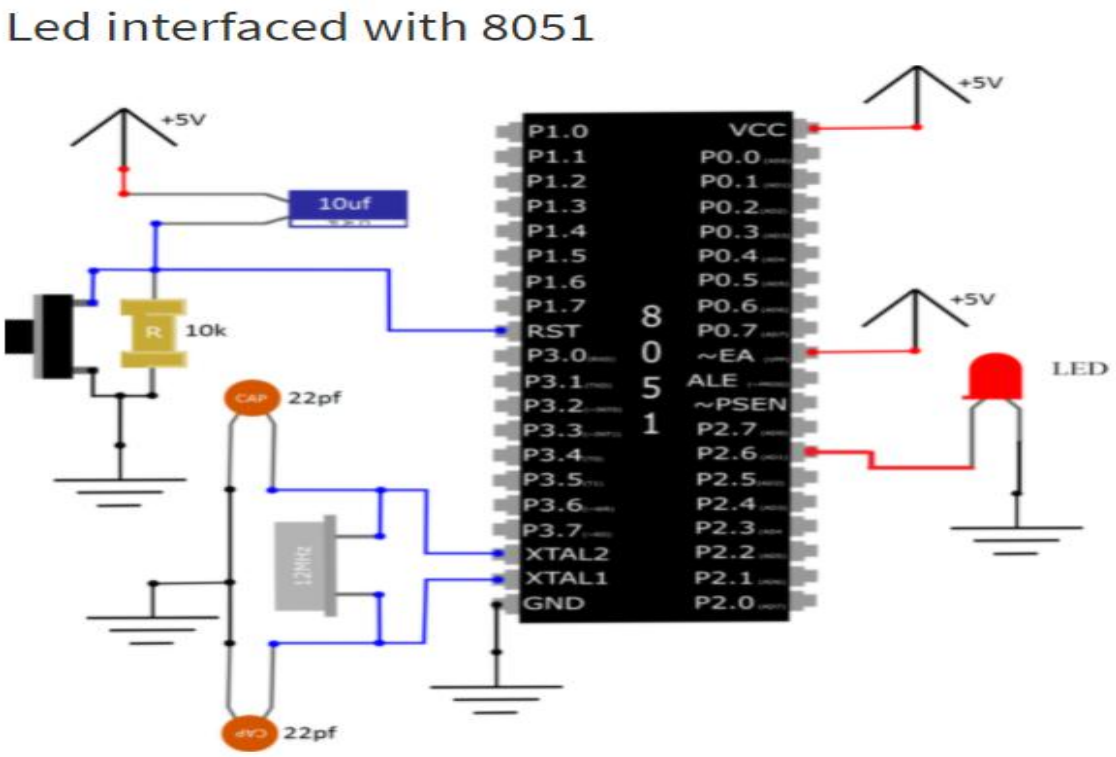


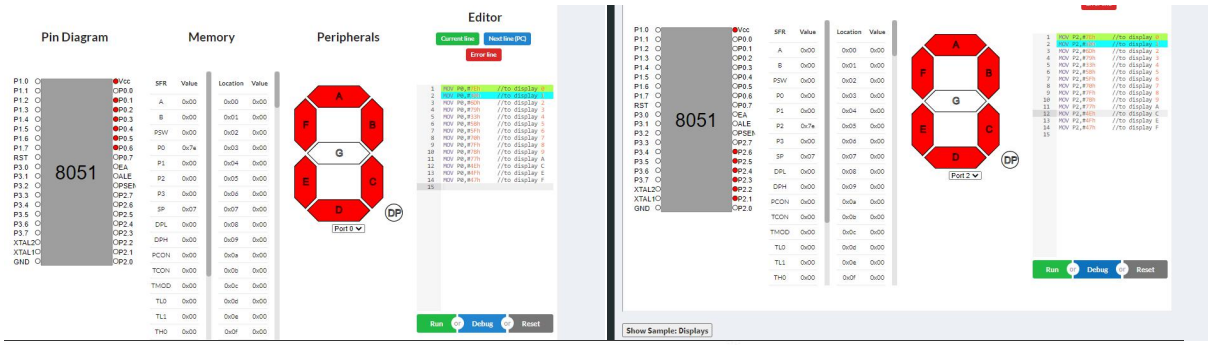
EXPERIMENT NO. 05

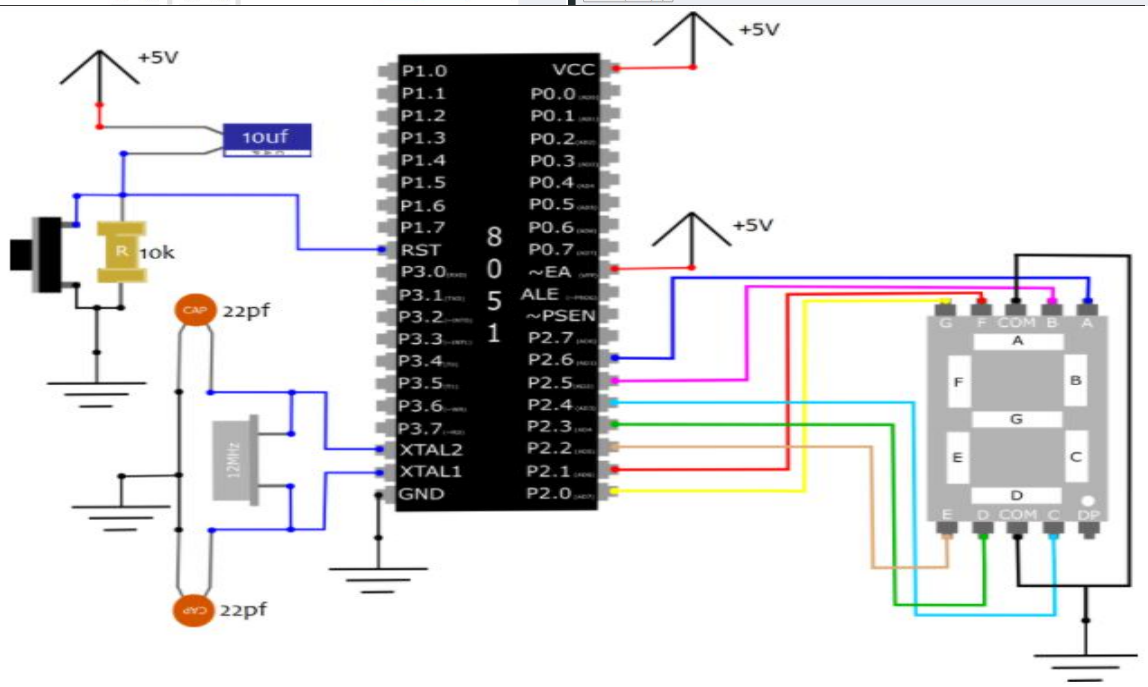
Title: Display of name in LED display.

Objective: Display your name using LED display.

Circuit Diagram:


Led interfaced with 8051
+5V
10uf
R
10k
CAP
22pf
12MHz
22pf
P1.0
P1.1
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
RST
P3.0
P3.1
P3.2
P3.3
P3.4
P3.5
P3.6
P3.7
XTAL2
XTAL1
GND
8051
VCC
P0.0
P0.1
P0.2
P0.3
P0.4
P0.5
P0.6
P0.7
~EA
ALE
~PSEN
P2.7
P2.6
P2.5
P2.4
P2.3
P2.2
P2.1
P2.0
+5V
+5V
LED

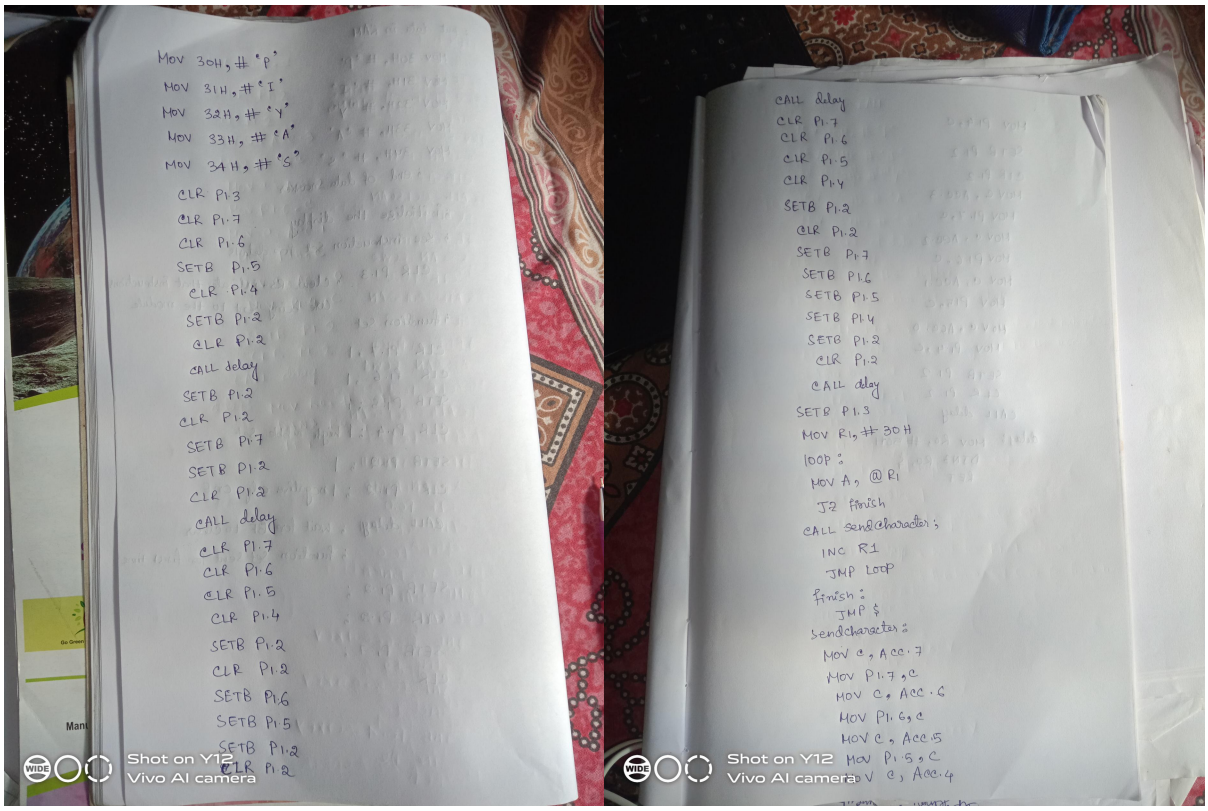




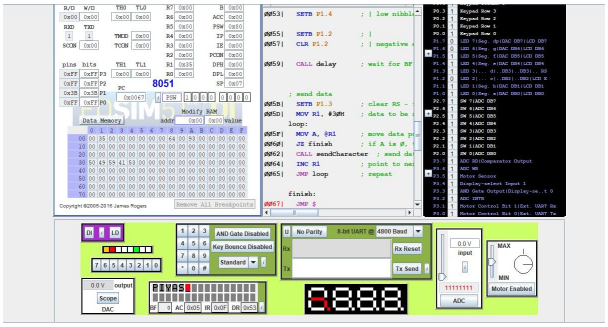
Problem statement:

Use LED for displaying your name. For example: A R P I T A

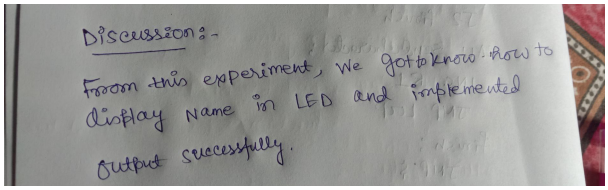
Program Code:



Practical Observations/Output:



Discussions:



EXPERIMENT NO. 06

Title: Design and Simulation of Encoders and Decoders.

Objective: Design and simulate 8:3 encoder and 3:8 decoder using VLAB.

Circuit Diagram and Truth Table:

i) 8:3 ENCODER:

I0	I1	I2	I3	I4	I5	I6	I7	Y2	Y1	Y0
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

table 3:Truth Table of octal to binary encoder

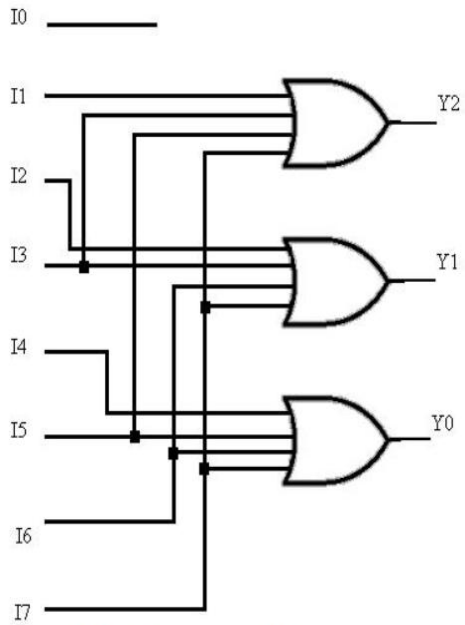


fig. 4:Logic Diagram of octal to binary encoder

ii) 3:8 DECODER:

X_2	X_1	X_0	Z_7	Z_6	Z_5	Z_4	Z_3	Z_2	Z_1	Z_0
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

Table 2:Truth table of 3:8 decoder

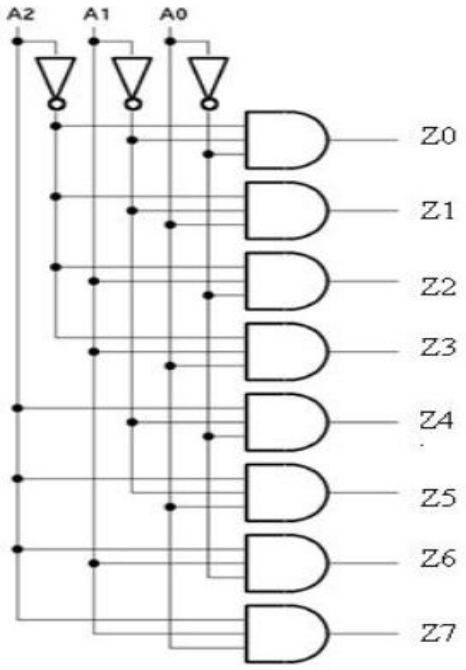
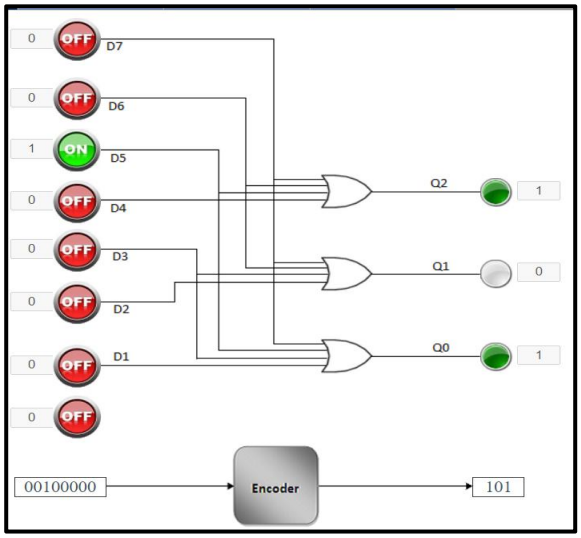
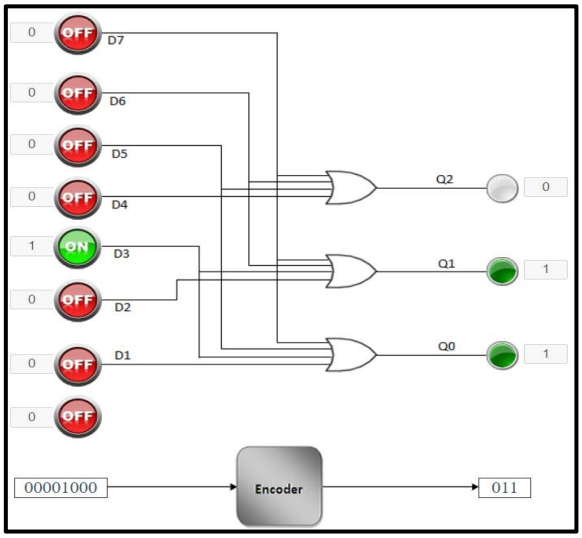
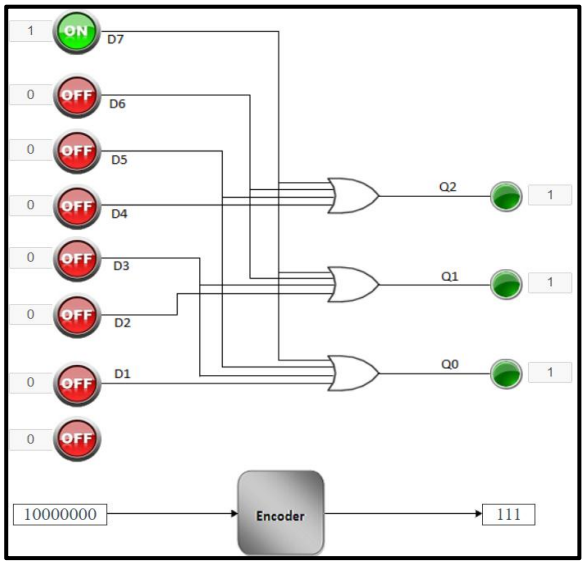


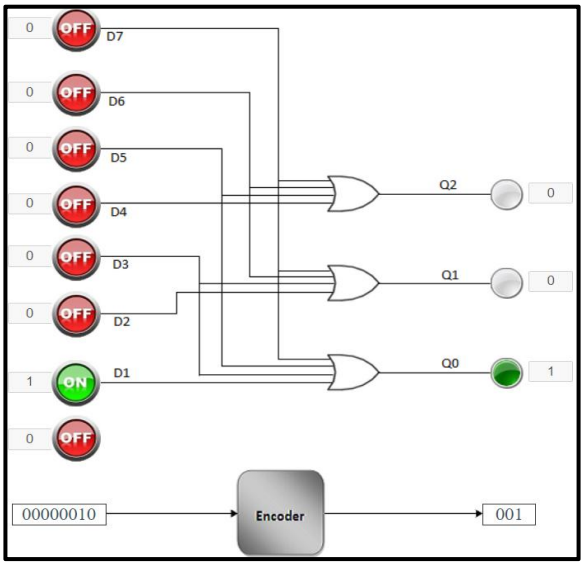
fig. 3 Logic Diagram of 3:8 decoder

Simulation Results for Encoder:

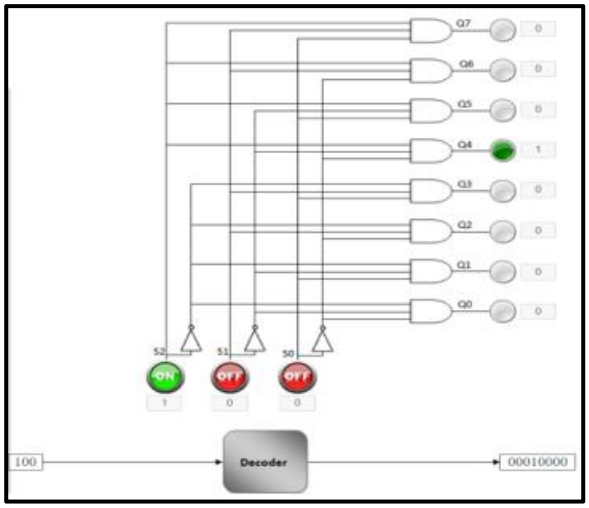


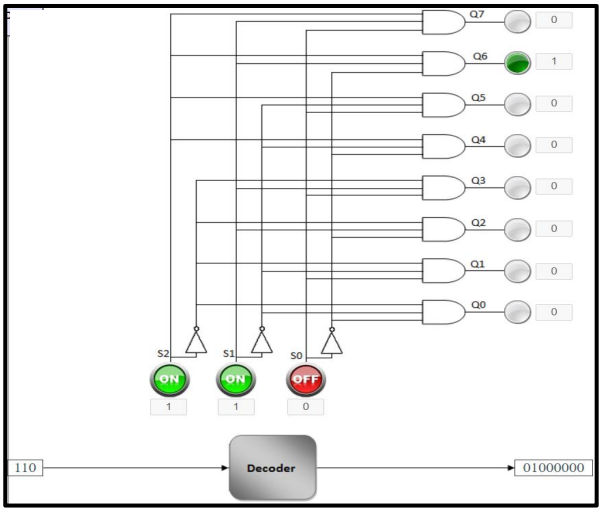


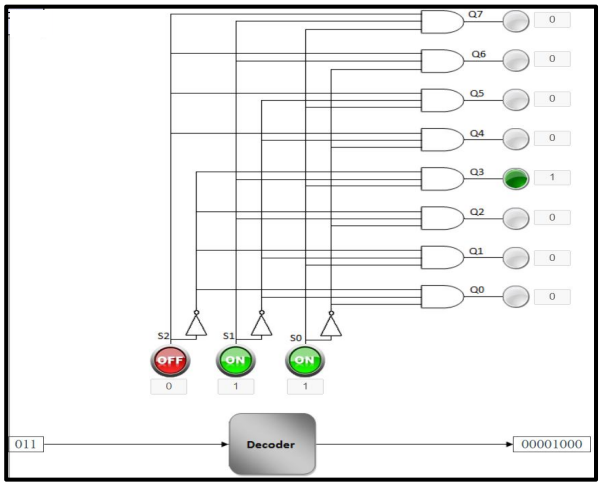


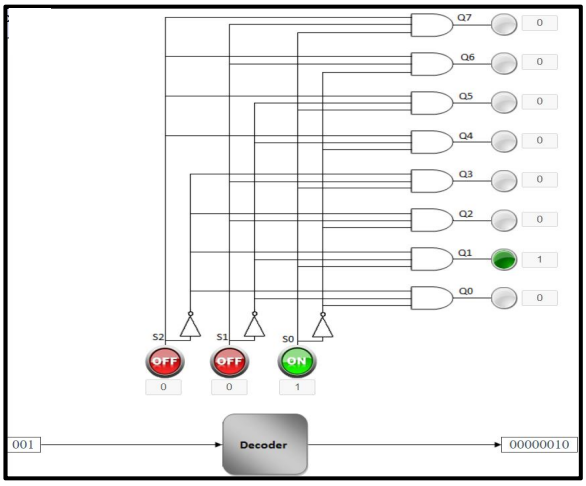


Simulation Results for Decoder:

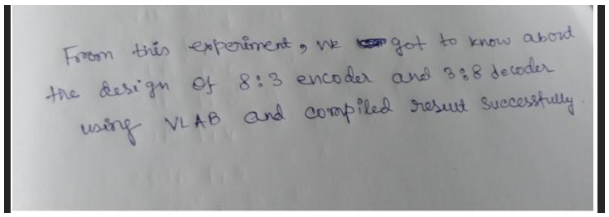








Discussions:



EXPERIMENT NO. 07

Title: Design and Simulation of Multiplexers and Demultiplexers.

Objective: Design and simulate 8:1 multiplexer and 1:8 demultiplexer using VLAB.

Circuit Diagram and Truth Table:

i) **8:1 MULTIPLEXER:**

S2	S1	S0	Y
0	0	0	D0
0	0	1	D1
0	1	0	D2
0	1	1	D3
1	0	0	D4
1	0	1	D5
1	1	0	D6
1	1	1	D7

table 5:Truth Table of 8:1 MUX

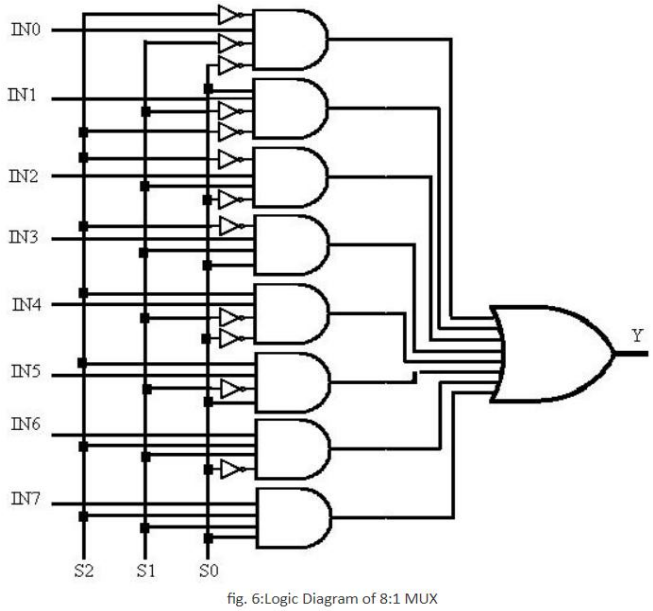


fig. 6:Logic Diagram of 8:1 MUX

ii) **1:8 DEMULTIPLEXER:**

S2	S1	S0	O7	O6	O5	O4	O3	O2	O1	O0
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

table 6:Truth Table of 1:8 DEMUX

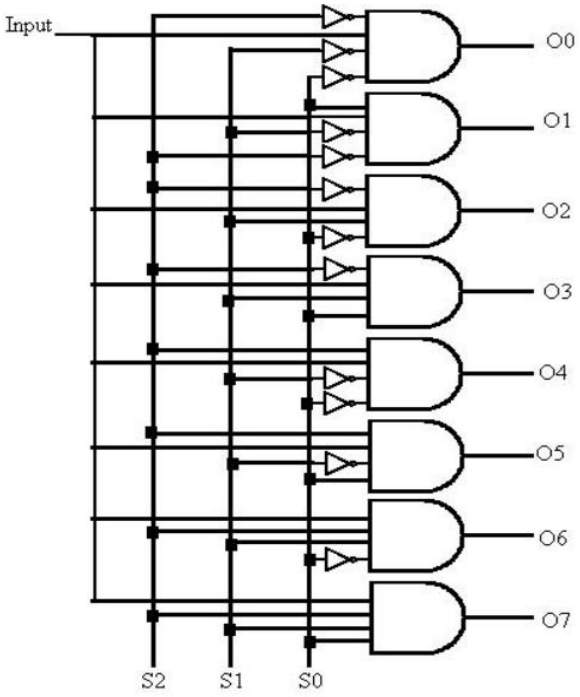
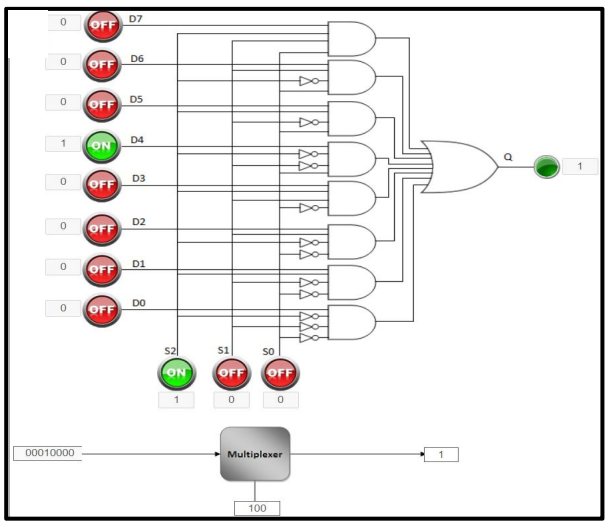
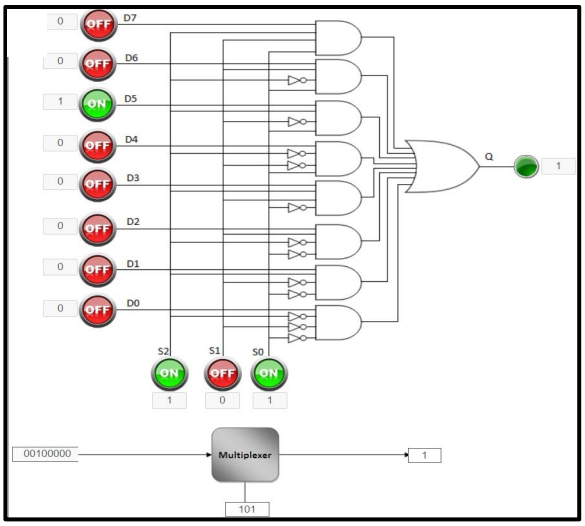
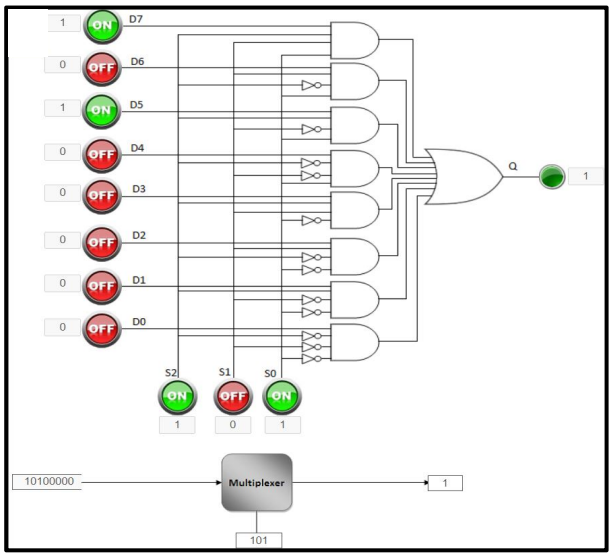


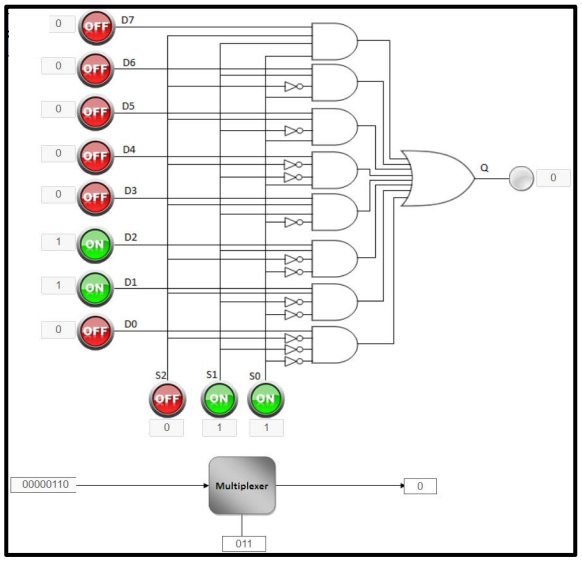
fig. 7:Logic Diagram of 1:8 DEMUX

Simulation Results for Multiplexer:

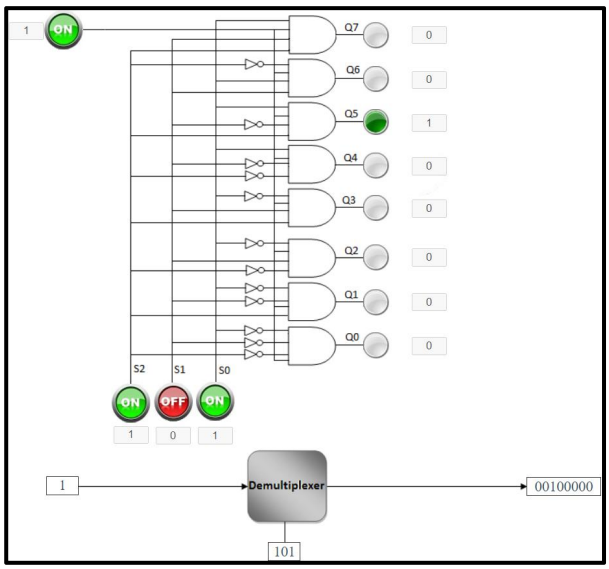


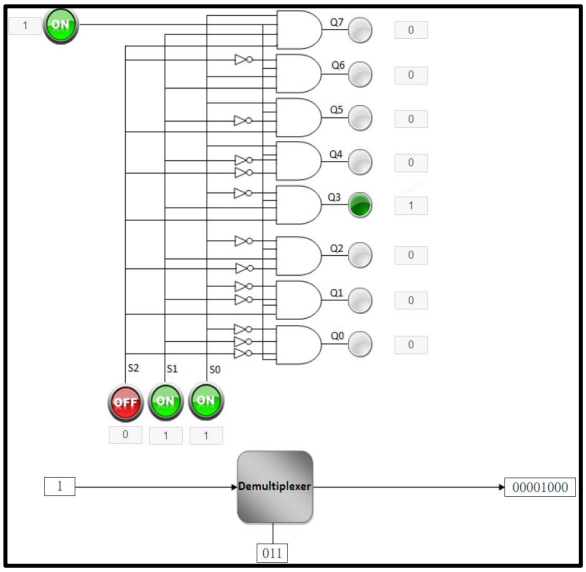


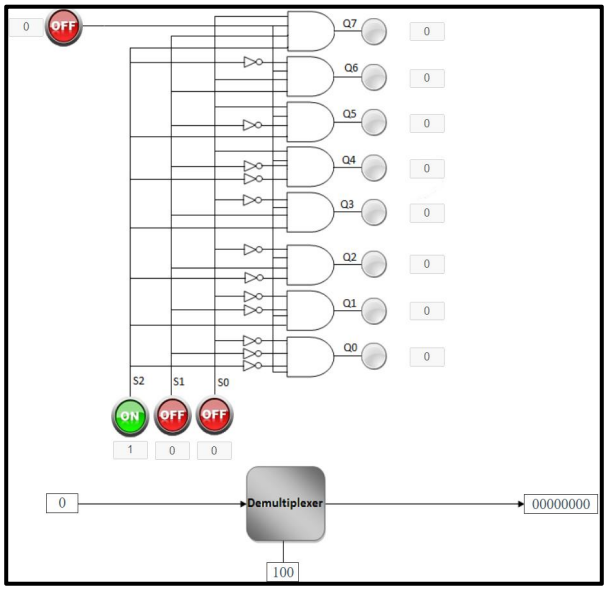


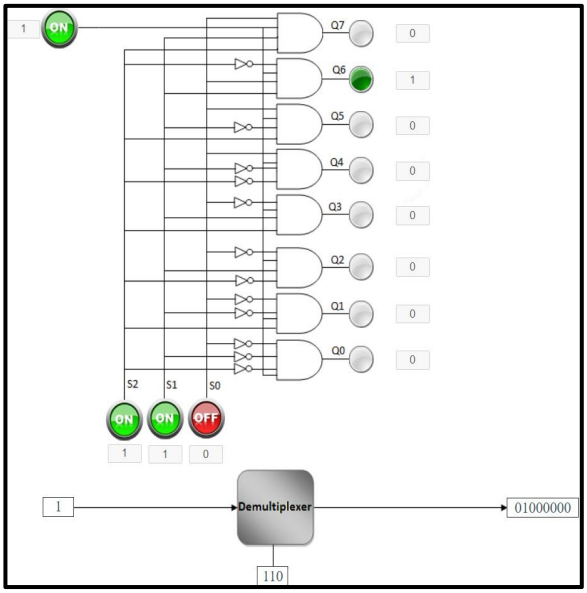


Simulation Results for Demultiplexer:

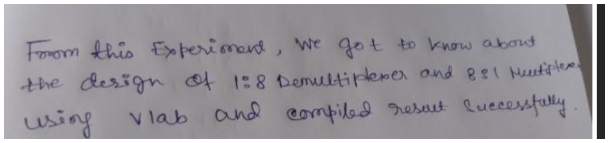








Discussions:



EXPERIMENT NO. 08

Title: Design and Simulation of Arithmetic Logic Unit and show the different logic operations.

Objective: Design and Simulation of Arithmetic Logic Unit and show the different logic operations using VLAB.

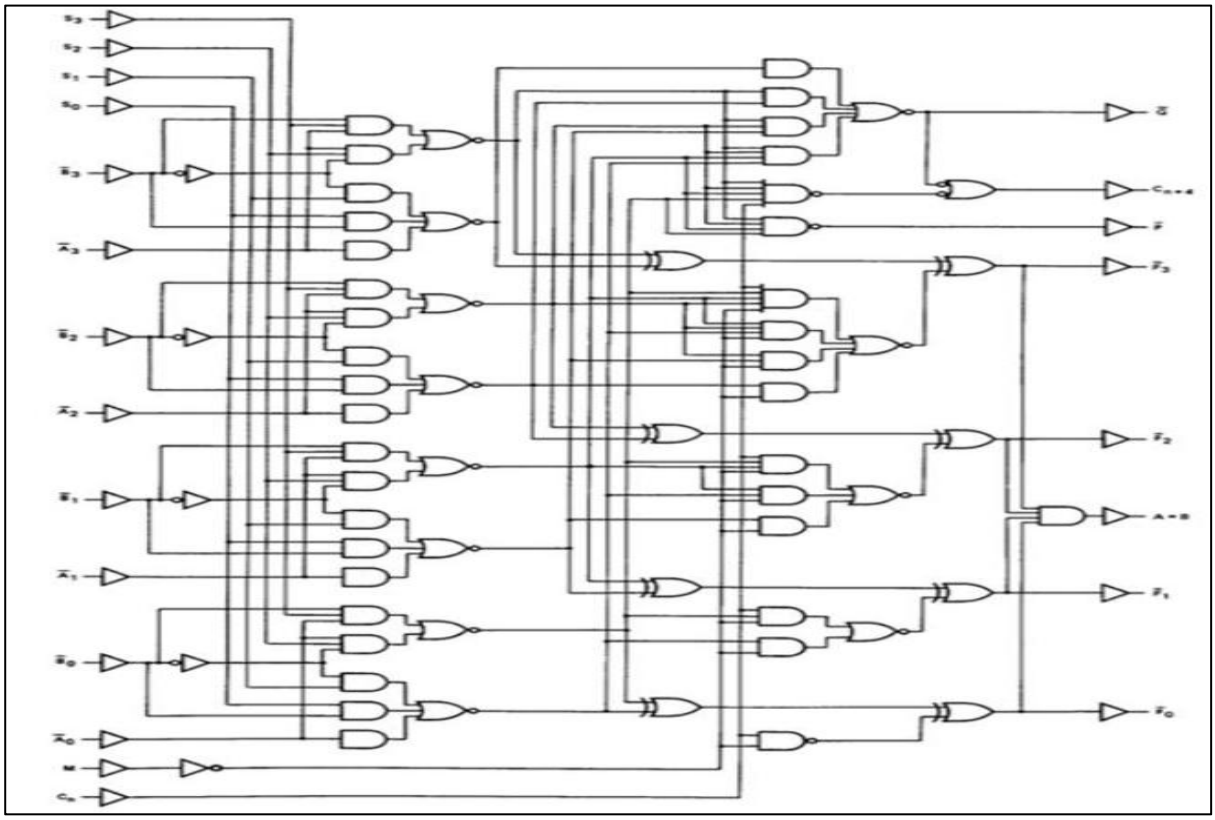
Circuit Diagram and Truth Table:

MODE SELECT INPUTS				ACTIVE HIGH INPUTS AND OUTPUTS	
S_3	S_2	S_1	S_0	LOGIC (M=H)	ARITHMETIC(2) (M=L; C_n=H)
L	L	L	L	$\overline{A}$	A
L	L	L	H	$\overline{A+B}$	A + B
L	L	H	L	$\overline{A}B$	$A+\overline{B}$
L	L	H	H	logical 0	minus 1
L	H	L	L	$\overline{AB}$	A plus $A\overline{B}$
L	H	L	H	$\overline{B}$	(A + B) plus $A\overline{B}$
L	H	H	L	$A \oplus B$	A minus B minus 1
L	H	H	H	$A\overline{B}$	$A\overline{B}$ minus 1
H	L	L	L	$\overline{A}+B$	A plus AB
H	L	L	H	$\overline{A \oplus B}$	A plus B
H	L	H	L	B	$(A+\overline{B})$ plus AB
H	L	H	H	AB	AB minus 1
H	H	L	L	logical 1	A plus A(1)
H	H	L	H	$A+\overline{B}$	$(A+B)$ plus A
H	H	H	L	A + B	$(A+\overline{B})$ plus A
H	H	H	H	A	A minus 1

Table 1:Functional table for active low inputs and outputs

MODE SELECT INPUTS				ACTIVE HIGH INPUTS AND OUTPUTS	
S_3	S_2	S_1	S_0	LOGIC (M=H)	ARITHMETIC(2) (M=L; C_n=H)
L	L	L	L	$\overline{A}$	A
L	L	L	H	$\overline{A+B}$	A + B
L	L	H	L	$\overline{A}B$	$A+\overline{B}$
L	L	H	H	logical 0	minus 1
L	H	L	L	$\overline{AB}$	A plus $A\overline{B}$
L	H	L	H	$\overline{B}$	$(A+B)$ plus $A\overline{B}$
L	H	H	L	$A \oplus B$	A minus B minus 1
L	H	H	H	$A\overline{B}$	$A\overline{B}$ minus 1
H	L	L	L	$\overline{A}+B$	A plus AB
H	L	L	H	$\overline{A \oplus B}$	A plus B
H	L	H	L	B	$(A+\overline{B})$ plus AB
H	L	H	H	AB	AB minus 1
H	H	L	L	logical 1	A plus A(1)
H	H	L	H	$A+\overline{B}$	$(A+B)$ plus A
H	H	H	L	A + B	$(A+\overline{B})$ plus A
H	H	H	H	A	A minus 1

Table 2:Function table for active high inputs and outputs

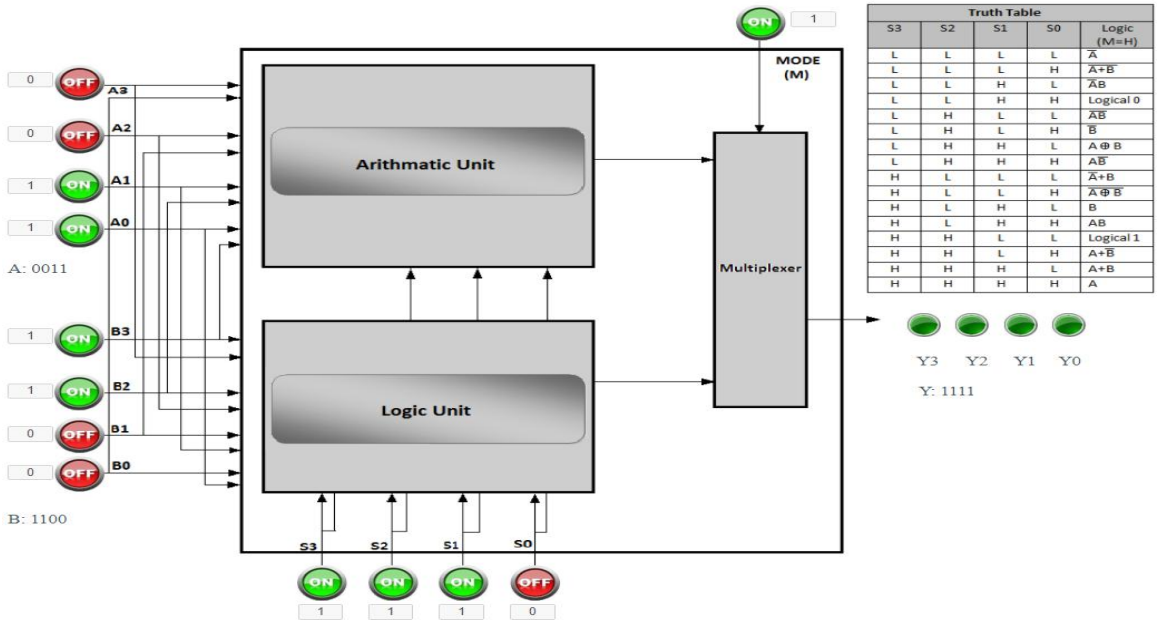


Problem statement: Show the logical operations:

a) A+B b) AB c) A XOR B d) A XNOR B e) $\overline{A}B$

Results obtained from Simulation: (Calculations must be shown side by side for verification)

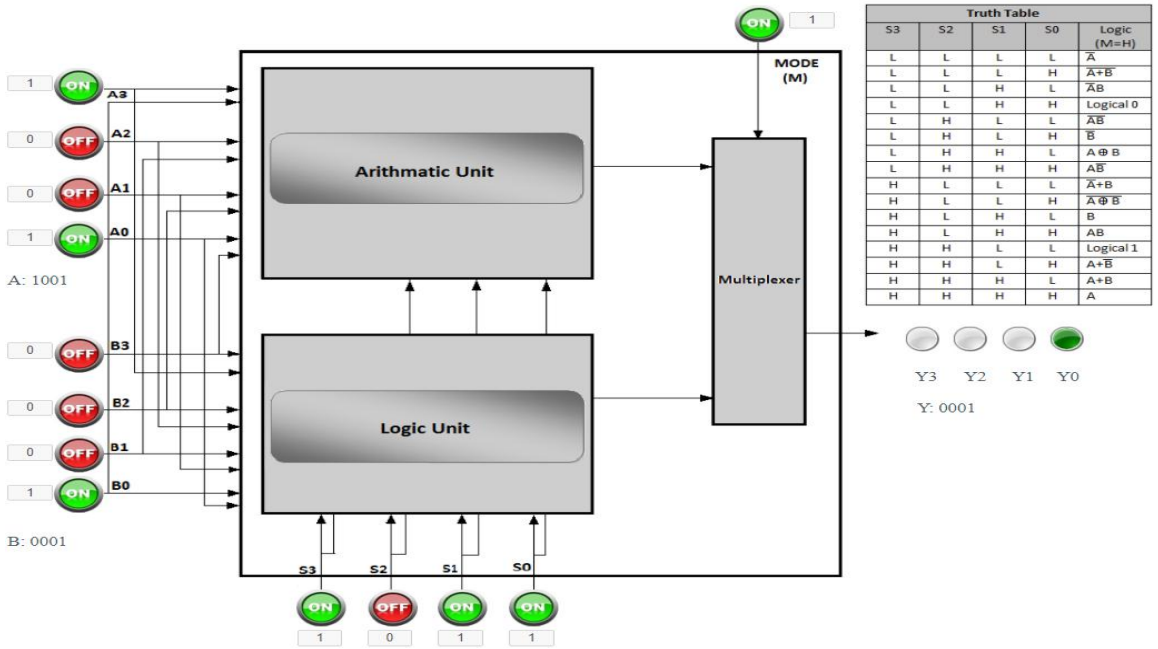
a) A+B



Truth Table				
S3	S2	S1	S0	Logic (M=H)
L	L	L	L	$\overline{A}$
L	L	L	H	$\overline{A+B}$
L	L	H	L	$\overline{AB}$
L	L	H	H	Logical 0
L	H	L	L	$\overline{AB}$
L	H	L	H	$\overline{B}$
L	H	H	L	$A \oplus B$
L	H	H	H	$A\overline{B}$
H	L	L	L	$\overline{A}+B$
H	L	L	H	$\overline{A \oplus B}$
H	L	H	L	B
H	L	H	H	AB
H	H	L	L	Logical 1
H	H	L	H	$A+\overline{B}$
H	H	H	L	A+B
H	H	H	H	A

Calculation: A = 0011; B = 1100
A + B = (0011 + 1100) = 1111

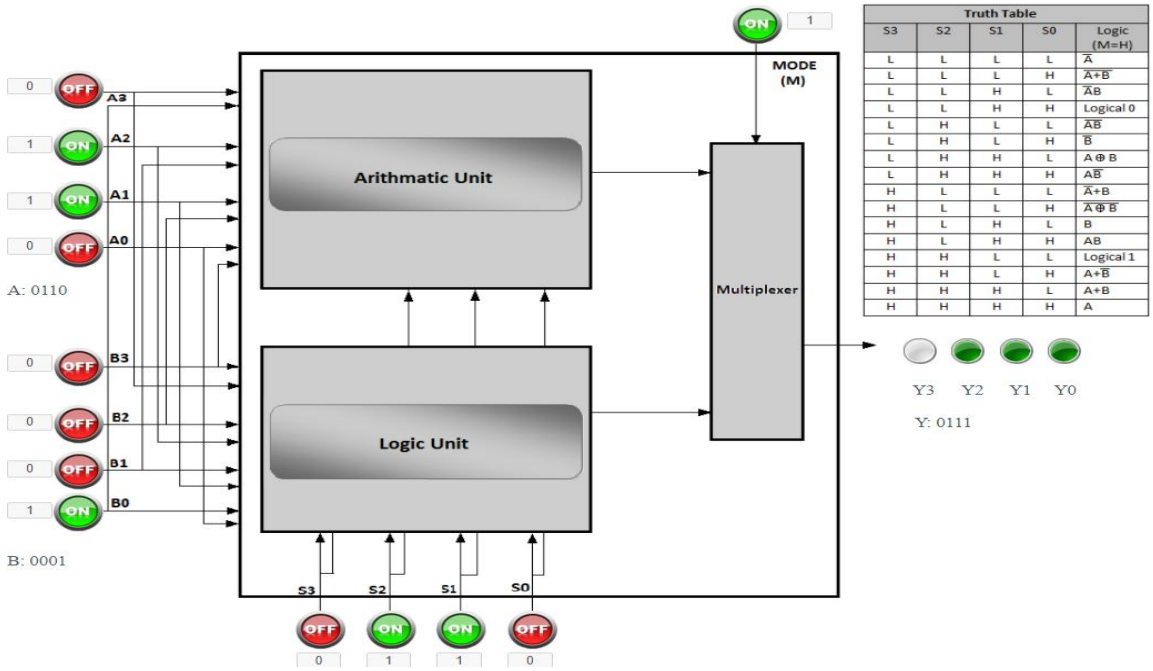
b) AB



Truth Table				
S3	S2	S1	S0	Logic (M=H)
L	L	L	L	$\overline{A}$
L	L	L	H	$\overline{A+B}$
L	L	H	L	$\overline{AB}$
L	L	H	H	Logical 0
L	H	L	L	$\overline{AB}$
L	H	L	H	$\overline{B}$
L	H	H	L	$A \oplus B$
L	H	H	H	$A\overline{B}$
H	L	L	L	$\overline{A}+B$
H	L	L	H	$\overline{A \oplus B}$
H	L	H	L	B
H	L	H	H	AB
H	H	L	L	Logical 1
H	H	L	H	$A+\overline{B}$
H	H	H	L	A+B
H	H	H	H	A

Calculation: A = 1001; B = 0001
AB = (1001 * 0001) = 0001

c) A XOR B

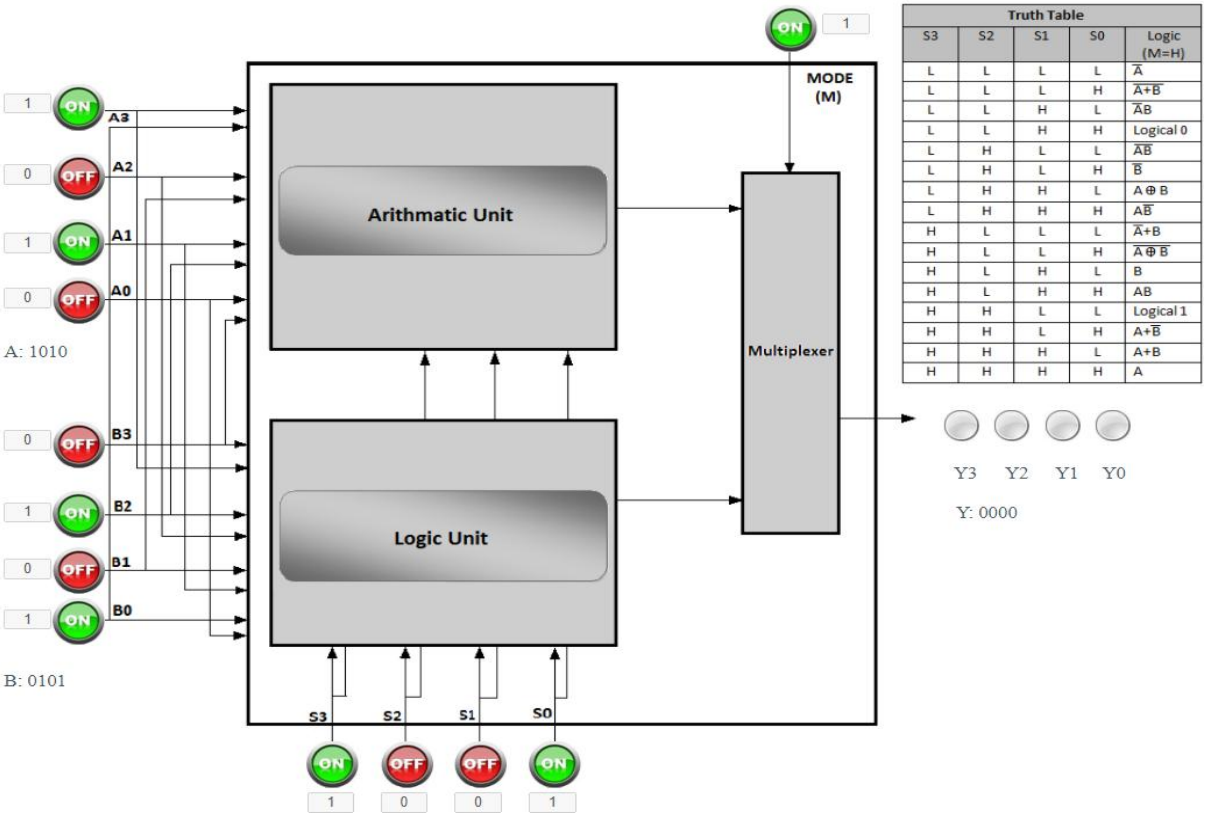


Truth Table				
S3	S2	S1	S0	Logic (M=H)
L	L	L	L	$\overline{A}$
L	L	L	H	$\overline{A+B}$
L	L	H	L	$\overline{A}B$
L	L	H	H	Logical 0
L	H	L	L	$\overline{AB}$
L	H	L	H	$\overline{B}$
L	H	H	L	$A \oplus B$
L	H	H	H	$A\overline{B}$
H	L	L	L	$\overline{A}+B$
H	L	L	H	$\overline{A \oplus B}$
H	L	H	L	B
H	L	H	H	AB
H	H	L	L	Logical 1
H	H	L	H	$A+\overline{B}$
H	H	H	L	A+B
H	H	H	H	A

Calculation: A = 1001; B = 0001

$A \oplus B = (1001 \oplus 0001) = 0111$

d) A XNOR B

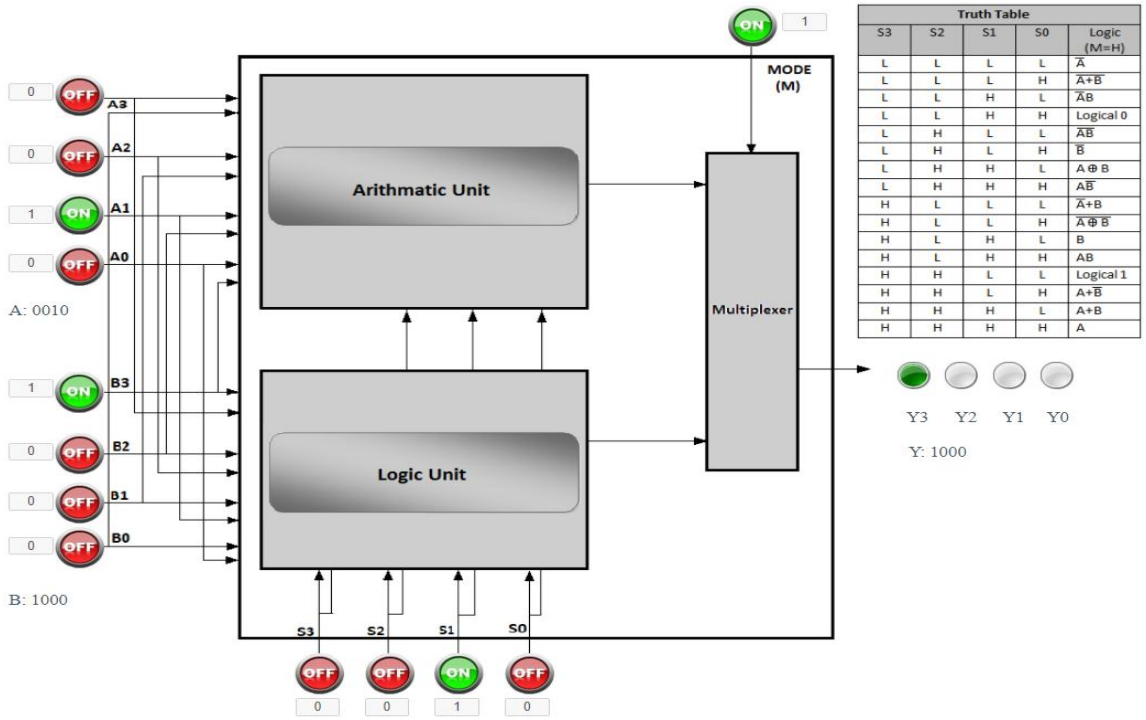


Truth Table				
S3	S2	S1	S0	Logic (M=H)
L	L	L	L	$\overline{A}$
L	L	L	H	$\overline{A+B}$
L	L	H	L	$\overline{A}B$
L	L	H	H	Logical 0
L	H	L	L	$\overline{AB}$
L	H	L	H	$\overline{B}$
L	H	H	L	$A \oplus B$
L	H	H	H	$A\overline{B}$
H	L	L	L	$\overline{A}+B$
H	L	L	H	$\overline{A \oplus B}$
H	L	H	L	B
H	L	H	H	AB
H	H	L	L	Logical 1
H	H	L	H	$A+\overline{B}$
H	H	H	L	A+B
H	H	H	H	A

Calculation: A = 1010; B = 0101

$$\overline{A \oplus B} = \overline{(1010 \oplus 0101)} = 0000$$

e) $\overline{A}B$

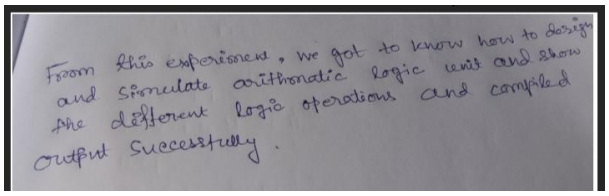


Truth Table				
S3	S2	S1	S0	Logic (M=H)
L	L	L	L	$\overline{A}$
L	L	L	H	$\overline{A+B}$
L	L	H	L	$\overline{A}B$
L	L	H	H	Logical 0
L	H	L	L	$\overline{AB}$
L	H	L	H	$\overline{B}$
L	H	H	L	$A \oplus B$
L	H	H	H	$A\overline{B}$
H	L	L	L	$\overline{A}+B$
H	L	L	H	$\overline{A \oplus B}$
H	L	H	L	B
H	L	H	H	AB
H	H	L	L	Logical 1
H	H	L	H	$A+\overline{B}$
H	H	H	L	A+B
H	H	H	H	A

Calculation: $\underline{A} = 0010; \underline{B} = 1000$

$\overline{A}B = (\overline{0010} * 1000) = 1000$

Discussions:



EXPERIMENT NO. 09

Title: Design and Simulation of Arithmetic Logic Unit and show the different arithmetic operations.

Objective: Design and Simulation of Arithmetic Logic Unit and show the different arithmetic operations using VLAB.

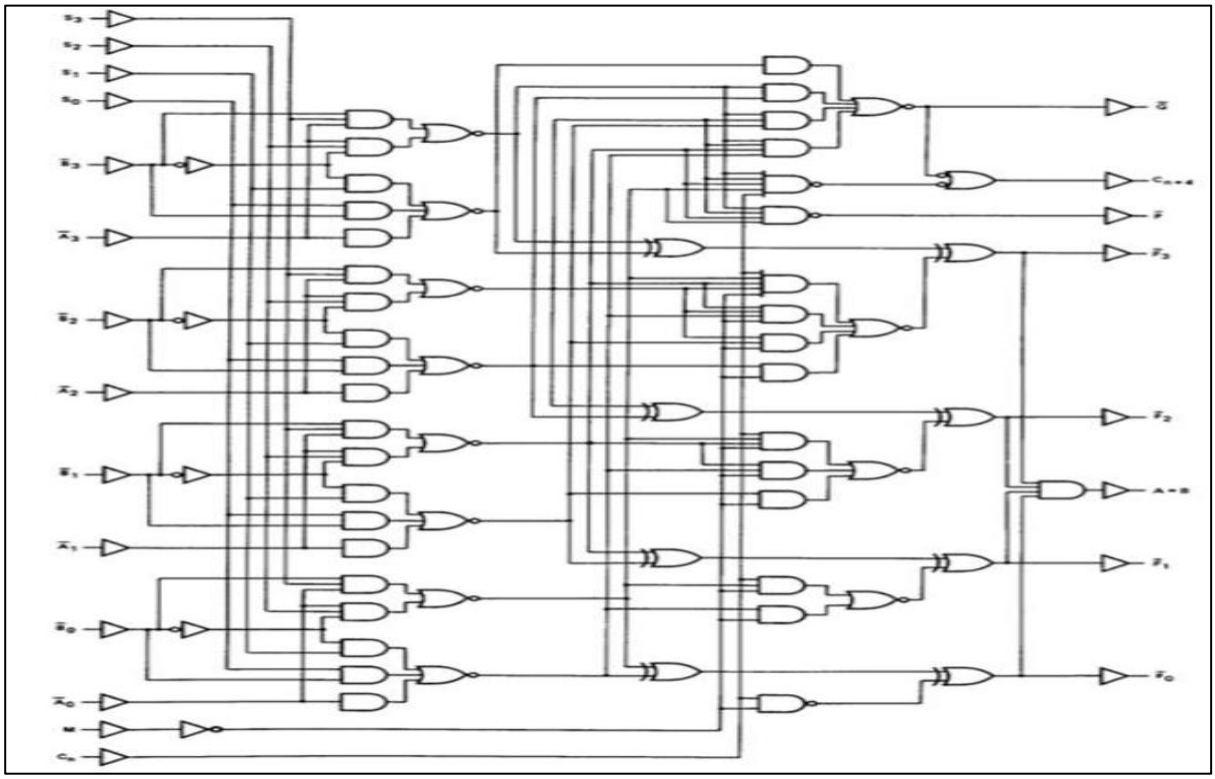
Circuit Diagram and Truth Table:

MODE SELECT INPUTS				ACTIVE HIGH INPUTS AND OUTPUTS	
S_3	S_2	S_1	S_0	LOGIC (M=H)	ARITHMETIC(2) (M=L; C_n=H)
L	L	L	L	$\overline{A}$	A
L	L	L	H	$\overline{A+B}$	A + B
L	L	H	L	$\overline{A}B$	A + $\overline{B}$
L	L	H	H	logical 0	minus 1
L	H	L	L	$\overline{AB}$	A plus A$\overline{B}$
L	H	L	H	$\overline{B}$	(A + B) plus A$\overline{B}$
L	H	H	L	A ⊕ B	A minus B minus 1
L	H	H	H	A$\overline{B}$	A$\overline{B}$ minus 1
H	L	L	L	$\overline{A}$ + B	A plus AB
H	L	L	H	$\overline{A \oplus B}$	A plus B
H	L	H	L	B	(A + $\overline{B}$) plus AB
H	L	H	H	AB	AB minus 1
H	H	L	L	logical 1	A plus A(1)
H	H	L	H	A + $\overline{B}$	(A + B) plus A
H	H	H	L	A + B	(A + $\overline{B}$) plus A
H	H	H	H	A	A minus 1

Table 1:Functional table for active low inputs and outputs

MODE SELECT INPUTS				ACTIVE HIGH INPUTS AND OUTPUTS	
S_3	S_2	S_1	S_0	LOGIC (M=H)	ARITHMETIC(2) (M=L; C_n=H)
L	L	L	L	$\overline{A}$	A
L	L	L	H	$\overline{A+B}$	A + B
L	L	H	L	$\overline{A}B$	A + $\overline{B}$
L	L	H	H	logical 0	minus 1
L	H	L	L	$\overline{AB}$	A plus A$\overline{B}$
L	H	L	H	$\overline{B}$	(A + B) plus A$\overline{B}$
L	H	H	L	A ⊕ B	A minus B minus 1
L	H	H	H	A$\overline{B}$	A$\overline{B}$ minus 1
H	L	L	L	$\overline{A}$ + B	A plus AB
H	L	L	H	$\overline{A \oplus B}$	A plus B
H	L	H	L	B	(A + $\overline{B}$) plus AB
H	L	H	H	AB	AB minus 1
H	H	L	L	logical 1	A plus A(1)
H	H	L	H	A + $\overline{B}$	(A + B) plus A
H	H	H	L	A + B	(A + $\overline{B}$) plus A
H	H	H	H	A	A minus 1

Table 2:Function table for active high inputs and outputs



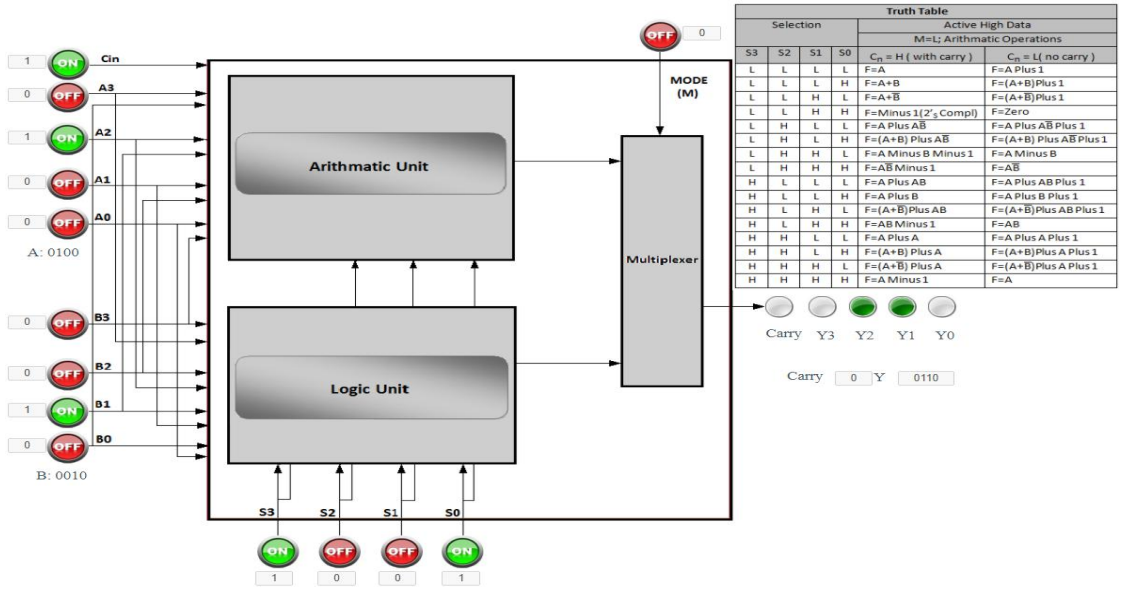
Problem statement: Show the arithmetic operations:

a) A plus B b) A plus AB c) A plus B plus 1 d) (A+B) plus 1 e) A plus A

Results obtained from Simulation: (Calculations must be shown side by side for verification)

a) A plus B

i. With carry:



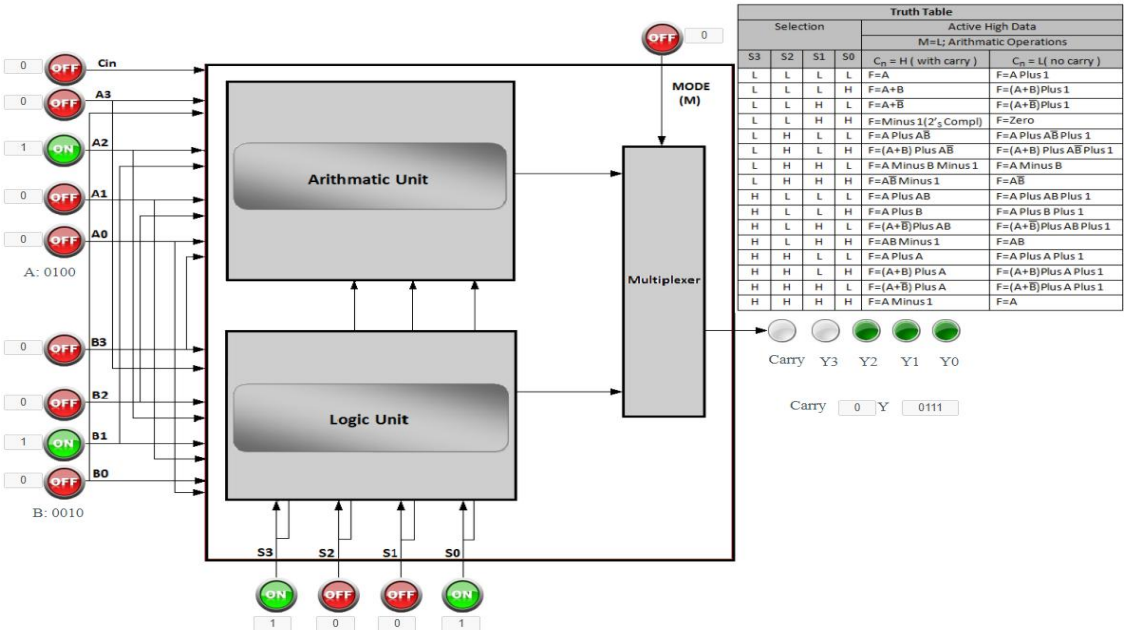
Truth Table

Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B) Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$) Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$) Plus AB	F=(A+$\overline{B}$) Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B) Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$) Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 0100; B = 0010; C_{in} = 1

A plus B = (0100 plus 0010) = 0110; Carry = 0

ii. Without carry:



Truth Table

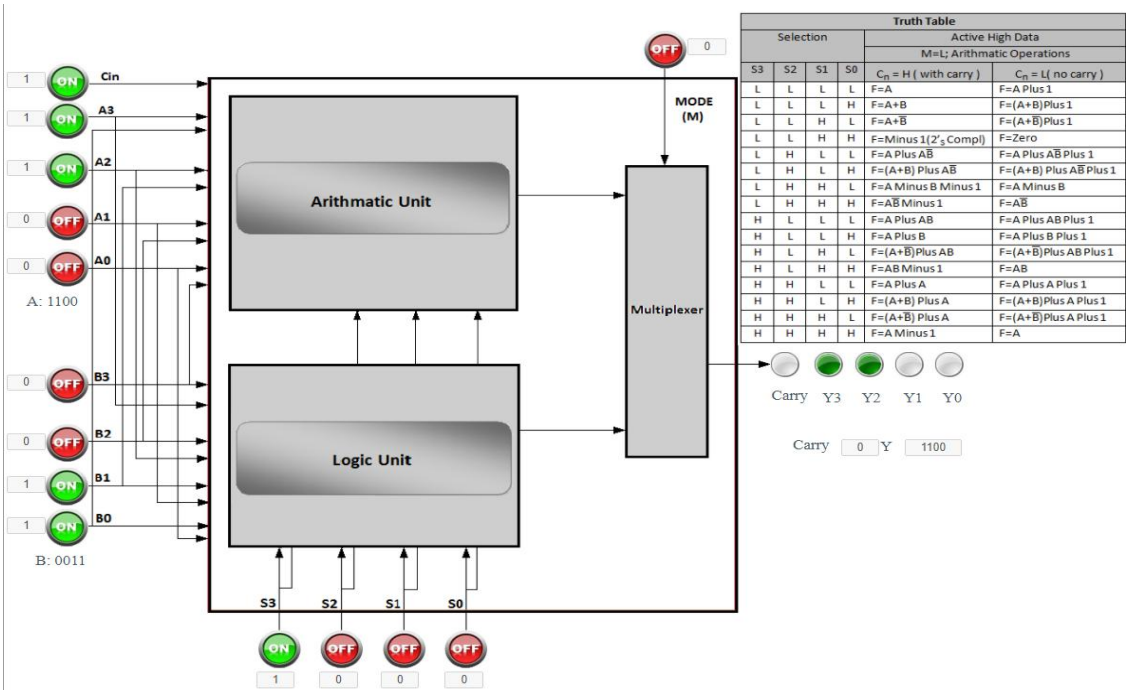
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B) Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$) Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$) Plus AB	F=(A+$\overline{B}$) Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B) Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$) Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 0100; B = 0010; C_{in} = 0

A plus B plus 1 = (0100 plus 0010 plus 1) = 0111; Carry = 0

b) A plus AB

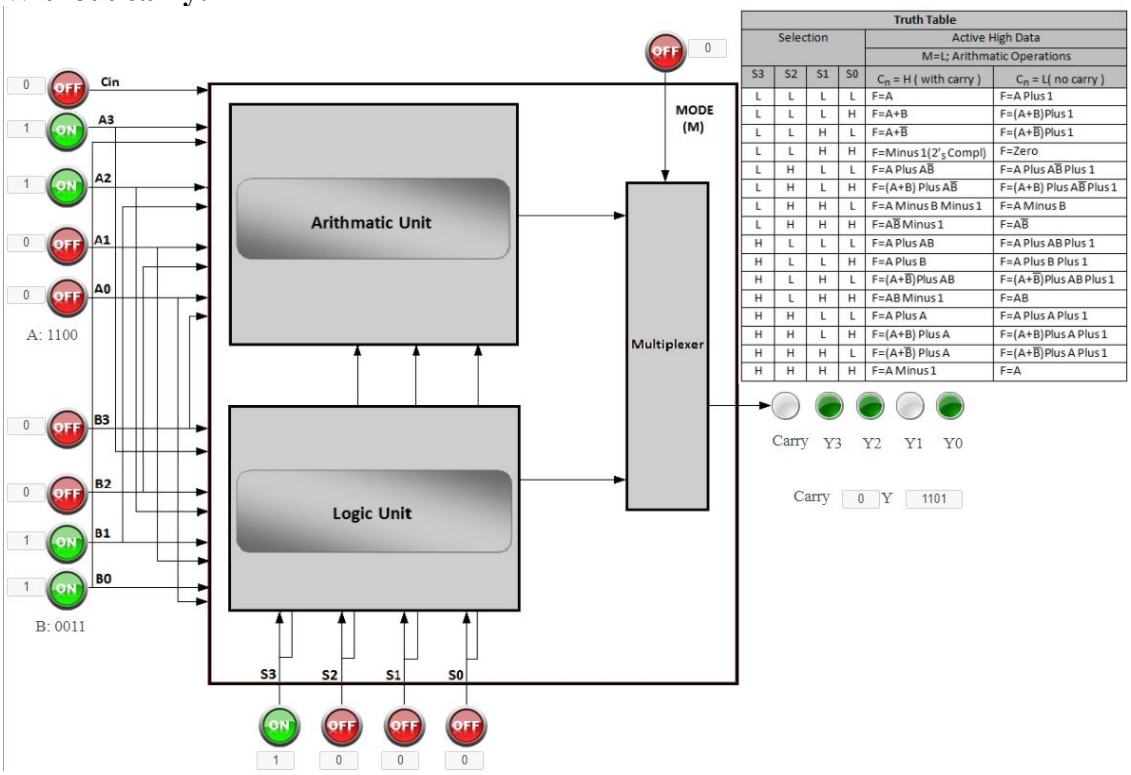
i. With carry:



Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1100; B = 0011; C_{in} = 1
A plus AB = (1100 plus 0000) = 1100; Carry = 0

ii. Without carry:

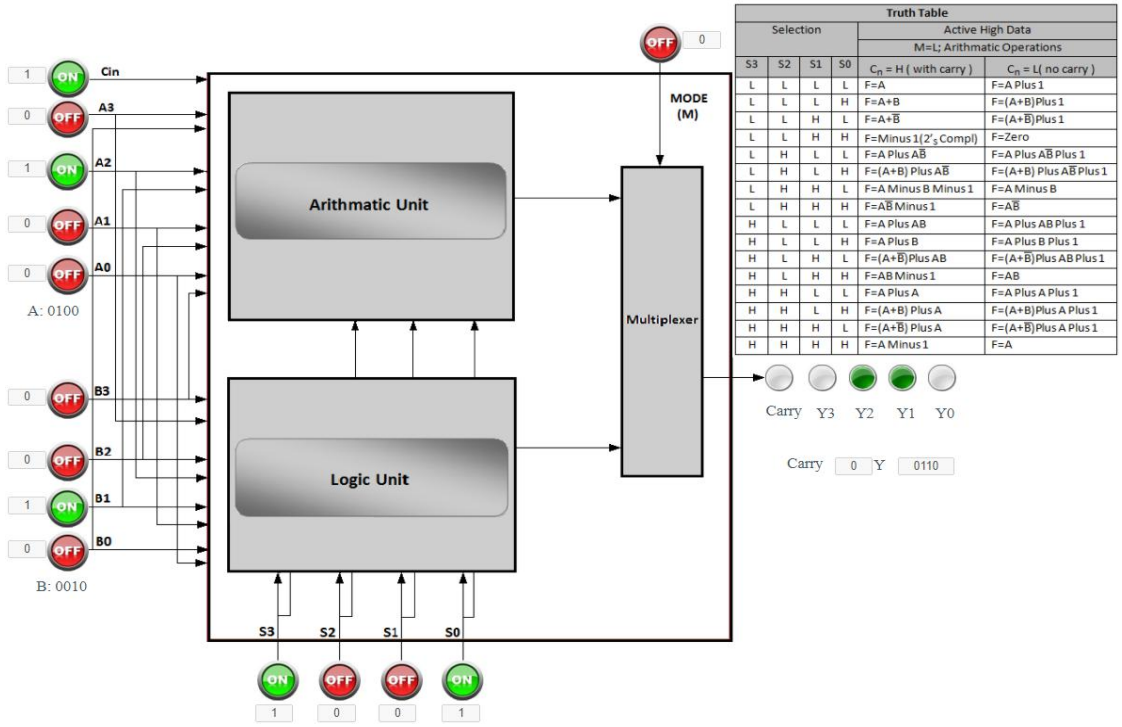


Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1100; B = 0011; C_{in} = 0
A plus AB plus 1 = (1100 plus 0000 plus 1) = 1101; Carry = 0

c) A plus B plus 1

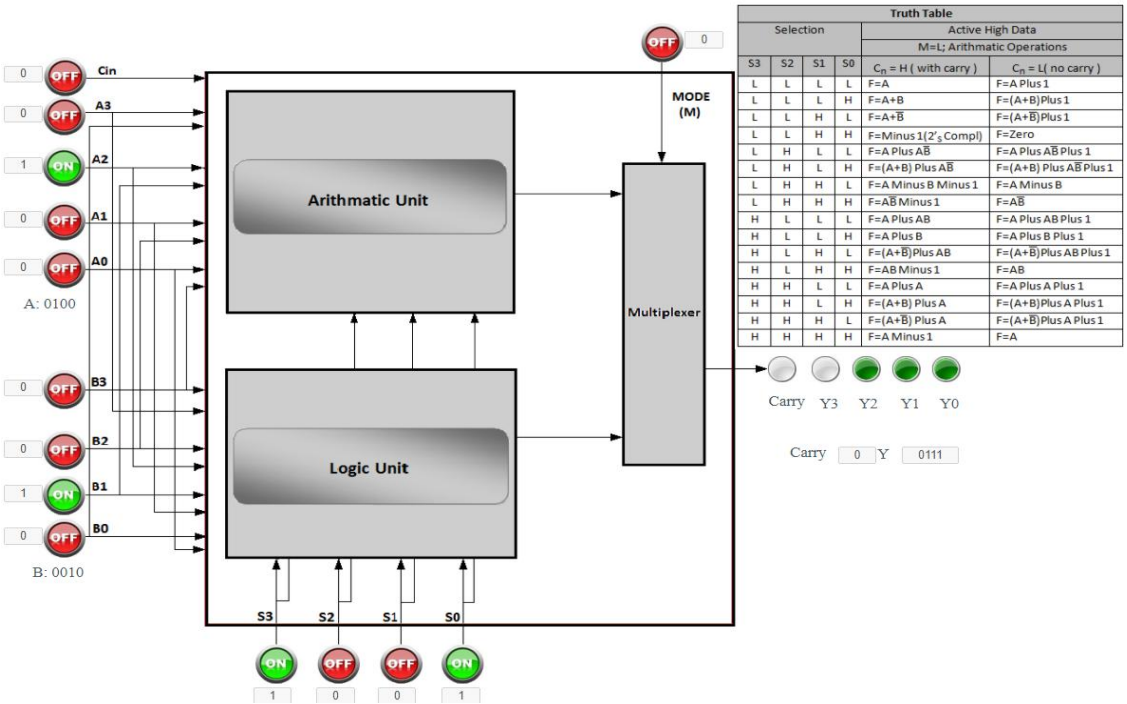
i. With carry:



Truth Table					
Selection				Active High Data	
				M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 0100; B = 0010; C_{in} = 1
A plus B = (0100 plus 0010) = 0110; Carry = 0

ii. Without carry:

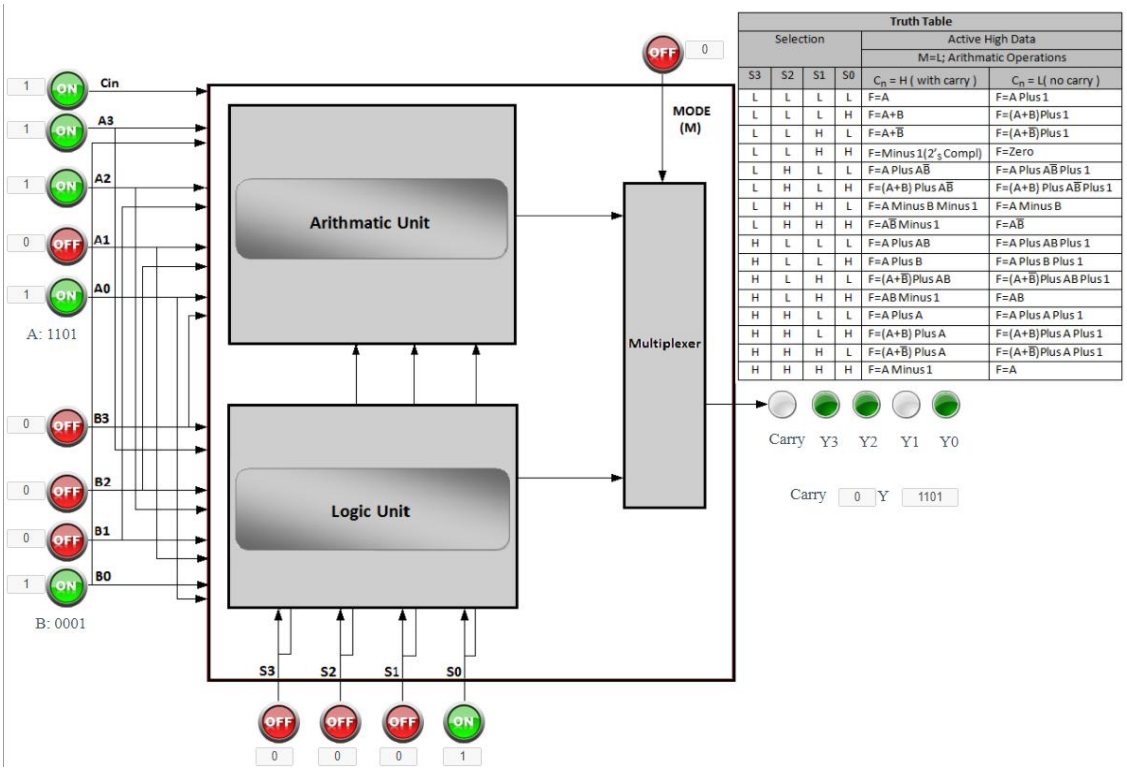


Truth Table					
Selection				Active High Data	
				M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 0100; B = 0010; C_{in} = 0
A plus B plus 1 = (0100 plus 0010 plus 1) = 0111; Carry = 0

d) (A + B) plus 1

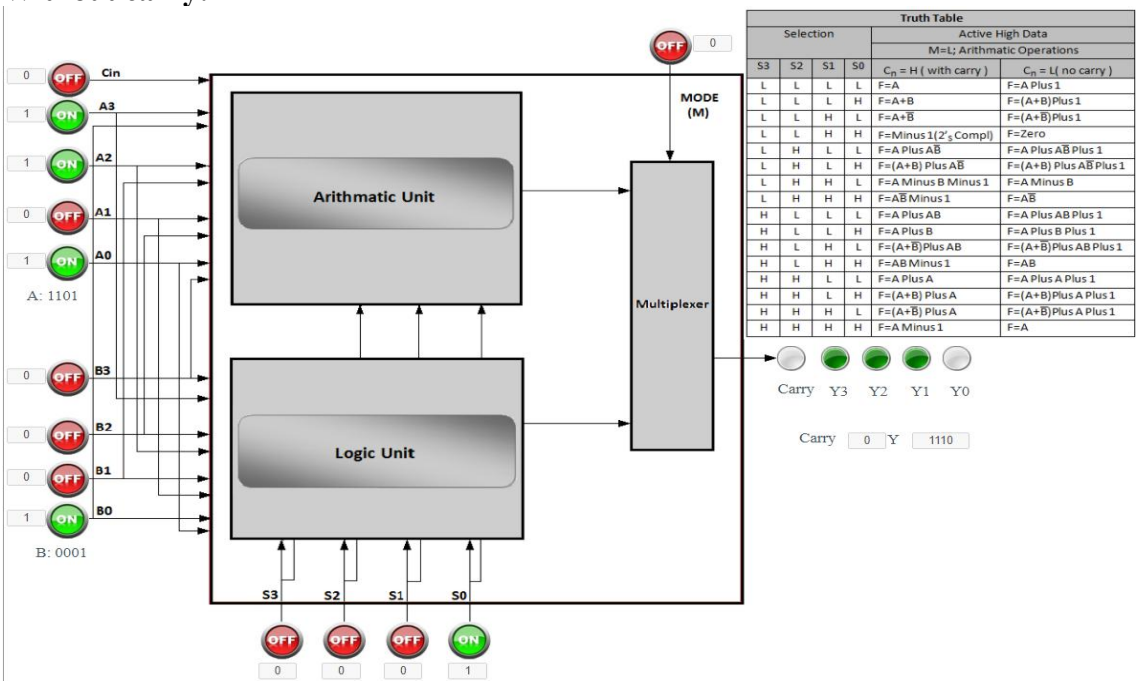
i. With carry:



Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1101; B = 0001; C_{in} = 1
A + B = (1101 + 0001) = 1101; Carry = 0

ii. Without carry:

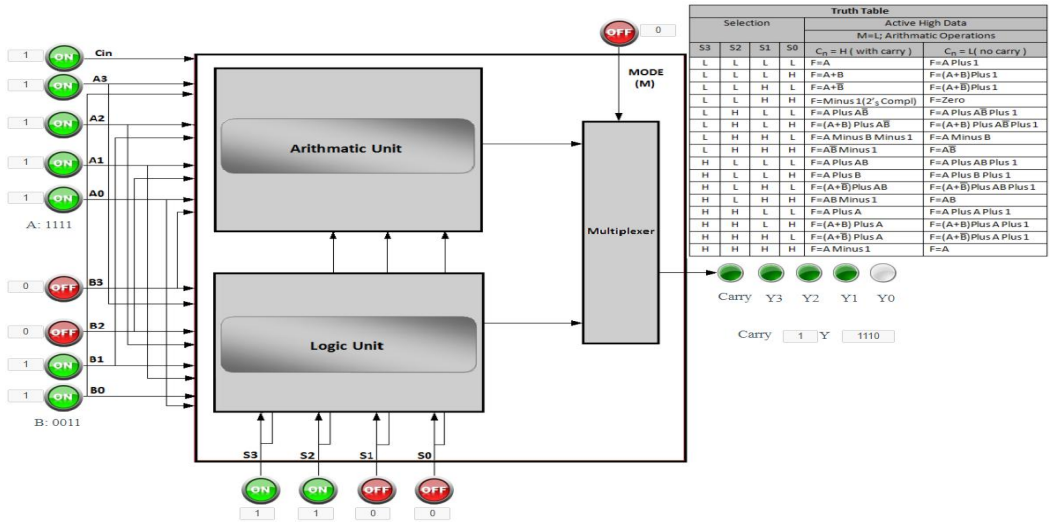


Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\overline{B}$	F=(A+$\overline{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\overline{B}$	F=A Plus A$\overline{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\overline{B}$	F=(A+B) Plus A$\overline{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\overline{B}$ Minus 1	F=A$\overline{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\overline{B}$)Plus AB	F=(A+$\overline{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\overline{B}$) Plus A	F=(A+$\overline{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1101; B = 0001; C_{in} = 0
(A + B) plus 1 = (1101 + 0001) plus 1 = 1110; Carry = 0

e) A plus A

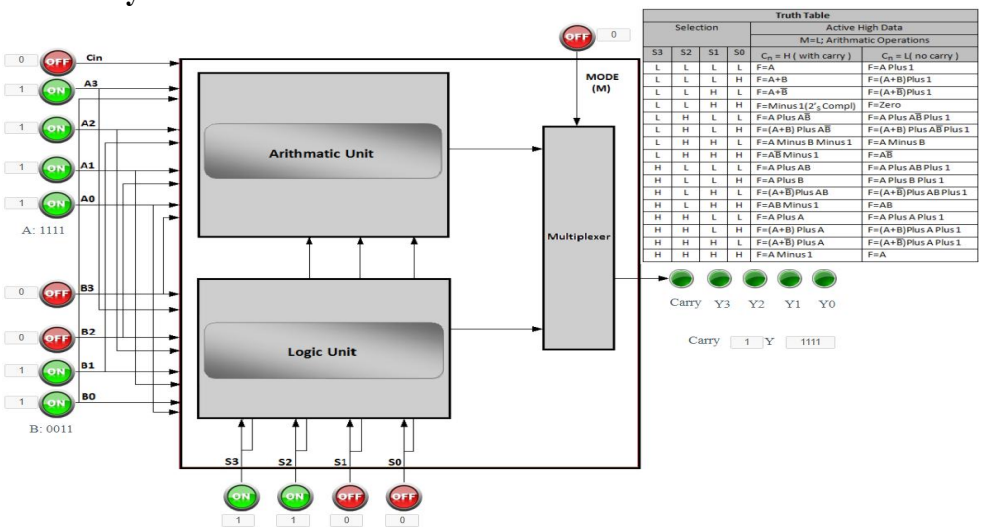
i. With carry:



Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\bar{B}$	F=(A+$\bar{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\bar{B}$	F=A Plus A$\bar{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\bar{B}$	F=(A+B) Plus A$\bar{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\bar{B}$ Minus 1	F=A$\bar{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\bar{B}$)Plus AB	F=(A+$\bar{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\bar{B}$) Plus A	F=(A+$\bar{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1111; B = 0011; C_{in} = 1
A plus A = (1111 plus 0011) = 1110; Carry = 1

ii. Without carry:



Truth Table					
Selection				Active High Data M=L; Arithmatic Operations	
S3	S2	S1	S0	C_n = H (with carry)	C_n = L(no carry)
L	L	L	L	F=A	F=A Plus 1
L	L	L	H	F=A+B	F=(A+B)Plus 1
L	L	H	L	F=A+$\bar{B}$	F=(A+$\bar{B}$)Plus 1
L	L	H	H	F=Minus 1(2's Compl)	F=Zero
L	H	L	L	F=A Plus A$\bar{B}$	F=A Plus A$\bar{B}$ Plus 1
L	H	L	H	F=(A+B) Plus A$\bar{B}$	F=(A+B) Plus A$\bar{B}$ Plus 1
L	H	H	L	F=A Minus B Minus 1	F=A Minus B
L	H	H	H	F=A$\bar{B}$ Minus 1	F=A$\bar{B}$
H	L	L	L	F=A Plus AB	F=A Plus AB Plus 1
H	L	L	H	F=A Plus B	F=A Plus B Plus 1
H	L	H	L	F=(A+$\bar{B}$)Plus AB	F=(A+$\bar{B}$)Plus AB Plus 1
H	L	H	H	F=AB Minus 1	F=AB
H	H	L	L	F=A Plus A	F=A Plus A Plus 1
H	H	L	H	F=(A+B) Plus A	F=(A+B)Plus A Plus 1
H	H	H	L	F=(A+$\bar{B}$) Plus A	F=(A+$\bar{B}$)Plus A Plus 1
H	H	H	H	F=A Minus 1	F=A

Calculation: A = 1111; B = 0011; C_{in} = 1
A plus A plus 1 = (1111 plus 0011) plus 1= 1111; Carry = 1

Discussions: