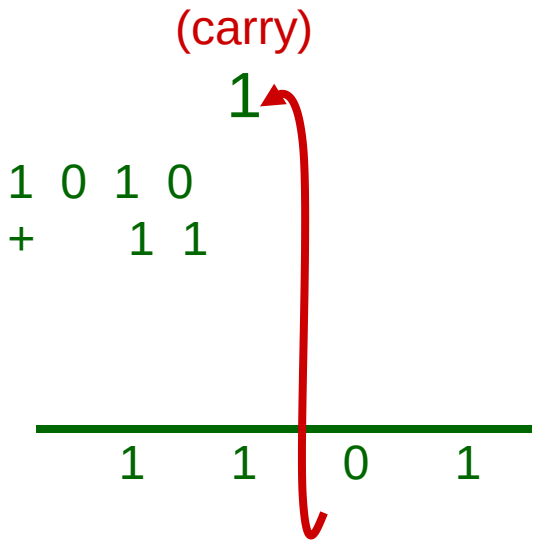
Overview of Adders and Subtractors

OVERVIEW

- Binary Addition
- Half & Full Adders
- Binary Subtraction
- Half & Full Subtractors
- Parallel Adders and Subtractors
- Using Adders for Subtraction
- Binary Multiplication
- Binary Multipliers
- Half & Full Adders
- 2s Complement

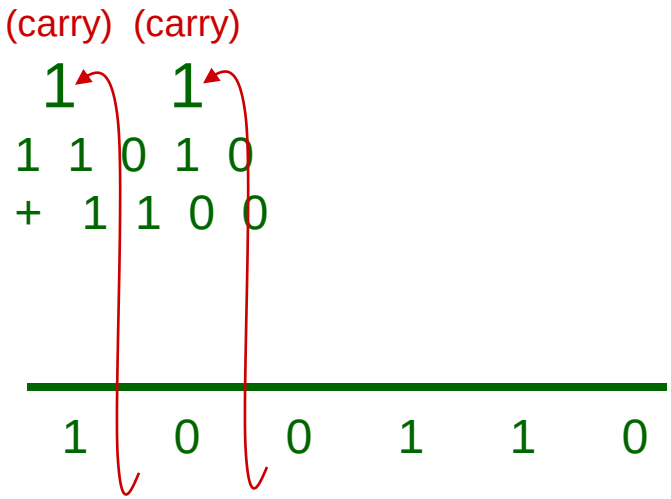
BINARY ADDITION

- Conceptually similar to decimal addition
- *Example:* Add the binary numbers 1010 and 11



TEST

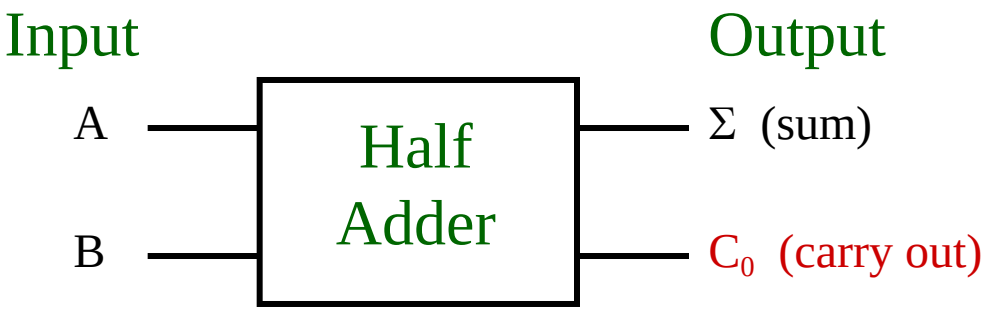
Add the Binary numbers 11010 and 1100



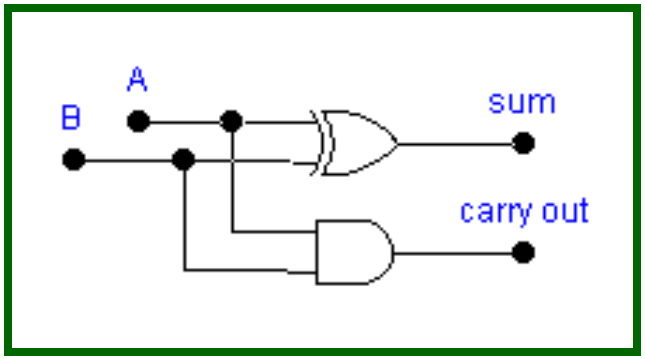
HALF ADDER

- Logic device that adds two binary numbers
- Only adds Least Significant Digit (LSD) column (1s column) in binary addition

Logic Symbol:



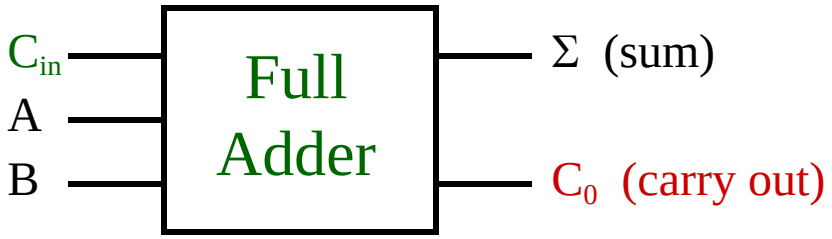
Logic Diagram:



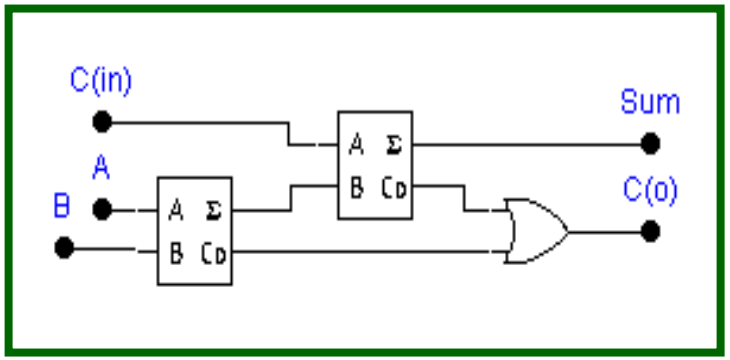
FULL ADDER

Used for adding binary place values other than the 1s place

Logic Symbol:

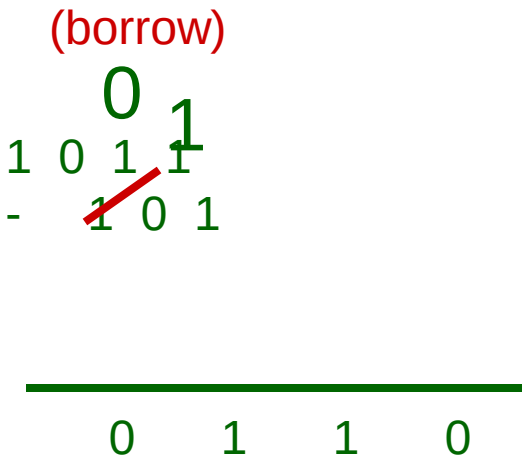


Logic Diagram:



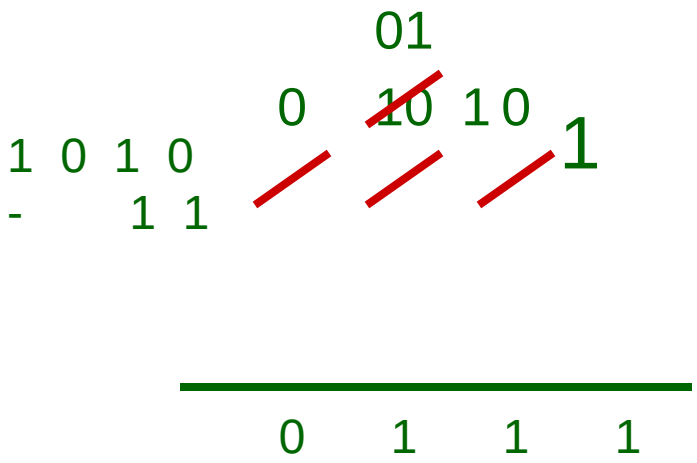
BINARY SUBTRACTION

Example: Subtract binary number 101 from 1011



TEST

Subtract binary number 11 from 1010

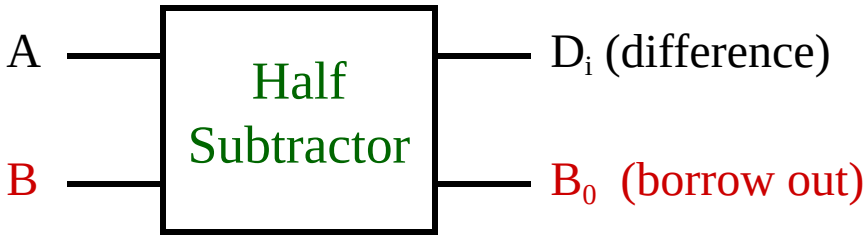


HALF SUBTRACTOR

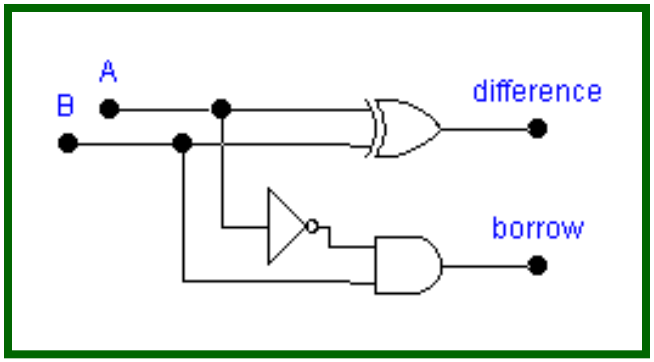
Subtracts LSD column in binary subtraction

Input Output

Logic Symbol:



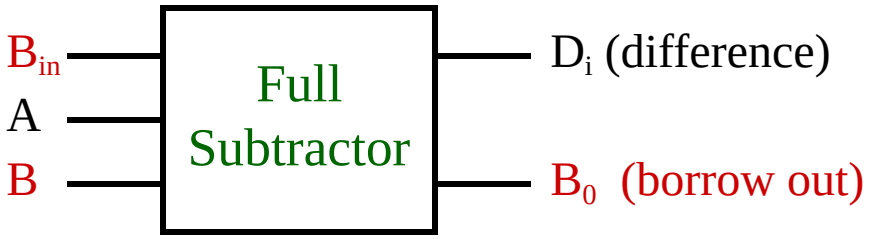
Logic Diagram:



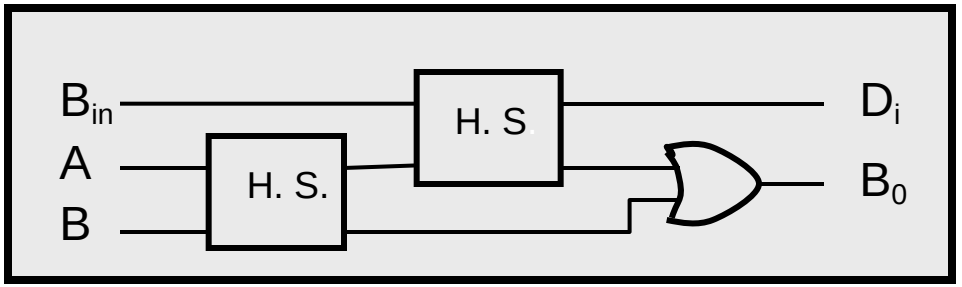
FULL SUBTRACTOR

Used for subtracting binary place values other than the 1s place

Logic Symbol:



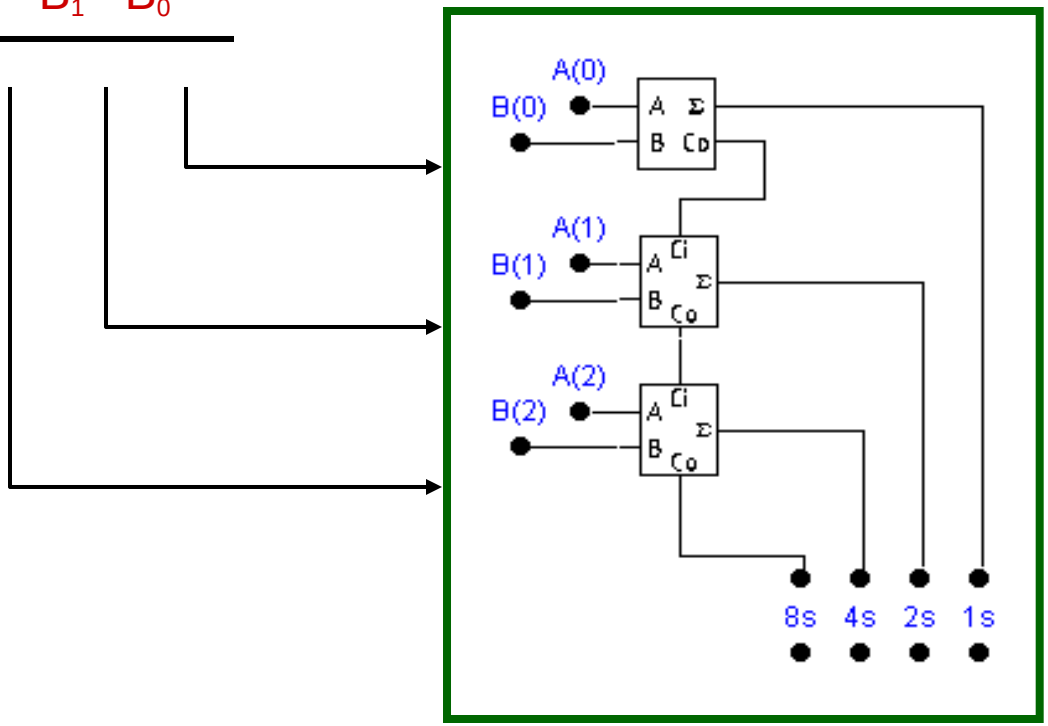
Logic Diagram:



PARALLEL ADDING

- Use half adder for LSD
- Use full adder for other digits

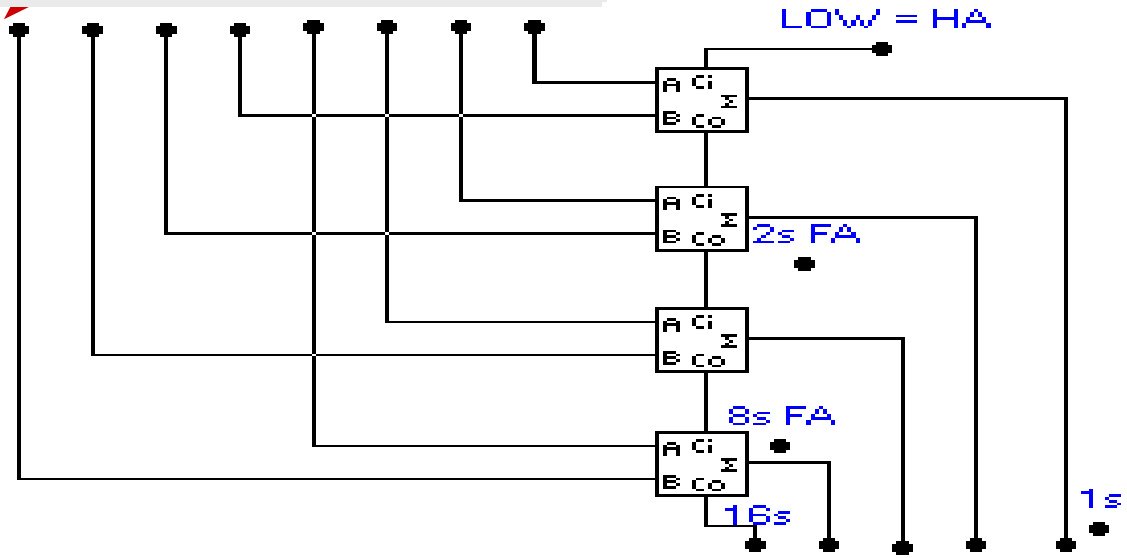
A_2 A_1 A_0
+ B_2 B_1 B_0



PARALLEL ADDER

Enter binary numbers to be added

1 1 1 0 + 0 1 1 0



1 0 1 0 0

Parallel adders are available in IC form.

1s place uses half-adder

2s, 4s, 8s places use full adders

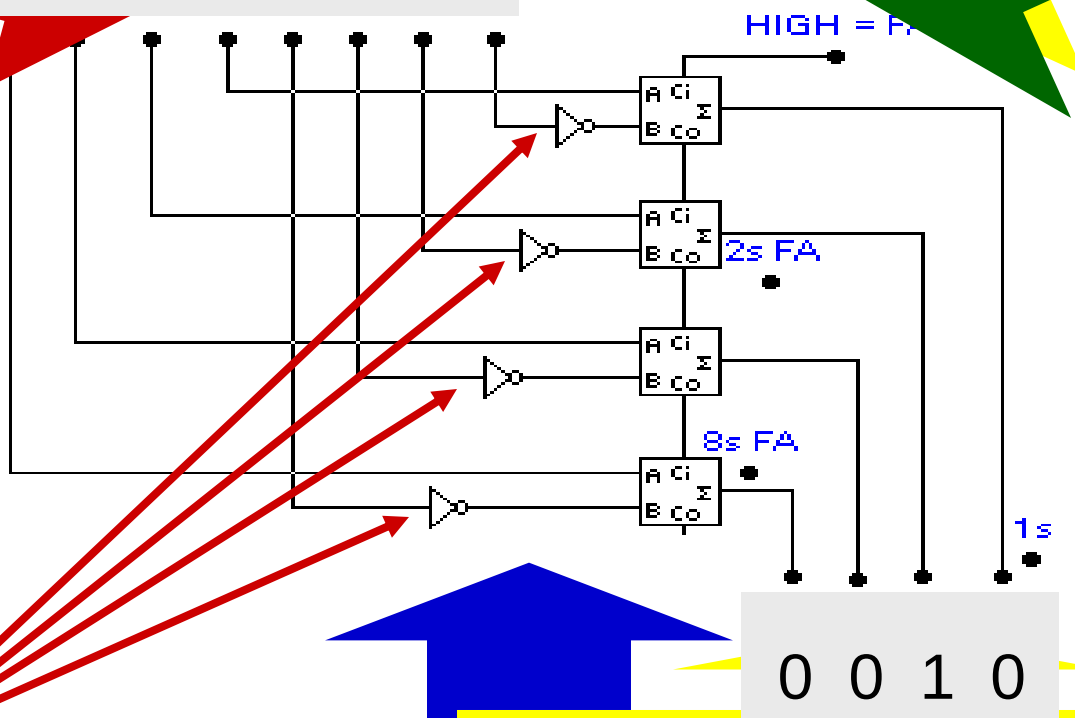
PARALLEL SUBTRACTOR USING FULL ADDERS

Binary numbers to be subtracted are input here

1 0 0 1 - 0 1 1 1

HIGH at Carry in input acts like adding +1 to a 1s C number to form the 2s complement.

1sC is formed by four inverters.



Inverters

0 0 1 0

The result (difference) of the subtraction problem will appear here.

Note the use of

Also notice the addition of four inverters on the B inputs to the FAs

BINARY MULTIPLICATION

Example: Multiply the binary numbers 111 and 101.

		1	1	1		Multiplicand
x		1	0	1		Multiplier
		1	1	1		1st partial product
	0	0	0			2nd partial product
1	1	1				3rd partial product
1	0	0	0	1	1	Product

TEST

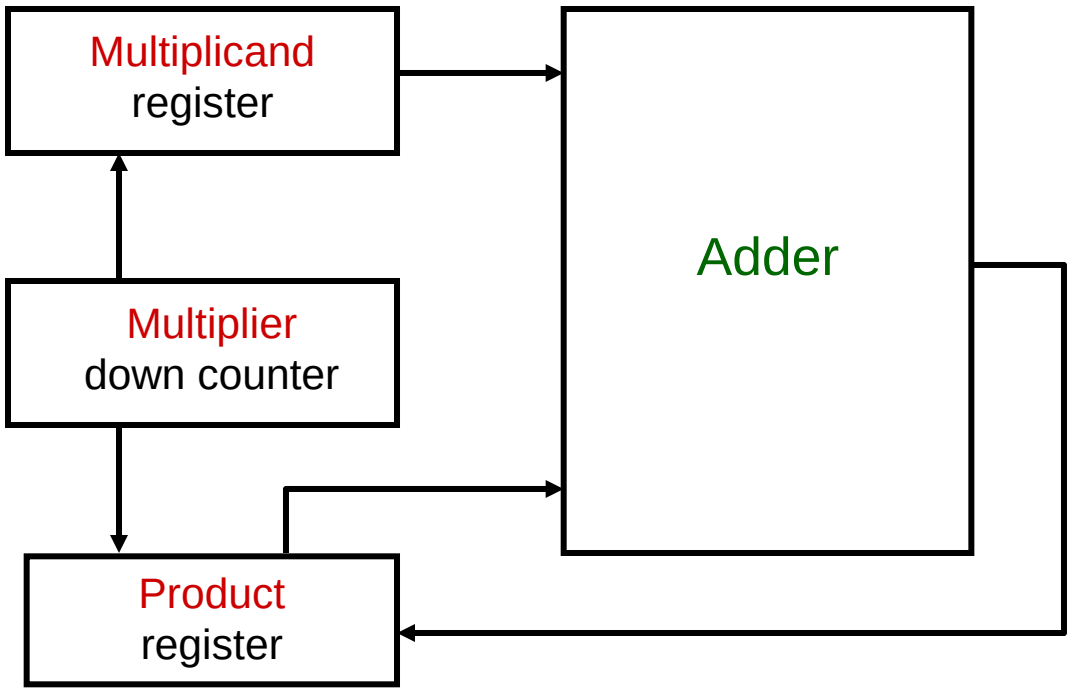
Multiply the binary numbers 101 and 100.

```
  1 0 1
x 1 0 0
-------
    0 0 0
  0 0 0
1 0 1
-------
1 0 1 0 0
```

BINARY MULTIPLIERS

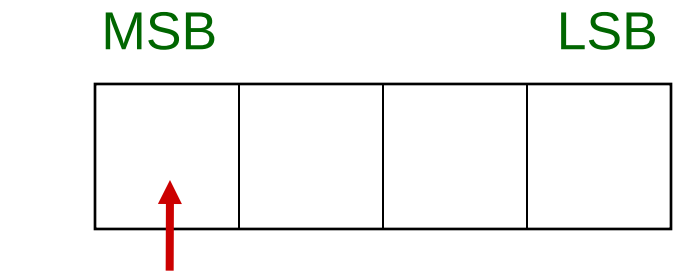
Binary multiplier circuits - utilize repeated addition

Block Diagram:



2s COMPLEMENT NOTATION

- 2s complement representation - widely used in microprocessors.
- Represents *sign* and *magnitude*



Decimal:	+7	+4	+1	0	-1	-4	-7
2s Complement:	0111	0100	0001	0000	1111	1100	1001

2s COMPLEMENT - CONVERSIONS

- Converting positive numbers to 2s complement:
  - Same as converting to binary
- Converting negative numbers to 2s complement:

Decimal to 2s Complement

- 4 (decimal)

↓ Convert decimal to binary

0 1 0 0

↓ 1s complement

1 0 1 1

↓ Add 1

- 4 = 1 1 0 0 (2s Complement)

2s Complement to Binary

1 1 0 0 (2s C)

↓ 1s complement

0 0 1 1

↓ Add 1

0 1 0 0 (Binary)

ADDING/SUBTRACTING IN 2s COMPLEMENT

2s complement notation makes it possible to add and subtract signed numbers

(Decimal)	2s Complement
(- 1)	1 1 1 1
+ (- 2)	+ 1 1 1 0
(- 3)	1 1 1 0 1

2s complement

Discard

(+1)	0 0 0 1
+ (- 3)	+ 1 1 0 1
(- 2)	1 1 1 0

TEST

Add the following 2s complement numbers:

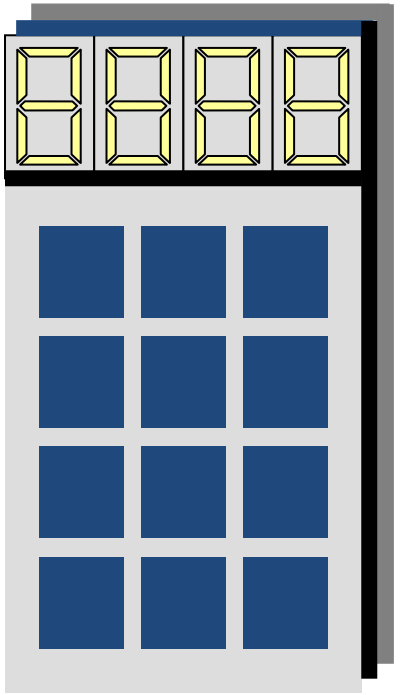
(+5) 0 1 0 1
+ (- 4) + 1 1 0 0

(+1) 1 0 0 0 1

Discard

PRACTICAL SUGGESTION FOR BINARY MATH

- Use a scientific calculator.
  - Most scientific calculators have DEC, BIN, OCT, and HEX modes and can either convert between codes or perform arithmetic in different number systems.
  - Most scientific calculators also have other functions that are valuable in digital electronics such as AND, OR, NOT, XOR, and XNOR logic functions.



THANK YOU