ACOL 215 (10th Sept.)

Signed Binary Numbers

Represent −5 in the following ways with 8 bits

i) signed − magnitude representation

10000101

ii) signed 1's complement "

11111010

iii) signed 2's complement "

11111011

Addition and Subtraction

Addition in the signed-magnitude system is straightforward

— do what we "normally" do

The addition of two signed binary numbers with negative numbers represented in signed 2's complement form is obtained by adding the two numbers, including their signed bits. A carry out of the sign-bits is discarded.

+6	00000110		−6	11111010
+13	00001101		+13	00001101
+19	00010011		+7	00000111

+6	00000110		−6	11111010
−13	11110011		−13	11110011
−7	11111001		−19	$\cancel{1}$11101101

Note that i) the negative numbers must be initially in signed 2's complement form

ii) if the sum obtained is negative, it is already in signed 2's complement form.

Subtraction is simple

$$(\pm A) - (+B) = (\pm A) + (-B)$$

$$(\pm A) - (-B) = (\pm A) + (+B)$$

take 2's complement

Example

$$\boxed{-6} - (\boxed{-13}) = +7$$

-6	11111010
-13	11110011
$+13$	00001101
$+7$	00000111

Why do we want them to fit into the same rules?

→ so that we can use a common hardware circuit for them all.

Exercise

i) $(+4) + (-11)$?

11111001

ii) $(-4) + (-11)$?

11110001

Binary code

Binary coded Decimal (BCD)

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

$279 = (0010\ 0111\ 1001)_{BCD}$

$185 = (0001\ 1000\ 0101)_{BCD}$

$= (10111001)_2$

What about adding two numbers in BCD representation ?

Important [[[Exercise : Read from the book page No. 40]].

ASCII

7-bit code

American Standard Code for Information Interchange

26 letters → lowercase
→ uppercase

10 numerals

32 printable characters

$, #, ␣

34 control characters

tabs, backspace

128

A 65
B 66
C 67

$\boxed{\text{1 byte}}$

Binary storage and registers

binary cell   0, 1

↳ stores 1 bit of information

register → continuous group of binary cells.

e.g. 16-bit register

1100001111001001

binary equivalent of a decimal number

1 1000011

C (67)

1 1001001

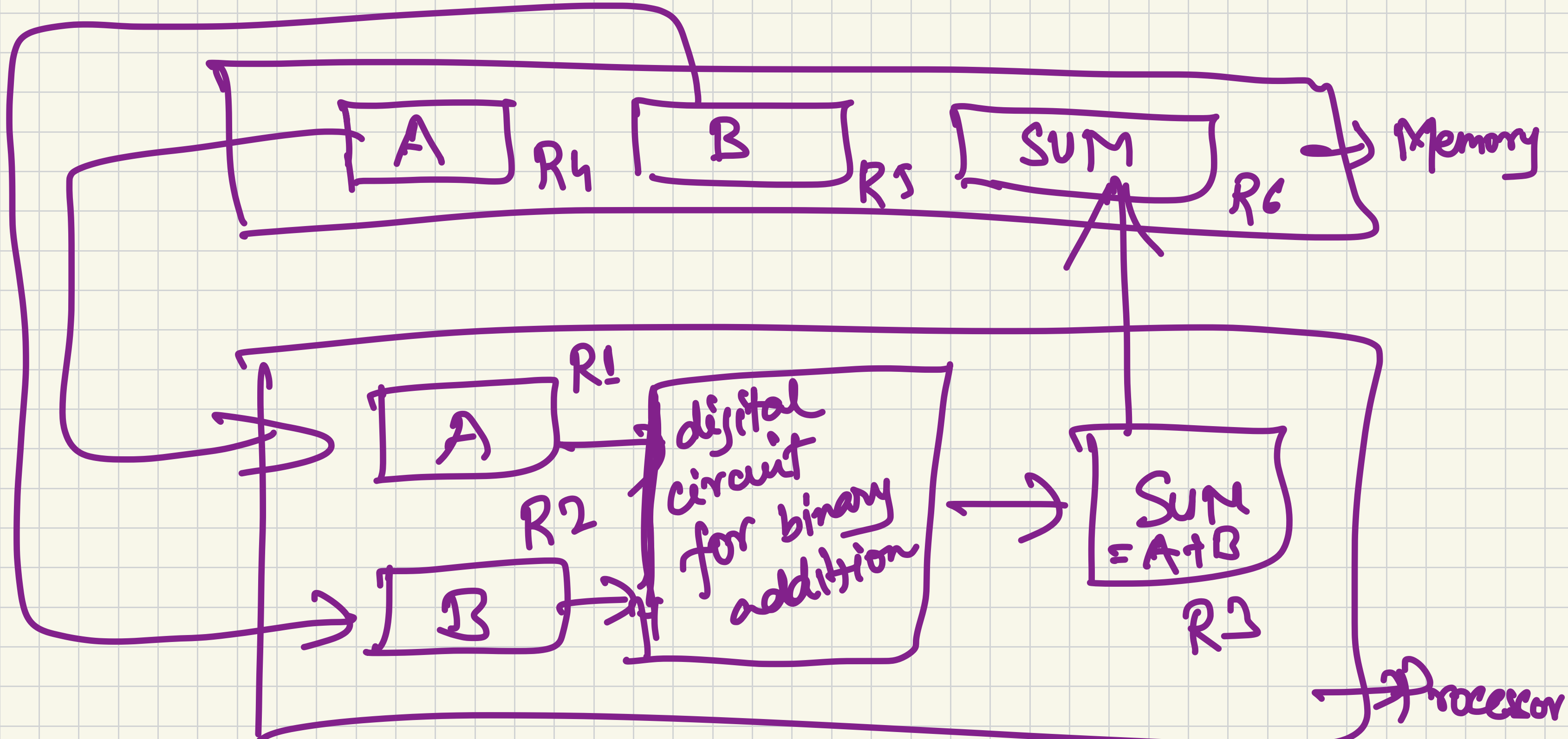
I (73)

even parity bit

A digital system is characterised by its registers and the components that perform data processing.

→ A basic operation that is frequently done in a digital system is register transfer

transferring information from one register to another, possibly via a processor



A
R4
B
R5
SUM
R6
Memory
R1
A
digital
circuit
for binary
addition
R2
B
SUM
= A+B
R3
Processor

Binary Logic

Variables that can take two discrete values (0 and 1)

operations → logical meaning.

AND

$x \cdot y$

OR

$x + y$

NOT

x'

Binary arithmetic where + means "plus" → $1 + 1 = 10$

Binary logic where + means "OR" → $1 + 1 = 1$

Logic Gates

→ basically electronic circuits that operate on one or more physical input signals and produce an output signal.

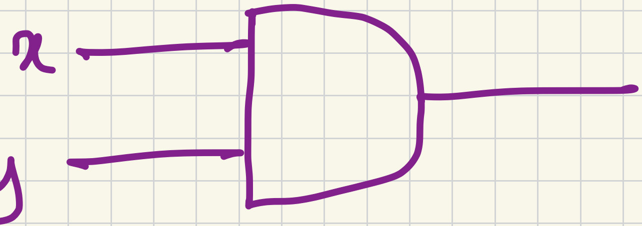
e.g. voltage operated circuits

two separate voltage levels corresponding to binary variables 0 and 1

0 - 3 volts

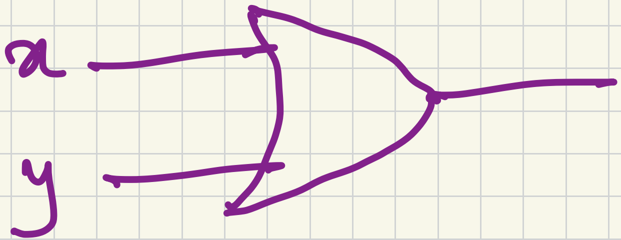
$$\frac{0-1}{0} \qquad \frac{2-3}{1}$$

AND



$z = x \cdot y$

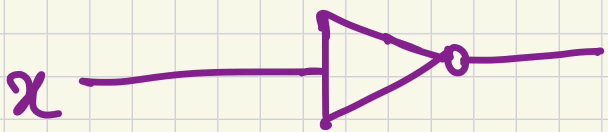
OR



$z = x + y$

NOT

Inverter



$z = x'$

Exercise

Q. Convert $+49$ and $+29$ decimal numbers to binary.

i) $(+29) + (-49)$

ii) $(-29) - (-49)$

using signed 2's complement to represent the numbers.