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1) PROCESSOR ARCHITECTURE

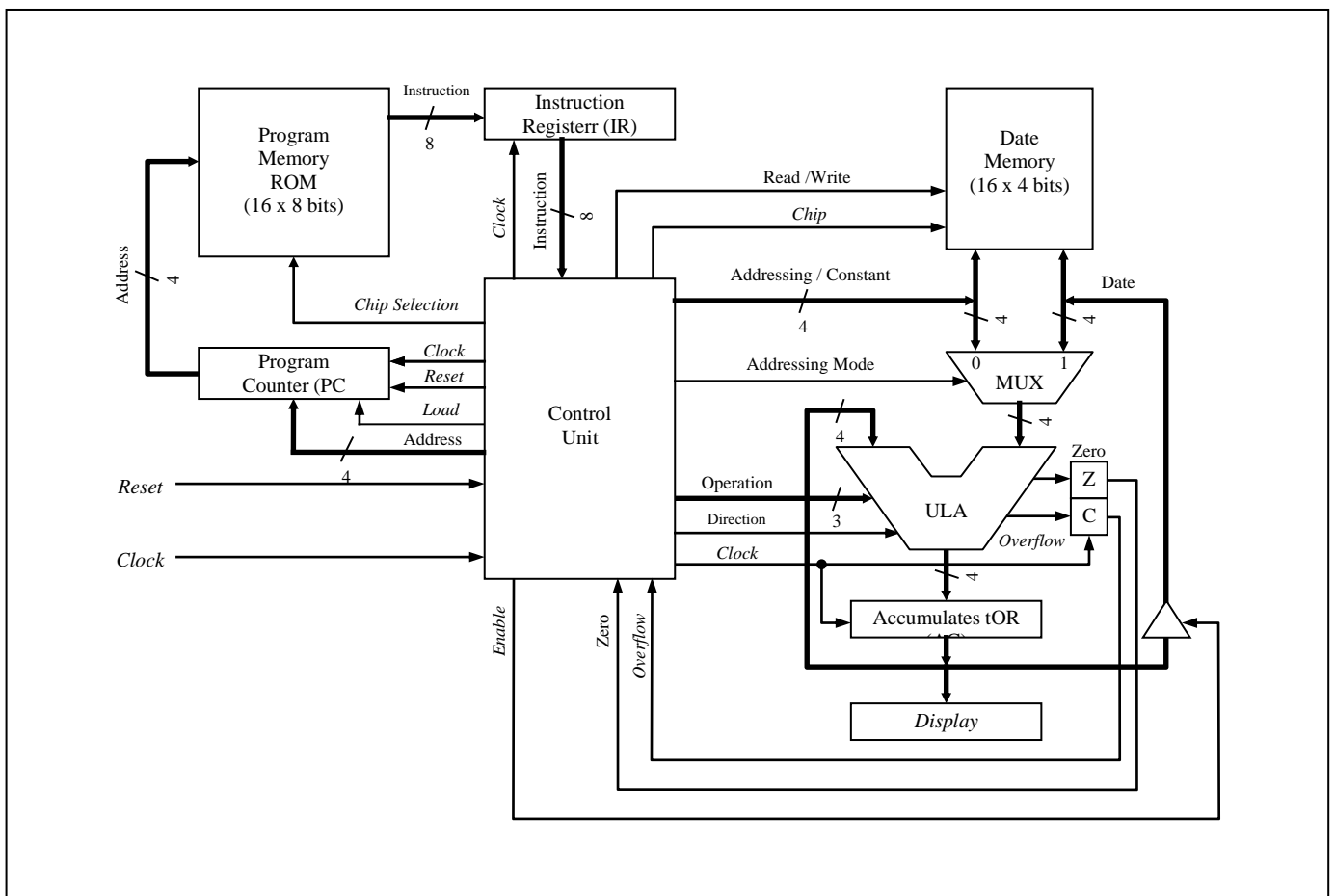


Figure 1 - Processor Architecture

2) INSTRUCTIONS DESCRIPTION

MOVES X, E

Description: Performs the move (copy) operation of a constant X, if E is equal to 0, or from the contents of the X address of the RAM, to the AC register.

Limits: $0 \leq X \leq 15$ (4 bits)
 $E = 0$ (OP = X) or $E = 1$ (OP = M(X))

Operation: $AC \leftarrow OP$

Affected bits: Z and O

Encoding: 000E XXXX

ADD X, E

Description: Performs the add-on operation between AC and a constant X, if E is equal to 0, or the addition between AC and the contents of the X address of the RAM. The result will always be stored in AC.

Limits: $0 \leq X \leq 15$ (4 bits)
 $E = 0$ (OP = X) or $E = 1$ (OP = M(X))

Operation: $AC \leftarrow AC + OP$

Affected bits: Z and O

Encoding: 001E XXXX

SUB X, E

Description: Performs the subtraction operation between AC and a constant X, if E is equal to 0, or the subtraction between AC and the contents of address X of RAM. The result will always be stored in AC expressed in 2's complements.

Limits: $0 \leq X \leq 15$ (4 bits)
 $E = 0$ (OP = X) or $E = 1$ (OP = M(X))

Operation: $AC \leftarrow AC - OP$

Affected bits: Z and O

Encoding: 010E XXXX

OR X, E

Description: Performs the logical operation 'OR' (or) between AC and a constant X, if E is equal to 0, or between AC and the contents of the X address of the RAM. The result will always be stored in AC.

Limits: $0 \leq X \leq 15$ (4 bits)
 $E = 0$ (OP = X) or $E = 1$ (OP = M(X))

Operation: $AC \leftarrow AC \text{ or } OP$

Affected bits: Z and O

Encoding: 011E XXXX

XOR X, E

Description: Performs the logical operation 'OR EXCLUSIVE' (xor) of a constant X, if E is equal to 0, or the contents of the X address of the RAM. The result will always be stored in AC.

Limits: $0 \leq X \leq 15$ (4 bits)
 $E = 0$ (OP = X) or $E = 1$ (OP = M(X))

Operation: $AC \leftarrow AC \text{ xor } OP$

Affected bits: Z and O

Encoding: 100E XXXX

SHIFT X, D

Description: Performs a shift to the right or left of the Q bits accumulator. If D is equal to 0 the offset will be left, otherwise to the right. The result will always be stored in AC.

Limits: $0 \leq Q \leq 15$ (4 bits)
 $D = 0$ (left shift) or $D = 1$ (right shift)

Operation: $AC \leftarrow AC \ll Q$, for $D = 0$ or
 $AC \leftarrow AC \gg Q$, for $D = 1$

Affected bits: Z

Encoding: 101 D QQQQ

JMP X, E

Description: Makes a conditional program jump so that the next executed statement is the one allocated at address X or address already pointed out by the PC, depending on the condition established. The jump is made by changing the contents of the PC by X, if the condition is true. The jump can occur if AC is equal to zero ($S = 0$) or if AC is non-negative ($S = 1$).

Limits: $0 \leq X \leq 15$ (4 bits)
 $S = 0$ (jumps if $AC = 0$) or $S = 1$ (jumps if $AC \geq 0$)

Operation: $PC \leftarrow X$, for $S = 0$ and if $AC = 0$ (i.e. $Z = 1$) or for $S = 1$ and $O = 1$ (i.e., overflow occurred)

Affected bits: none

Encoding: 110 S XXXX

GOTO X

Description: Makes an unconditional program jump so that the next executed statement is the one allocated to the X address of the ROM memory. The jump is made by changing the contents of the PC by X.

Limits: $0 \leq X \leq 15$ (4 bits)

Operation: PC

Affected bits: none

Encoding: 1110 XXXX

STORE X

Description: Performs the storage operation of the contents of the AC register to the X address of the RAM.

Limits: $0 \leq X \leq 15$ (4 bits)

Operation: M(X)

Affected bits: none

Encoding: 1111 XXXX