COMPUTER REGISTERS
&
COMMON BUS SYSTEM

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What is a Register?

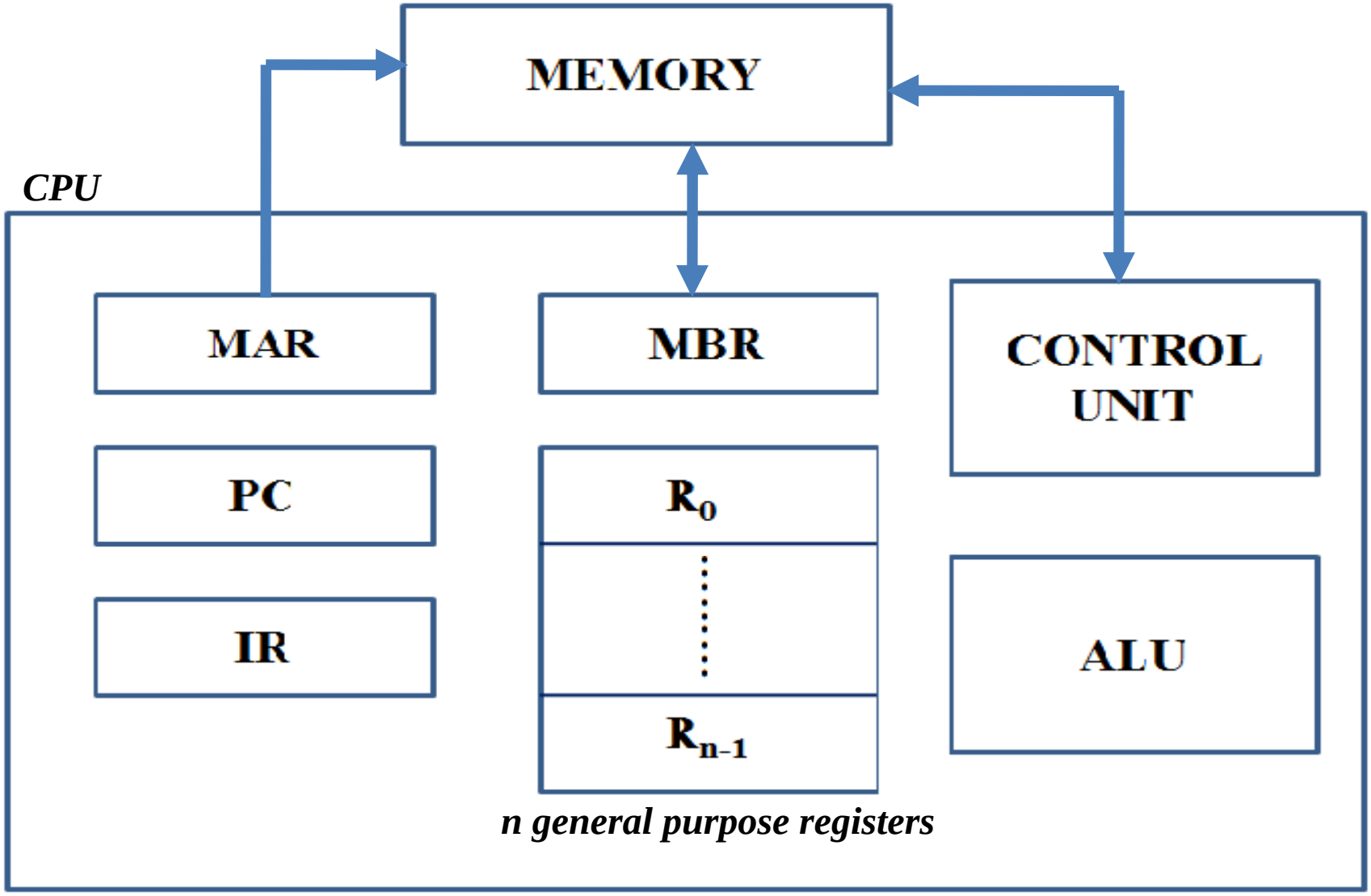
- A register is a very small amount of very fast memory that is built into the CPU (central processing unit).
- Contents can be accessed at extremely high speeds.
- Registers are used to store data temporarily during the execution of a program.
- Different processors have different register sizes.
- Registers are normally measured by the number of bits they can hold, for example, an 8-bit register means it can store 8 bits of data or a 32-bit register means it can store 32 bit of data.

Basic Registers in a Computer System

The following registers are used for the movement of data between the CPU and memory in a basic computer system.

- **Program Counter (PC):** It contains the address of an instruction to be fetched.
- **Instruction Register (IR):** It contains the instruction most recently fetched.
- **Memory Address Register (MAR):** It contains the address of a location in memory.
- **Memory Buffer Register/ Memory Data Register (MBR/MDR):** It contains a word of data to be written to memory or the word most recently read.
- **General Purpose Registers/Temporary Registers:** Provide temporary storage of variables or results during execution of an instruction. A computer system may have several general purpose registers.

Basic Organization



Mano's Computer

Considering a 16-bit computer

Register Symbol	Register Name	Number of Bits	Description
AC	Accumulator	16	Processor Register
DR	Data Register	16	Hold memory data
TR	Temporary Register	16	Holds temporary Data
IR	Instruction Register	16	Holds Instruction Code
AR	Address Register	12	Holds memory address
PC	Program Counter	12	Holds address of next instruction
INPR	Input Register	8	Holds Input data
OUTR	Output Register	8	Holds Output data

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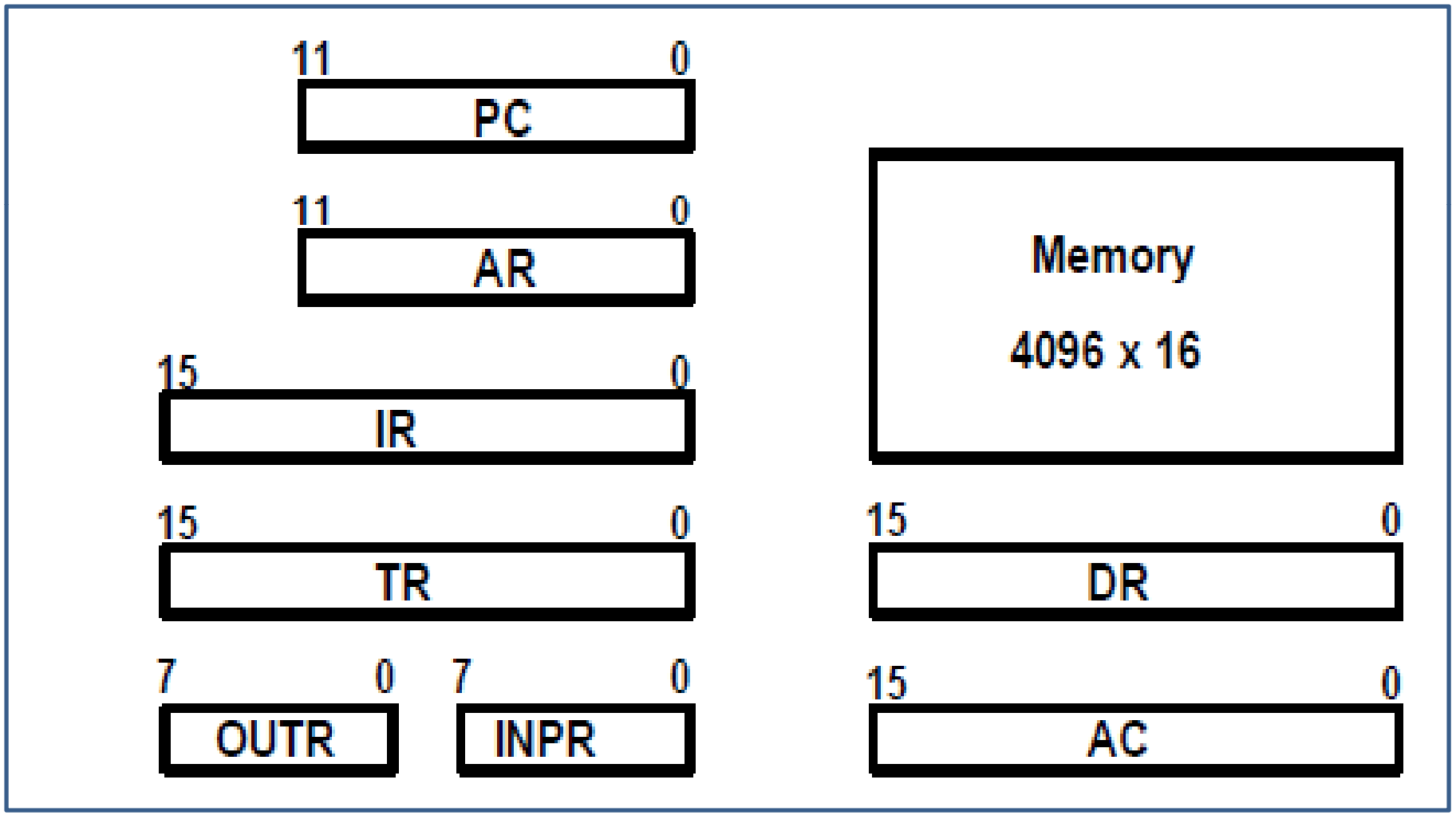
Registers in the Basic Computer



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- ***ACCUMULATOR (AC):***

  The processor register AC consists of 16-bits. It is used to hold the results or partial results of arithmetic and logical operations. An accumulator is a register in which intermediate arithmetic and logic results are stored.

- ***DATA REGISTER (DR):***

  The register DR consists of 16-bits and it is used to hold memory operands (data). This register contains the data to be written into memory or receives the data read from memory.

Cntd…

- ***TEMPORARY REGISTER (TR):***

  Temporary register have 16-bits and it provides temporary storage of variables or results.

- ***INSTRUCTION REGISTER (IR):***

  The instruction register consists of 16-bits. The purpose of the instruction register is to hold a copy of the instruction which the processor is to execute. In our basic computer, instruction register (IR) holds instruction code which is read from memory.

- ***ADDRESS REGISTER (AR):***

  This register specifies the address in memory for next read or writes operations. The address register consists of 12-bits.

Cntd…

- ***PROGRAM COUNTER (PC):***

  Program counter has 12-bits and it holds the address of the next instruction to be read from memory after the current execution is executed. The instructions are read sequentially because the program counter automatically increments after fetching the current instruction.

- ***INPUT REGISTER (INPR):***

  Input register has 8-bits. INPR register receives a character from an input device and delivers it to the AC.

- ***OUTPUT REGISTER (OUTR):***

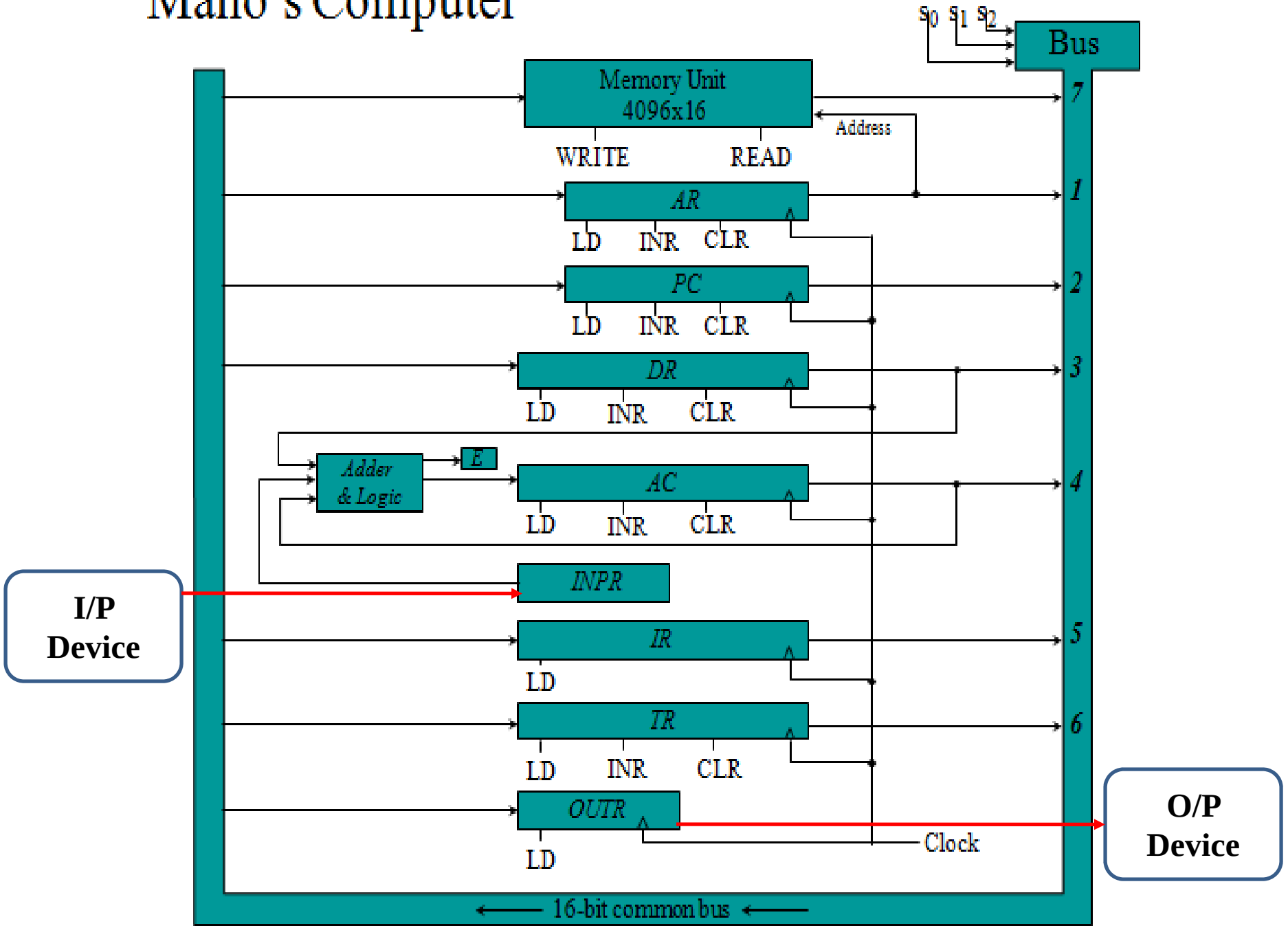
  Output register has 8-bits. The output register receives information from AC and transfer it to the output device.

COMMON BUS SYSTEM

- ***BUS:***
  A wire or a collection of wires that carry some multi-bit information is known as bus. Main purpose of bus is to transfer information form one system to another.

- ***DESCRIPTION:***
  1. The basic computer has eight registers (AC, PC, DR, AC, IR, TR, INPR, OUTR), a memory unit and a control unit. Path must be provided to transfer information from one register to another and between memory and registers.
  2. The number of wires will be excessive if connections are made between the output of each register and input of other registers. A more efficient scheme is to use a common bus.
  3. Thus common bus provides a path between memory unit and registers.

Mano's Computer



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- The connection of the registers and memory of the basic computer to a common bus system :

  - The outputs of seven registers (except INPR) and memory are connected to the common bus
  - The specific output is selected by mux(S0, S1, S2) :
    1. Memory(7), AR(1), PC(2), DR(3), AC(4), IR(5), TR(6)
    2. When LD(Load Input) is enable, the particular register receives the data from the bus

  - ***Control Input :*** LD, INC, CLR, Write, Read
    1. Selection switches for selecting the source of information
    2. Enable switches at the destination device to accept the information.

Control Signals

- Five registers have three control inputs: LD (load), INR (increment) and CLR (clear). Two registers have only a LD input.

1. ***Load (LD):***

The particular register whose LD input is enabled receives the data from the bus. When LD = 1 for a register, the data on the common bus is read into the register during the next clock pulse transition.

2. ***Increment input (INR)****:* Increments the content of a register.

3. ***Clear input (CLR)****:* Clear the content of a register to zero.

CIRCUIT OPERATION DESCRIPTION

1. ***Memory Unit:***

The memory receives the 16-bit information from the bus when its write input is enabled and the memory places its 16-bit information onto the bus when its read input is activated and S2S1S0 = 111.

2. ***Address Register (AR):***

This register specifies the address in memory for next read or writes operations. The address register consists of 12 bits.

When selection inputs S2S1S0 =001 is applied to the bus, the address register AR receives or transfers address from or to the bus when its LD input is enable. The address is incremented or clear by the inputs INR or CLR.

Cntd…

3. Program Counter (PC):

Program counter has 12 bits and it holds the address of the next instruction to be read from memory after the current execution is executed.

When selection inputs S2S1S0 = 010 is applied to the bus, the program counter (PC) receives or transfers address from or to the bus when its LD input is enable. The address is incremented or clear by the inputs INR or CLR.

4. Data Register (DR):

The register DR consists of 16-bits and memory operands (data). This register contains the data to be written into memory or receives the data read from memory.

When selection inputs S2S1S0 = 011 is applied to the bus, the data register DR receives or transfers data from or to the bus when its LD input is enable. The data is incremented or clear by the inputs INR or CLR.

Cntd…

5. ***Accumulator (AC):***

The processor register AC consists of 16 bits. The 16-bit inputs to the Adder / logic circuit come from the outputs of AC. They are used to implement register micro operation such as complement and shift the contents of AC.

The results of these micro operations are again transferred to AC. So an accumulator is a register in which intermediate arithmetic and logic results are stored.

When selection inputs S2S1S0 = 100 is applied to the bus, the processor register AC receives or transfers its data to the bus by enabling the LD input of DR, it transfers the contents of DR through the adder / logic circuit into AC when its LD input is enable. The data of AC is incremented or clear by the inputs INR or CLR.

Cntd…

6. Instruction Register (IR):

The instruction register consists of 16-bits. The purpose of the instruction register is to hold a copy of the instruction which the processor is to execute. The instruction read from memory is placed in the IR.

When selection inputs S2S1S0 = 101 is applied to the bus, the instruction register IR receives or transfers instruction code from or to the bus when its LD input is enable.

7. Temporary Register (TR):

Temporary registers have 16 bits. It provides temporary storage of variables or results.

When selection inputs S2S1S0 = 111 is applied to the bus, the temporary register TR receives or transfers temporary data from or to the bus when its LD input is enable. The data is incremented or clear by the inputs INR or CLR.

Cntd…

8. **Input Register (INPR):**

The Input Register INPR consists of 8-bits and hold alphanumeric input information. The serial information from the input device is shifted into input of 8-bit register INPR.

When LD input of AC is enable, the 8-bit information of INPR is transferred to the AC via Adder/logic circuit.

9. Output Register (OUTR):

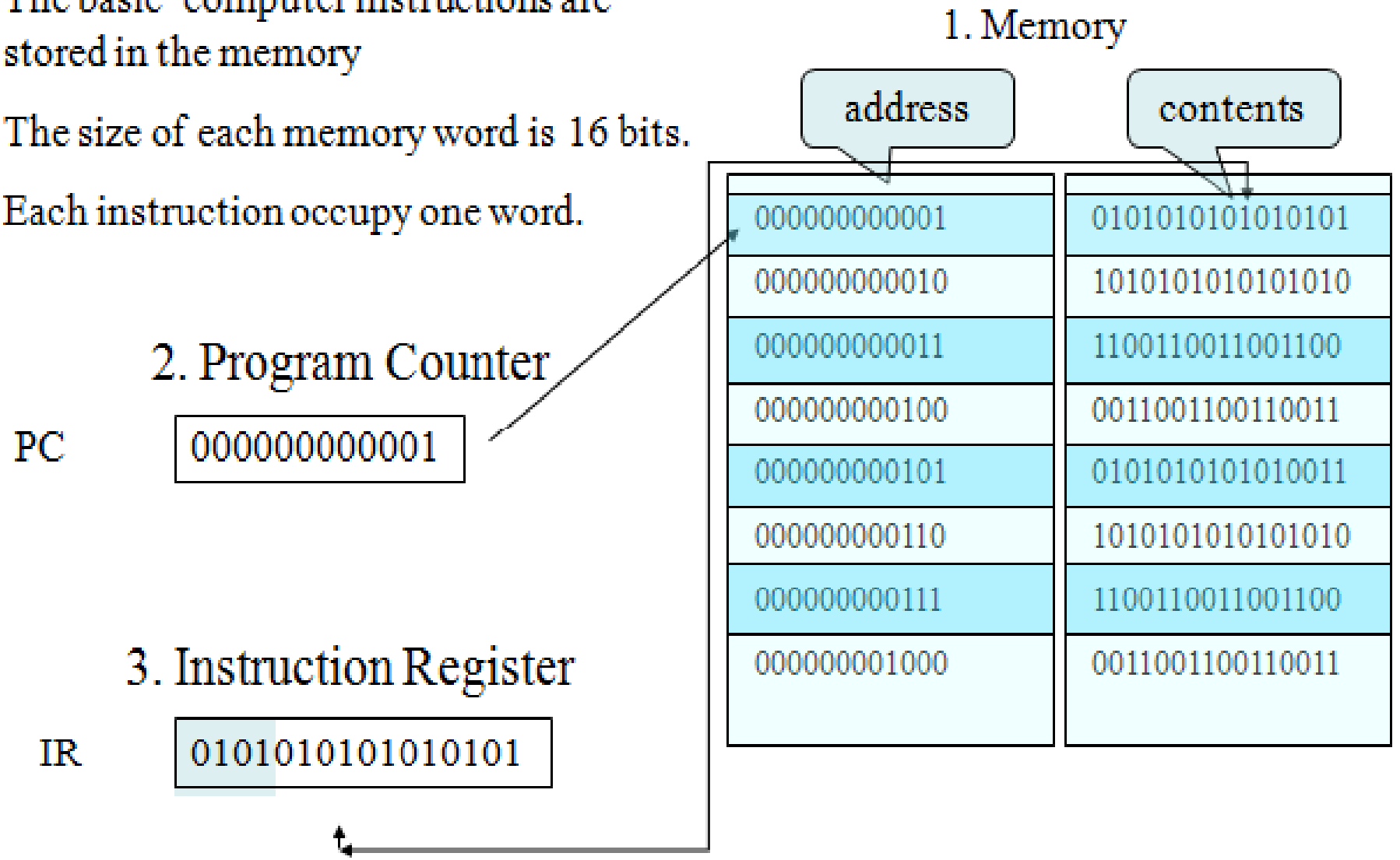
The output OUTR receives information from AC and transfers it to the output device.

Building A Basic Computer!

The basic computer instructions are stored in the memory

The size of each memory word is 16 bits.

Each instruction occupy one word.



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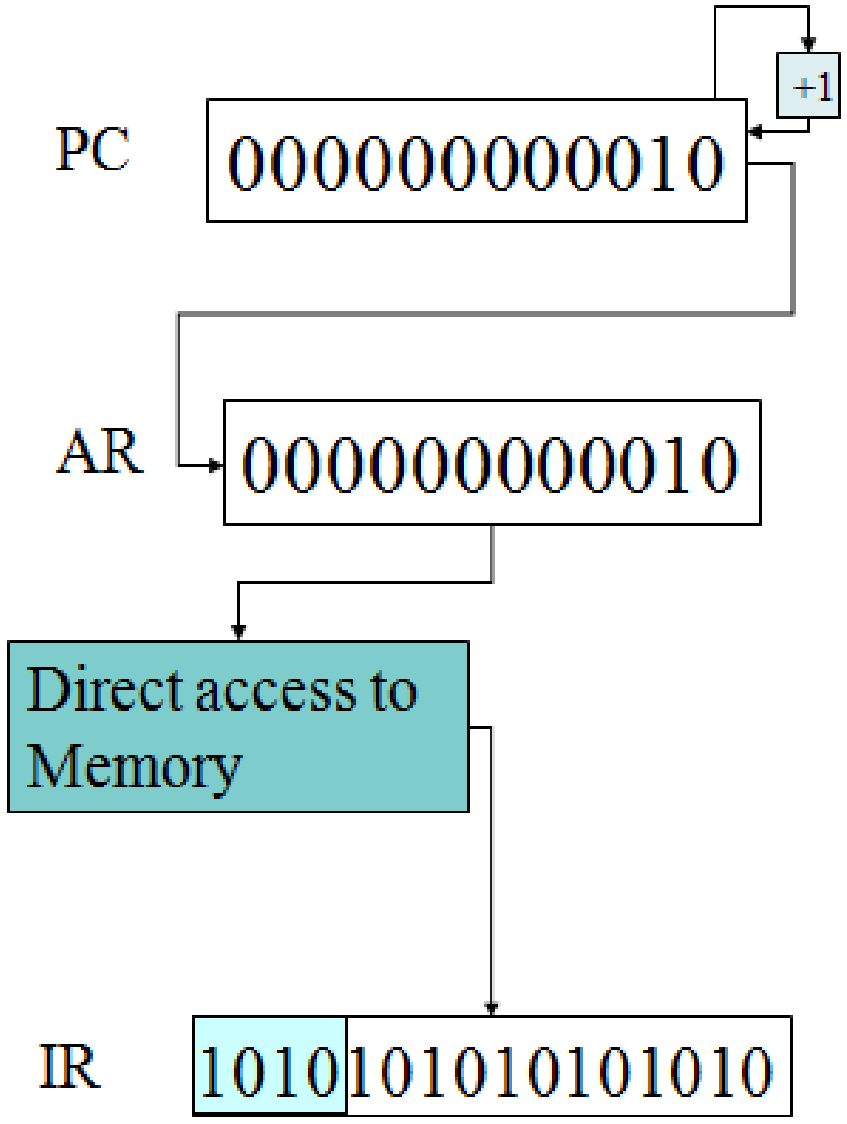
The Program Counter points to the next address of the program

1. Program Counter Increments

by units of addresses

2. The next address is put on the bus and is loaded into the Address Register

3. The Bits of the AR are wired directly to the RAM Address lines to enable loading the memory into the Instruction R.




Q+A

1. The register that keeps track of the next instructions in the program stored in memory is ……..

   A) AR B) PC C) DR D) IR

2. Data transfer between the main memory and the CPU registers takes place through two registers namely .....

   A) general purpose register and MDR
   B) accumulator and program counter
   C) MAR and MDR
   D) MAR and Accumulator

3. Collection of lines that connects several devices is called .....

   A) bus B) peripheral connection wires
   C) Both a and b D) internal wires

4. 3. PC is also called .....

   A) instruction pointer B) memory pointer
   C) data counter D) file pointer

5. Accumulator is …..

   A) Address register B) Temporary rgister
   C) Processor register D) Instruction register

6. IR keeps track of ……

   A) Current instruction B) Next instruction
   C) Current instruction address D) Next instruction address

7. For a 16 bit computer, System bus is of ……bits
   A) 8 B) 12 C) 16 D) 32
8. For a 16 bit computer, AR is of ……bits
   A) 8 B) 12 C) 16 D) 32
9. For a 16 bit computer, DR is of ……bits
   A) 8 B) 12 C) 16 D) 32
10. For a 16 bit computer, IR is of ……bits
   A) 8 B) 12 C) 16 D) 32
11. For a 16 bit computer, PC is of ……bits
   A) 8 B) 12 C) 16 D) 32
12. For a 16 bit computer, AC is of ……bits
   A) 8 B) 12 C) 16 D) 32
13. For a 16 bit computer, TR is of ……bits
   A) 8 B) 12 C) 16 D) 32
14. For a 16 bit computer, INPR is of ……bits
   A) 8 B) 12 C) 16 D) 32
15. For a 16 bit computer, OUTR is of ……bits
   A) 8 B) 12 C) 16 D) 32

16. Different processors have different register sizes.
    A) True B) False
17. A computer system may have several general purpose registers.
    A) True B) False
18. Bus provides a path between memory unit and registers.
    A) True B) False
19. INPR is connected to the common bus.
    A) True B) False
20. Control input to a register…….
    A) LD B) INR C) CLR D) All of these
21. ……register has only one control input.
    A) AR B) DR C) IR D) AC
22. No INR & CLR control inputs for …….. Register
    A) PC B) TR C) AC D) OUTR
23. …….. Has no control inputs.
    A) PC B) INPR C) AC D) OUTR
24. Adder logic is connected to …….
    A) AR B) DR C) IR D) AC

References

1. Computer Organization – Carl Hamacher
2. Computer System Architecture – Morris Mano