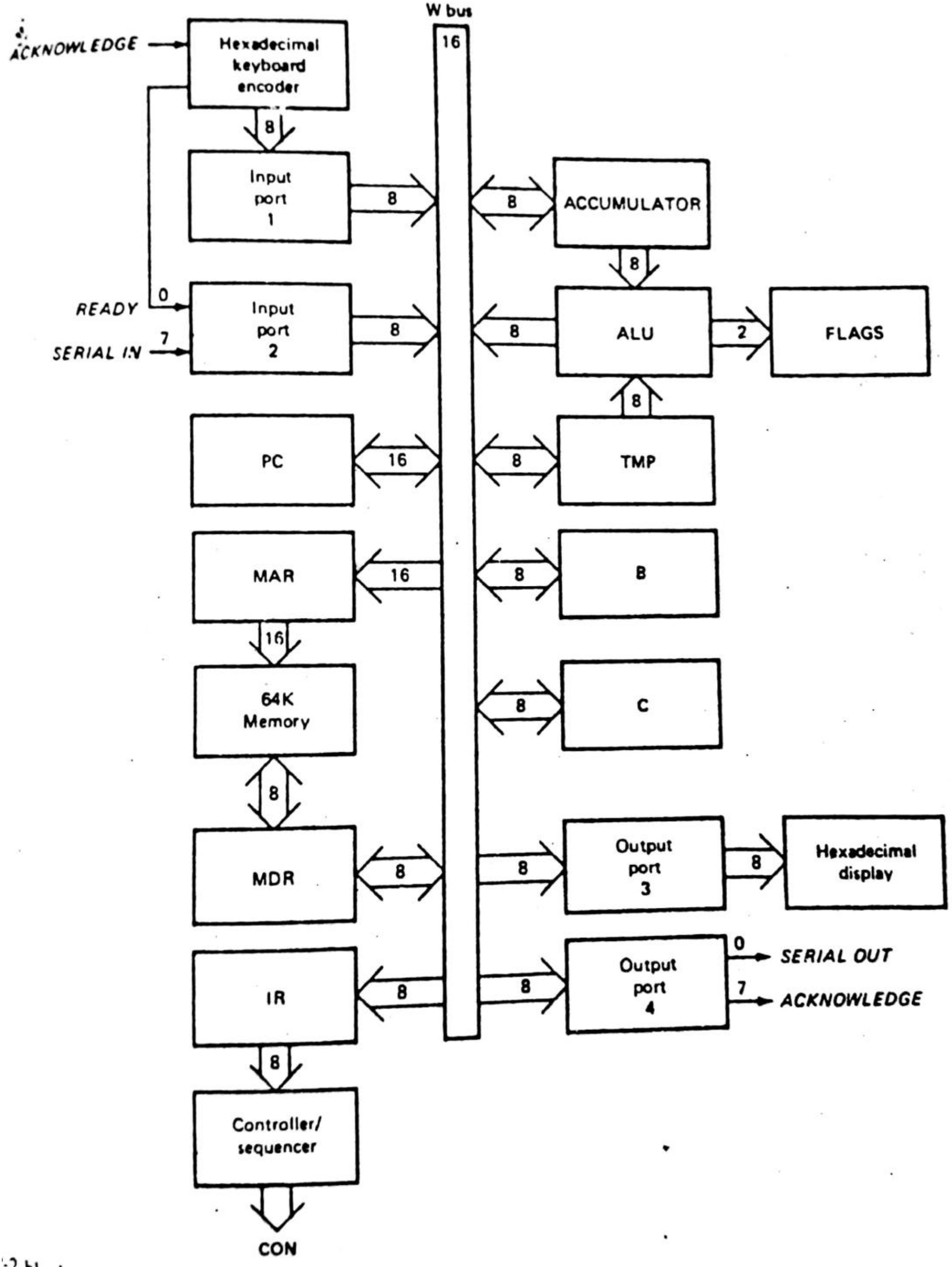
Simple as Possible 2
SAP-2

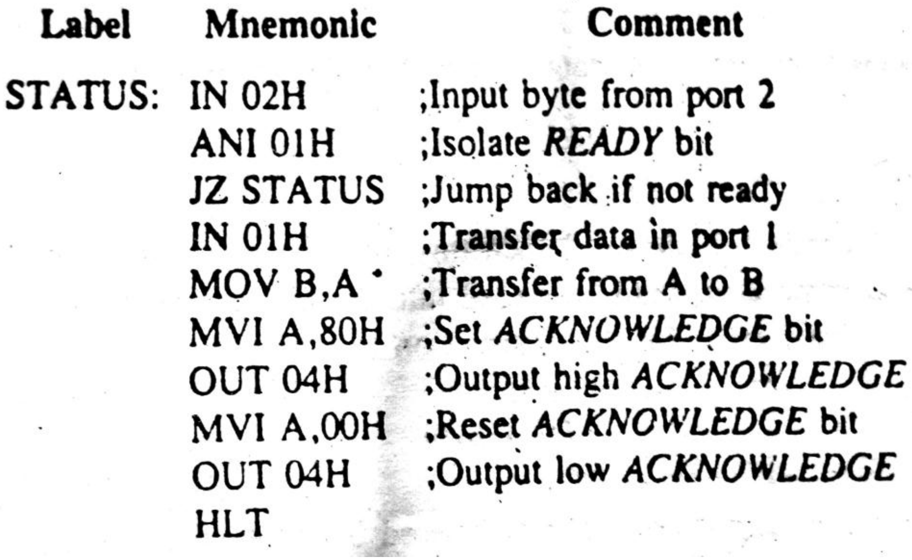
SAP 2 Block Architecture

- Evolution towards modern computers because it includes JUMP instruction.



Input Port

- Port 1 and Port 2
- Port 1
  - Hexadecimal keyboard encoder
  - Sends ready signal to bit 0 of port 2 (indicates that data in port 1 is valid)
- Port 2
  - Serial In



```
Label      Mnemonic      Comment

STATUS:    IN 02H        ;Input byte from port 2
           ANI 01H       ;Isolate READY bit
           JZ STATUS     ;Jump back if not ready
           IN 01H        ;Transfer data in port 1
           MOV B,A       ;Transfer from A to B
           MVI A,80H     ;Set ACKNOWLEDGE bit
           OUT 04H       ;Output high ACKNOWLEDGE
           MVI A,00H     ;Reset ACKNOWLEDGE bit
           OUT 04H       ;Output low ACKNOWLEDGE
           HLT
```

Program Counter

- 16 bit address
- Thus can count from
- PC = 0000 0000 0000 0000
- PC = 1111 1111 1111 1111 (FFFF H)

MAR and Memory

- 16-bit address to MAR
- MAR output to RAM
- Memory Capacity
  - 2K ROM (0000H to 07FFFH) Monitor Program
  - 62K RAM (0800H to FFFFH)

Memory Data Register (MDR)

- 8-bit Register
- Output setup RAM
- Receives data from the bus before write operation
- Data to the bus after read operation

Instruction Register (IR)

- 8-bit op code
- Can accommodate 256 instructions
- Only 42 instruction

Controller Sequencer

- As usual
  - Generates the control word (microinstructions)
  - Has more hardware (larger number of instructions)
  - Control word is bigger (CON)

Accumulator

- Same as SAP-1

ALU and Flags

- ALU
  - Includes both arithmetic and logical operations.
- Flags
  - Represent the status of the arithmetic and logical operation.
  - Flip flops are used:
    - Zero Flag (Z)
    - Sign Flag (S)

Temp, B and C Registers

- Temporary register (TEMP)
- Register B and C are used to move data during program run and accessible to programmers.

Outport Ports

- Two output ports (3 and 4)
- Port 3:
  - Drives Hexadecimal display
- Port 4:
  - Sends ACKNOWLEDGE signals used to hexadecimal encoder. (Handshaking)
- Serial Out:
  - Serial Transmission of data

Instructions

- LDA and STA
- For example:
  - LDA 2000H
  - STA 8000H

MVI

- MVI- Move Immediate
- For example:
- MVI A, 37H
- Other instructions are:
  - MVI B, byte
  - MVI C, byte

Register Instructions

- MOV
  - MOV A, B
  - MOV A,C
  - MOV B, A
  - MOV B, C
  - MOV C,A
  - MOV C,B

Register Instruction

- ADD and SUB
- For example:
  - ADD B
  - ADD C
  - SUB B
  - SUB C

Register Instruction

- INR and DCR

- INR A/ DCR A
- INR B/ DCR B
- INR C/ DCR C

Jump And Call Instruction

- JMP
- For example:
  - JMP 3000 H
- JM (Jump if Minus)
- JZ (Jump if Zero)
- JNZ (Jump if not zero)

Jump And Call Instruction

- CALL
  - Call is used to call the subroutine

- RET
  - Return back from subroutine
  - Program counter contents are stored in the last two location of memory (FFFEH and FFFFF)

Logic Instruction

- CMA-Complement the accumulator
- ANA-And the accumulator with specified register. For example: ANA B
- ORA- OR the accumulator with specified register. For example: ORA B
- XRA- XOR the accumulator with specified register. For example XRA B

Logic Instruction

- ANI: And Immediate
- For example:
- ANI C7H (AND accumulator with immediate data C7H)

- ORI: OR immediate
- For example: ORI C7H

- XRI: XOR immediate
- For example: XRI C7H

Other Instruction

- OUT byte
- For example: OUT 03 H; accumulator to designated port.

- HLT

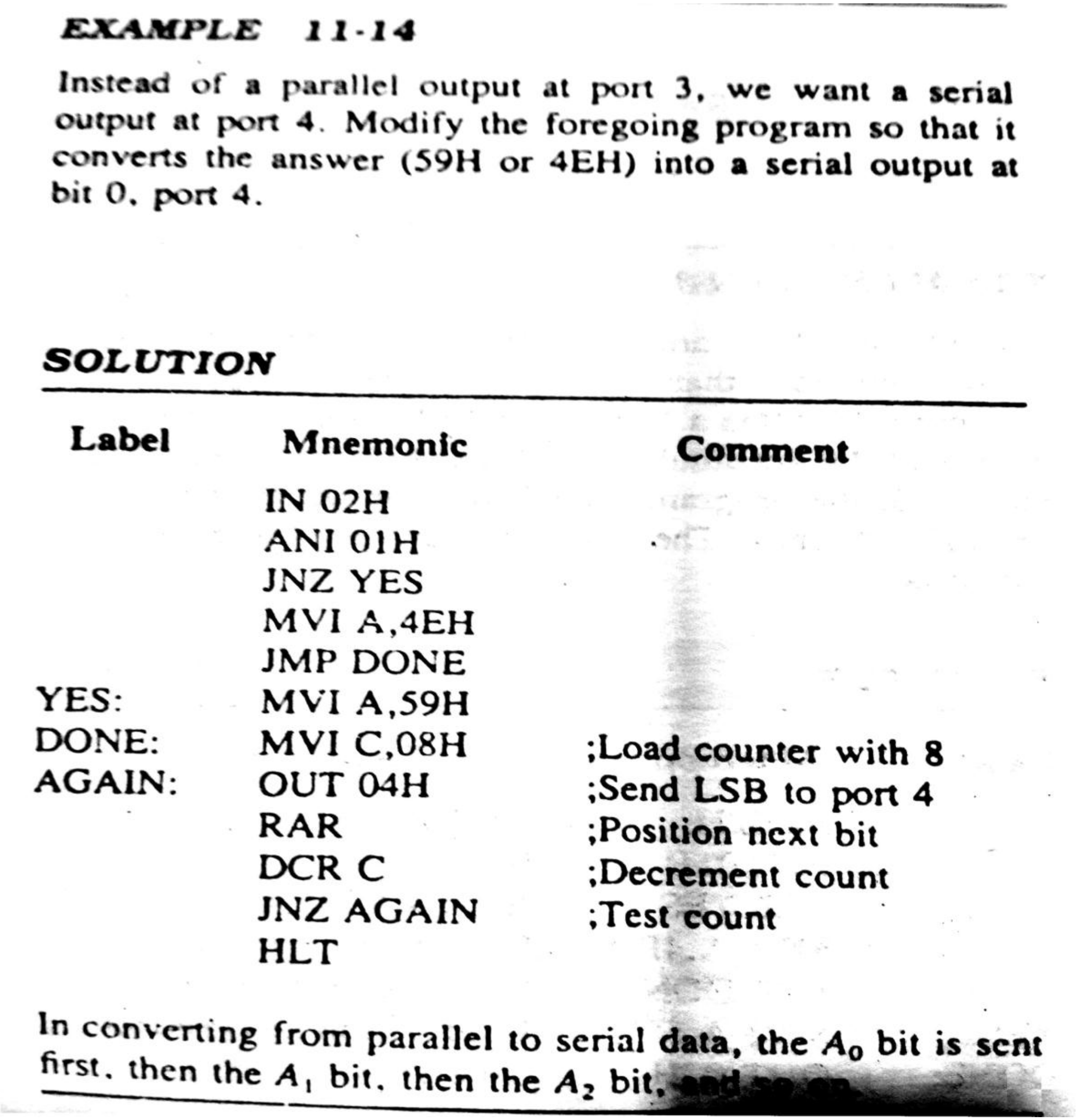
- IN (Input: Enter the data from designated input port to accumulator)
- For example: IN 01 H

- NOP

- RAL (Rotate the accumulator left)

- RAR (Rotate the accumulator right)

Parallel to Serial Data Out



EXAMPLE 11-14

Instead of a parallel output at port 3, we want a serial output at port 4. Modify the foregoing program so that it converts the answer (59H or 4EH) into a serial output at bit 0, port 4.

SOLUTION

```
 Label      Mnemonic            Comment
            IN 02H
            ANI 01H
            JNZ YES
            MVI A,4EH
            JMP DONE
YES:        MVI A,59H
DONE:       MVI C,08H           ;Load counter with 8
AGAIN:      OUT 04H             ;Send LSB to port 4
            RAR                 ;Position next bit
            DCR C               ;Decrement count
            JNZ AGAIN           ;Test count
            HLT
```

In converting from parallel to serial data, the A_0 bit is sent first, then the A_1 bit, then the A_2 bit, and so on.