Microprocessors

Organization & ISA

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EE-309: Microprocessors

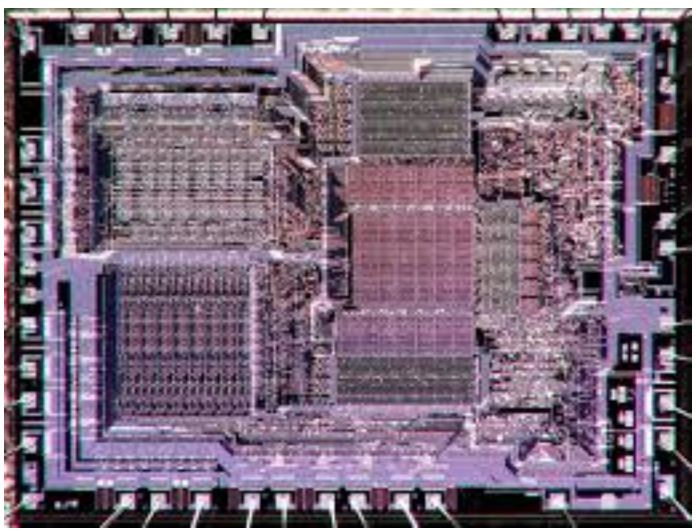
Lecture 3 (25 July 2015)

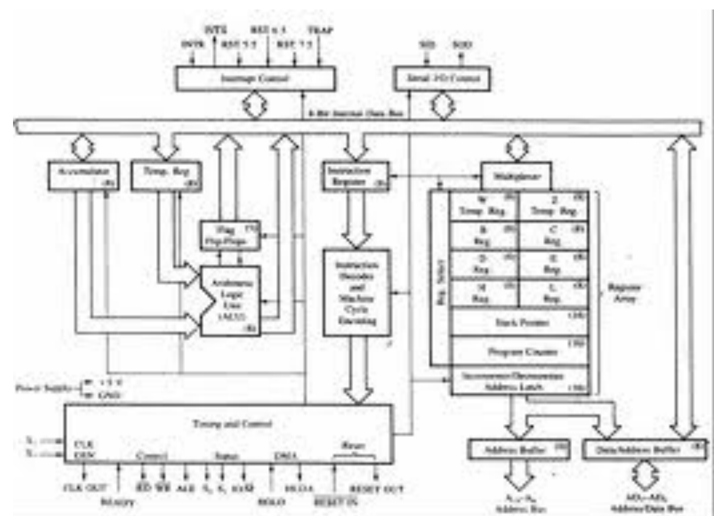
CADSL

MICROPROCESSOR

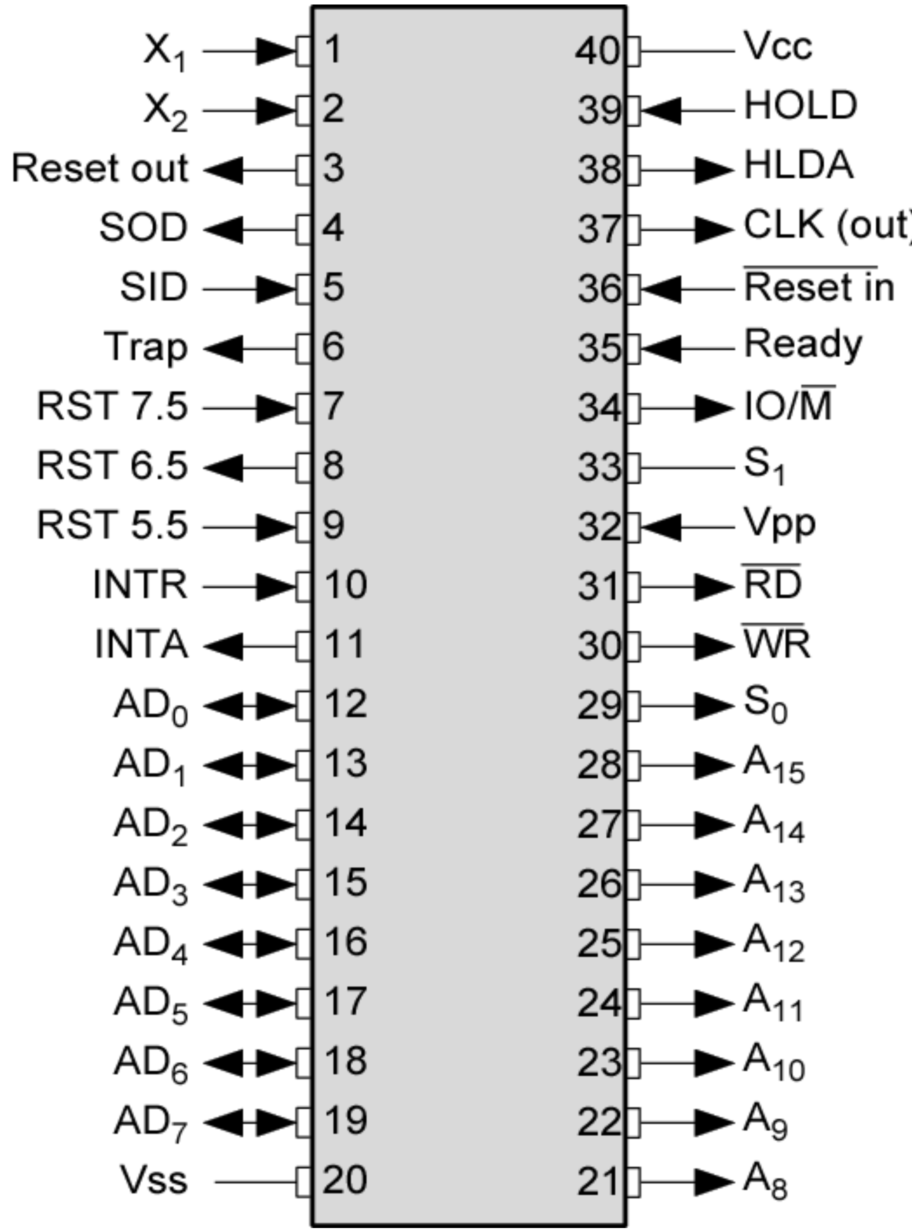
8085

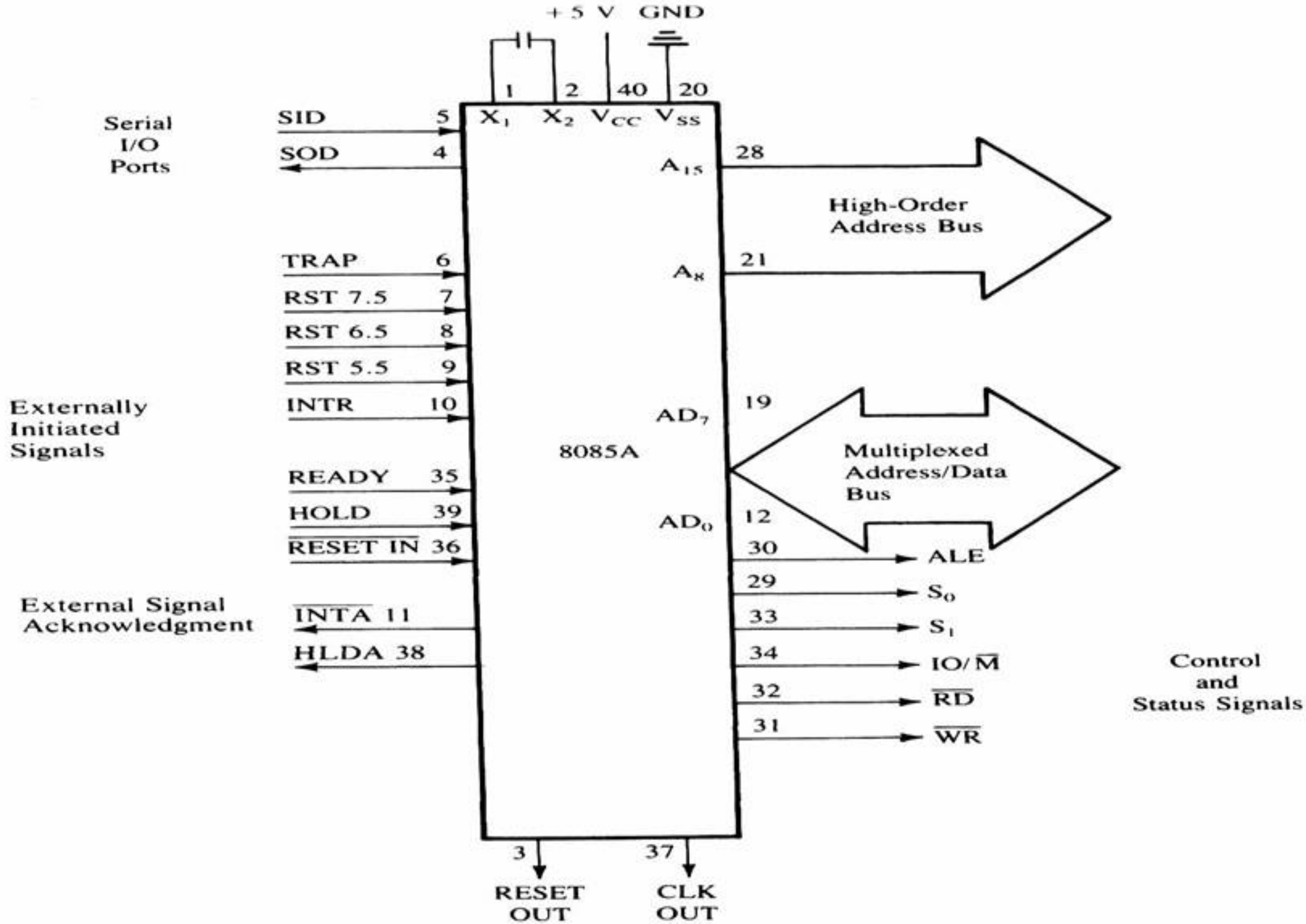
Microprocessor: 8085





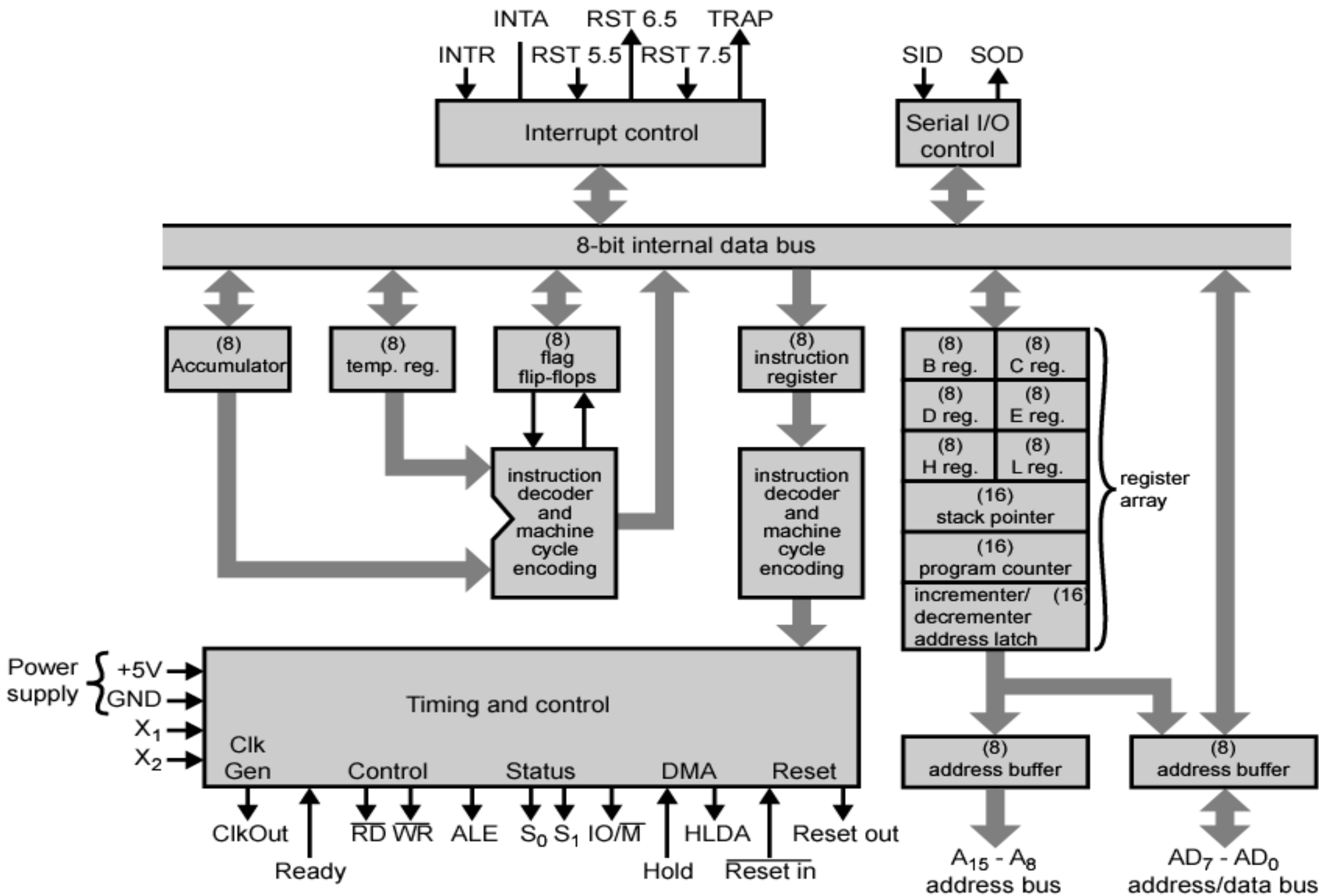
Intel 8085 Pin Configuration





Signals and I/O Pins

Intel 8085 CPU Block Diagram



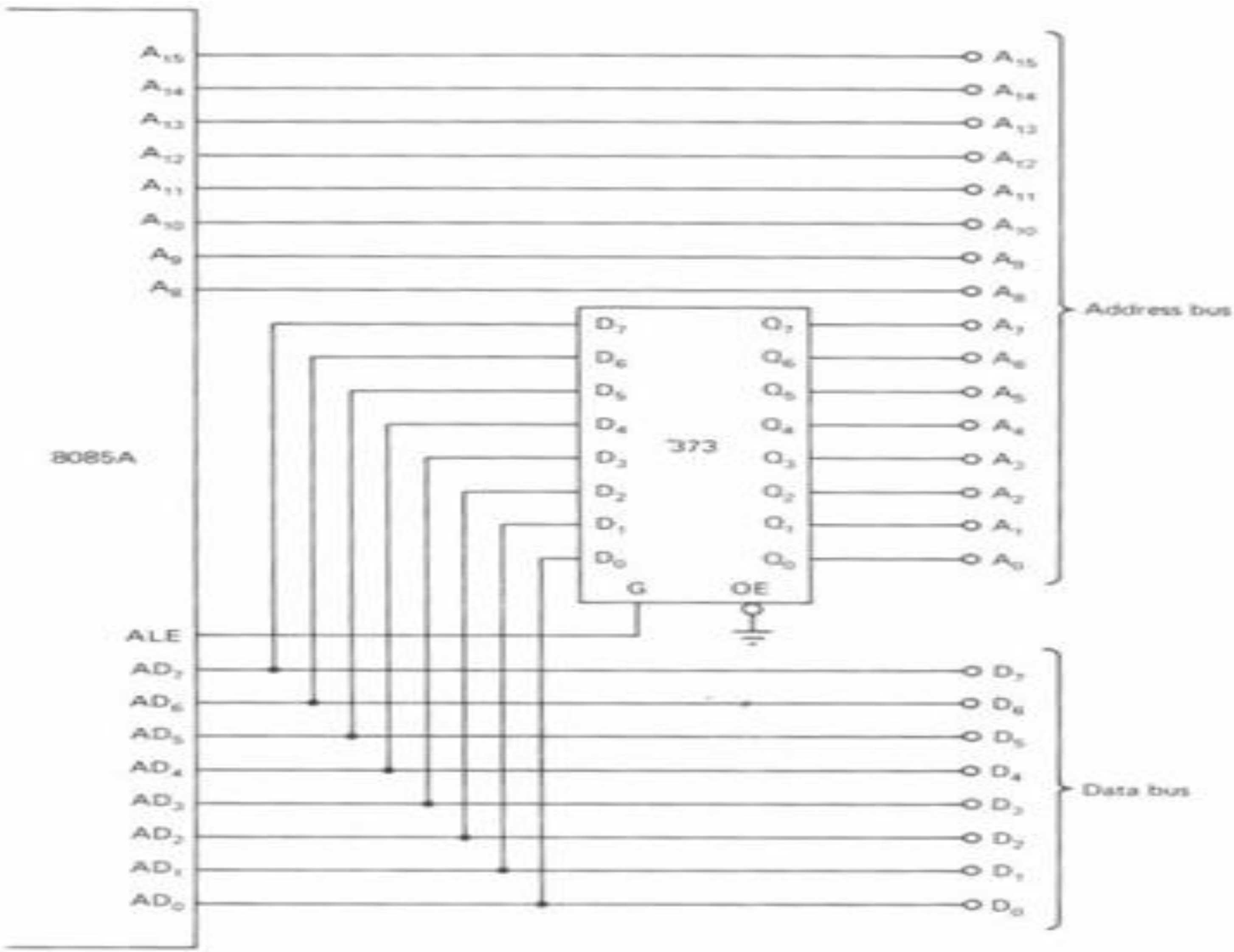
The 8085 and Its Buses

- 8-bit general purpose microprocessor that can address 64K Byte of memory.
- 40 pins and uses +5V for power. It can run at a maximum frequency of 3 MHz.
  - The pins on the chip can be grouped into 6 groups
    - Address Bus.
    - Data Bus.
    - Control and Status Signals.
    - Power supply and frequency.
    - Externally Initiated Signals.
    - Serial I/O ports.

The Address and Data Bus Systems

- The address bus has 8 signal lines A8 – A15 which are unidirectional.
- The other 8 address bits are multiplexed (time shared) with the 8 data bits.
  - So, the bits AD0 – AD7 are bi-directional and serve as A0 – A7 and D0 – D7 at the same time.
    - During the execution of the instruction, these lines carry the address bits during the early part, then during the late parts of the execution, they carry the 8 data bits.
  - In order to separate the address from the data, we can use a latch to save the value before the function of the bits changes.

Demultiplexing of Address/Data Bus

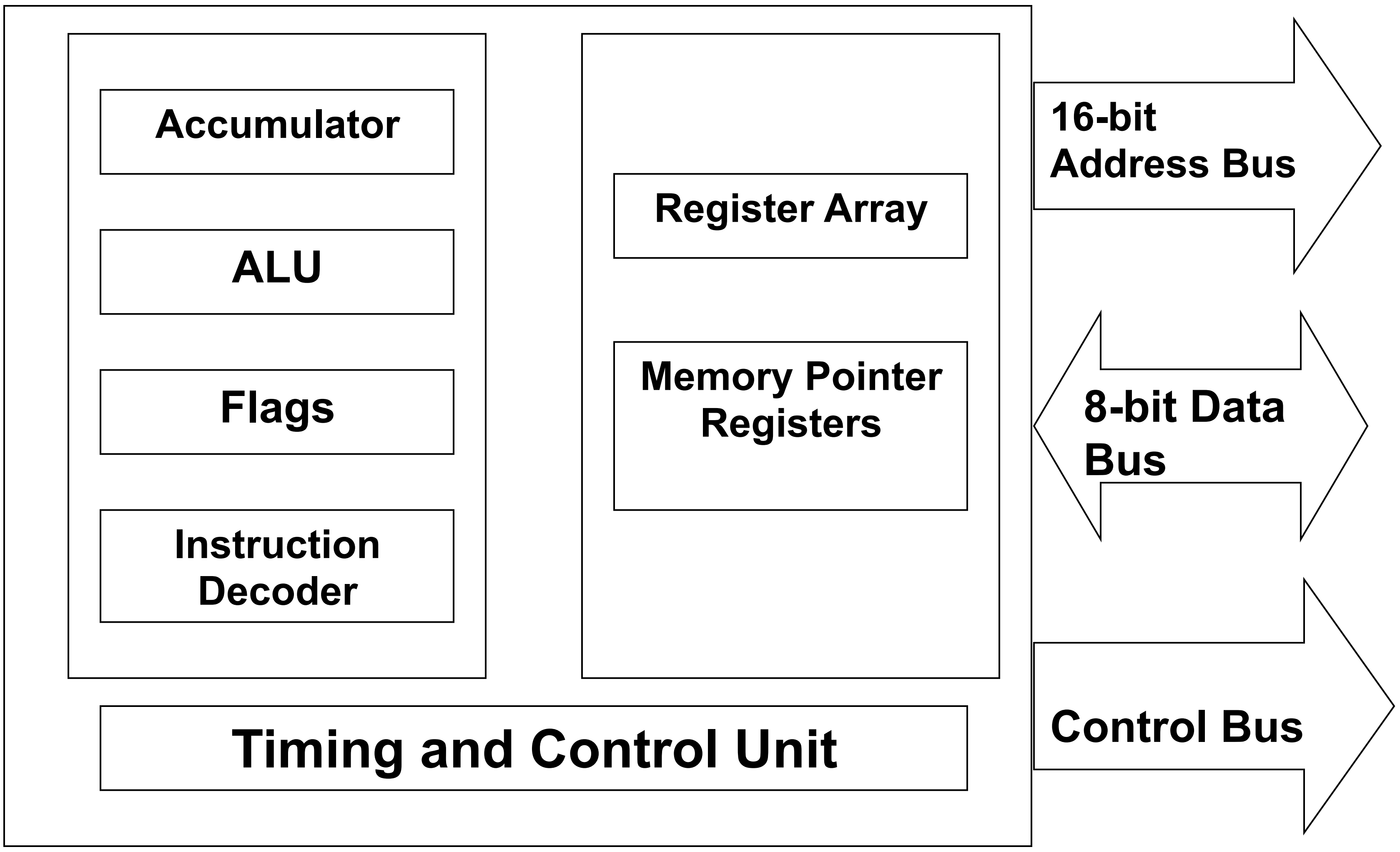


The Control and Status Signals

- 4 main control and status signals.
  - ALE: Address Latch Enable. This signal is a pulse that become 1 when the AD0 – AD7 lines have an address on them. It becomes 0 after that. This signal can be used to enable a latch to save the address bits from the AD lines.
  - RD: Read. Active low.
  - WR: Write. Active low.
  - IO/M: This signal specifies whether the operation is a memory operation (IO/M=0) or an I/O operation (IO/M=1).
  - S1 and S0 : Status signals to specify the kind of operation being performed. Usually not used in small systems.

INSTRUCTION SET OF 8085

Programming model of 8085



Programming model of 8085

<table>
<tr><td rowspan="2">Accumulator (8-bit)</td><td colspan="8">Flag Register (8-bit)</td></tr>
<tr><td>S</td><td>Z</td><td></td><td>AC</td><td></td><td>P</td><td></td><td>CY</td></tr>
<tr><td>B (8-bit)</td><td colspan="8">C (8-bit)</td></tr>
<tr><td>D (8-bit)</td><td colspan="8">E (8-bit)</td></tr>
<tr><td>H (8-bit)</td><td colspan="8">L (8-bit)</td></tr>
<tr><td colspan="9">Stack Pointer (SP) (16-bit)</td></tr>
<tr><td colspan="9">Program Counter (PC) (16-bit)</td></tr>
</table>

8- Lines

Bidirectional

16- Lines

Unidirectional

Instruction Set of 8085

- Instructions
  - 74 operation codes, e.g. ADD
  - 246 Instructions, e.g. ADD B
- 8085 instructions can be classified as

1. **Data Transfer (Copy)**
2. **Arithmetic**
3. **Logical and Bit manipulation**
4. **Branch**
5. **Machine Control**

Addressing Modes of 8085

- The various formats of specifying operands are called addressing modes
- Addressing modes of 8085
  - Register Addressing
  - Immediate Addressing
  - Memory Addressing
  - Input/Output Addressing

Data movement instructions for the 8085 microprocessor

Instruction	Operation
NOP	No operation
MOV $r1, r2$	$r1 = r2$
MOV r, M	$r = \mathrm{M}[HL]$
MOV M, r	$\mathrm{M}[HL] = r$
MVI r, n	$r = n$
MVI M, n	$\mathrm{M}[HL] = n$
LXI rp, Γ	$rp = \Gamma$
LDA Γ	$A = \mathrm{M}[\Gamma]$
STA Γ	$\mathrm{M}[\Gamma] = A$
LHLD Γ	$HL = \mathrm{M}[\Gamma], \mathrm{M}[\Gamma+1]$
SHDL Γ	$\mathrm{M}[\Gamma], \mathrm{M}[\Gamma+1] = HL$

Instruction	Operation
LDAX rp	$A = \mathrm{M}[rp]$ ($rp = BC, DE$)
STAX rp	$\mathrm{M}[rp] = A$ ($rp = BC, DE$)
XCHG	$DE \leftrightarrow HL$
PUSH rp	Stack $= rp$ ($rp \neq SP$)
PUSH PSW	Stack $= A$, flag register
POP rp	$rp =$ Stack ($rp \neq SP$)
POP PSW	A, flag register $=$ Stack
XTHL	$HL \leftrightarrow$ Stack
SPHL	$SP = HL$
IN n	$A =$ input port n
OUT n	output port $n = A$

Data Operation instructions for the 8085 microprocessor

Instruction	Operation	Flags
ADD r	$A = A + r$	All
ADD M	$A = A + \mathrm{M}[HL]$	All
ADI n	$A = A + n$	All
ADC r	$A = A + r + CY$	All
ADC M	$A = A + \mathrm{M}[HL] + CY$	All
ACI n	$A = A + n + CY$	All
SUB r	$A = A - r$	All
SUB M	$A = A - \mathrm{M}[HL]$	All
SUI n	$A = A - n$	All
SBB r	$A = A - r - CY$	All
SBB M	$A = A - \mathrm{M}[HL] - CY$	All
SBI n	$A = A - n - CY$	All
INR r	$r = r + 1$	Not CY
INR M	$\mathrm{M}[HL] = \mathrm{M}[HL] + 1$	Not CY
DCR n	$r = r - 1$	Not CY
DCR M	$\mathrm{M}[HL] = \mathrm{M}[HL] - 1$	Not CY
INX rp	$rp = rp + 1$	None
DCX rp	$rp = rp - 1$	None
DAD rp	$HL = HL + rp$	CY
DAA	Decimal adjust	All

Instruction	Operation	Flags
ANA r	$A = A \wedge r$	All
ANA M	$A = A \wedge \mathrm{M}[HL]$	All
ANI n	$A = A \wedge n$	All
ORA r	$A = A \vee r$	All
ORA M	$A = A \vee \mathrm{M}[HL]$	All
ORI n	$A = A \vee n$	All
XRA r	$A = A \oplus r$	All
XRA M	$A = A \oplus \mathrm{M}[HL]$	All
XRI n	$A = A \oplus n$	All
CMP r	Compare A and r	All
CMP M	Compare A and $\mathrm{M}[HL]$	All
CPI n	Compare A and n	All
RLC	$CY = \mathrm{A}_7,\ A = \mathrm{A}_{6-0},\ \mathrm{A}_7$	CY
RRC	$CY = \mathrm{A}_0,\ A = \mathrm{A}_0,\ \mathrm{A}_{7-1}$	CY
RAL	$CY, A = A, CY$	CY
RAR	$A, CY = CY, A$	CY
CMA	$A = A'$	None
CMC	$CY = CY'$	CY
STC	$CY = 1$	CY

Program Control instructions for the 8085 microprocessor

Instruction	Operation
JUMP Γ	GOTO Γ
J*cond* Γ	If condition is true then GOTO Γ
PCHL	GOTO address in *HL*
CALL Γ	Call subroutine at Γ
C*cond* Γ	If condition is true then call subroutine at Γ
RET	Return from subroutine
R*cond*	If condition is true then return from subroutine
RSTn	Call subroutine at 8*n (n = 5.5, 6.5, 7.5)
RIM	$A = IM$
SIM	$IM = A$
DI	Disable interrupts
EI	Enable interrupts
HLT	Halt the CPU

Register Addressing

- Operands are one of the internal registers of 8085
- Examples-

  MOV A, B

  ADD C

Immediate Addressing

- Value of the operand is given in the instruction itself
- Example-

  MVI A, 20H

  LXI H, 2050H

  ADI 30H

  SUI 10H

Memory Addressing

- One of the operands is a memory location
- Depending on how address of memory location is specified, **memory** addressing is of two types
  - **Direct** addressing
  - **Indirect** addressing

Direct Addressing

- 16-bit Address of the memory location is specified in the instruction directly
- Examples-

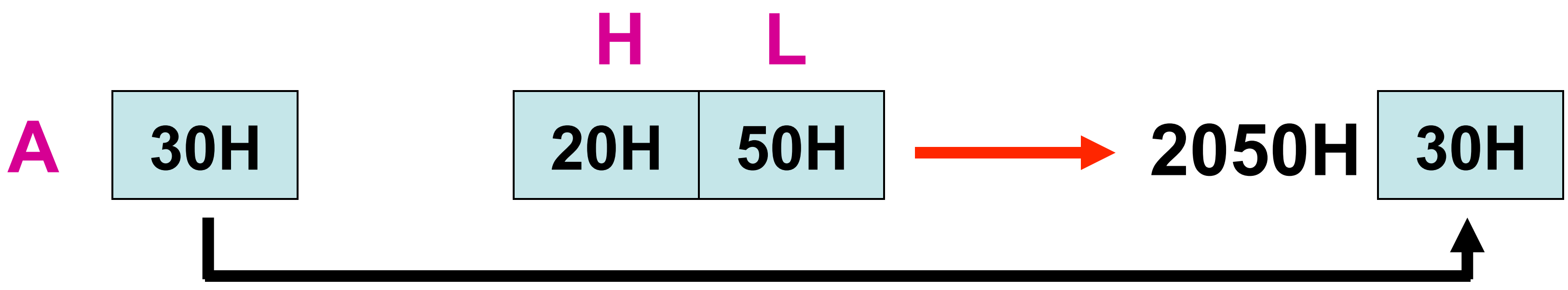
LDA 2050H

STA 3050H

Indirect Addressing

- A memory pointer register is used to store the address of the memory location
- Example-

MOV M, A ;copy register A to memory location whose address is stored in register pair HL



Input/Output Addressing

- 8-bit address of the port is directly specified in the instruction
- Examples-

  IN 07H

  OUT 21H

Instruction & Data Formats

Instruction classification according to size

- 1-byte Instructions
- 2-byte Instructions
- 3-byte Instructions

One-byte Instructions

- Includes Opcode and Operand in the same byte
- Examples-

Opcode	Operand	Binary Code	Hex Code
MOV	**C, A**	0100 1111	**4F**H
ADD	**B**	1000 0000	**80**H
HLT		0111 0110	**76**H

Two-byte Instructions

- First byte specifies Operation Code
- Second byte specifies Operand

Opcode	Operand	Binary Code	Hex Code
MVI	A, 32H	0011 1110 0011 0010	3EH 32H
MVI	B, F2H	0000 0110 1111 0010	06H F2H

Three-byte Instructions

- First byte specifies Operation Code
- Second & Third byte specifies Operand

Opcode	Operand	Binary Code	Hex Code
LXI	H, 2050H	0010 0001	21H
		0101 0000	50H
		0010 0000	20H
LDA	3070H	0011 1010	3AH
		0111 0000	70H
		0011 0000	30H

Data Transfer (Copy) Operations

1. **Load** a 8-bit number in a Register
2. **Copy** from Register to Register
3. **Copy** between Register and Memory
4. **Copy** between Input/Output Port and Accumulator
5. **Load** a 16-bit number in a Register pair
6. **Copy** between Register pair and Stack memory

Example Data Transfer (Copy) Operations / Instructions

Operations	Instructions
1. **Load** a 8-bit number 4F in register B	**MVI B, 4FH**
2. **Copy** from Register B to Register A	**MOV A,B**
3. **Load** a 16-bit number 2050 in Register pair HL	**LXI H, 2050H**
4. **Copy** from Register B to Memory Address 2050	**MOV M,B**
5. **Copy** between Input/Output Port and Accumulator	**OUT 01H** **IN 07H**

Arithmetic Operations

1. **Addition** of two 8-bit numbers
2. **Subtraction** of two 8-bit numbers
3. **Increment/ Decrement** a 8-bit number

Example Arithmetic Operations / Instructions

Operation	Instruction
1. **Add** a 8-bit number 32H to Accumulator	**ADI 32H**
2. **Add** contents of Register B to Accumulator	**ADD B**
3. **Subtract** a 8-bit number 32H from Accumulator	**SUI 32H**
4. **Subtract** contents of Register C from Accumulator	**SUB C**
5. **Increment** the contents of Register D by 1	**INR D**
6. **Decrement** the contents of Register E by 1	**DCR E**

Logical & Bit Manipulation Operations

- **AND** two 8-bit numbers
- **OR** two 8-bit numbers
- **Exclusive-OR** two 8-bit numbers
- **Compare** two 8-bit numbers
- **Complement**
- **Rotate** Left/Right Accumulator bits

Example Logical & Bit Manipulation Operations / Instructions

Operations	Instructions
Logically **AND** Register H with Accumulator	**ANA H**
Logically **OR** Register L with Accumulator	**ORA L**
Logically **XOR** Register B with Accumulator	**XRA B**
Compare contents of Register C with Accumulator	**CMP C**
Complement Accumulator	**CMA**
Rotate Accumulator Left	**RAL**

Branching Operations

- control the flow of program execution
  - **Jumps**
    - Conditional jumps
    - Unconditional jumps
  - **Call** & **Return**
    - Conditional Call & Return
    - Unconditional Call & Return

Example Branching Operations / Instructions

Operations	Instructions
1. **Jump** to a 16-bit Address 2080H if Carry flag is **SET**	JC **2080H**
2. Unconditional **Jump**	JMP **2050H**
3. **Call** a subroutine with its 16-bit Address	CALL **3050H**
4. **Return back** from the Call	RET
5. **Call** a subroutine with its 16-bit Address if **C**arry flag is **RESET**	CNC 3050H
6. **Return** if **Z**ero flag is **SET**	RZ

Machine Control Instructions

- Affect the operation of the processor

HLT	Stop program execution
NOP	Do not perform any operation

Writing a Assembly Language Program

Steps to write a program

- Analyze the problem
- Develop algorithm
- Draw a flowchart
- Convert flowchart to Assembly language by picking appropriate 8085 instructions

Example 1

- Add two numbers
- Copy 8-bit result in A to C
- If CARRY is generated
  - Handle it
- Result is in register pair BC

Algorithm Development

1. Load two numbers in registers D, E

3. Add them

5. Store 8 bit result in C

7. Check CARRY flag

8. If CARRY flag is SET
   - Store CARRY in register B

9. Stop

- Load registers D, E

- Copy register D to A
- Add register E to A

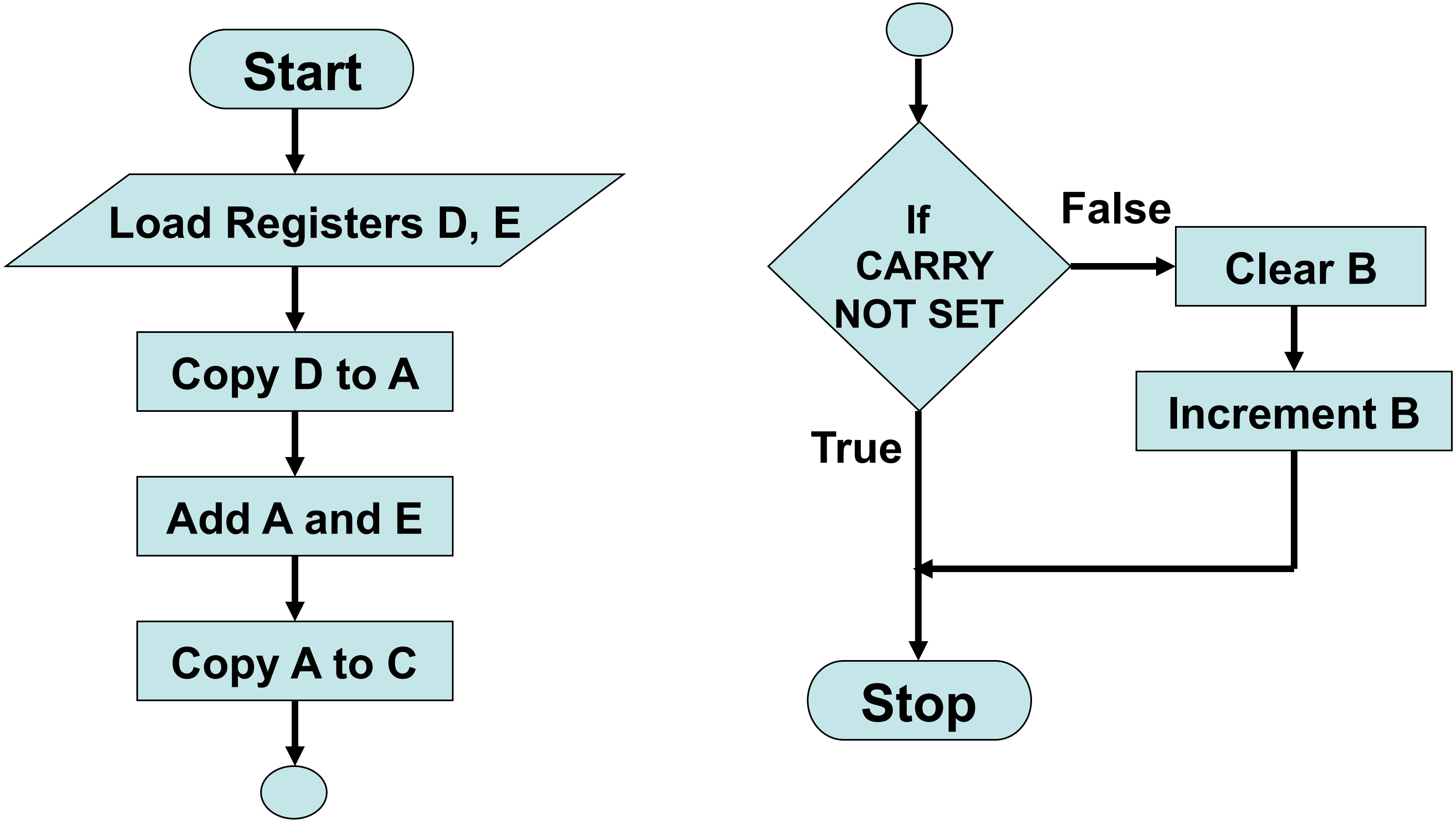
- Copy A to register C

- Use Conditional Jump instructions

- Clear register B
- Increment B

- Stop processing

Flowchart


Start
Load Registers D, E
Copy D to A
Add A and E
Copy A to C
If
CARRY
NOT SET
False
Clear B
Increment B
True
Stop

Assembly Language Program

• Load registers D, E	MVI D, 2H MVI E, 3H
• Copy register D to A • Add register E to A	MOV A, D ADD E
• Copy A to register C	MOV C, A
• Use Conditional Jump instructions	JNC END
• Clear register B • Increment B	MVI B, 0H INR B
• Stop processing	**END:** HLT

Example 2: Sum of Natural Numbers

The Algorithm of the program

1:	total = 0, i = 0	n + (n - 1) + … + 1
2:	i = i + 1	
3:	total = total + i	
4:	IF I /= n THEN GOTO **2**	

The 8085 coding of the program

LDA n MOV B, A	i = n
XRA A	sum = A XOR A = 0
Loop: ADD B	sum = sum + i
DCR B	i = i - 1
JNZ Loop	IF I /= 0 THEN GOTO Loop
STA total	total = sum

MICROCONTROLLER

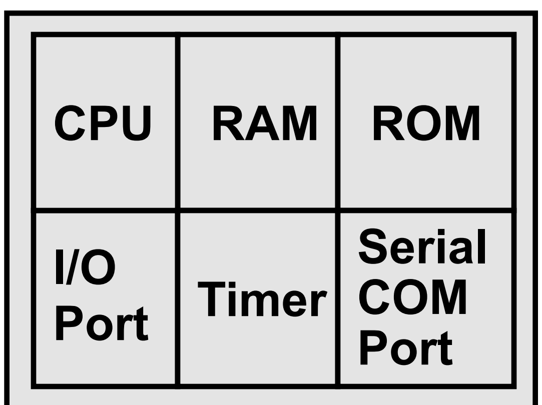
8051

Three criteria in Choosing a Microcontroller

- meeting the computing needs of the task efficiently and cost effectively
  - speed, the amount of ROM and RAM, the number of I/O ports and timers, size, packaging, power consumption
  - easy to upgrade
  - cost per unit
- availability of software development tools
  - assemblers, debuggers, C compilers, emulator, simulator, technical support
- wide availability and reliable sources of the microcontrollers

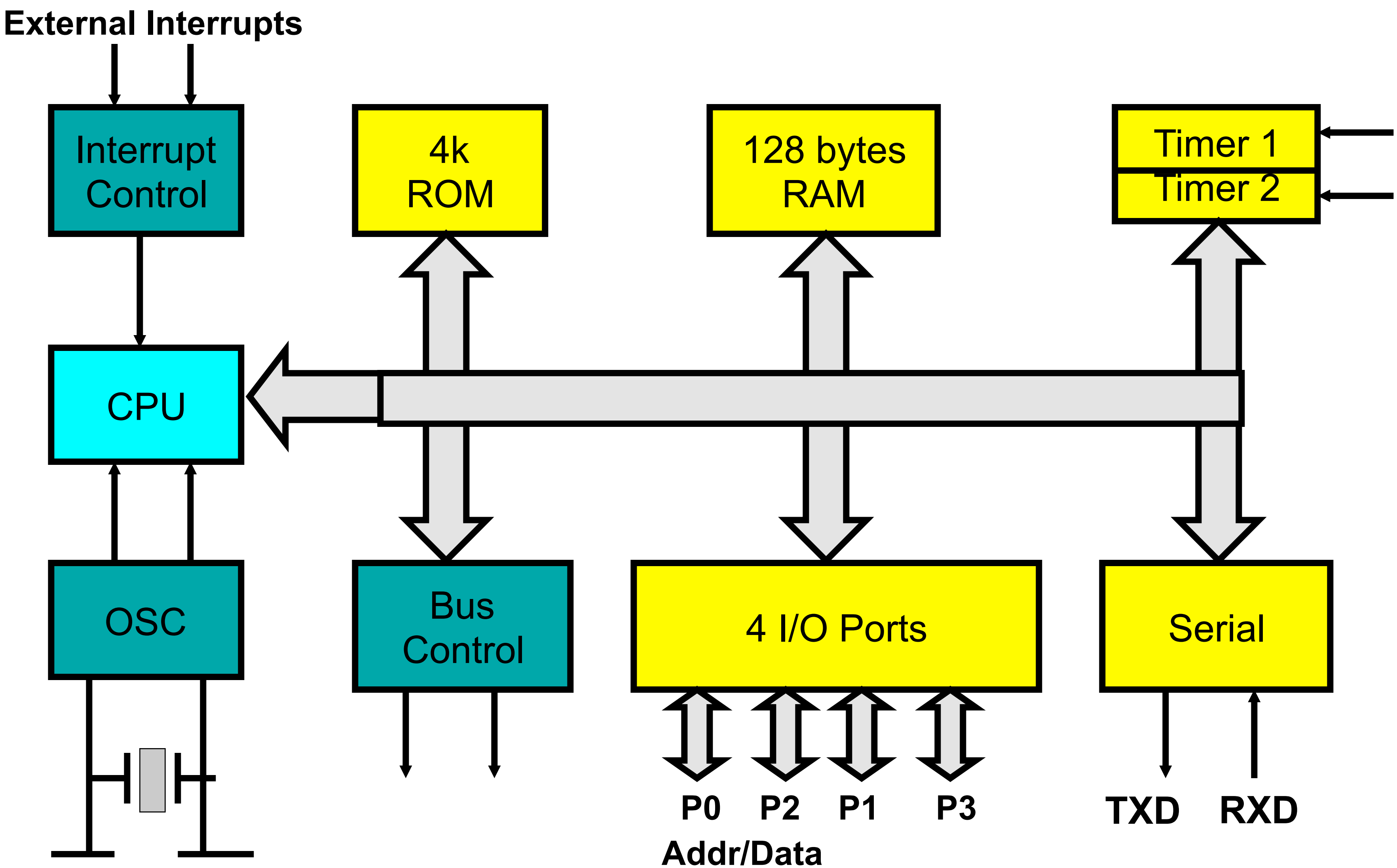
8051 Basic Component

- 4K bytes internal ROM
- 128 bytes internal RAM
- Four 8-bit I/O ports (P0 - P3).
- Two 16-bit timers/counters
- One serial interface

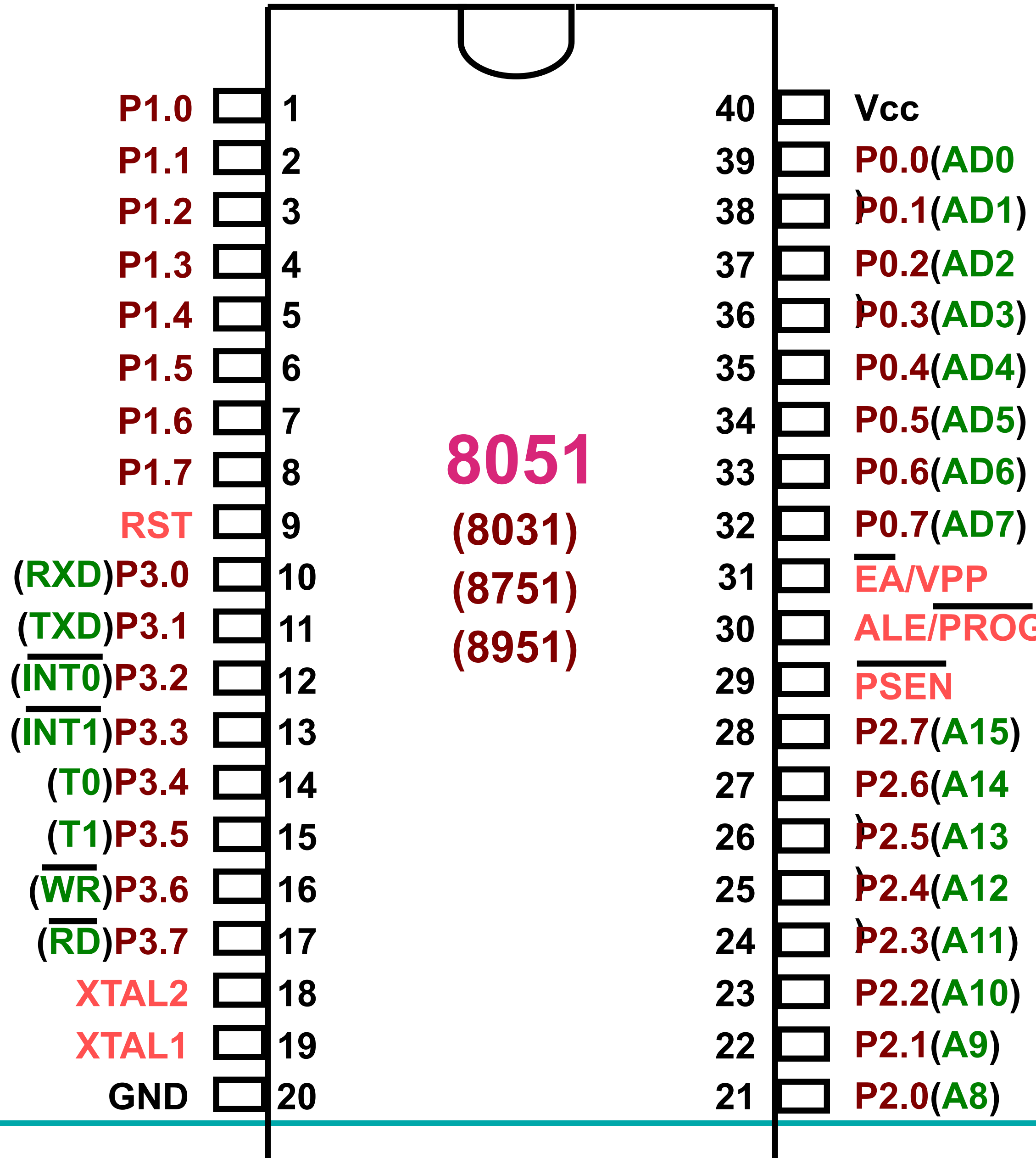


A single chip Microcontroller

Block Diagram



8051 Foot Print



Thank You