8051 Microcontroller: Programming

Virendra Singh
Associate Professor
Computer Architecture and Dependable Systems Lab
Department of Electrical Engineering
Indian Institute of Technology Bombay
http://www.ee.iitb.ac.in/~viren/
E-mail: viren@ee.iitb.ac.in

EE-309: Microprocessors

Lecture 7 (31 July 2014)

CADSL

Addressing Modes

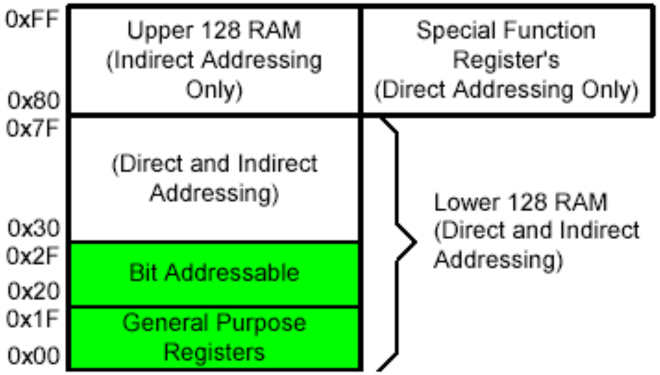
- Eight modes of addressing are available
- The different addressing modes determine how the operand byte is selected

Addressing Modes	Instruction
Register	MOV A, B
Direct	MOV 30H,A
Indirect	ADD A,@R0
Immediate Constant	ADD A,#80H
Relative*	SJMP AHEAD
Absolute*	AJMP BACK
Long*	LJMP FAR_AHEAD
Indexed	MOVC A,@A+PC

* Related to program branching instructions

Data Transfer Instructions

- Data transfer instructions can be used to transfer data between an internal RAM location and an SFR location without going through the accumulator
- It is also possible to transfer data between the internal and external RAM by using indirect addressing
- The upper 128 bytes of data RAM are accessed only by indirect addressing and the SFRs are accessed only by direct addressing



0xFF
0x80
0x7F
0x30
0x2F
0x20
0x1F
0x00

Upper 128 RAM (Indirect Addressing Only)

Special Function Register's (Direct Addressing Only)

(Direct and Indirect Addressing)

Bit Addressable

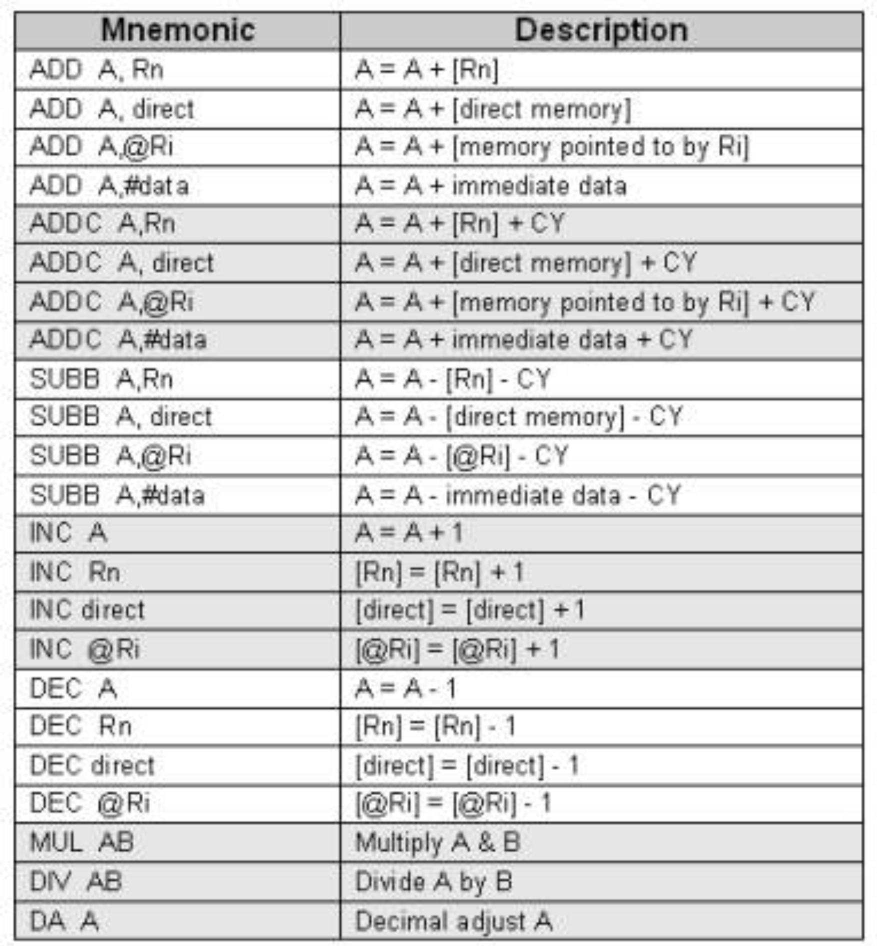
General Purpose Registers

Lower 128 RAM (Direct and Indirect Addressing)

Mnemonic	Description
MOV @Ri, direct	[@Ri] = [direct]
MOV @Ri, #data	[@Ri] = immediate data
MOV DPTR, #data 16	[DPTR] = immediate data
MOVC A,@A+DPTR	A = Code byte from [@A+DPTR]
MOVC A,@A+PC	A = Code byte from [@A+PC]
MOVX A,@Ri	A = Data byte from external ram [@Ri]
MOVX A,@DPTR	A = Data byte from external ram [@DPTR]
MOVX @Ri, A	External[@Ri] = A
MOVX @DPTR,A	External[@DPTR] = A
PUSH direct	Push into stack
POP direct	Pop from stack
XCH A,Rn	A = [Rn], [Rn] = A
XCH A, direct	A = [direct], [direct] = A
XCH A, @Ri	A = [@Rn], [@Rn] = A
XCHD A,@Ri	Exchange low order digits

Arithmetic Operations

- The appropriate status bits in the PSW are set when specific conditions are met, which allows the user software to manage the different data formats



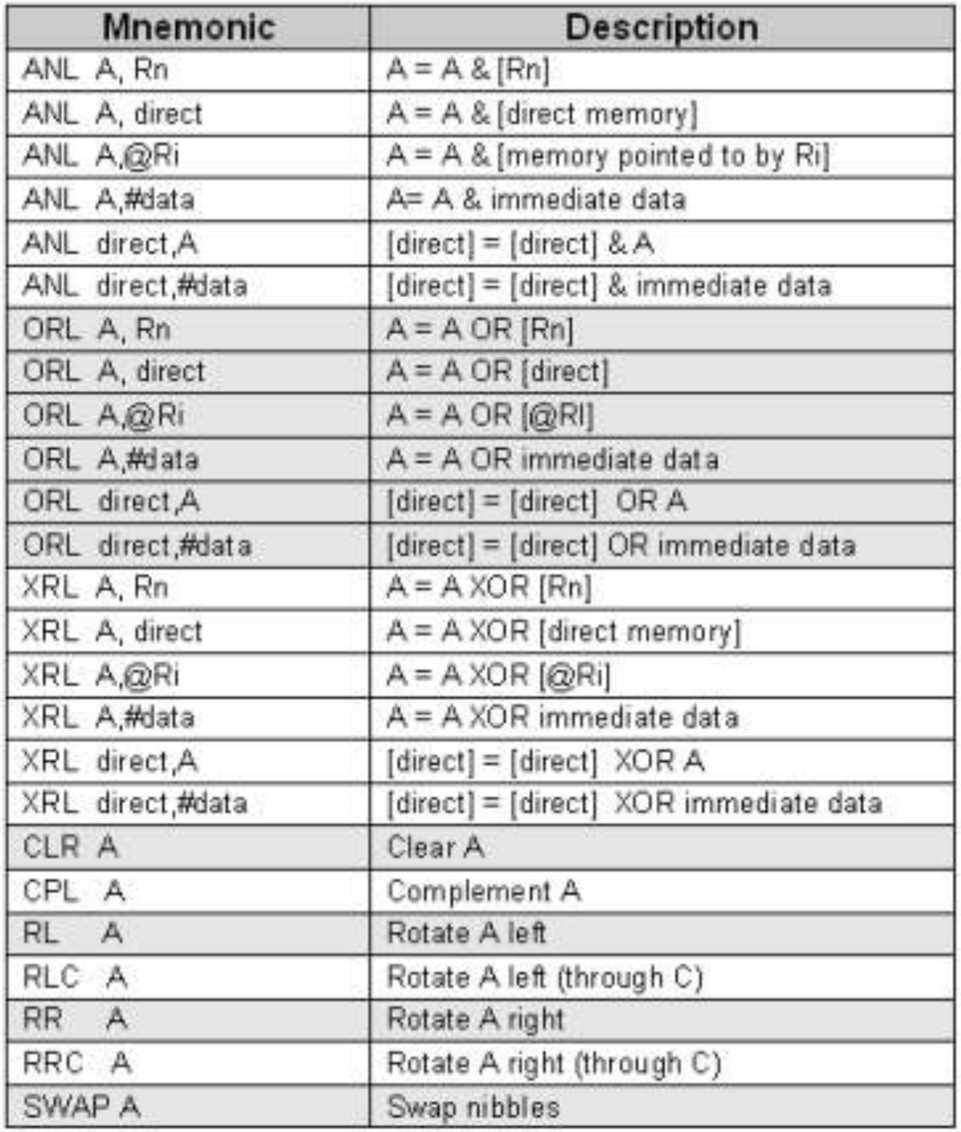
Mnemonic	Description
ADD A, Rn	A = A + [Rn]
ADD A, direct	A = A + [direct memory]
ADD A,@Ri	A = A + [memory pointed to by Ri]
ADD A,#data	A = A + immediate data
ADDC A,Rn	A = A + [Rn] + CY
ADDC A, direct	A = A + [direct memory] + CY
ADDC A,@Ri	A = A + [memory pointed to by Ri] + CY
ADDC A,#data	A = A + immediate data + CY
SUBB A,Rn	A = A - [Rn] - CY
SUBB A, direct	A = A - [direct memory] - CY
SUBB A,@Ri	A = A - [@Ri] - CY
SUBB A,#data	A = A - immediate data - CY
INC A	A = A + 1
INC Rn	[Rn] = [Rn] + 1
INC direct	[direct] = [direct] + 1
INC @Ri	[@Ri] = [@Ri] + 1
DEC A	A = A - 1
DEC Rn	[Rn] = [Rn] - 1
DEC direct	[direct] = [direct] - 1
DEC @Ri	[@Ri] = [@Ri] - 1
MUL AB	Multiply A & B
DIV AB	Divide A by B
DA A	Decimal adjust A

- [@Ri] implies contents of memory location pointed to by R0 or R1
- Rn refers to registers R0-R7 of the currently selected register bank

Logical Operations

- Logical instructions perform Boolean operations (AND, OR, XOR, and NOT) on data bytes on a *bit-by-bit* basis
- Examples:

```
ANL  A, #02H ;Mask bit 1
ORL  TCON, A ;TCON=TCON-OR-A
```



Mnemonic	Description
ANL A, Rn	A = A & [Rn]
ANL A, direct	A = A & [direct memory]
ANL A,@Ri	A = A & [memory pointed to by Ri]
ANL A,#data	A= A & immediate data
ANL direct,A	[direct] = [direct] & A
ANL direct,#data	[direct] = [direct] & immediate data
ORL A, Rn	A = A OR [Rn]
ORL A, direct	A = A OR [direct]
ORL A,@Ri	A = A OR [@RI]
ORL A,#data	A = A OR immediate data
ORL direct,A	[direct] = [direct] OR A
ORL direct,#data	[direct] = [direct] OR immediate data
XRL A, Rn	A = A XOR [Rn]
XRL A, direct	A = A XOR [direct memory]
XRL A,@Ri	A = A XOR [@Ri]
XRL A,#data	A = A XOR immediate data
XRL direct,A	[direct] = [direct] XOR A
XRL direct,#data	[direct] = [direct] XOR immediate data
CLR A	Clear A
CPL A	Complement A
RL A	Rotate A left
RLC A	Rotate A left (through C)
RR A	Rotate A right
RRC A	Rotate A right (through C)
SWAP A	Swap nibbles

Boolean Variable Instructions

8051 can perform single bit operations

- The operations include *set, clear, and, or* and *complement* instructions
- Also included are bit–level moves or conditional jump instructions
- All bit accesses use direct addressing

- **Examples:**

```
SETB  TR0    ;Start Timer0.

POLL: JNB    TR0, POLL  ;Wait
   till timer overflows.
```

Mnemonic	Description
CLR C	Clear C
CLR bit	Clear direct bit
SETB C	Set C
SETB bit	Set direct bit
CPL C	Complement c
CPL bit	Complement direct bit
ANL C,bit	AND bit with C
ANL C,/bit	AND NOT bit with C
ORL C,bit	OR bit with C
ORL C,/bit	OR NOT bit with C
MOV C,bit	MOV bit to C
MOV bit,C	MOV C to bit
JC rel	Jump if C set
JNC rel	Jump if C not set
JB bit,rel	Jump if specified bit set
JNB bit,rel	Jump if specified bit not set
JBC bit,rel	if specified bit set then clear it and jump

Program Branching Instructions

- Program branching instructions are used to control the flow of program execution
- Some instructions provide decision making capabilities before transferring control to other parts of the program (conditional branches).

Mnemonic	Description
ACALL addr11	Absolute subroutine call
LCALL addr16	Long subroutine call
RET	Return from subroutine
RETI	Return from interrupt
AJMP addr11	Absolute jump
LJMP addr16	Long jump
SJMP rel	Short jump
JMP @A+DPTR	Jump indirect
JZ rel	Jump if A=0
JNZ rel	Jump if A NOT=0
CJNE A,direct,rel	Compare and Jump if Not Equal
CJNE A,#data,rel	
CJNE Rn,#data,rel	
CJNE @Ri,#data,rel	
DJNZ Rn,rel	Decrement and Jump if Not Zero
DJNZ direct,rel	
NOP	No Operation

Example 1:ASCII to BCD

Convert ASCII character to BCD

```
            MOV A, #’8’          ; (A) = 38 H ASCII code of 8
            MOV R1, #’6’         ; (R1) = 36 H
            ANL A, #0FH
            ANL R1, #0FH
            SWAP A
            L A, R1
STOP:       SJMP STOP
```

Example 2: Conversion to 3 digit BCD

Conversion of one byte binary data to 3 digit BCD

```
        MOV A, #‘C’
        MOV B, #100
        DIV AB
        MOV R1, A
        XCH A, B
        MOV B, #10
        DIV AB
        SWAP A
        ADD A, B
        MOV R2, A
STOP:   SJMP STOP
```

Example 3: Multibyte Addition

Addition of Multiple numbers stored at 50H

```
            MOV R1, #50H
            MOV R2, #5
            CLR A
            MOV R5, A
AGAIN:      ADD A, @R1
            JNC NEXT
            INC R5
NEXT        INC R1
            DJNZ R2, AGAIN
HERE        SJMP HERE
```

Example 4: Checksum Computation

Checksum computation of 50 numbers

```
            MOV R1, @30H
            MOV R2, #50
            CLR A
AGAIN:      ADD A, @R1
            INC R1
            DJNZ R2, AGAIN
            MOV R3, A
STOP:       SJMP STOP
```

Example 5: Sequential Search

Sequential Search

```
NUM:      EQU 49H
          MOV B, #50
          MOV R0, #40H
NEXT:     MOV A, @R0
          CJNE A, #NUM, FORWARD
          MOV R3, 00H
          SJMP STOP
FORWARD:  INC R0
          DJNZ R2, NEXT
          CLR A
STOP:     SJMP STOP
```

Example 6: Bubble Sort

Bubble Sort

```
        MOV R2, #50
LOOP2:  MOV R0, #40H
        MOV R3, 2
LOOP1:  DEC R3
        CLR C
        MOV A, @R0
        INC R0
        MOV R6, A
        SUBB A, @R0
        JC NEXT
        MOV A, R6
        XCH A, @R0
        DEC R0
        MOV @R0, A
        INC R0
NEXT:   CJNE R3, #0, LOOP1
        DEC R2
        CJNE R2, #0, LOOP2
STOP:   SJMP STOP
```

Example 7: Subroutine Call

Delay Routine

```
        ORG 0
0000    MOV A, #55H
0002    MOV R4, #80H
0004    MOV R6, #98H
0006    LCALL DELAY
0009    ADD A, R4
        . . .
        . . .
```

```
        ORG 200H
DELAY:  MOV R4, #0DEH
LOOP:   MOV R6, #0FEH
HERE:   DJNZ R6, HERE
        DJNZ R4, LOOP
        RET
```

Example 7: Subroutine Call (Contd..)

Delay Routine

```
        ORG 0
0000    MOV A, #55H
0002    MOV R4, #80H
0004    MOV R6, #98H
0006    LCALL DELAY
0009    ADD A, R4
        . . .
        . . .
```

```
        ORG 200H
DELAY:  PUSH 4
        PUSH 6
        MOV R4, #0DEH
LOOP:   MOV R6, #0FEH
HERE:   DJNZ R6, HERE
        DJNZ R4, LOOP
        POP 6
        POP 4
        RET
```

Thank You