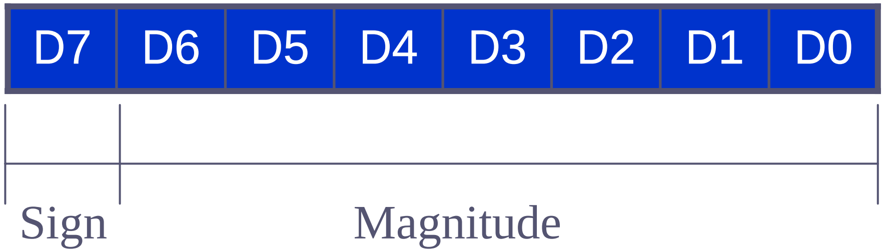
Signed 8-bit Operands

- D7 (MSB) is the sign and D0 to D6 are the magnitude of the number
  - If D7=0, the operand is positive, and if D7=1, it is negative



D7	D6	D5	D4	D3	D2	D1	D0

- Positive numbers are 0 to +127
- Negative number representation (2's complement)
  1. Write the magnitude of the number in 8-bit binary (no sign)
  2. Invert each bit
  3. Add 1 to it

SIGNED ARITHMETIC INSTRUCTIONS

Signed 8-bit Operands (cont')

Show how the 8051 would represent -34H

Solution:

```
1.    0011 0100     34H given in binary
2.    1100 1011     invert each bit
3.    1100 1100     add 1 (which is CC in hex)
```

Signed number representation of -34 in 2's complement is CCH

Decimal	Binary	Hex
-128	1000 0000	80
-127	1000 0001	81
-126	1000 0010	82
...	... ...	...
-2	1111 1110	FE
-1	1111 1111	FF
0	0000 0000	00
+1	0000 0001	01
+2	0000 0010	02
...	... ...	...
+127	0111 1111	7F

SIGNED ARITHMETIC INSTRUCTIONS

Overflow Problem

- If the result of an operation on signed numbers is too large for the register
  - An overflow has occurred and the programmer must be noticed

Examine the following code and analyze the result.

```
        MOV     A,#+96        ;A=0110 0000 (A=60H)
        MOV     R1,#+70       ;R1=0100 0110(R1=46H)
        ADD     A,R1          ;A=1010 0110
                              ;A=A6H=-90,INVALID
```

Solution:

```
        +96     0110 0000
      + +70     0100 0110
      ______    _________
      + 166     1010 0110 and OV =1
```

According to the CPU, the result is -90, which is wrong. The CPU sets OV=1 to indicate the overflow

SIGNED ARITHMETIC INSTRUCTIONS

OV Flag

- In 8-bit signed number operations, OV is set to 1 if either occurs:
  1. There is a carry from D6 to D7, but no carry out of D7 (CY=0)
  2. There is a carry from D7 out (CY=1), but no carry from D6 to D7

```
   MOV  A,#-128   ;A=1000 0000(A=80H)
   MOV  R4,#-2    ;R4=1111 1110(R4=FEH)
   ADD  A,R4      ;A=0111 1110(A=7EH=+126,INVALID)
        -128            1000 0000
     +    -2            1111 1110
        ----            ---------
        -130            0111 1110 and OV=1
```

OV = 1
The result +126 is wrong

SIGNED ARITHMETIC INSTRUCTIONS

OV Flag (cont')

```
MOV  A,#-2     ;A=1111 1110(A=FEH)
MOV  R1,#-5    ;R1=1111 1011(R1=FBH)
ADD  A,R1      ;A=1111 1001(A=F9H=-7,
               ;Correct, OV=0)
      -2           1111 1110
   +  -5           1111 1011
      -7           1111 1001 and OV=0
```

OV = 0
The result -7 is correct

```
MOV  A,#+7     ;A=0000 0111(A=07H)
MOV  R1,#+18   ;R1=0001 0010(R1=12H)
ADD  A,R1      ;A=0001 1001(A=19H=+25,
               ;Correct,OV=0)
       7           0000 0111
   +  18           0001 0010
      25           0001 1001 and OV=0
```

OV = 0
The result +25 is correct

SIGNED ARITHMETIC INSTRUCTIONS

OV Flag
(cont')

- In unsigned number addition, we must monitor the status of CY (carry)
  - Use JNC or JC instructions
- In signed number addition, the OV (overflow) flag must be monitored by the programmer
  - `JB PSW.2` or `JNB PSW.2`

SIGNED ARITHMETIC INSTRUCTIONS

2's Complement

- To make the 2’s complement of a number

```
      CPL     A           ;1’s complement (invert)
      ADD     A,#1        ;add 1 to make 2’s comp.
```