Microprocessor Based Systems

Spring 2013

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CHAPTER 7

LOGIC , SHIFT & ROTATE INSTRUCTIONS

AND, OR, and XOR Instructions

AND destination, source

OR destination, source

XOR destination, source

Effect on flags:

SF, ZF, PF reflect the result

AF is undefined

CF, OF = 0

Rules

- The destination must be a register or memory location.
- The source may be a constant, register, or memory location.
- The memory-to-memory operations are not allowed.

Use of AND, OR, and XOR Instructions

- Selectively modify the bits in the destination
- Construct a source bit pattern, **mask**
- Only desired destination bits are modified

AND

- can be used to **clear** specific destination bits while preserving the others.
- A 0 mask bit clears the corresponding destination bit.
- A 1 mask bit preserves the corresponding destination bit.

OR

- can be used to **set** specific destination bits while preserving the others.
- A 1 mask bit sets the corresponding destination bit.
- A 0 mask bit preserves the corresponding destination bit.

XOR

- can be used to **complement** specific destination bits while preserving the others.
- A 1 mask bit complements the corresponding destination bit.
- A 0 mask bit preserves the corresponding destination bit.

Clear the sign bit of AL while leaving the other bits unchanged.

Use AND with 0111 1111b = 7Fh as the mask.

Thus,

AND AL, 7Fh

Set msb and lsb of AL while preserving the other bits.

Use OR with 1000 0001b = 81h as the mask.

Thus,

OR AL, 81h

Change the sign bit of DX.

Use XOR with a mask of 8000h. Thus,

XOR DX, 8000h

Converting an ASCII Digit to a Number

If the "5" key is pressed, AL gets 35h instead of 5. To get 5 in AL, we could do this:

SUB AL, 30h

Another method is to use AND to clear the high nibble (high four bits) of AL:

AND AL, 0FH

Because the codes "0" to "9" are 30h to 39h.

Converting a Lowercase Letter to Upper Case

The ASCII codes of “a” to “z” range from 61h to 7Ah; the codes “A” to “Z” go from 41h to 5Ah.

Thus for example, if DL contains the code of a lowercase letter, we could convert to upper case by executing

SUB DL, 20h

Converting a Lowercase Letter to Upper Case

Character	Code	Character	Code
a	011**1**0 0001	A	010**0** 0001
b	011**1**0 0010	B	010**0** 0010
.	.	.	.
.	.	.	.
.	.	.	.
z	011**1**1 1010	Z	010**0**1 1010

Converting a Lowercase Letter to Upper Case

We need only clear bit 5 by using AND with 1101 1111b or 0DFh.

So if the lowercase character to be converted is in DL, execute

AND DL, 0DFh

Clearing a Register

To clear AX, we could execute

```
MOV     AX, 0
SUB     AX, AX
```

Using the fact that **1 XOR 1 = 0** and **0 XOR 0 = 0**, a third way is

```
XOR     AX, AX
```

Testing a Register for Zero

OR CX, CX

Because **1 OR 1 = 1** and **0 OR 0 = 0**, it leaves the content of CX unchanged; however, it affects ZF and SF, and in particular if CX contains 0 then ZF = 1.

So it can be used as an alternative to

CMP CX, 0

NOT Instruction

NOT **destination**

Complement the bits in AX.

NOT AX

TEST Instruction

TEST destination, source

Effect on flags:

SF, ZF, PF reflect the result

AF is undefined

CF, OF = 0

TEST Instruction

- performs an AND operation but does not change the destination content.
- The purpose of TEST is to set the status flags.

Examining Bits

TEST destination, mask

Because **1 AND b = b** and **0 AND b = 0**, the result will have 1's in the tested bit positions if and only if the destination has 1's in these positions; it will have 0's elsewhere.

If destination has 0's in all the tested position, the result will be 0 and so ZF = 1.

Jump to label BELOW if AL contains an even number

Even numbers have a 0 in bit 0. Thus, the mask is 0000 0001b = 1.

```
TEST    AL, 1     ; is AL even?
JZ      BELOW     ; yes, go to BELOW
```

Shift and Rotate Instructions

For a single shift or rotate, the form is

Opcode destination, 1

For a shift or rotate of N positions, the form is

Opcode destination, CL

Where CL contains N.

In both cases, destination is an 8- or 16-bit register or memory location.

Shift Left

SHL shifts the bits in the destination to the left.

Effect on flags:

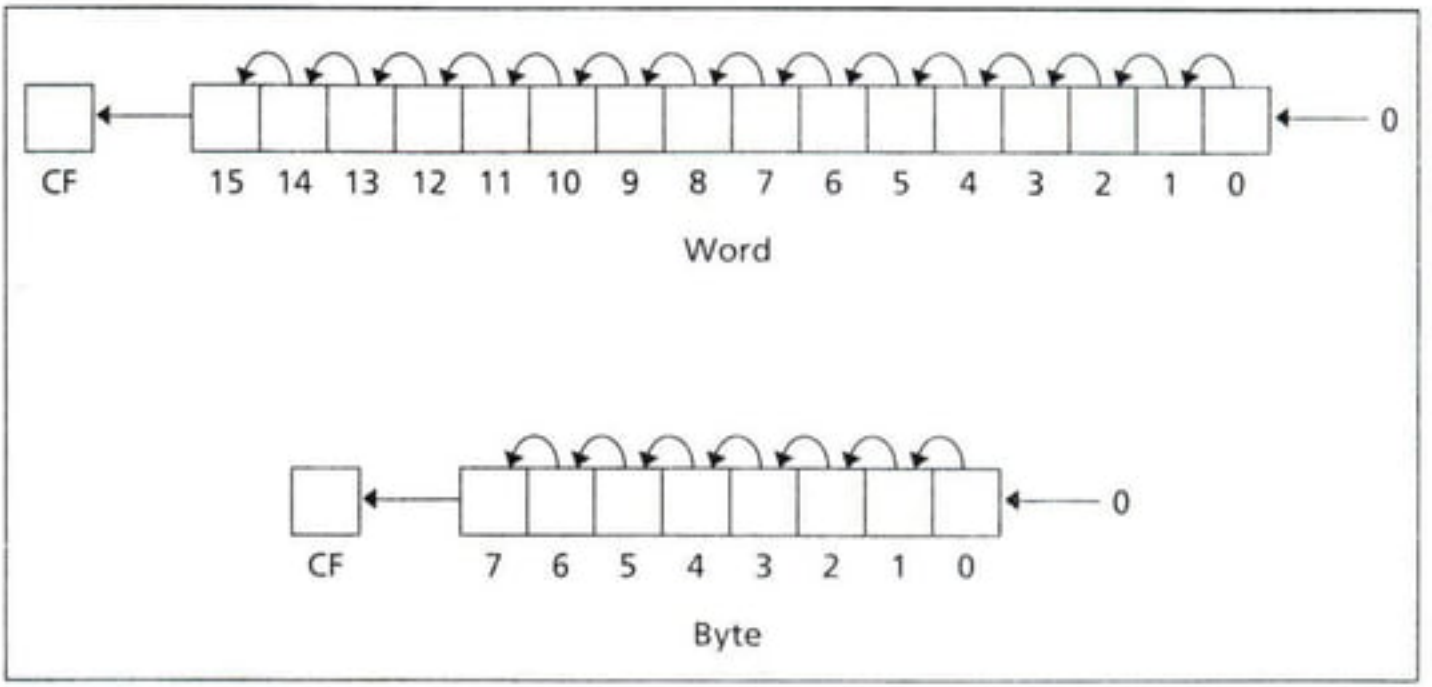
SF, ZF, PF reflect the result

AF is undefined

CF = last bit shifted out

OF = 1 if result changes sign on last shift

SHL and SAL



Multiplication by Left Shift

A left shift on a binary number multiplies it by 2.

Suppose that AL contains 5 = 00000101b. A left shift gives 00001010b = 10d, thus doubling its value.

If AX is FFFFh (–1), then shifting three times will yield AX = FFF8h (–8).

Shift Arithmetic Left

SAL is often used in instances where numeric multiplication is intended.

Both instructions generate the same machine code.

Overflow

The overflow flags are not reliable indicators for a multiple left shift because it is really a series of single shifts, and CF, OF only reflect the result of the last shift.

Overflow

If BL contains 80h, CL contains 2and we execute SHL BL, CL, then CF = OF = 0 even though both signed and unsigned overflow occur.

Write some code to multiply the value of AX by 8. Assume that overflow will not occur.

```
MOV     CL, 3       ; number of shifts to do
SAL     AX, CL      ; multiply by 8
```

Shift Right

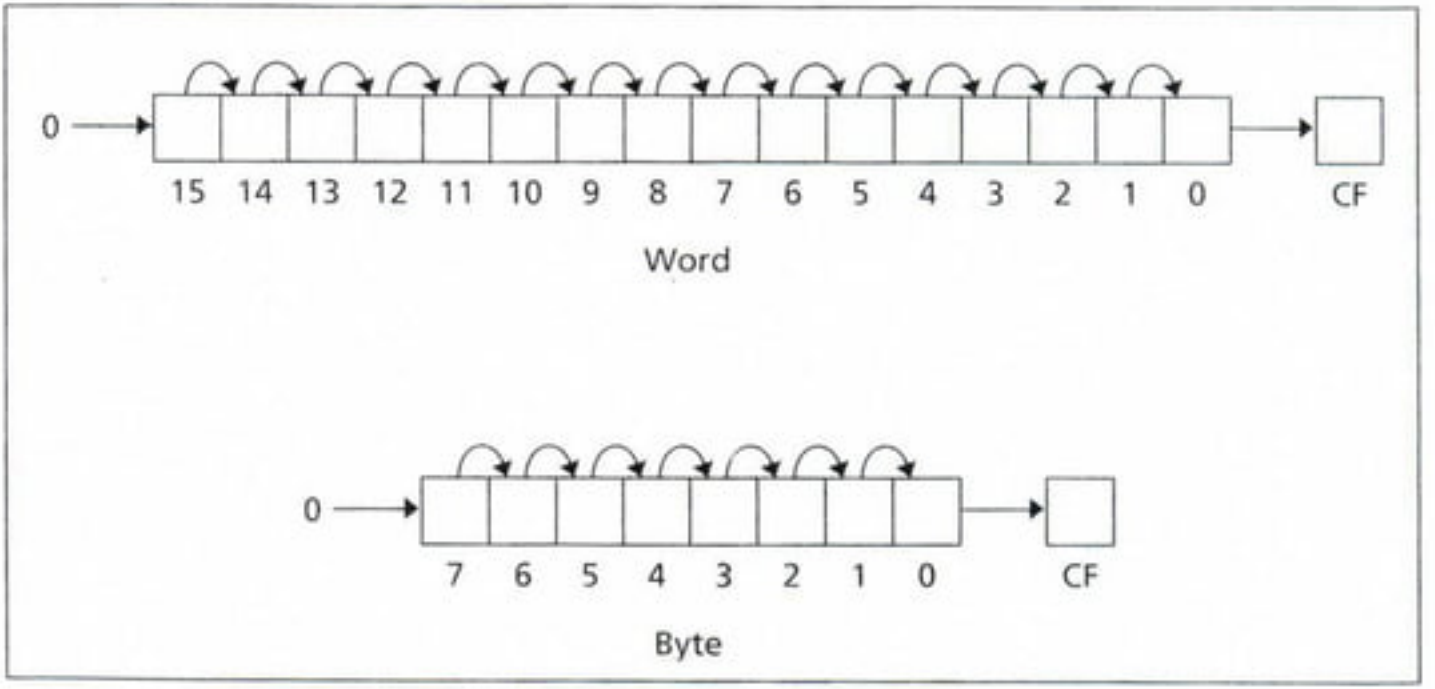
SHR performs right shifts on the destination operand.

A 0 is shifted into the msb position, and the rightmost bit is shifted into CF.

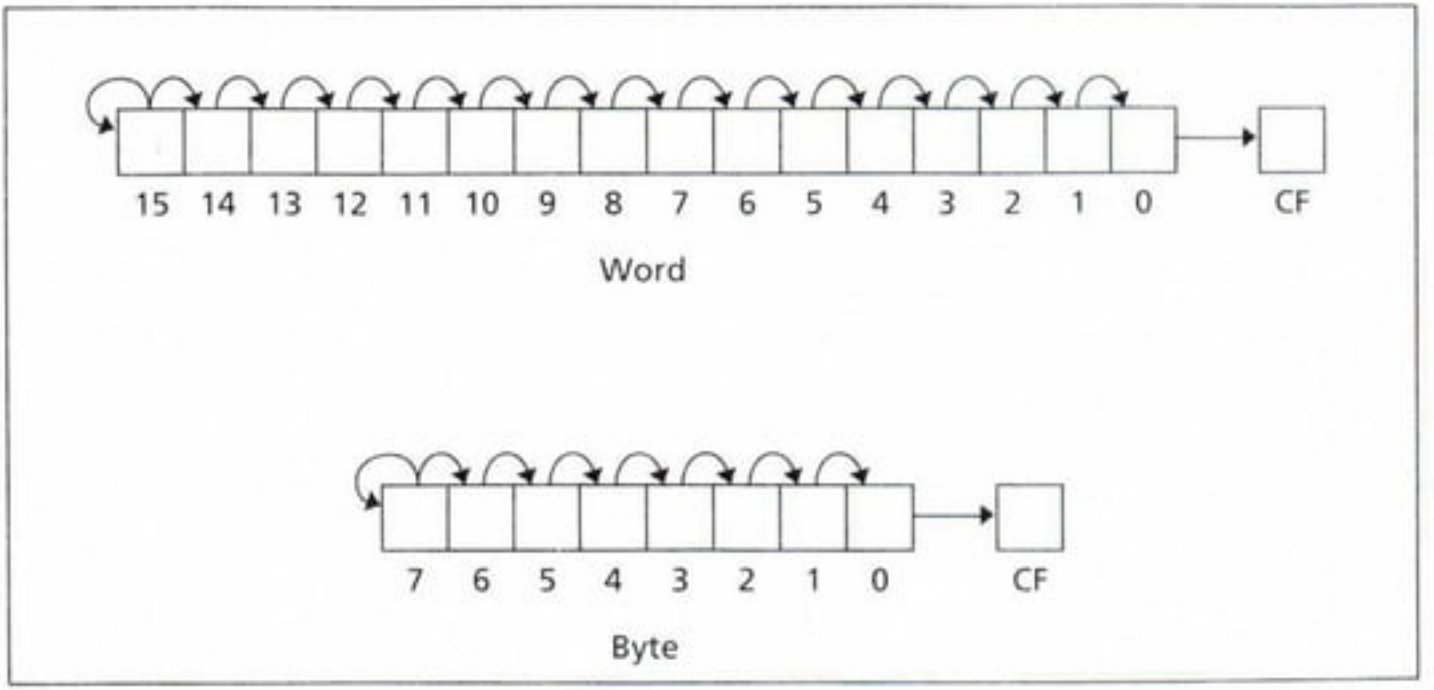
Shift Arithmetic Right

SAR operates like SHR, with one difference: the msb retains its original value.

SHR



SAR



Division by Right Shift

For even numbers, a right shift divides the destination's value by 2.

For odd numbers, a right shift halves the destination's value and round down to the nearest integer.

If BL contains 00000101b = 5, then after a right shift BL will contain 00000010b = 2.

Signed and Unsigned Division

If an unsigned interpretation is being given, SHR should be used.

For a signed interpretation, SAR must be used, because it preserves the sign.

Rotate Left

ROL shifts bits to the left.

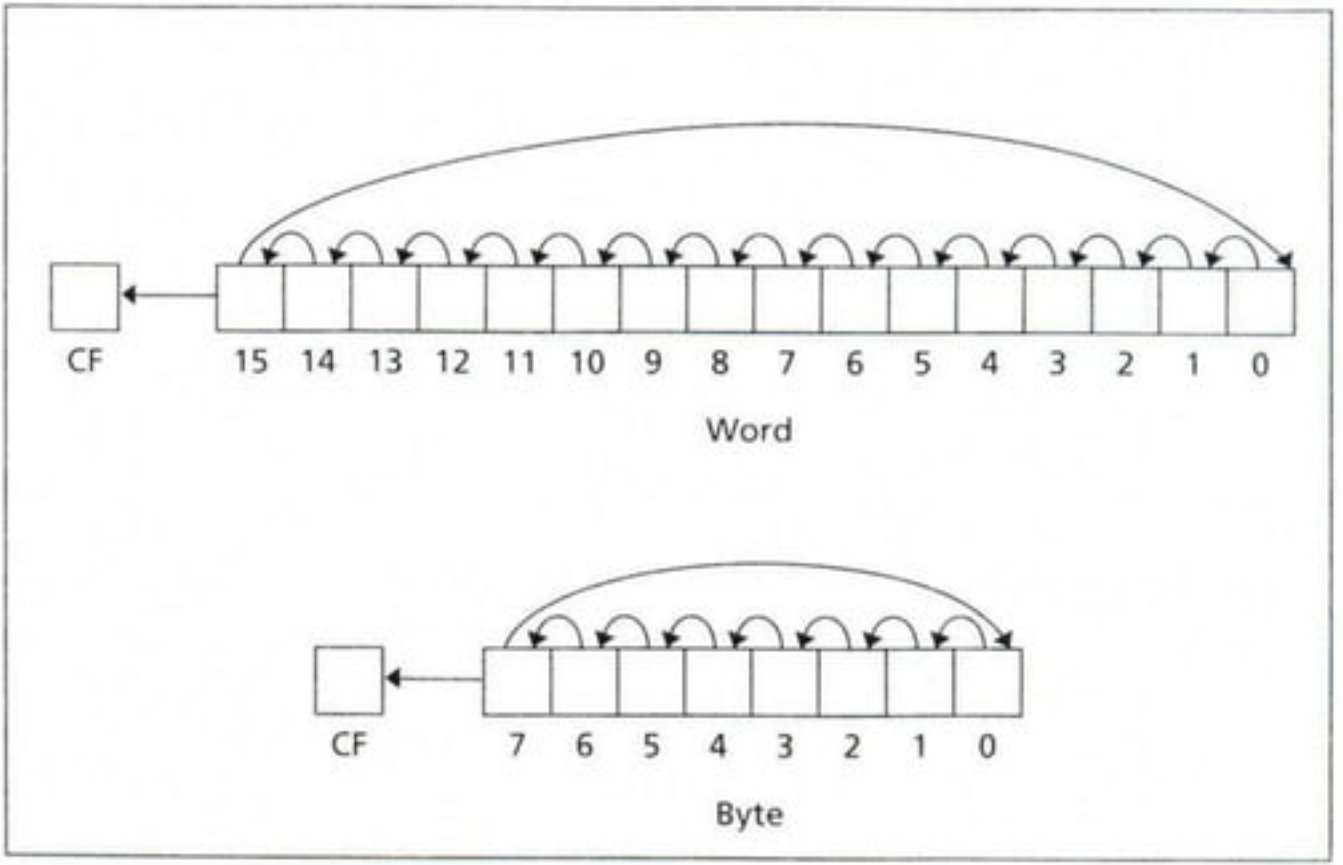
The msb is shifted into the rightmost bit.

The CF also gets the bit shifted out of the msb.

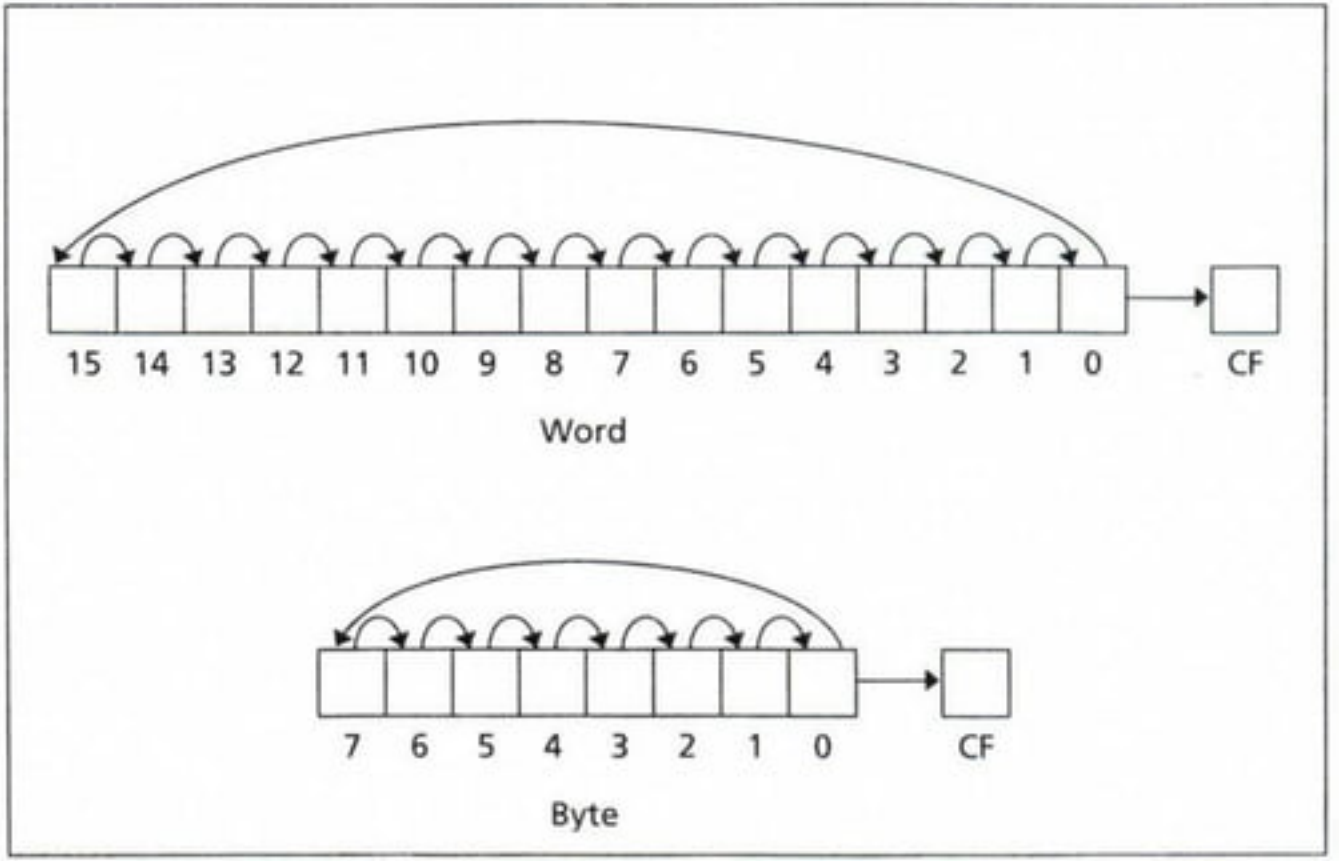
Rotate Right

ROR works just like ROL, except that the bits are rotated to the right.

ROL



ROR



Use ROL to count the number of 1 bits in BX, without changing BX. Put the answer in AX.

```
        XOR  AX, AX      ; AX counts bits
        MOV CX, 16       ; loop counter
TOP:
        ROL  BX, 1       ; CF = bit rotated out
        JNC  NEXT        ; 0 bit
        INC  AX          ; 1 bit, increment total
NEXT:
        LOOP TOP         ; loop until done
```

Use ROL to count the number of 1 bits in BX, without changing BX. Put the answer in AX.

In this example, we used **JNC** (jump if no carry), which causes a jump if CF = 0.

Rotate Carry Left

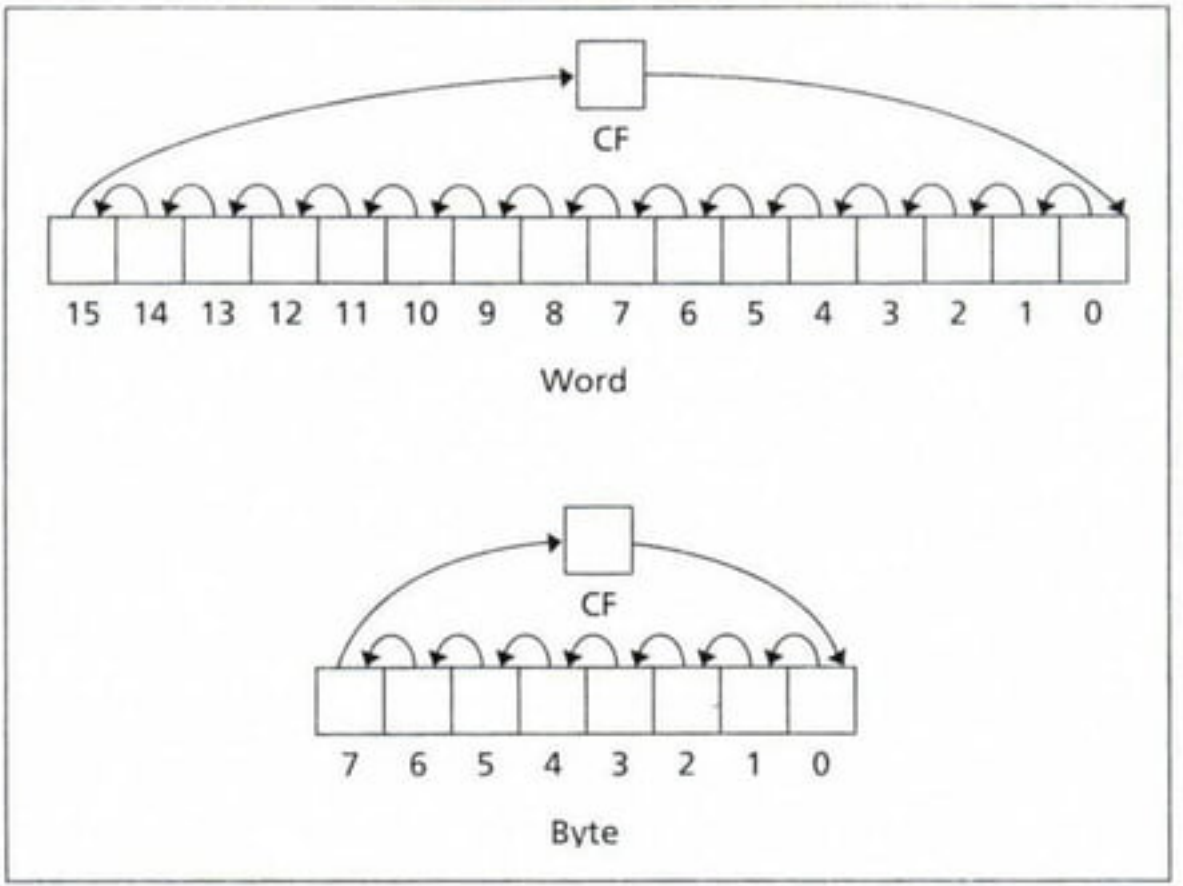
RCL shifts bits of the destination to the left.

The msb is shifted into the CF, and the previous value of CF is shifted into the rightmost bit.

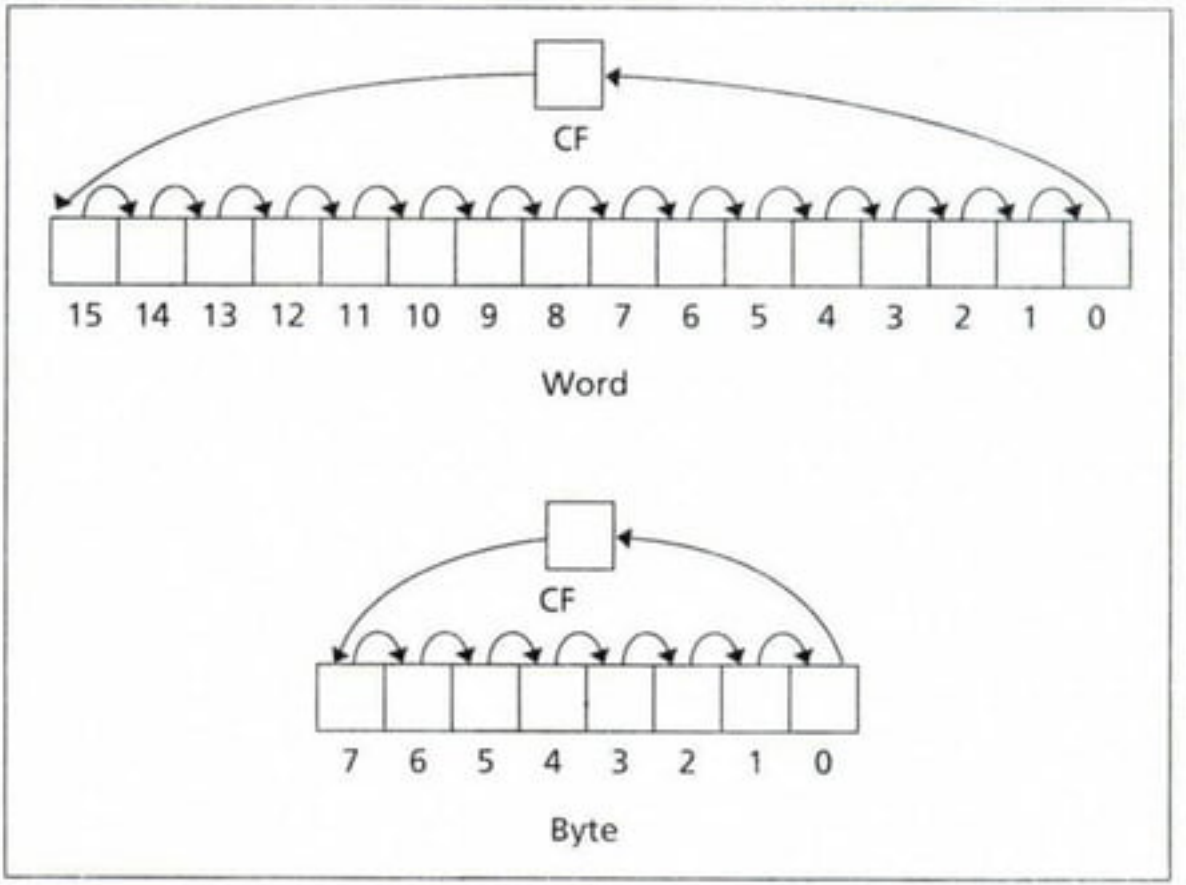
Rotate Carry Right

RCR works just like RCL, except that the bits are rotated to the right.

RCL



RCR



An application: Reversing a Bit Pattern

```
        MOV CX, 8          ; number of operations to do
REVERSE:
        SHL  AL, 1         ; get a bit into CF
        RCR  BL, 1         ; rotate it to BL
        LOOP REVERSE       ; loop until done
        MOV AL, BL         ; AL gets reversed pattern
```