The 8086 / 80286 / 80386 / 80486 Instruction Set

A Instructions

AAA - Ascii Adjust for Addition

```
Usage:  AAA
Modifies flags: AF CF (OF,PF,SF,ZF undefined)

Changes contents of AL to valid unpacked decimal.  The high order
nibble is zeroed.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              8     3     4     3            1
```

AAD - Ascii Adjust for Division

```
Usage:  AAD
Modifies flags: SF ZF PF (AF,CF,OF undefined)

Used before dividing unpacked decimal numbers.   Multiplies AH by
10 and the adds result into AL.  Sets AH to zero.  This instruction
is also known to have an undocumented behavior.

AL := 10*AH+AL
AH := 0

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              60    14    19    14            2
```

AAM - Ascii Adjust for Multiplication

```
Usage:  AAM
Modifies flags: PF SF ZF (AF,CF,OF undefined)

AH := AL / 10
AL := AL mod 10

Used after multiplication of two unpacked decimal numbers, this
instruction adjusts an unpacked decimal number.  The high order
nibble of each byte must be zeroed before using this instruction.
This instruction is also known to have an undocumented behavior.

                          Clocks                Size
Operands         808x  286   386   486          Bytes
```

```
none              83    16    17    15            2
```

AAS - Ascii Adjust for Subtraction

```
Usage:  AAS
Modifies flags: AF CF (OF,PF,SF,ZF undefined)

Corrects result of a previous unpacked decimal subtraction in AL.
High order nibble is zeroed.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

none              8     3     4     3             1
```

ADC - Add With Carry

```
Usage:  ADC     dest,src
Modifies flags: AF CF OF SF PF ZF

Sums two binary operands placing the result in the destination.
If CF is set, a 1 is added to the destination.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg,reg           3     2     2     1             2
mem,reg         16+EA   7     7     3            2-4  (W88=24+EA)
reg,mem          9+EA   7     6     2            2-4  (W88=13+EA)
reg,immed         4     3     2     1            3-4
mem,immed       17+EA   7     7     3            3-6  (W88=23+EA)
accum,immed       4     3     2     1            2-3
```

ADD - Arithmetic Addition

```
Usage:  ADD     dest,src
Modifies flags: AF CF OF PF SF ZF

Adds "src" to "dest" and replacing the original contents of "dest".
Both operands are binary.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg,reg           3     2     2     1             2
mem,reg         16+EA   7     7     3            2-4  (W88=24+EA)
reg,mem          9+EA   7     6     2            2-4  (W88=13+EA)
reg,immed         4     3     2     1            3-4
mem,immed       17+EA   7     7     3            3-6  (W88=23+EA)
accum,immed       4     3     2     1            2-3
```

AND - Logical And

```
Usage:  AND     dest,src
Modifies flags: CF OF PF SF ZF (AF undefined)

Performs a logical AND of the two operands replacing the destination
with the result.
```

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
reg,reg	3	2	2	1	2	
mem,reg	16+EA	7	7	3	2-4	(W88=24+EA)
reg,mem	9+EA	7	6	1	2-4	(W88=13+EA)
reg,immed	4	3	2	1	3-4	
mem,immed	17+EA	7	7	3	3-6	(W88=23+EA)
accum,immed	4	3	2	1	2-3	

ARPL - Adjusted Requested Privilege Level of Selector (286+ PM)

Usage: ARPL dest,src
(286+ protected mode)
Modifies flags: ZF

Compares the RPL bits of "dest" against "src". If the RPL bits of "dest" are less than "src", the destination RPL bits are set equal to the source RPL bits and the Zero Flag is set. Otherwise the Zero Flag is cleared.

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg,reg	-	10	20	9	2
mem,reg	-	11	21	9	4

B Instructions

BOUND - Array Index Bound Check (80188+)

```
Usage:  BOUND   src,limit
Modifies flags: None

Array index in source register is checked against upper and lower
bounds in memory source.  The first word located at "limit" is
the lower boundary and the word at "limit+2" is the upper array bound.
Interrupt 5 occurs if the source value is less than or higher than
the source.
```

Operands	808x	Clocks 286	386	486	Size Bytes
reg16,mem32	-	nj=13	nj=10	7	2
reg32,mem64	-	nj=13	nj=10	7	2

- nj = no jump taken

BSF - Bit Scan Forward (386+)

```
Usage:  BSF     dest,src
Modifies flags: ZF

Scans source operand for first bit set.  Sets ZF if a bit is found
set and loads the destination with an index to first set bit.  Clears
ZF is no bits are found set.  BSF scans forward across bit pattern
(0-n) while BSR scans in reverse (n-0).
```

Operands	808x	Clocks 286	386	486	Size Bytes
reg,reg	-	-	10+3n	6-42	3
reg,mem	-	-	10+3n	7-43	3-7
reg32,reg32	-	-	10+3n	6-42	3-7
reg32,mem32	-	-	10+3n	7-43	3-7

BSR - Bit Scan Reverse (386+)

```
Usage:  BSR     dest,src
Modifies flags: ZF

Scans source operand for first bit set.  Sets ZF if a bit is found
set and loads the destination with an index to first set bit.  Clears
ZF is no bits are found set.  BSF scans forward across bit pattern
(0-n) while BSR scans in reverse (n-0).
```

Operands	808x	Clocks 286	386	486	Size Bytes
reg,reg	-	-	10+3n	6-103	3
reg,mem	-	-	10+3n	7-104	3-7
reg32,reg32	-	-	10+3n	6-103	3-7
reg32,mem32	-	-	10+3n	7-104	3-7

BSWAP - Byte Swap (486+)

```
Usage:  BSWAP   reg32
Modifies flags: none

Changes the byte order of a 32 bit register from big endian to
little endian or vice versa.   Result left in destination register
is undefined if the operand is a 16 bit register.
```

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg32	-	-	-	1	2

BT - Bit Test (386+)

```
Usage:  BT      dest,src
Modifies flags: CF

The destination bit indexed by the source value is copied into the
Carry Flag.
```

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16,immed8	-	-	3	3	4-8
mem16,immed8	-	-	6	6	4-8
reg16,reg16	-	-	3	3	3-7
mem16,reg16	-	-	12	12	3-7

BTC - Bit Test with Compliment (386+)

```
Usage:  BTC     dest,src
Modifies flags: CF

The destination bit indexed by the source value is copied into the
Carry Flag after being complimented (inverted).
```

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16,immed8	-	-	6	6	4-8
mem16,immed8	-	-	8	8	4-8
reg16,reg16	-	-	6	6	3-7
mem16,reg16	-	-	13	13	3-7

BTR - Bit Test with Reset (386+)

```
Usage:  BTR     dest,src
Modifies flags: CF

The destination bit indexed by the source value is copied into the
Carry Flag and then cleared in the destination.
```

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16,immed8	-	-	6	6	4-8
mem16,immed8	-	-	8	8	4-8
reg16,reg16	-	-	6	6	3-7
mem16,reg16	-	-	13	13	3-7

BTS - Bit Test and Set (386+)

```
Usage:  BTS     dest,src
Modifies flags: CF

The destination bit indexed by the source value is copied into the
Carry Flag and then set in the destination.
```

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16,immed8	-	-	6	6	4-8
mem16,immed8	-	-	8	8	4-8
reg16,reg16	-	-	6	6	3-7
mem16,reg16	-	-	13	13	3-7

C Instructions

CALL - Procedure Call

```
Usage:  CALL    destination
Modifies flags: None

Pushes Instruction Pointer (and Code Segment for far calls) onto
stack and loads Instruction Pointer with the address of proc-name.
Code continues with execution at CS:IP.
```

Operands	Clocks 808x	286	386	486
rel16 (near, IP relative)	19	7	7+m	3
rel32 (near, IP relative)	-	-	7+m	3
reg16 (near, register indirect)	16	7	7+m	5
reg32 (near, register indirect)	-	-	7+m	5
mem16 (near, memory indirect)	-	21+EA	11	10+m 5
mem32 (near, memory indirect)	-	-	10+m	5
ptr16:16 (far, full ptr supplied)	28	13	17+m	18
ptr16:32 (far, full ptr supplied)	-	-	17+m	18
ptr16:16 (far, ptr supplied, prot. mode)	-	26	34+m	20
ptr16:32 (far, ptr supplied, prot. mode)	-	-	34+m	20
m16:16 (far, indirect)	37+EA	16	22+m	17
m16:32 (far, indirect)	-	-	22+m	17
m16:16 (far, indirect, prot. mode)	-	29	38+m	20
m16:32 (far, indirect, prot. mode)	-	-	38+m	20
ptr16:16 (task, via TSS or task gate)	-	177	TS	37+TS
m16:16 (task, via TSS or task gate)	-	180/185	5+TS	37+TS
m16:32 (task)	-	-	TS	37+TS
m16:32 (task)	-	-	5+TS	37+TS
ptr16:16 (gate, same privilege)	-	41	52+m	35
ptr16:32 (gate, same privilege)	-	-	52+m	35
m16:16 (gate, same privilege)	-	44	56+m	35
m16:32 (gate, same privilege)	-	-	56+m	35
ptr16:16 (gate, more priv, no parm)	-	82	86+m	69
ptr16:32 (gate, more priv, no parm)	-	-	86+m	69
m16:16 (gate, more priv, no parm)	-	83	90+m	69
m16:32 (gate, more priv, no parm)	-	-	90+m	69
ptr16:16 (gate, more priv, x parms)	-	86+4x	94+4x+m	77+4x
ptr16:32 (gate, more priv, x parms)	-	-	94+4x+m	77+4x
m16:16 (gate, more priv, x parms)	-	90+4x	98+4x+m	77+4x
m16:32 (gate, more priv, x parms)	-	-	98+4x+m	77+4x

CBW - Convert Byte to Word

```
Usage:  CBW
Modifies flags: None

Converts byte in AL to word Value in AX by extending sign of AL
throughout register AH.
```

Operands	Clocks 808x	286	386	486	Size Bytes

```
        none              2     2     3     3            1
```

CDQ - Convert Double to Quad (386+)

```
        Usage:  CDQ
        Modifies flags: None

        Converts signed DWORD in EAX to a signed quad word in EDX:EAX by
        extending the high order bit of EAX throughout EDX

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        none              -     -     2     3             1
```

CLC - Clear Carry

```
        Usage:  CLC
        Modifies flags: CF

        Clears the Carry Flag.

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        none              2     2     2     2             1
```

CLD - Clear Direction Flag

```
        Usage:  CLD
        Modifies flags: DF

        Clears the Direction Flag causing string instructions to increment
        the SI and DI index registers.

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        none              2     2     2     2             1
```

CLI - Clear Interrupt Flag (disable)

```
        Usage:  CLI
        Modifies flags: IF

        Disables the maskable hardware interrupts by clearing the Interrupt
        flag.  NMI's and software interrupts are not inhibited.

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        none              2     2     3     5             1
```

CLTS - Clear Task Switched Flag (286+ privileged)

```
        Usage:  CLTS
        Modifies flags: None
```

Clears the Task Switched Flag in the Machine Status Register. This is a privileged operation and is generally used only by operating system code.

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
none	-	2	5	7	2	

CMC - Complement Carry Flag

Usage: CMC
Modifies flags: CF

Toggles (inverts) the Carry Flag

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
none	2	2	2	2	1	

CMP - Compare

Usage: CMP dest,src
Modifies flags: AF CF OF PF SF ZF

Subtracts source from destination and updates the flags but does not save result. Flags can subsequently be checked for conditions.

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
reg,reg	3	2	2	1	2	
mem,reg	9+EA	7	5	2	2-4	(W88=13+EA)
reg,mem	9+EA	6	6	2	2-4	(W88=13+EA)
reg,immed	4	3	2	1	3-4	
mem,immed	10+EA	6	5	2	3-6	(W88=14+EA)
accum,immed	4	3	2	1	2-3	

CMPS - Compare String (Byte, Word or Doubleword)

Usage: CMPS dest,src
CMPSB
CMPSW
CMPSD (386+)
Modifies flags: AF CF OF PF SF ZF

Subtracts destination value from source without saving results. Updates flags based on the subtraction and the index registers (E)SI and (E)DI are incremented or decremented depending on the state of the Direction Flag. CMPSB inc/decrements the index registers by 1, CMPSW inc/decrements by 2, while CMPSD increments or decrements by 4. The REP prefixes can be used to process entire data items.

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
dest,src	22	8	10	8	1	(W88=30)

CMPXCHG - Compare and Exchange

```
Usage:  CMPXCHG dest,src  (486+)
Modifies flags: AF CF OF PF SF ZF

Compares the accumulator (8-32 bits) with "dest".  If equal the
"dest" is loaded with "src", otherwise the accumulator is loaded
with "dest".

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg,reg           -     -     -     6            2
mem,reg           -     -     -     7            2

- add 3 clocks if the "mem,reg" comparison fails
```

CWD - Convert Word to Doubleword

```
Usage:  CWD
Modifies flags: None

Extends sign of word in register AX throughout register DX forming
a doubleword quantity in DX:AX.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              5     2     2     3            1
```

CWDE - Convert Word to Extended Doubleword (386+)

```
Usage:  CWDE
Modifies flags: None

Converts a signed word in AX to a signed doubleword in EAX by
extending the sign bit of AX throughout EAX.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              -     -     3     3            1
```

D Instructions

DAA - Decimal Adjust for Addition

```
        Usage:  DAA
        Modifies flags: AF CF PF SF ZF (OF undefined)

        Corrects result (in AL) of a previous BCD addition operation.
        Contents of AL are changed to a pair of packed decimal digits.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        none              4     3     4     2            1
```

DAS - Decimal Adjust for Subtraction

```
        Usage:  DAS
        Modifies flags: AF CF PF SF ZF (OF undefined)

        Corrects result (in AL) of a previous BCD subtraction operation.
        Contents of AL are changed to a pair of packed decimal digits.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        none              4     3     4     2            1
```

DEC - Decrement

```
        Usage:  DEC     dest
        Modifies flags: AF OF PF SF ZF

        Unsigned binary subtraction of one from the destination.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        reg8              3     2     2     1            2
        mem              15+EA  7     6     3           2-4
        reg16/32          3     2     2     1            1
```

DIV - Divide

```
        Usage:  DIV     src
        Modifies flags: (AF,CF,OF,PF,SF,ZF undefined)

        Unsigned binary division of accumulator by source.  If the source
        divisor is a byte value then AX is divided by "src" and the quotient
        is placed in AL and the remainder in AH.  If source operand is a word
        value, then DX:AX is divided by "src" and the quotient is stored in AX
        and the remainder in DX.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        reg8             80-90  14    14    16           2
        reg16           144-162 22    22    24           2
        reg32             -     -     38    40           2
        mem8        (86-96)+EA  17    17    16          2-4
```

mem16	(150-168)+EA	25	25	24	2-4	(W88=158-176+EA)
mem32	-	-	41	40	2-4	

E Instructions

ENTER - Make Stack Frame (80188+)

```
        Usage:  ENTER   locals,level
        Modifies flags: None

        Modifies stack for entry to procedure for high level language.
        Operand "locals" specifies the amount of storage to be allocated
        on the stack.   "Level" specifies the nesting level of the routine.
        Paired with the LEAVE instruction, this is an efficient method of
        entry and exit to procedures.

                                    Clocks                      Size
        Operands          808x    286       386       486       Bytes

        immed16,0          -       11       10         14         4
        immed16,1          -       15       12         17         4
        immed16,immed8     -   12+4(n-1) 15+4(n-1)    17+3n        4
```

ESC - Escape

```
        Usage:  ESC     immed,src
        Modifies flags: None

        Provides access to the data bus for other resident processors.
        The CPU treats it as a NOP but places memory operand on bus.

                                Clocks                  Size
        Operands          808x  286   386   486         Bytes

        immed,reg          2   9-20    ?                 2
        immed,mem          2   9-20    ?                2-4
```

H Instructions

HLT - Halt CPU

```
        Usage:   HLT
        Modifies flags: None

        Halts CPU until RESET line is activated, NMI or maskable interrupt
        received.  The CPU becomes dormant but retains the current CS:IP
        for later restart.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none               2     2     5     4              1
```

I Instructions

IDIV - Signed Integer Division

```
Usage:   IDIV   src
Modifies flags: (AF,CF,OF,PF,SF,ZF undefined)

Signed binary division of accumulator by source.  If source is a
byte value, AX is divided by "src" and the quotient is stored in
AL and the remainder in AH.  If source is a word value, DX:AX is
divided by "src", and the quotient is stored in AL and the
remainder in DX.
                            Clocks                  Size
Operands          808x  286   386   486             Bytes

reg8           101-112   17    19    19               2
reg16          165-184   25    27    27               2
reg32             -      -     43    43               2
mem8     (107-118)+EA    20    22    20              2-4
mem16    (171-190)+EA    38    30    28              2-4  (W88=175-194)
mem32             -      -     46    44              2-4
```

IMUL - Signed Multiply

```
Usage:  IMUL    src
        IMUL    src,immed        (286+)
        IMUL    dest,src,immed8  (286+)
        IMUL    dest,src         (386+)
Modifies flags: CF OF (AF,PF,SF,ZF undefined)

Signed multiplication of accumulator by "src" with result placed
in the accumulator.  If the source operand is a byte value, it
is multiplied by AL and the result stored in AX.  If the source
operand is a word value it is multiplied by AX and the result is
stored in DX:AX.  Other variations of this instruction allow
specification of source and destination registers as well as a
third immediate factor.

                              Clocks                Size
Operands          808x   286   386   486            Bytes

reg8               80-98   13   9-14  13-18            2
reg16             128-154  21   9-22  13-26            2
reg32                -     -    9-38  12-42            2
mem8               86-104  16  12-17  13-18           2-4
mem16             134-160  24  12-25  13-26           2-4
mem32                -     -   12-41  13-42           2-4
reg16,reg16          -     -    9-22  13-26           3-5
reg32,reg32          -     -    9-38  13-42           3-5
reg16,mem16          -     -   12-25  13-26           3-5
reg32,mem32          -     -   12-41  13-42           3-5
reg16,immed          -     21   9-22  13-26            3
reg32,immed          -     21   9-38  13-42           3-6
reg16,reg16,immed    -     2    9-22  13-26           3-6
reg32,reg32,immed    -     21   9-38  13-42           3-6
reg16,mem16,immed    -     24  12-25  13-26           3-6
reg32,mem32,immed    -     24  12-41  13-42           3-6
```

IN - Input Byte or Word From Port

```
Usage:  IN      accum,port
Modifies flags: None
```

A byte, word or dword is read from "port" and placed in AL, AX or EAX respectively. If the port number is in the range of 0-255 it can be specified as an immediate, otherwise the port number must be specified in DX. Valid port ranges on the PC are 0-1024, though values through 65535 may be specified and recognized by third party vendors and PS/2's.

	Clocks				Size
Operands	808x	286	386	486	Bytes
accum,immed8	10/14	5	12	14	2
accum,immed8 (PM)			6/26	8/28/27	2
accum,DX	8/12	5	13	14	1
accum,DX (PM)			7/27	8/28/27	1

- 386+ protected mode timings depend on privilege levels.

  first number is the timing if: CPL ≤ IOPL
  second number is the timing if: CPL > IOPL or in VM 86 mode (386)
  CPL ≥ IOPL (486)
  third number is the timing when: virtual mode on 486 processor
- 486 virtual mode always requires 27 cycles

INC - Increment

Usage: INC dest
Modifies flags: AF OF PF SF ZF

Adds one to destination unsigned binary operand.

	Clocks				Size	
Operands	808x	286	386	486	Bytes	
reg8	3	2	2	1	2	
reg16	3	2	2	1	1	
reg32	3	2	2	1	1	
mem	15+EA	7	6	3	2-4	(W88=23+EA)

INS - Input String from Port (80188+)

Usage: INS dest,port
INSB
INSW
INSD (386+)
Modifies flags: None

Loads data from port to the destination ES:(E)DI (even if a destination operand is supplied). (E)DI is adjusted by the size of the operand and increased if the Direction Flag is cleared and decreased if the Direction Flag is set. For INSB, INSW, INSD no operands are allowed and the size is determined by the mnemonic.

	Clocks				Size
Operands	808x	286	386	486	Bytes
dest,port	-	5	15	17	1
dest,port (PM)	-	5	9/29	10/32/30	1
none	-	5	15	17	1
none (PM)	-	5	9/29	10/32/30	1

- 386+ protected mode timings depend on privilege levels.

  first number is the timing if: CPL ≤ IOPL

```
          second number is the timing if:   CPL > IOPL
          third number is the timing if:    virtual mode on 486 processor
```

INT - Interrupt

```
        Usage:  INT     num
        Modifies flags: TF IF

        Initiates a software interrupt by pushing the flags, clearing the
        Trap and Interrupt Flags, pushing CS followed by IP and loading
        CS:IP with the value found in the interrupt vector table.  Execution
        then begins at the location addressed by the new CS:IP

                                                Clocks           Size
            Operands                     808x  286   386   486   Bytes

 3 (constant)                           52/72  23+m   33    26     2
 3 (prot. mode, same priv.)               -    40+m   59    44     2
 3 (prot. mode, more priv.)               -    78+m   99    71     2
 3 (from VM86 to PL 0)                    -     -    119    82     2
 3 (prot. mode via task gate)             -   167+m   TS  37+TS    2
 immed8                                 51/71  23+m   37    30     1
 immed8 (prot. mode, same priv.)          -    40+m   59    44     1
 immed8 (prot. mode, more priv.)          -    78+m   99    71     1
 immed8 (from VM86 to PL 0)               -     -    119    86     1
 immed8 (prot. mode, via task gate)       -   167+m   TS  37+TS    1
```

INTO - Interrupt on Overflow

```
        Usage:  INTO
        Modifies flags: IF TF

        If the Overflow Flag is set this instruction generates an INT 4
        which causes the code addressed by 0000:0010 to be executed.

                                          Clocks           Size
        Operands                  808x    286   386   486    Bytes

        none: jump               53/73   24+m    35    28      1
              no jump              4       3     3     3
        (prot. mode, same priv.) -        -     59    46      1
        (prot. mode, more priv.) -        -     99    73      1
        (from VM86 to PL 0)      -        -    119    84      1
        (prot. mode, via task gate)       -     TS  39+TS     1
```

INVD - Invalidate Cache (486+)

```
        Usage:  INVD
        Modifies flags: none

        Flushes CPU internal cache.  Issues special function bus cycle
        which indicates to flush external caches.   Data in write-back
        external caches is lost.

                                  Clocks                Size
        Operands          808x   286   386   486         Bytes

        none               -      -     -     4           2
```

INVLPG - Invalidate Translation Look-Aside Buffer Entry (486+)

```
Usage:  INVLPG
Modifies flags: none

Invalidates a single page table entry in the Translation
Look-Aside Buffer.  Intel warns that this instruction may be
implemented differently on future processors.

                            Clocks                Size
Operands         808x   286   386   486          Bytes

none              -      -     -     12            2

- timing is for TLB entry hit only.
```

IRET/IRETD - Interrupt Return

```
Usage:  IRET
        IRETD  (386+)
Modifies flags: AF CF DF IF PF SF TF ZF

Returns control to point of interruption by popping IP, CS
and then the Flags from the stack and continues execution at
this location.  CPU exception interrupts will return to the
instruction that cause the exception because the CS:IP placed
on the stack during the interrupt is the address of the offending
instruction.

                                    Clocks                Size
    Operands              808x   286   386   486          Bytes

iret                     32/44  17+m    22    15            1
iret  (prot. mode)         -    31+m    38    15            1
iret  (to less privilege)  -    55+m    82    36            1
iret  (different task, NT=1) -  169+m    TS  TS+32           1
iretd                      -      -   22/38   15            1
iretd (to less privilege)  -      -     82    36            1
iretd (to VM86 mode)       -      -     60    15            1
iretd (different task, NT=1) -    -     TS  TS+32           1

- 386 timings are listed as real-mode/protected-mode
```

J Instructions

Jxx - Jump Instructions Table

Mnemonic	Meaning	Jump Condition
JA	Jump if Above	CF=0 and ZF=0
JAE	Jump if Above or Equal	CF=0
JB	Jump if Below	CF=1
JBE	Jump if Below or Equal	CF=1 or ZF=1
JC	Jump if Carry	CF=1
JCXZ	Jump if CX Zero	CX=0
JE	Jump if Equal	ZF=1
JG	Jump if Greater (signed)	ZF=0 and SF=OF
JGE	Jump if Greater or Equal (signed)	SF=OF
JL	Jump if Less (signed)	SF != OF
JLE	Jump if Less or Equal (signed)	ZF=1 or SF != OF
JMP	Unconditional Jump	unconditional
JNA	Jump if Not Above	CF=1 or ZF=1
JNAE	Jump if Not Above or Equal	CF=1
JNB	Jump if Not Below	CF=0
JNBE	Jump if Not Below or Equal	CF=0 and ZF=0
JNC	Jump if Not Carry	CF=0
JNE	Jump if Not Equal	ZF=0
JNG	Jump if Not Greater (signed)	ZF=1 or SF != OF
JNGE	Jump if Not Greater or Equal (signed)	SF != OF
JNL	Jump if Not Less (signed)	SF=OF
JNLE	Jump if Not Less or Equal (signed)	ZF=0 and SF=OF
JNO	Jump if Not Overflow (signed)	OF=0
JNP	Jump if No Parity	PF=0
JNS	Jump if Not Signed (signed)	SF=0
JNZ	Jump if Not Zero	ZF=0
JO	Jump if Overflow (signed)	OF=1
JP	Jump if Parity	PF=1
JPE	Jump if Parity Even	PF=1
JPO	Jump if Parity Odd	PF=0
JS	Jump if Signed (signed)	SF=1
JZ	Jump if Zero	ZF=1

	Clocks				Size
Operands	808x	286	386	486	Bytes
Jx: jump	16	7+m	7+m	3	2
no jump	4	3	3	1	
Jx near-label	-	-	7+m	3	4
no jump	-	-	3	1	

- It's a good programming practice to organize code so the expected case is executed without a jump since the actual jump takes longer to execute than falling through the test.
- see JCXZ and JMP for their respective timings

JCXZ/JECXZ - Jump if Register (E)CX is Zero

```
Usage:  JCXZ    label
        JECXZ   label  (386+)
Modifies flags: None

Causes execution to branch to "label" if register CX is zero.  Uses
unsigned comparision.
```

	Clocks				Size
Operands	808x	286	386	486	Bytes

```
label:  jump      18   8+m   9+m    8            2
        no jump    6    4     5     5
```

JMP - Unconditional Jump

```
Usage:  JMP     target
Modifies flags: None

Unconditionally transfers control to "label".  Jumps by default
are within -32768 to 32767 bytes from the instruction following
the jump.  NEAR and SHORT jumps cause the IP to be updated while FAR
jumps cause CS and IP to be updated.
```

Operands	Clocks 808x	286	386	486
rel8 (relative)	15	7+m	7+m	3
rel16 (relative)	15	7+m	7+m	3
rel32 (relative)	-	-	7+m	3
reg16 (near, register indirect)	11	7+m	7+m	5
reg32 (near, register indirect)	-	-	7+m	5
mem16 (near, mem indirect)	18+EA	11+m	10+m	5
mem32 (near, mem indirect)	24+EA	15+m	10+m	5
ptr16:16 (far, dword immed)	-	-	12+m	17
ptr16:16 (far, PM dword immed)	-	-	27+m	19
ptr16:16 (call gate, same priv.)	-	38+m	45+m	32
ptr16:16 (via TSS)	-	175+m	TS	42+TS
ptr16:16 (via task gate)	-	180+m	TS	43+TS
mem16:16 (far, indirect)	-	-	43+m	13
mem16:16 (far, PM indirect)	-	-	31+m	18
mem16:16 (call gate, same priv.)	-	41+m	49+m	31
mem16:16 (via TSS)	-	178+m	5+TS	41+TS
mem16:16 (via task gate)	-	183+m	5+TS	42+TS
ptr16:32 (far, 6 byte immed)	-	-	12+m	13
ptr16:32 (far, PM 6 byte immed)	-	-	27+m	18
ptr16:32 (call gate, same priv.)	-	-	45+m	31
ptr16:32 (via TSS)	-	-	TS	42+TS
ptr16:32 (via task state)	-	-	TS	43+TS
m16:32 (far, address at dword)	-	-	43+m	13
m16:32 (far, address at dword)	-	-	31+m	18
m16:32 (call gate, same priv.)	-	-	49+m	31
m16:32 (via TSS)	-	-	5+TS	41+TS
m16:32 (via task state)	-	-	5+TS	42+TS

L Instructions

LAHF - Load Register AH From Flags

```
Usage: LAHF

Modifies Flags: None

Copies bits 0-7 of the flags register into AH.
This includes flags AF, CF, PF, SF and ZF other bits
are undefined.

AH := SF ZF xx AF xx PF xx CF
```

Timing:

Clocks operands	286	386	486	Size in Bytes
none	2	2	3	1

LAR - Load Access Rights (286+ protected)

```
Usage: LAR dest,src

Modifies Flags: ZF

The high byte of the of the destination register is overwritten
by the value of the access rights byte and the low order byte
is zeroed depending on the selection in the source operand.
The Zero Flag is set if the load operation is successful.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg16,reg16	14	15	11	3
reg32,reg32		15	11	3
reg16,mem16	16	16	11	3-7
reg32,mem32		16	11	3-7

LEA - Load Effective Address

```
Usage: LEA dest,src

Modifies Flags: None

Transfers offset address of "src" to the destination register.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg,mem	3	2	1	2-4

LEAVE - Restore Stack for Procedure Exit (80188+)

```
Usage: LEAVE

Modifies Flags: LEAVE

Releases the local variables created by the previous ENTER
```

```
instruction by restoring SP and BP to their condition before
the procedure stack frame was initialized.
```

Timing:

Clocks operands	286	386	486	Size Bytes
none	5	4	5	1

LES - Load Pointer Using ES

```
Usage: LES dest,src

Modifies Flags: None

Loads 32-bit pointer from memory source to destination
register and ES. The offset is placed in the destination
register and the segment is placed in ES. To use this
instruction the word at the lower memory address must
contain the offset and the word at the higher address
must contain the segment. This simplifies the loading
of far pointers from the stack and the interrupt vector table.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg,mem	7	7	6	2-4
reg,mem (PM)		22	12	5-7

LFS - Load Pointer Using FS

```
Usage: LFS dest,src

Modifies Flags: None

Loads 32-bit pointer from memory source to destination
register and FS. The offset is placed in the destination
register and the segment is placed in FS. To use this
instruction the word at the lower memory address must
contain the offset and the word at the higher address must
contain the segment. This simplifies the loading of far pointers
from the stack and the interrupt vector table.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg,mem	7	6	5-7	
reg,mem (PM)	22	12	5-7	

LGDT - Load Global Descriptor Table (286+ privileged)

```
Usage: LGDT src

Modifies Flags: None

Loads a value from an operand into the Global Descriptor Table
(GDT) register.
```

Timing:

Clocks operands	286	386	486	Size Bytes
mem64	11	11	11	5

LGS - Load Pointer Using GS (386+)

```
Usage: LGS dest,src

Modifies Flags: None

Loads 32-bit pointer from memory source to destination
register and GS. The offset is placed in the destination
register and the segment is placed in GS. To use this
instruction the word at the lower memory address must
contain the offset and the word at the higher address must
contain the segment. This simplifies the loading of far pointers
from the stack and the interrupt vector table.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg,mem		7	6	5-7
reg,mem (PM)		22	12	5-7

LIDT - Load Interrupt Descriptor Table (286+ privileged)

```
Usage: LIDT src

Modifies Flags: None

Loads a value from an operand into the Interrupt Descriptor
Table (IDT) register.
```

Timing:

Clocks operands	286	386	486	Size Bytes
mem64	12	11	11	5

LLDT - Load Local Descriptor Table (286+ privileged)

```
Usage: LLDT src

Modifies Flags: None

Loads a value from an operand into the Local Descriptor Table
Register (LDTR).
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg16	17	20	11	3
mem16	19	24	11	5

LMSW - Load Machine Status Word (286+ privileged)

```
 Usage: LMSW src

Modifies Flags: None
```

```
Loads the Machine Status Word (MSW) from data found at
"src".
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg16	3	10	13	3
mem16	6	13	13	5

LOCK - Lock Bus

```
Usage: LOCK
           LOCK: (386+ prefix)

Modifies Flags: None

This instruction is a prefix that causes the CPU assert bus lock
signal during the execution of the next instruction. Used to
avoid two processors from updating the same data location.
The 286 always asserts lock during an XCHG with memory
operands. This should only be used to lock the bus prior to
XCHG, MOV, IN and OUT instructions.
```

Timing:

Clocks operands	286	386	486	Size Bytes
none	0	0	1	1

LODS - Load String (Byte, Word or Double)

```
Usage: LODS src
           LODSB
           LODSW
           LODSD (386+)

Modifies Flags: None

Transfers string element addressed by DS:SI (even if
an operand is supplied) to the accumulator. SI is incremented
based on the size of the operand or based on the instruction
used. If the Direction Flag is set SI is decremented, if
the Direction Flag is clear SI is incremented. Use with REP
prefixes.
```

Timing:

Clocks operands	286	386	486	Size Bytes
src	5	5	5	1

LOOP - Decrement CX and Loop if CX Not Zero

```
Usage: LOOP label

Modifies Flags: None

Decrements CX by 1 and transfers control to "label" if CX
is not Zero. The "label" operand must be within -128 or 127
bytes of the instruction following the loop instruction
```

Timing:

Clocks operands	286	386	486	Size Bytes
label: jump	8+m	11+m	6	2
no jump	4	?	2	2

LOOPE/LOOPZ - Loop While Equal / Loop While Zero

```
Usage: LOOPE label
           LOOPZ label

Modifies Flags: None

Decrements CX by 1 (without modifying the flags) and
transfers control to "label" if CX != 0 and the Zero Flag is set.
The "label" operand must be within -128 or 127 bytes of
the instruction following the loop instruction.
```

Timing:

Clocks operands	286	386	486	Size Bytes
label: jump	8+m	11+m	9	2
no jump	4	?	6	2

LOOPNE/LOOPNZ - Loop While Not Equal / Loop While Not Zero

```
Usage: LOOPNZ label
           LOOPNE label

Modifies Flags: None

Decrements CX by 1 (without modifying the flags) and
transfers control to "label" if CX != 0 and the Zero Flag
is clear. The "label" operand must be within -128 or 127
bytes of the instruction following the loop instruction.
```

Timing:

Clocks operands	286	386	486	Size Bytes
label: jump	8+m	11+m	9	2
no jump	4	?	6	2

LSL - Load Segment Limit (286+ protected)

```
Usage: LSL dest,src

Modifies Flags: ZF

Loads the segment limit of a selector into the destination
register if the selector is valid and visible at the current
privilege level. If loading is successful the Zero Flag is set,
otherwise it is cleared.
```

Timing:

Clocks operands	286	386	486	Size Bytes

reg16,reg16	14	20/25	10	3
reg32,reg32		20/25	10	3
reg16,mem16	16	21/26	10	5
reg32,mem32		21/26	10	5

386 times are listed "byte granular" / "page granular"

LSS - Load Pointer Using SS (386+)

```
Usage: LSS dest,src

Modifies Flags: None

Loads 32-bit pointer from memory source to destination
register and SS. The offset is placed in the destination
register and the segment is placed in SS. To use this
instruction the word at the lower memory address must
contain the offset and the word at the higher address must
contain the segment. This simplifies the loading of far pointers
from the stack and the interrupt vector table.
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg,mem		7	6	5-7
reg,mem (PM)		22	12	5-7

LTR - Load Task Register (286+ privileged)

```
Usage: LTR src

Modifies Flags: None

Loads the current task register with the value specified in "src".
```

Timing:

Clocks operands	286	386	486	Size Bytes
reg16	17	23	20	3
mem16	19	27	20	5

M Instructions

MOV - Move Byte or Word

```
Usage:  MOV     dest,src
Modifies flags: None

Copies byte or word from the source operand to the destination
operand.  If the destination is SS interrupts are disabled except
on early buggy 808x CPUs.  Some CPUs disable interrupts if the
destination is any of the segment registers
```

Operands	Clocks 808x	286	386	486	Size Bytes	
reg,reg	2	2	2	1	2	
mem,reg	9+EA	3	2	1	2-4	(W88=13+EA)
reg,mem	8+EA	5	4	1	2-4	(W88=12+EA)
mem,immed	10+EA	3	2	1	3-6	(W88=14+EA)
reg,immed	4	2	2	1	2-3	
mem,accum	10	3	2	1	3	(W88=14)
accum,mem	10	5	4	1	3	(W88=14)
segreg,reg16	2	2	2	3	2	
segreg,mem16	8+EA	5	5	9	2-4	(W88=12+EA)
reg16,segreg	2	2	2	3	2	
mem16,segreg	9+EA	3	2	3	2-4	(W88=13+EA)
reg32,CR0/CR2/CR3	-	-	6	4		
CR0,reg32	-	-	10	16		
CR2,reg32	-	-	4	4	3	
CR3,reg32	-	-	5	4	3	
reg32,DR0/DR1/DR2/DR3	-	-	22	10	3	
reg32,DR6/DR7	-	-	22	10	3	
DR0/DR1/DR2/DR3,reg32	-	-	22	11	3	
DR6/DR7,reg32	-	-	16	11	3	
reg32,TR6/TR7	-	-	12	4	3	
TR6/TR7,reg32	-	-	12	4	3	
reg32,TR3				3		
TR3,reg32				6		

```
- when the 386 special registers are used all operands are 32 bits
```

MOVS - Move String (Byte or Word)

```
Usage:  MOVS    dest,src
        MOVSB
        MOVSW
        MOVSD  (386+)
Modifies flags: None

Copies data from addressed by DS:SI (even if operands are given) to
the location ES:DI destination and updates SI and DI based on the
size of the operand or instruction used.  SI and DI are incremented
when the Direction Flag is cleared and decremented when the Direction
Flag is Set.  Use with REP prefixes.
```

Operands	Clocks 808x	286	386	486	Size Bytes	
dest,src	18	5	7	7	1	(W88=26)

MOVSX - Move with Sign Extend (386+)

```
Usage:  MOVSX   dest,src
Modifies flags: None
```

Copies the value of the source operand to the destination register with the sign extended.

Operands	808x	Clocks 286	386	486	Size Bytes
reg,reg	-	-	3	3	3
reg,mem	-	-	6	3	3-7

MOVZX - Move with Zero Extend (386+)

Usage: MOVZX dest,src
Modifies flags: None

Copies the value of the source operand to the destination register with the zeroes extended.

Operands	808x	Clocks 286	386	486	Size Bytes
reg,reg	-	-	3	3	3
reg,mem	-	-	6	3	3-7

MUL - Unsigned Multiply

Usage: MUL src
Modifies flags: CF OF (AF,PF,SF,ZF undefined)

Unsigned multiply of the accumulator by the source. If "src" is a byte value, then AL is used as the other multiplicand and the result is placed in AX. If "src" is a word value, then AX is multiplied by "src" and DX:AX receives the result. If "src" is a double word value, then EAX is multiplied by "src" and EDX:EAX receives the result. The 386+ uses an early out algorithm which makes multiplying any size value in EAX as fast as in the 8 or 16 bit registers.

Operands	808x	Clocks 286	386	486	Size Bytes
reg8	70-77	13	9-14	13-18	2
reg16	118-113	21	9-22	13-26	2
reg32	-	-	9-38	13-42	2-4
mem8	(76-83)+EA	16	12-17	13-18	2-4
mem16	(124-139)+EA	24	12-25	13-26	2-4
mem32	-	-	12-21	13-42	2-4

N Instructions

NEG - Two's Complement Negation

```
Usage:  NEG     dest
Modifies flags: AF CF OF PF SF ZF

Subtracts the destination from 0 and saves the 2s complement of
"dest" back into "dest".

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg               3     2     2     1             2
mem             16+EA   7     6     3            2-4   (W88=24+EA)
```

NOP - No Operation (90h)

```
Usage:  NOP
Modifies flags: None

This is a do nothing instruction.  It results in occupation of both
space and time and is most useful for patching code segments.
(This is the original XCHG AL,AL instruction)

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

none              3     3     3     1             1
```

NOT - One's Compliment Negation (Logical NOT)

```
Usage:  NOT     dest
Modifies flags: None

Inverts the bits of the "dest" operand forming the 1s complement.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg               3     2     2     1             2
mem             16+EA   7     6     3            2-4   (W88=24+EA)
```

O Instructions

OR - Inclusive Logical OR

```
        Usage:  OR      dest,src
        Modifies flags: CF OF PF SF ZF (AF undefined)

        Logical inclusive OR of the two operands returning the result in
        the destination.  Any bit set in either operand will be set in the
        destination.

                                 Clocks                  Size
        Operands          808x  286   386   486          Bytes

        reg,reg             3     2     2     1            2
        mem,reg           16+EA   7     7     3           2-4   (W88=24+EA)
        reg,mem            9+EA   7     6     2           2-4   (W88=13+EA)
        reg,immed           4     3     2     1           3-4
        mem8,immed8       17+EA   7     7     3           3-6
        mem16,immed16     25+EA   7     7     3           3-6
        accum,immed         4     3     2     1           2-3
```

OUT - Output Data to Port

```
        Usage:  OUT     port,accum
        Modifies flags: None

        Transfers byte in AL,word in AX or dword in EAX to the specified
        hardware port address.  If the port number is in the range of 0-255
        it can be specified as an immediate.  If greater than 255 then the
        port number must be specified in DX.  Since the PC only decodes 10
        bits of the port address, values over 1023 can only be decoded by
        third party vendor equipment and also map to the port range 0-1023.

                                 Clocks                  Size
        Operands          808x  286   386    486         Bytes

        immed8,accum     10/14   3     10     16           2
        immed8,accum (PM)  -     -    4/24 11/31/29       2
        DX,accum          8/12   3     11     16           1
        DX,accum (PM)      -     -    5/25 10/30/29       1

        - 386+ protected mode timings depend on privilege levels.

          first number is the timing when:    CPL ⩽ IOPL
          second number is the timing when:   CPL > IOPL
          third number is the timing when:    virtual mode on 486 processor
```

OUTS - Output String to Port (80188+)

```
        Usage:  OUTS    port,src
                OUTSB
                OUTSW
                OUTSD   (386+)
        Modifies flags: None

        Transfers a byte, word or doubleword from "src" to the hardware
        port specified in DX.  For instructions with no operands the "src"
        is located at DS:SI and SI is incremented or decremented by the
        size of the operand or the size dictated by the instruction format.
        When the Direction Flag is set SI is decremented, when clear, SI is
```

incremented. If the port number is in the range of 0-255 it can be specified as an immediate. If greater than 255 then the port number must be specified in DX. Since the PC only decodes 10 bits of the port address, values over 1023 can only be decoded by third party vendor equipment and also map to the port range 0-1023.

	Clocks				Size
Operands	808x	286	386	486	Bytes
port,src	-	5	14	17	1
port,src (PM)	-	-	8/28	10/32/30	1

- 386+ protected mode timings depend on privilege levels.

  first number is the timing when: CPL $\leqslant$ IOPL
  second number is the timing when: CPL > IOPL
  third number is the timing when: virtual mode on 486 processor

P Instructions

POP - Pop Word off Stack

```
        Usage:  POP     dest
        Modifies flags: None

        Transfers word at the current stack top (SS:SP) to the destination
        then increments SP by two to point to the new stack top.  CS is not
        a valid destination.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        reg16              8     5     4     4             1
        reg32              4     -     -     4             1
        segreg             8     5     7     3             1
        mem16            17+EA   5     5     6            2-4
        mem32              5     -     -     6            2-4
```

POPA/POPAD - Pop All Registers onto Stack (80188+)

```
        Usage:  POPA
                POPAD  (386+)
        Modifies flags: None

        Pops the top 8 words off the stack into the 8 general purpose 16/32
        bit registers.   Registers are popped in the following order: (E)DI,
        (E)SI, (E)BP, (E)SP, (E)DX, (E)CX and (E)AX.  The (E)SP value popped
        from the stack is actually discarded.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none               -     19    24    9             1
```

POPF/POPFD - Pop Flags off Stack

```
        Usage:  POPF
                POPFD  (386+)
        Modifies flags: all flags

        Pops word/doubleword from stack into the Flags Register and then
        increments SP by 2 (for POPF) or 4 (for POPFD).

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none              8/12   5     5     9             1  (W88=12)
        none  (PM)         -     -     5     6             1
```

PUSH - Push Word onto Stack

```
        Usage:  PUSH    src
                PUSH    immed   (80188+ only)
        Modifies flags: None

        Decrements SP by the size of the operand (two or four, byte values
        are sign extended) and transfers one word from source to the stack
        top (SS:SP).
```

```
                            Clocks                  Size
Operands          808x  286   386   486             Bytes

reg16            11/15   3     2     1               1
reg32              -     -     2     1               1
mem16            16+EA   5     5     4              2-4  (W88=24+EA)
mem32              -     -     5     4              2-4
segreg           10/14   3     2     3               1
immed              -     3     2     1              2-3
```

PUSHA/PUSHAD - Push All Registers onto Stack (80188+)

```
Usage:  PUSHA
        PUSHAD  (386+)
Modifies flags: None

Pushes all general purpose registers onto the stack in the following
order: (E)AX, (E)CX, (E)DX, (E)BX, (E)SP, (E)BP, (E)SI, (E)DI.  The
value of SP is the value before the actual push of SP.

                            Clocks                  Size
Operands          808x  286   386   486             Bytes

none               -     19    24    11               1
```

PUSHF/PUSHFD - Push Flags onto Stack

```
Usage:  PUSHF
        PUSHFD  (386+)
Modifies flags: None

Transfers the Flags Register onto the stack.  PUSHF saves a 16 bit
value while PUSHFD saves a 32 bit value.

                            Clocks                  Size
Operands          808x  286   386   486             Bytes

none             10/14   3     4     4               1
none  (PM)         -     -     4     3               1
```

R Instructions

RCL - Rotate Through Carry Left

```
        Usage:  RCL     dest,count
        Modifies flags: CF OF

            +-----+----------------------+
       +---|  C  | 7 <---------------- 0 |<--+
       |   +-----+----------------------+   |
       |                                    |
       +------------------------------------+
```

Rotates the bits in the destination to the left "count" times with all data pushed out the left side re-entering on the right. The Carry Flag holds the last bit rotated out.

Operands	Clocks 808x	286	386	486	Size Bytes	
reg,1	2	2	9	3	2	
mem,1	15+EA	7	10	4	2-4	(W88=23+EA)
reg,CL	8+4n	5+n	9	8-30	2	
mem,CL	20+EA+4n	8+n	10	9-31	2-4	(W88=28+EA+4n)
reg,immed8	-	5+n	9	8-30	3	
mem,immed8	-	8+n	10	9-31	3-5	

RCR - Rotate Through Carry Right

```
        Usage:  RCR     dest,count
        Modifies flags: CF OF

            +----------------------+-----+
       +-->| 7 ----------------> 0 |  C  |---+
       |   +----------------------+-----+   |
       |                                    |
       +------------------------------------+
```

Rotates the bits in the destination to the right "count" times with all data pushed out the right side re-entering on the left. The Carry Flag holds the last bit rotated out.

Operands	Clocks 808x	286	386	486	Size Bytes	
reg,1	2	2	9	3	2	
mem,1	15+EA	7	10	4	2-4	(W88=23+EA)
reg,CL	8+4n	5+n	9	8-30	2	
mem,CL	20+EA+4n	8+n	10	9-31	2-4	(W88=28+EA+4n)
reg,immed8	-	5+n	9	8-30	3	
mem,immed8	-	8+n	10	9-31	3-5	

REP - Repeat String Operation

```
        Usage:  REP
        Modifies flags: None
```

Repeats execution of string instructions while CX != 0. After each string operation, CX is decremented and the Zero Flag is tested. The combination of a repeat prefix and a segment override on CPU's before the 386 may result in errors if an interrupt occurs before CX=0. The following code shows code that is susceptible to this and how to avoid it:

```
again:  rep movs  byte ptr ES:[DI],ES:[SI]   ; vulnerable instr.
            jcxz  next              ; continue if REP successful
            loop  again             ; interrupt goofed count
next:

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              2     2     2                   1
```

REPE/REPZ - Repeat Equal / Repeat Zero

```
Usage:  REPE
        REPZ
Modifies flags: None

Repeats execution of string instructions while CX != 0 and the Zero
Flag is set.  CX is decremented and the Zero Flag tested after
each string operation.   The combination of a repeat prefix and a
segment override on processors other than the 386 may result in
errors if an interrupt occurs before CX=0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              2     2     2                   1
```

REPNE/REPNZ - Repeat Not Equal / Repeat Not Zero

```
Usage:  REPNE
        REPNZ
Modifies flags: None

Repeats execution of string instructions while CX != 0 and the Zero
Flag is clear.   CX is decremented and the Zero Flag tested after
each string operation.   The combination of a repeat prefix and a
segment override on processors other than the 386 may result in
errors if an interrupt occurs before CX=0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              2     2     2                   1
```

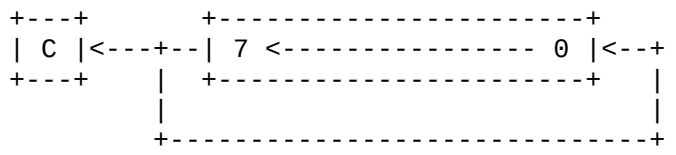
RET/RETF - Return From Procedure

```
Usage:  RET     nBytes
        RETF    nBytes
        RETN    nBytes
Modifies flags: None

Transfers control from a procedure back to the instruction address
saved on the stack.  "n bytes" is an optional number of bytes to
release.  Far returns pop the IP followed by the CS, while near
returns pop only the IP register.

                          Clocks                Size
Operands         808x  286    386   486         Bytes

retn            16/20  11+m  10+m    5           1
retn immed      20/24  11+m  10+m    5           3
```

```
retf            26/34  15+m  18+m    13          1
retf (PM, same priv.)   -    32+m    18          1
retf (PM, lesser priv.) -      68    33          1
retf immed      25/33  15+m  18+m    14          3
retf immed (PM, same priv.)  32+m    17          1
retf immed (PM, lesser priv.)  68    33          1
```

ROL - Rotate Left

```
Usage:  ROL     dest,count
Modifies flags: CF OF
```

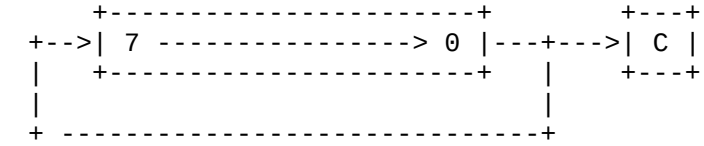


```
Rotates the bits in the destination to the left "count" times with
all data pushed out the left side re-entering on the right.  The
Carry Flag will contain the value of the last bit rotated out.
```

Operands	808x	286	386	486	Size Bytes	
reg,1	2	2	3	3	2	
mem,1	15+EA	7	7	4	2-4	(W88=23+EA)
reg,CL	8+4n	5+n	3	3	2	
mem,CL	20+EA+4n	8+n	7	4	2-4	(W88=28+EA+4n)
reg,immed8	-	5+n	3	2	3	
mem,immed8	-	8+n	7	4	3-5	

ROR - Rotate Right

```
Usage:  ROR     dest,count
Modifies flags: CF OF
```



```
Rotates the bits in the destination to the right "count" times with
all data pushed out the right side re-entering on the left.  The
Carry Flag will contain the value of the last bit rotated out.
```

Operands	808x	286	386	486	Size Bytes	
reg,1	2	2	3	3	2	
mem,1	15+EA	7	7	4	2-4	(W88=23+EA)
reg,CL	8+4n	5+n	3	3	2	
mem,CL	20+EA+4n	8+n	7	4	2-4	(W88=28+EA+4n)
reg,immed8	-	5+n	3	2	3	
mem,immed8	-	8+n	7	4	3-5	

S Instructions

SAHF - Store AH Register into FLAGS

```
        Usage:  SAHF
        Modifies flags: AF CF PF SF ZF

        Transfers bits 0-7 of AH into the Flags Register.  This includes
        AF, CF, PF, SF and ZF.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none               4     2     3     2             1
```

SAL/SHL - Shift Arithmetic Left / Shift Logical Left

```
        Usage:  SAL     dest,count
                SHL     dest,count
        Modifies flags: CF OF PF SF ZF (AF undefined)

        +---+   +-----------------------+
        | C |<--| 7 <---------------- 0 |<--0
        +---+   +-----------------------+

        Shifts the destination left by "count" bits with zeroes shifted
        in on right.  The Carry Flag contains the last bit shifted out.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        reg,1              2     2     3     3             2
        mem,1            15+EA   7     7     4           2-4   (W88=23+EA)
        reg,CL             8+4n  5+n   3     3             2
        mem,CL          20+EA+4n 8+n   7     4           2-4   (W88=28+EA+4n)
        reg,immed8         -     5+n   3     2             3
        mem,immed8         -     8+n   7     4           3-5
```

SAR - Shift Arithmetic Right

```
        Usage:  SAR     dest,count
        Modifies flags: CF OF PF SF ZF (AF undefined)

            +-----------------------+   +---+
       +-->| 7 ----------------> 0 |-->| C |
       |   +-----------------------+   +---+
       |     |
       +-----+

        Shifts the destination right by "count" bits with the current sign
        bit replicated in the leftmost bit.  The Carry Flag contains the
        last bit shifted out.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        reg,1              2     2     3     3             2
        mem,1            15+EA   7     7     4           2-4   (W88=23+EA)
        reg,CL             8+4n  5+n   3     3             2
        mem,CL          20+EA+4n 8+n   7     4           2-4   (W88=28+EA+4n)
        reg,immed8         -     5+n   3     2             3
        mem,immed8         -     8+n   7     4           3-5
```

SBB - Subtract with Borrow/Carry

```
Usage:  SBB     dest,src
Modifies flags: AF CF OF PF SF ZF

Subtracts the source from the destination, and subtracts 1 extra if
the Carry Flag is set.   Results are returned in "dest".

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg,reg            3     2     2     1             2
mem,reg          16+EA   7     6     3            2-4  (W88=24+EA)
reg,mem           9+EA   7     7     2            2-4  (W88=13+EA)
reg,immed          4     3     2     1            3-4
mem,immed        17+EA   7     7     3            3-6  (W88=25+EA)
accum,immed        4     3     2     1            2-3
```

SCAS - Scan String (Byte, Word or Doubleword)

```
Usage:  SCAS    string
        SCASB
        SCASW
        SCASD   (386+)
Modifies flags: AF CF OF PF SF ZF

Compares value at ES:DI (even if operand is specified) from the
accumulator and sets the flags similar to a subtraction.  DI is
incremented/decremented based on the instruction format (or
operand size) and the state of the Direction Flag.  Use with REP
prefixes.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

string             15    7     7     6             1  (W88=19)
```

SETAE/SETNB - Set if Above or Equal / Set if Not Below (386+)

```
Usage:  SETAE   dest
        SETNB   dest
(unsigned, 386+)
Modifies flags: none

Sets the byte in the operand to 1 if the Carry Flag is clear
otherwise sets the operand to 0.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg8               -     -     4     3             3
mem8               -     -     5     4             3
```

SETB/SETNAE - Set if Below / Set if Not Above or Equal (386+)

```
Usage:  SETB    dest
        SETNAE  dest
(unsigned, 386+)
Modifies flags: none
```

```
Sets the byte in the operand to 1 if the Carry Flag is set
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETBE/SETNA - Set if Below or Equal / Set if Not Above (386+)

```
Usage:  SETBE   dest
        SETNA   dest
(unsigned, 386+)
Modifies flags: none

Sets the byte in the operand to 1 if the Carry Flag or the Zero
Flag is set, otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETE/SETZ - Set if Equal / Set if Zero (386+)

```
Usage:  SETE    dest
        SETZ    dest
Modifies flags: none

Sets the byte in the operand to 1 if the Zero Flag is set,
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETNE/SETNZ - Set if Not Equal / Set if Not Zero (386+)

```
Usage:  SETNE   dest
        SETNZ   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Zero Flag is clear,
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETL/SETNGE - Set if Less / Set if Not Greater or Equal (386+)

```
Usage:  SETL    dest
        SETNGE  dest
(signed, 386+)
```

```
Modifies flags: none

Sets the byte in the operand to 1 if the Sign Flag is not equal
to the Overflow Flag, otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETGE/SETNL - Set if Greater or Equal / Set if Not Less (386+)

```
Usage:  SETGE   dest
        SETNL   dest
(signed, 386+)
Modifies flags: none

Sets the byte in the operand to 1 if the Sign Flag equals the
Overflow Flag, otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETLE/SETNG - Set if Less or Equal / Set if Not greater or Equal (386+)

```
Usage:  SETLE   dest
        SETNG   dest
(signed, 386+)
Modifies flags: none

Sets the byte in the operand to 1 if the Zero Flag is set or the
Sign Flag is not equal to the Overflow Flag,  otherwise sets the
operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETG/SETNLE - Set if Greater / Set if Not Less or Equal (386+)

```
Usage:  SETG    dest
        SETNLE  dest
(signed, 386+)
Modifies flags: none

Sets the byte in the operand to 1 if the Zero Flag is clear or the
Sign Flag equals to the Overflow Flag,  otherwise sets the operand
to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETS - Set if Signed (386+)

```
Usage:  SETS    dest
Modifies flags: none

Sets the byte in the operand to 1 if the Sign Flag is set, otherwise
sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETNS - Set if Not Signed (386+)

```
Usage:  SETNS   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Sign Flag is clear,
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETC - Set if Carry (386+)

```
Usage:  SETC    dest
Modifies flags: none

Sets the byte in the operand to 1 if the Carry Flag is set,
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETNC - Set if Not Carry (386+)

```
Usage:  SETNC   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Carry Flag is clear,
otherwise sets the operand to 0.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg8              -     -     4     3            3
mem8              -     -     5     4            3
```

SETO - Set if Overflow (386+)

```
Usage:  SETO    dest
```

```
Modifies flags: none

Sets the byte in the operand to 1 if the Overflow Flag is set,
otherwise sets the operand to 0.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg8              -     -     4     3             3
mem8              -     -     5     4             3
```

SETNO - Set if Not Overflow (386+)

```
Usage:  SETNO   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Overflow Flag is clear,
otherwise sets the operand to 0.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg8              -     -     4     3             3
mem8              -     -     5     4             3
```

SETP/SETPE - Set if Parity / Set if Parity Even (386+)

```
Usage:  SETP    dest
        SETPE   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Parity Flag is set,
otherwise sets the operand to 0.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg8              -     -     4     3             3
mem8              -     -     5     4             3
```

SETNP/SETPO - Set if No Parity / Set if Parity Odd (386+)

```
Usage:  SETNP   dest
        SETPO   dest
Modifies flags: none

Sets the byte in the operand to 1 if the Parity Flag is clear,
otherwise sets the operand to 0.

                          Clocks                  Size
Operands         808x  286   386   486           Bytes

reg8              -     -     4     3             3
mem8              -     -     5     4             3
```

SGDT - Store Global Descriptor Table (286+ privileged)

```
Usage:  SGDT    dest
Modifies flags: none
```

```
        Stores the Global Descriptor Table (GDT) Register into the
        specified operand.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        mem64              -     11    9     10             5
```

SIDT - Store Interrupt Descriptor Table (286+ privileged)

```
        Usage:  SIDT    dest
        Modifies flags: none

        Stores the Interrupt Descriptor Table (IDT) Register into the
        specified operand.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        mem64              -     12    9     10             5
```

SHL - Shift Logical Left

```
        See: SAL
```

SHR - Shift Logical Right

```
        Usage:  SHR     dest,count
        Modifies flags: CF OF PF SF ZF (AF undefined)

        +-----------------------+   +---+
    0-->| 7 ----------------> 0 |-->| C |
        +-----------------------+   +---+

        Shifts the destination right by "count" bits with zeroes shifted
        in on the left.  The Carry Flag contains the last bit shifted out.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        reg,1               2     2     3                2
        mem,1             15+EA   7     7               2-4   (W88=23+EA)
        reg,CL              8+4n  5+n   3                2
        mem,CL          20+EA+4n  8+n   7               2-4   (W88=28+EA+4n)
        reg,immed8          -     5+n   3                3
        mem,immed8          -     8+n   7               3-5
```

SHLD/SHRD - Double Precision Shift (386+)

```
        Usage:  SHLD    dest,src,count
                SHRD    dest,src,count
        Modifies flags: CF PF SF ZF (OF,AF undefined)

        SHLD shifts "dest" to the left "count" times and the bit positions
        opened are filled with the most significant bits of "src".  SHRD
        shifts "dest" to the right "count" times and the bit positions
        opened are filled with the least significant bits of the second
        operand.  Only the 5 lower bits of "count" are used.

                                        Clocks                  Size
```

Operands	808x	286	386	486	Bytes
reg16,reg16,immed8	-	-	3	2	4
reg32,reg32,immed8	-	-	3	2	4
mem16,reg16,immed8	-	-	7	3	6
mem32,reg32,immed8	-	-	7	3	6
reg16,reg16,CL	-	-	3	3	3
reg32,reg32,CL	-	-	3	3	3
mem16,reg16,CL	-	-	7	4	5
mem32,reg32,CL	-	-	7	4	5

SLDT - Store Local Descriptor Table (286+ privileged)

Usage: SLDT dest
Modifies flags: none

Stores the Local Descriptor Table (LDT) Register into the specified operand.

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16	-	2	2	2	3
mem16	-	2	2	3	5

SMSW - Store Machine Status Word (286+ privileged)

Usage: SMSW dest
Modifies flags: none

Store Machine Status Word (MSW) into "dest".

	Clocks				Size
Operands	808x	286	386	486	Bytes
reg16	-	2	10	2	3
mem16	-	3	3	3	5

STC - Set Carry

Usage: STC
Modifies flags: CF

Sets the Carry Flag to 1.

	Clocks				Size
Operands	808x	286	386	486	Bytes
none	2	2	2	2	1

STD - Set Direction Flag

Usage: STD
Modifies flags: DF

Sets the Direction Flag to 1 causing string instructions to auto-decrement SI and DI instead of auto-increment.

	Clocks				Size
Operands	808x	286	386	486	Bytes

```
none              2     2     2     2            1
```

STI - Set Interrupt Flag (Enable Interrupts)

```
Usage:  STI
Modifies flags: IF

Sets the Interrupt Flag to 1, which enables recognition of all
hardware interrupts.  If an interrupt is generated by a hardware
device, an End of Interrupt (EOI) must also be issued to enable
other hardware interrupts of the same or lower priority.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

none              2     2     2     5            1
```

STOS - Store String (Byte, Word or Doubleword)

```
Usage:  STOS    dest
        STOSB
        STOSW
        STOSD
Modifies flags: None

Stores value in accumulator to location at ES:(E)DI (even if operand
is given).  (E)DI is incremented/decremented based on the size of
the operand (or instruction format) and the state of the Direction
Flag.   Use with REP prefixes.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

dest              11    3     4     5            1  (W88=15)
```

STR - Store Task Register (286+ privileged)

```
Usage:  STR     dest
Modifies flags: None

Stores the current Task Register to the specified operand.

                          Clocks                Size
Operands         808x  286   386   486          Bytes

reg16             -     2     2     2            3
mem16             -     3     2     3            5
```

SUB - Subtract

```
Usage:  SUB     dest,src
Modifies flags: AF CF OF PF SF ZF

The source is subtracted from the destination and the result is
stored in the destination.

                          Clocks                Size
Operands         808x  286   386   486          Bytes
```

reg,reg	3	2	2	1	2	
mem,reg	16+EA	7	6	3	2-4	(W88=24+EA)
reg,mem	9+EA	7	7	2	2-4	(W88=13+EA)
reg,immed	4	3	2	1	3-4	
mem,immed	17+EA	7	7	3	3-6	(W88=25+EA)
accum,immed	4	3	2	1	2-3	

T Instructions

TEST - Test For Bit Pattern

```
        Usage:  TEST    dest,src
        Modifies flags: CF OF PF SF ZF (AF undefined)

        Performs a logical AND of the two operands updating the flags
        register without saving the result.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        reg,reg            3     2     1     1             2
        reg,mem           9+EA   6     5     1            2-4  (W88=13+EA)
        mem,reg           9+EA   6     5     2            2-4  (W88=13+EA)
        reg,immed          5     3     2     1            3-4
        mem,immed        11+EA   6     5     2            3-6
        accum,immed        4     3     2     1            2-3
```

V Instructions

VERR - Verify Read (286+ protected)

```
        Usage:  VERR    src
        Modifies flags: ZF

        Verifies the specified segment selector is valid and is readable
        at the current privilege level.  If the segment is readable,
        the Zero Flag is set, otherwise it is cleared.

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        reg16             -     14    10    11             3
        mem16             -     16    11    11             5
```

VERW - Verify Write (286+ protected)

```
        Usage:  VERW    src
        Modifies flags: ZF

        Verifies the specified segment selector is valid and is ratable
        at the current privilege level.  If the segment is writable,
        the Zero Flag is set, otherwise it is cleared.

                                  Clocks                  Size
        Operands         808x  286   386   486           Bytes

        reg16             -     14    15    11             3
        mem16             -     16    16    11             5
```

W Instructions

WAIT/FWAIT - Event Wait

```
        Usage:  WAIT
                FWAIT
        Modifies flags: None

        CPU enters wait state until the coprocessor signals it has finished
        its operation.  This instruction is used to prevent the CPU from
        accessing memory that may be temporarily in use by the coprocessor.
        WAIT and FWAIT are identical.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none               4     3     6+   1-3             1
```

WBINVD - Write-Back and Invalidate Cache (486+)

```
        Usage:  WBINVD
        Modifies flags: None

        Flushes internal cache, then signals the external cache to write
        back current data followed by a signal to flush the external cache.

                                  Clocks                  Size
        Operands          808x  286   386   486           Bytes

        none               -     -     -     5             2
```

X Instructions

XCHG - Exchange

```
        Usage:  XCHG    dest,src
        Modifies flags: None

        Exchanges contents of source and destination.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        reg,reg            4     3     3     3            2
        mem,reg          17+EA   5     5     5           2-4  (W88=25+EA)
        reg,mem          17+EA   5     5     3           2-4  (W88=25+EA)
        accum,reg          3     3     3     3            1
        reg,accum          3     3     3     3            1
```

XLAT/XLATB - Translate

```
        Usage:  XLAT    translation-table
                XLATB   (masm 5.x)
        Modifies flags: None

        Replaces the byte in AL with byte from a user table addressed by
        BX.  The original value of AL is the index into the translate table.
        The best way to describe this is MOV AL,[BX+AL]

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        table offset      11    5     5     4            1
```

XOR - Exclusive OR

```
        Usage:  XOR     dest,src
        Modifies flags: CF OF PF SF ZF (AF undefined)

        Performs a bitwise exclusive OR of the operands and returns
        the result in the destination.

                                Clocks                  Size
        Operands         808x  286   386   486          Bytes

        reg,reg            3     2     2     1            2
        mem,reg          16+EA   7     6     3           2-4  (W88=24+EA)
        reg,mem           9+EA   7     7     2           2-4  (W88=13+EA)
        reg,immed          4     3     2     1           3-4
        mem,immed        17+EA   7     7     3           3-6  (W88=25+EA)
        accum,immed        4     3     2     1           2-3
```