

## D16/M Instruction Set

### Addressing Modes

The D16/M processor has five addressing modes, including Implied Addressing (0 address instructions), as follows:

|             |                                                                                                                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| INSTR --    | <b>Implied Addressing.</b><br>The instruction operates on the CPU, and there is no memory operand.                                                                                                                                          |
| INSTR m     | <b>Immediate Addressing.</b><br>The memory word following the instruction opcode is the operand for the instruction.                                                                                                                        |
| INSTR (m)   | <b>Direct Addressing.</b><br>The memory word following the opcode is the address of the operand.                                                                                                                                            |
| INSTR [m]   | <b>Indirect Addressing.</b><br>The memory word following the opcode is the address of the address of the operand.                                                                                                                           |
| INSTR [m++] | <b>Post-Indexed Indirect Addressing.</b><br>As in Indirect Addressing, the memory word following the opcode is the address of the address of the operand. After the instruction executes, the address of the operand is incremented by one. |

### D16/M Zero-Address Instructions

| <u>Mnemonic</u> | <u>Opcode</u> | <u>Function</u>                                               | <u>Cycles (Extended)</u> |
|-----------------|---------------|---------------------------------------------------------------|--------------------------|
| INC             | 001A          | Increment Accumulator                                         | 7 (1)                    |
| DEC             | 001B          | Decrement Accumulator                                         | 7 (1)                    |
| COM             | 001C          | Ones Complement Accumulator                                   | 6 (1)                    |
| NEG             | 001D          | Twos Complement Accumulator                                   | 6 (1)                    |
| SET             | 001E          | Set Accumulator<br>(AC < FFFF)                                | 6 (1)                    |
| CLR             | 001F          | Clear Accumulator<br>(AC < 0000)                              | 6 (1)                    |
| SHL             | 0020          | Shift Left Accumulator<br>(CF < AC15, AC0 < 0)                | 6 (1)                    |
| LSR             | 0021          | Logical Shift Right Accumulator<br>(AC15 < 0, CF < AC0)       | 6 (1)                    |
| ASR             | 0022          | Arithmetic Shift Right Accumulator<br>(AC15 < AC15, CF < AC0) | 6 (1)                    |
| ROL             | 0023          | Rotate Left Accumulator<br>(CF < AC15, AC0 < CF)              | 6 (1)                    |
| ROR             | 0024          | Rotate Right Accumulator<br>(AC15 < CF, CF < AC0)             | 6 (1)                    |
| LSW             | 0025          | Load Accumulator with Switch Register                         | 6 (1)                    |

|     |      |                                            |        |
|-----|------|--------------------------------------------|--------|
| SCF | 0026 | Set Carry Flag<br>(CF < 1)                 | 6 (1)  |
| CCF | 0027 | Clear Carry Flag<br>(CF < 0)               | 6 (1)  |
| PSA | 0028 | Push Accumulator onto Stack                | 7 (2)  |
| POA | 0029 | Pop Accumulator off of Stack               | 6 (2)  |
| PSF | 002A | Push Flag Register onto Stack              | 7 (2)  |
| POF | 002B | Pop Flag Register off of Stack             | 6 (2)  |
| ENI | 002C | Enable Interrupts                          | 5 (1)  |
| DII | 002D | Disable Interrupts                         | 5 (1)  |
| RTN | 002E | Return from Subroutine                     | 6 (2)  |
| RTI | 002F | Return from Interrupt, Enabling Interrupts | 10 (4) |
| HLT | 00FF | Processor Halt                             | 5 (1)  |
| NOP | 0030 | No Operation                               | 6 (1)  |

### **D16/M Memory Reference (One Address) Instructions**

| <b><u>Mnemonic<br/>(Extended)</u></b> | <b><u>Opcode</u></b> | <b><u>Function</u></b>                   | <b><u>Cycles</u></b> |
|---------------------------------------|----------------------|------------------------------------------|----------------------|
| LDA m0301                             |                      | Load Accumulator (Immediate)             | 8 (2)                |
| LDA (m)                               | 0101                 | Load Accumulator (Direct)                | 8 (3)                |
| LDA [m]                               | 0501                 | Load Accumulator (Indirect)              | 9 (4)                |
| LDA [m++]                             | 0D01                 | Load Accumulator (Indirect Post-Indexed) | 12 (5)               |
| LDS m0302                             |                      | Load Stack Pointer                       | 8 (2)                |
| LDS (m)                               | 0102                 |                                          | 8 (3)                |
| LDS [m]                               | 0502                 |                                          | 9 (4)                |
| LDS [m++]                             | 0D02                 |                                          | 12 (5)               |
| STA (m)                               | 0103                 | Store Accumulator                        | 7 (3)                |

|                                                  |      |                                       |       |        |
|--------------------------------------------------|------|---------------------------------------|-------|--------|
| STA [m]                                          | 0503 |                                       |       | 8 (4)  |
| STA [m++]                                        | 0D03 |                                       |       | 11 (5) |
| STS (m)                                          | 0104 | Store Stack Pointer                   |       | 7 (3)  |
| STS [m]                                          | 0504 |                                       |       | 8 (4)  |
| STS [m++]                                        | 0D04 |                                       |       | 11 (5) |
| ADD m                                            | 0305 | Add to Accumulator                    |       | 7 (2)  |
| ADD (m)                                          | 0105 |                                       |       | 8 (3)  |
| ADD [m]                                          | 0505 |                                       |       | 9 (4)  |
| ADD [m++]                                        | 0D05 |                                       |       | 12 (5) |
| ADC m0306                                        |      | Add to Accumulator with Carry         | 7 (2) |        |
| ADC (m)                                          | 0106 |                                       |       | 8 (3)  |
| ADC [m]                                          | 0506 |                                       |       | 9 (4)  |
| ADC [m++]                                        | 0D06 |                                       |       | 12 (5) |
| SUB m0307                                        |      | Subtract from Accumulator             | 7 (2) |        |
| SUB (m)                                          | 0107 |                                       |       | 8 (3)  |
| SUB [m]                                          | 0507 |                                       |       | 9 (4)  |
| SUB [m++]                                        | 0D07 |                                       |       | 12 (5) |
| SBC m0308                                        |      | Subtract from Accumulator with Borrow | 7 (2) |        |
| SBC (m)                                          | 0108 |                                       |       | 8 (3)  |
| SBC [m]                                          | 0508 |                                       |       | 9 (4)  |
| SBC [m++]                                        | 0D08 |                                       |       | 12 (5) |
| AND m                                            | 0309 | Logical AND with Accumulator          | 7 (2) |        |
| AND (m)                                          | 0109 |                                       |       | 8 (3)  |
| AND [m]                                          | 0509 |                                       |       | 9 (4)  |
| AND [m++]                                        | 0D09 |                                       |       | 12 (5) |
| ORA m030A                                        |      | Logical OR with Accumulator           | 7 (2) |        |
| ORA (m)                                          | 010A |                                       |       | 8 (3)  |
| ORA [m]                                          | 050A |                                       |       | 9 (4)  |
| ORA [m++]                                        | 0D0A |                                       |       | 12 (5) |
| XOR m030B                                        |      | Logical Exclusive-OR with Accumulator | 7 (2) |        |
| XOR (m)                                          | 010B |                                       |       | 8 (3)  |
| XOR [m]                                          | 050B |                                       |       | 9 (4)  |
| XOR [m++]                                        | 0D0B |                                       |       | 12 (5) |
| ISZ (m)010C                                      |      | Increment and Skip if Zero            |       | 9 (4)  |
| ISZ [m]050C                                      |      |                                       |       | 10 (5) |
| DSZ (m)                                          | 010D | Decrement and Skip if Zero            |       | 9 (4)  |
| DSZ [m]                                          | 050D |                                       |       | 10 (5) |
| <i>Any Skipped instruction after ISZ or DSZ:</i> |      |                                       |       | 4 (1)  |
| JMP m030E                                        |      | Unconditional Jump                    | 7 (2) |        |
| JMP (m)                                          | 010E |                                       |       | 8 (3)  |
| JOZ m 030F                                       |      | Jump on Zero Accumulator              |       | 9 (2)  |
| JOZ (m)010F                                      |      |                                       |       | 10 (3) |
| JNZ m 0310                                       |      | Jump on Non-Zero Accumulator          | 9 (2) |        |

|            |      |                                            |       |        |
|------------|------|--------------------------------------------|-------|--------|
| JNZ (m)    | 0110 |                                            |       | 10 (3) |
| JPL m      | 0311 | Jump on Plus Accumulator                   |       | 9 (2)  |
| JPL (m)    | 0111 |                                            |       | 10 (3) |
| JMI m      | 0312 | Jump on Minus Accumulator                  |       | 9 (2)  |
| JMI (m)    | 0112 |                                            |       | 10 (3) |
| JOC m 0313 |      | Jump on Carry (CF = 1)                     | 9 (2) |        |
| JOC (m)    | 0113 |                                            |       | 10 (3) |
| JNC m 0314 |      | Jump on No Carry (CF = 0)                  | 9 (2) |        |
| JNC (m)    | 0114 |                                            |       | 10 (3) |
| JOV m 0315 |      | Jump on Twos Complement Overflow (OVF = 1) | 9 (2) |        |
| JOV (m)    | 0115 |                                            |       | 10 (3) |
| JNV m 0316 |      | Jump on No Overflow (OVF = 0)              | 9 (2) |        |
| JNV (m)    | 0116 |                                            |       | 10 (3) |
| CSR m 0317 |      | Call Subroutine                            | 9 (3) |        |

#### **D16/M Input/Output Instructions**

| <b><u>Mnemonic</u></b><br><b><u>(Extended)</u></b> | <b><u>Opcode</u></b> | <b><u>Function</u></b>                           | <b><u>Cycles</u></b> |
|----------------------------------------------------|----------------------|--------------------------------------------------|----------------------|
| INP (m)                                            | 0118                 | Input to Accumulator from I/O port at address m  | 7 (3)                |
| OUT (m)                                            | 0119                 | Output from Accumulator to I/O port at address m | 7 (3)                |