

# MSM6442

## CMOS 4-BIT SINGLE CHIP MICROCONTROLLER WITH LCD DRIVER

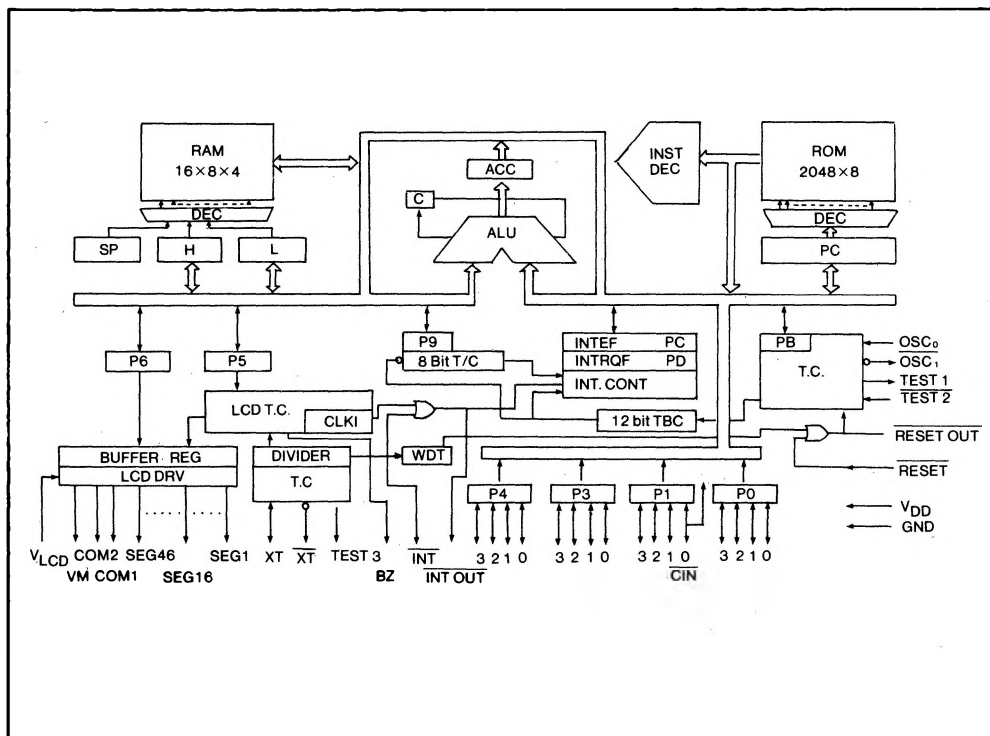
## GENERAL DESCRIPTION

The OKI MSM6442 is a low power, high performance single chip device implemented in complementary metal oxide semiconductor technology with 46 segment outputs and 2 commons. Also integrated onto this chip are 16K bits mask program ROM, 512 bits of data RAM, 28 Input/Output lines and oscillator. 71 instructions include binary, BCD, logical operations; bit set, reset, test; subroutine call and return.

## FEATURES

- Low Power Consumption 30mW (typ)
- 2048 × 8 Internal ROM
- 128 × 4 Internal RAM
- Two built-in counters
  - 12-bit time-base counter
  - 8-bit programmable timer/event counter
- 16 Input/Output Ports and 46 LCD Output Port and 2 Common Output
- Self-contained Oscillator
- 71 Instructions
- 4 Interrupt Levels
- 16 Stack Levels
- -40 to +85°C Operating Temperature
- 4.5 to 5.5V Operating V<sub>DD</sub> at 4.2 MHz
- 3.0 to 6.0V Operating V<sub>DD</sub> at 1 MHz
- TTL Compatible

## FUNCTIONAL BLOCK DIAGRAM



### LOGIC SYMBOL

## FUNCTIONAL DESCRIPTION

### ROM

Organized into 2048 words by 8 bits, ROM is used to store developed application programs (instructions). It is addressed by the program counter (PC).

### PROGRAM COUNTER (PC)

The program counter consists of a 11-bit binary counter. It is used to address ROM.

### STACK

An interrupt or CAL instruction causes the contents of the PC to be saved in the stack. Also, the PUSH instruction causes the contents of accumulator, carry-flag, H- and L-register to be saved in it. These are allowed to be restored by the RT instruction or POP instruction.

### RAM

Organized into 128 words of 4 bits, RAM is addressed by the H- and L-register or the contents of the second byte of an instruction.

### L-REGISTER

A 4-bit register which specifies the row address of RAM and the port-address in the port operation instructions. It is also used as a working register.

### H-REGISTER

A 4-bit register which specifies the column address of RAM and is used as a working register.

### ALU

A 4-bit logic circuit which provides arithmetic and logical operations.

### ACCUMULATOR (ACL)

Consisting of a 4-bit register, the accumulator holds the result of operations or the data present on ports.

### C-FLAG

The flag that holds a carry generated from the result of operations.

### INPUT/OUTPUT Ports (16 bits)

16 input/output ports are provided for effecting and controlling data transfer to and from an external source. The ports are selected by codes included in the instructions.

### 12-bit TIME-BASE COUNTER

The time base counter consists of a 12-bit binary counter. It is used to divide the frequency of the OSC<sub>0</sub> input by 2<sup>12</sup> and generate the interrupt request at every over-flow signal.

### 8-bit TIMER EVENT COUNTER

The timer event counter consists of a 8-bit counter (8-bit) register, comparing and controlling circuits. It is used to count pulses of an internal or external source. Coincidentally, if value between the counter and the register causes interrupt request occur.

### LCD DRIVER

The LCD driver is used to effect LCD display by transferring data in a program to the register assigned as port 5 and 6. It is available to select driving in static or dynamic operation (1/2 duty cycle) and frame frequency (128 Hz/64 Hz) and to drive up to 92 segments at 1/2 duty. Also, 16 outputs(SEG1~SEG16)of the segment terminals can be used as normal data outputs.

A standard LCD clock is produced by the oscillation dividing a crystal oscillator (32.768 kHz) connected to XT and XT terminals. This is also used as standard clock of displaying, clock interrupting and watch dog timer. (This clock can be also produced by dividing a frequency of 4.194304 MHz. Note the selection of the frame frequency, when the crystal oscillator is used without a frequency of 4.194304 MHz.)

### INTERRUPT

As shown below, 1 ~ 4 is available to interrupt;

1. External interrupt at the falling edge of INT signal input
2. Clock interrupt at every second (32.768 kHz crystal oscillator)
3. Time base counter interrupt at the occurrence of an overflow of the timer base counter.
4. Timer event counter interrupt coinciding between the signals of the 8-bit counter and register.

Interrupts 1 and 2 are also used to release the power down mode.

### WATCH DOG TIMER (WDT)

A timer for detecting the overrunning of the program. This timer produces the overflow signal by dividing the 64 Hz frequency by 4 generated from the oscillation of a frequency of 32.768 kHz. It can be also halted, when unused.

### TIMING CONTROL (T.C)

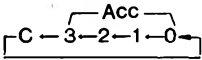
A 0 level on the RESET pin for longer than predetermined period initializes the internal circuitry and ports.

Clock pulses are supplied to the OSC<sub>0</sub> pin from an external source. A crystal or ceramic oscillator may be connected to OSC<sub>0</sub> and OSC<sub>1</sub> to form an oscillator circuit to produce clock pulses.

## INSTRUCTION SET

|                         | Mnemonic   | Hex op code | Byte | Cycle | Description               |
|-------------------------|------------|-------------|------|-------|---------------------------|
| Load                    | LAI     n  | 90 - 9F     | 1    | 1     | Acc ← n                   |
|                         | LLI     n  | 80 - 8F     | 1    | 1     | L ← n                     |
|                         | LAL        | 21          | 1    | 1     | Acc ← L                   |
|                         | LLA        | 2D          | 1    | 1     | L ← Acc                   |
|                         | LAH        | 22          | 1    | 1     | Acc ← H                   |
|                         | LHA        | 2E          | 1    | 1     | H ← Acc                   |
|                         | LAM        | 38          | 1    | 1     | Acc ← M                   |
|                         | LMA        | 2F          | 1    | 1     | M ← Acc                   |
|                         | X          | 28          | 1    | 1     | Acc ↔ M                   |
|                         | LMI     nn | 14 · nn     | 2    | 2     | M(W) ← nn                 |
|                         | LHLI   nn  | 15 · nn     | 2    | 2     | HL ← nn                   |
|                         | LAMD   mm  | 10 · mm     | 2    | 2     | Acc ← Md                  |
|                         | LMAD   mm  | 11 · mm     | 2    | 2     | Md ← Acc                  |
|                         | LMCT       | 3E · 59     | 2    | 2     | M(W) ← CT                 |
|                         | LCTM       | 3E · 51     | 2    | 2     | CT ← M(W)                 |
|                         | IPD     p  | 3D · pD     | 2    | 2     | Acc ← Pp                  |
|                         | OPD     p  | 3D · pC     | 2    | 2     | Pp ← Acc                  |
| Control                 | MEI        | 3E · 60     | 2    | 2     | MEIF ← "1"                |
|                         | MDI        | 3E · 61     | 2    | 2     | MEIF ← "0"                |
|                         | EIEX       | 3D · C8     | 2    | 2     | EIEXF ← "1"               |
|                         | EICT       | 3D · CB     | 2    | 2     | EICTF ← "1"               |
|                         | DIEX       | 3D · C4     | 2    | 2     | EIEXF ← "0"               |
|                         | DICT       | 3D · C7     | 2    | 2     | EICTF ← "0"               |
|                         | TIEX       | 3D · C0     | 2    | 2     | SKIP IF EIEXF="1"         |
|                         | TICT       | 3D · C3     | 2    | 2     | SKIP IF EICTF="1"         |
|                         | TQEX       | 3D · 20     | 2    | 2     | SKIP IF IRQEX="1"         |
|                         | TQCT       | 3D · D2     | 2    | 2     | SKIP IF IRQCT="1"         |
|                         | RQEX       | 3D · 24     | 2    | 2     | IRQEX ← "0"               |
|                         | RQCT       | 3D · D6     | 2    | 2     | IRQCT ← "0"               |
| Increment/<br>decrement | INL        | 31          | 1    | 1     | L ← L+1, SKIP IF L="0"    |
|                         | INH        | 32          | 1    | 1     | H ← H+1, SKIP IF H="0"    |
|                         | INM        | 33          | 1    | 1     | M ← M+1, SKIP IF M="0"    |
|                         | DCL        | 35          | 1    | 1     | L ← L-1, SKIP IF L="F"    |
|                         | DCH        | 36          | 1    | 1     | H ← H-1, SKIP IF H="F"    |
|                         | DCM        | 37          | 1    | 1     | M ← M-1, SKIP IF M="M"    |
|                         | INMD   mm  | 12 · mm     | 2    | 2     | Md ← Md+1, SKIP IF Md="0" |

## INSTRUCTION SET (CONT.)

|              | Mnemonic  | Hex op code        | Byte | Cycle | Description                                                                         |
|--------------|-----------|--------------------|------|-------|-------------------------------------------------------------------------------------|
| Bit handling | TAB n2    | 54 - 57            | 1    | 1     | SKIP IF (ACC-Bit n2) = "1"                                                          |
|              | TPB n2    | 50 - 53            | 1    | 1     | SKIP IF (P-Bit n2) = "1"                                                            |
|              | RPB n2    | 60 - 63            | 1    | 1     | (P-Bit n2) ← "0"                                                                    |
|              | SPB n2    | 70 - 73            | 1    | 1     | (P-Bit n2) ← "1"                                                                    |
|              | TMB n2    | 58 - 5B            | 1    | 1     | SKIP IF (M-Bit n2) = "1"                                                            |
|              | RMB n2    | 68 - 6B            | 1    | 1     | (M-Bit n2) ← "0"                                                                    |
|              | SMB n2    | 78 - 7B            | 1    | 1     | (M-Bit n2) ← "1"                                                                    |
|              | TPBD p n2 | 3D · p0~3          | 2    | 2     | SKIP IF (Pp-Bit n2) = "1"                                                           |
|              | RPBD p n2 | 3D · p4~7          | 2    | 2     | (Pp-Bit n2) ← "0"                                                                   |
|              | SPBD p n2 | 3D · p8~B          | 2    | 2     | (Pp-Bit n2) ← "1"                                                                   |
|              | TC        | 09                 | 1    | 1     | SKIP IF C = "1"                                                                     |
|              | RC        | 08                 | 1    | 1     | C ← "0"                                                                             |
|              | SC        | 07                 | 1    | 1     | C ← "1"                                                                             |
| Arithmetic   | ADS       | 02                 | 1    | 1     | Acc ← Acc+M, SKIP IF Cy="1"                                                         |
|              | ADC       | 03                 | 1    | 1     | C, Acc ← C+Acc+M                                                                    |
|              | AIS n     | 3E · 4n            | 2    | 2     | Acc ← Acc+n, SKIP IF Cy="1"                                                         |
|              | DAS       | 0A                 | 1    | 1     | Acc ← Acc+10                                                                        |
|              | AND       | 0D                 | 1    | 1     | Acc ← Acc∧M                                                                         |
|              | OR        | 05                 | 1    | 1     | Acc ← Acc∨M                                                                         |
|              | EOR       | 04                 | 1    | 1     | Acc ← Acc⊕M                                                                         |
|              | CMA       | 0B                 | 1    | 1     | Acc ← Acc                                                                           |
|              | CAM       | 16                 | 1    | 1     | SKIP IF Acc=M                                                                       |
|              | CAI n     | 3E · 0n            | 2    | 2     | SKIP IF Acc=n                                                                       |
| Branch       | RAL       | 0E                 | 1    | 1     |  |
|              | JCP a6    | C0 - FF            | 1    | 1     | PC ← a6                                                                             |
|              | JP a11    | 40 - 47<br>00 - FF | 2    | 2     | PC ← a11                                                                            |
|              | CAL a11   | A0 - A7<br>00 - FF | 2    | 4     | STACK ← PC+2,<br>PC ← a11, SP ← SP-1                                                |
| Others       | RT        | 1E                 | 1    | 4     | PC ← STACK, SP ← SP+1                                                               |
|              | PUSH      | 1C                 | 1    | 3     | STACK ← C, Acc, H, L,<br>SP ← SP-1                                                  |
|              | POP       | 1D                 | 1    | 3     | C, Acc, H, L ← STACK,<br>SP ← SP+1                                                  |
|              | STOP      | 3D · B9            | 2    | 2     | CLOCK STOP                                                                          |
|              | NOP       | 00                 | 1    | 1     | NO OPERATION                                                                        |