

## 4-Bit Micro-Controller With EPROM, 1K Word

### Features

- Very low current dissipation.
- Wide operating voltage range.
- Supports both Ag and Li batteries.
- Powerful instruction set.
- 4-level subroutine nesting (including interrupt).
- 4 event-driven interrupts, 2 external and 2 internal.
- ROM size: 1024x15 bits.
- RAM size: 64x4 bits.
- Input ports: 2 ports/ 8 pins (S and M).
- Output port: 1 port/ 4 pins (P).
- Pseudo serial output port (P).
- Input/Output ports: 2 ports/ 8 pins (I/OA and I/OB).
- Control outputs: ALARM, LIGHT.
- LCD driver outputs (can drive up to 75 LCD segments).
- PROM option to select 4 LCD drive modes: static, duplex (1/2 duty 1/2 bias, 1/3 duty 1/2 bias or 1/3 duty 1/3 bias).
- PROM option permits LCD driver output pins to be used for DC output ports; up to 25 pins are available.
- Segment PLA circuit permits any layout on LCD panel.
- Built-in clock generator (crystal or RC).
- Built-in voltage doubler, halver, tripler.
- Endurance: More than 100 write cycles/word.
- Security bit for read/write protection.

### General Description

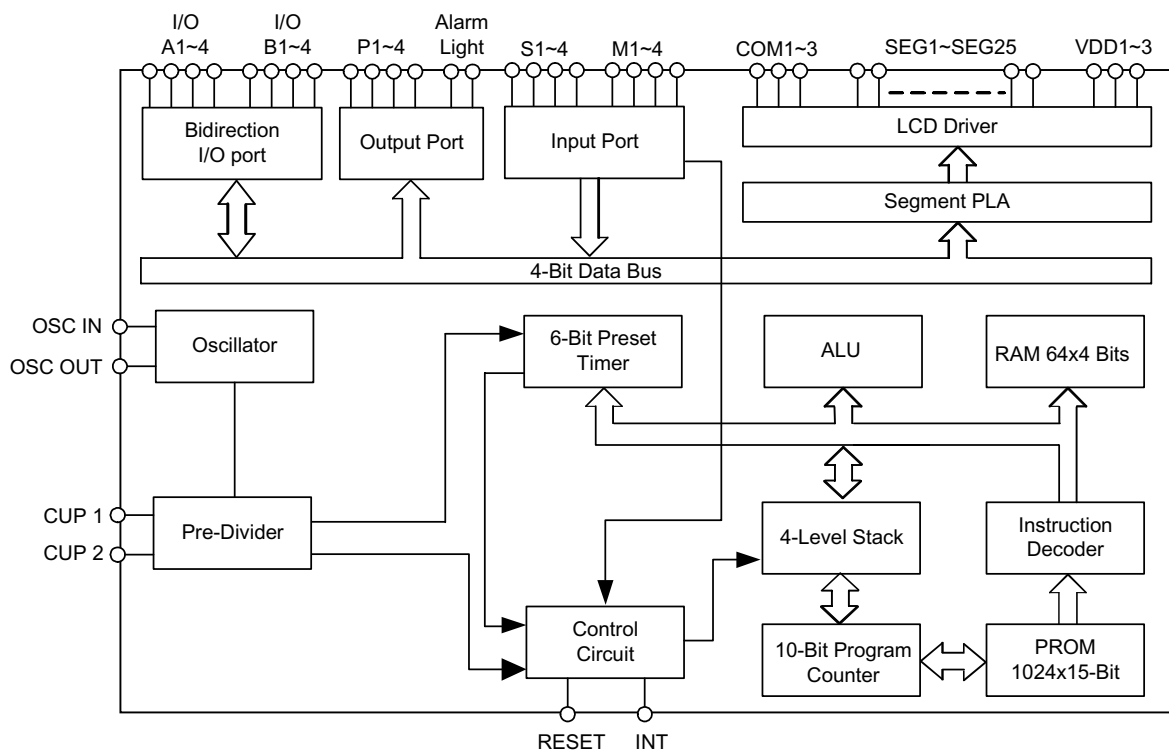
The APU4003T is an EEPROM-equipped high-performance 4-bit microcomputer.

It contains not only all functions compatible with APU4003T, but also an EEPROM, providing customers such conveniences as on-board verification,

customized code, small quantity sample production, etc.

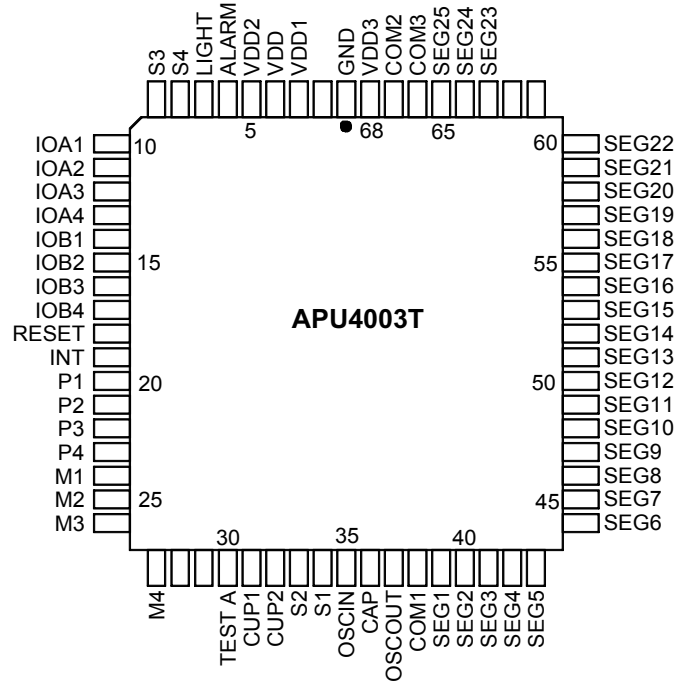
This chip especially provides a security bit to protect the customer's code.

### Block Diagram



## Package Information

Package type 68Pin PLCC



## Pin/Pad Assignment

Unit:  $\mu\text{m}$

| Pin No. | Name  | Pin No. | Name  | Pin No. | Name   | Pin No. | Name  |
|---------|-------|---------|-------|---------|--------|---------|-------|
| 1       | VSS   | 18      | RESET | 35      | OSCIN  | 52      | SEG14 |
| 2       | ----- | 19      | INT   | 36      | CAP    | 53      | SEG15 |
| 3       | VDD1  | 20      | P1    | 37      | OSCOUT | 54      | SEG16 |
| 4       | VDD   | 21      | P2    | 38      | COM1   | 55      | SEG17 |
| 5       | VDD2  | 22      | P3    | 39      | SEG1   | 56      | SEG18 |
| 6       | ALARM | 23      | P4    | 40      | SEG2   | 57      | SEG19 |
| 7       | LIGHT | 24      | M1    | 41      | SEG3   | 58      | SEG20 |
| 8       | S4    | 25      | M2    | 42      | SEG4   | 59      | SEG21 |
| 9       | S3    | 26      | M3    | 43      | SEG5   | 60      | SEG22 |
| 10      | IOA1  | 27      | M4    | 44      | SEG6   | 61      | ----- |
| 11      | IOA2  | 28      | ----- | 45      | SEG7   | 62      | ----- |
| 12      | IOA3  | 29      | ----- | 46      | SEG8   | 63      | SEG23 |
| 13      | IOA4  | 30      | TESTA | 47      | SEG9   | 64      | SEG24 |
| 14      | IOB1  | 31      | CUP1  | 48      | SEG10  | 65      | SEG25 |
| 15      | IOB2  | 32      | CUP2  | 49      | SEG11  | 66      | COM3  |
| 16      | IOB3  | 33      | S2    | 50      | SEG12  | 67      | COM2  |
| 17      | IOB4  | 34      | S1    | 51      | SEG13  | 68      | VDD3  |

**Pin Name Description**

| Name    | Type | Description  |
|---------|------|--|
| OSCIN   | I    | Typical crystal(32.768KHz) is connected across OSCIN/OSCOUT for oscillation; R/C oscillation mode is also available.   |
| OSCOUT  | O    |  |
| S1~4    | I    | Input ports with chattering eliminator option for CK10 (32ms), CK8 (8ms) & CK6 (2ms).                                  |
| M1~4    | I    |  |
| P1~4    | O    | Output ports.  |
| IOA1~4  | I/O  | Input/Output ports.  |
| IOB1~4  | I/O  | Input/Output ports.  |
| INT     | I    | External interrupt request control input pin.  |
| RESET   | I    | System reset pin.  |
| LIGHT   | O    | Output only for outputting the signal to drive the transistor for light.   |
| ALARM   | O    | Output only for outputting the 4kHz/2kHz/1kHz modulation signal. Also can be used to output the non-modulation signal. |
| VDD     |      | (+)Power supply pin.   |
| VDD1    |      | * For Ag version, apply (+) side to VDD & VDD1 together.   |
| VDD2    |      | For other than Ag version, apply (+) side to VDD & VDD2 together.  |
| VDD3    |      | Power supply pin for LCD driver power supply.  |
| VSS     |      | (-)Power supply pin.   |
| CUP1~2  | O    | Pins for connecting the voltage step-up (step-down) capacitor.   |
| COM1~3  | O    | Output pins for LCD panel common plate.  |
| SEG1~25 | O    | Output pins for LCD panel segments.  |

**Absolute Maximum Rating**

Ta = 0 to 70°C

| Name                          | Symbol      | Rating                | Unit |
|-------------------------------|-------------|-----------------------|------|
| Maximum Supply Voltage        | $V_{SS1/2}$ | -0.3 ~ +5.5           | V    |
|                               | $V_{SS3}$   | -0.3 ~ +8.5           | V    |
| Maximum Input Voltage         | $V_{IN1}$   | -0.3 to $V_{DD}+0.3$  | V    |
| Maximum Output Voltage        | $V_{OUT1}$  | -0.3 to $V_{DD1}+0.3$ | V    |
|                               | $V_{OUT2}$  | -0.3 to $V_{DD2}+0.3$ | V    |
|                               | $V_{OUT3}$  | -0.3 to $V_{DD3}+0.3$ | V    |
| Maximum Operating Temperature | $t_{OPG}$   | 0 to +70              | °C   |
| Maximum Storage Temperature   | $t_{STG}$   | -25 to +125           | °C   |

**Allowable operating conditions**

Ta = 0 to 70°C

| Name              | Symbol     | Condition              | Min.         | Max.         | Unit |
|-------------------|------------|------------------------|--------------|--------------|------|
| Supply Voltage    | $V_{DD1}$  | External Voltage Mode  | 2.0          | 5.5          | V    |
|                   | $V_{DD2}$  |                        | 4.0          | 5.5          | V    |
|                   | $V_{DD3}$  |                        | 4.0          | 8.25         | V    |
| Supply Voltage    | $V_{DD1}$  | Ag & Li Battery Mode   | 1.3          | 5.5          | V    |
|                   | $V_{DD2}$  |                        | 2.6          | 5.5          | V    |
|                   | $V_{DD3}$  |                        | 2.6          | 8.25         | V    |
| Input "H" Voltage | $V_{IH1}$  | All Input Except OSCIN | $0.7V_{DDO}$ | $V_{DDO}$    | V    |
| Input "L" Voltage | $V_{IL1}$  |                        | 0            | $0.3V_{DDO}$ | V    |
| Input "H" Voltage | $V_{IH2}$  | OSCIN at Ext. RC Mode  | $0.8V_{DDO}$ | $V_{DDO}$    | V    |
| Input "L" Voltage | $V_{IL2}$  |                        | 0            | $0.2V_{DDO}$ | V    |
| Operating Freq.   | $f_{OPG1}$ | Ag Battery Mode        | 32           | 32           | kHz  |
|                   | $f_{OPG2}$ | Li Battery Mode        | 32           | 100          | kHz  |
|                   | $f_{OPG3}$ | External Voltage Mode  | 32           | 3580         | kHz  |
|                   | $f_{OPG4}$ | External RC Mode       | 32           | 5000         | kHz  |

**Electrical Characteristics**

Ta=0 to 70°C

**Input resistance**

| Name                          | Symbol              | Condition  | Min. | Typ. | Max. | Unit |
|-------------------------------|---------------------|--|------|------|------|------|
| "L"-Level Hold t <sub>R</sub> | R <sub>I IH1</sub>  | V <sub>I</sub> =0.2V <sub>DD1</sub> , #1                 | 10   | 40   | 100  | kΩ   |
|                               | R <sub>I IH2</sub>  | V <sub>I</sub> =0.2V <sub>DD2</sub> , #2                 | 10   | 40   | 100  | kΩ   |
|                               | R <sub>I IH3</sub>  | V <sub>I</sub> =0.3V <sub>DD2</sub> , #3                 | 5    | 20   | 50   | kΩ   |
| M/S Pull-Down t <sub>R</sub>  | R <sub>M SD1</sub>  | V <sub>I</sub> =V <sub>DD1</sub> , #1                    | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>M SD2</sub>  | V <sub>I</sub> =V <sub>DD2</sub> , #2                    | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>M SD3</sub>  | V <sub>I</sub> =V <sub>DD2</sub> , #3                    | 100  | 250  | 500  | kΩ   |
| INT Pull-Up t <sub>R</sub>    | R <sub>I NTU1</sub> | V <sub>I</sub> =V <sub>SS</sub> , #1                     | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>I NTU2</sub> | V <sub>I</sub> =V <sub>SS</sub> , #2                     | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>I NTU3</sub> | V <sub>I</sub> =V <sub>SS</sub> , #3                     | 100  | 250  | 500  | kΩ   |
| INT Pull-Down t <sub>R</sub>  | R <sub>I NTD1</sub> | V <sub>I</sub> =V <sub>DD1</sub> , #1                    | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>I NTD2</sub> | V <sub>I</sub> =V <sub>DD2</sub> , #2                    | 200  | 500  | 1000 | kΩ   |
|                               | R <sub>I NTD3</sub> | V <sub>I</sub> =V <sub>DD2</sub> , #3                    | 100  | 250  | 500  | kΩ   |
| RES Pull-Down t <sub>R</sub>  | R <sub>R ES1</sub>  | V <sub>I</sub> =V <sub>DD</sub> or V <sub>SS1</sub> , #1 | 5    | 20   | 50   | kΩ   |
|                               | R <sub>R ES2</sub>  | V <sub>I</sub> =V <sub>DD</sub> or V <sub>SS2</sub> , #2 | 5    | 20   | 50   | kΩ   |
|                               | R <sub>R ES3</sub>  | V <sub>I</sub> =V <sub>DD</sub> or V <sub>SS2</sub> , #3 | 5    | 20   | 50   | kΩ   |

 Note: #1: V<sub>DD1</sub>= 1.3V (Ag), #2: V<sub>DD2</sub>= 2.6V (Li), #3: V<sub>DD2</sub>= 4.5V (ExtV).

**DC output characteristics**

| Name               | Symbol             | Condition                   | For                | Min. | Typ. | Max. | Unit |
|--------------------|--------------------|-----------------------------|--------------------|------|------|------|------|
| Output "H" Voltage | V <sub>O H1a</sub> | I <sub>OH</sub> =-200μA, #1 | Alarm Light        | 0.9  | 1.1  |      | V    |
|                    | V <sub>O H2a</sub> | I <sub>OH</sub> =-1mA, #2   |                    | 1.8  | 2.1  |      | V    |
|                    | V <sub>O H3a</sub> | I <sub>OH</sub> =-3mA, #3   |                    | 3.0  | 3.5  |      | V    |
| Output "L" Voltage | V <sub>O L1a</sub> | I <sub>OL</sub> =400μA, #1  | P-port IOA-n IOB-n |      | 0.3  | 0.5  | V    |
|                    | V <sub>O L2a</sub> | I <sub>OL</sub> =2mA, #2    |                    |      | 0.6  | 1    | V    |
|                    | V <sub>O L3a</sub> | I <sub>OL</sub> =6mA, #3    |                    |      | 1.0  | 1.5  | V    |
| Output "H" Voltage | V <sub>O H1b</sub> | I <sub>OH</sub> =-100μA, #1 | P-port IOA-n IOB-n | 0.9  | 1.1  |      | V    |
|                    | V <sub>O H2b</sub> | I <sub>OH</sub> =-500μA, #2 |                    | 1.8  | 2.1  |      | V    |
|                    | V <sub>O H3b</sub> | I <sub>OH</sub> =-1.5mA, #3 |                    | 3.0  | 3.5  |      | V    |
| Output "L" Voltage | V <sub>O L1b</sub> | I <sub>OL</sub> =200μA, #1  | P-port IOA-n IOB-n |      | 0.3  | 0.5  | V    |
|                    | V <sub>O L2b</sub> | I <sub>OL</sub> =1mA, #2    |                    |      | 0.6  | 1    | V    |
|                    | V <sub>O L3b</sub> | I <sub>OL</sub> =3mA, #3    |                    |      | 1.0  | 1.5  | V    |

 Note: #1: V<sub>DD1</sub>= 1.3V (Ag), #2: V<sub>DD2</sub>= 2.6V (Li), #3: V<sub>DD2</sub>= 4.5V (ExtV).

**Segment driver output characteristics**

| Name                       | Symbol             | Condition                     | For   | Min. | Typ. | Max. | Unit |
|----------------------------|--------------------|-------------------------------|-------|------|------|------|------|
| <b>DC output mode</b>      |                    |                               |       |      |      |      |      |
| Output "H" Voltage         | V <sub>O H1c</sub> | I <sub>OH</sub> =-10μA, #1    | SEG-n | 0.9  | 1.1  |      | V    |
|                            | V <sub>O H2c</sub> | I <sub>OH</sub> =-50μA, #2    |       | 1.8  | 2.1  |      | V    |
|                            | V <sub>O H3c</sub> | I <sub>OH</sub> =-200μA, #3   |       | 3.0  | 3.5  |      | V    |
| Output "L" Voltage         | V <sub>O L1c</sub> | I <sub>OL</sub> =20μA, #1     | SEG-n |      | 0.3  | 0.5  | V    |
|                            | V <sub>O L2c</sub> | I <sub>OL</sub> =100μA, #2    |       |      | 0.6  | 1    | V    |
|                            | V <sub>O L3c</sub> | I <sub>OL</sub> =400μA, #3    |       |      | 1.0  | 1.5  | V    |
| <b>Static display mode</b> |                    |                               |       |      |      |      |      |
| Output "H" Voltage         | V <sub>O H2d</sub> | I <sub>OH</sub> =-1μA, #1, #2 | SEG-n | 2.5  |      |      | V    |
|                            | V <sub>O H3d</sub> | I <sub>OH</sub> =-1μA, #3     |       | 4.3  |      |      | V    |
| Output "L" Voltage         | V <sub>O L2d</sub> | I <sub>OL</sub> =1μA, #1, #2  | SEG-n |      |      | 0.2  | V    |
|                            | V <sub>O L3d</sub> | I <sub>OL</sub> =1μA, #3      |       |      |      | 0.2  | V    |

| Name  | Symbol             | Condition                       | For   | Min. | Typ. | Max. | Unit |
|---|--------------------|---------------------------------|-------|------|------|------|------|
| Output "H" Voltage                              | V <sub>OH2e</sub>  | I <sub>OH</sub> =-10μA, #1, #2  | COM-n | 2.5  |      |      | V    |
|   | V <sub>OH3e</sub>  | I <sub>OH</sub> =-10μA, #3      |       | 4.3  |      |      | V    |
| Output "L" Voltage                              | V <sub>OL2e</sub>  | I <sub>OL</sub> =10μA, #1, #2   |       |      |      | 0.2  | V    |
|   | V <sub>OL3e</sub>  | I <sub>OL</sub> =10μA, #3       |       |      |      | 0.2  | V    |
| <b>Duplex (1/2 bias, 1/2 duty) display mode</b> |                    |                                 |       |      |      |      |      |
| Output "H" Voltage                              | V <sub>OH12f</sub> | I <sub>OH</sub> =-1μA, #1, #2   | SEG-n | 2.4  |      |      | V    |
|   | V <sub>OH3f</sub>  | I <sub>OH</sub> =-1μA, #3       |       | 4.3  |      |      | V    |
| Output "L" Voltage                              | V <sub>OL12f</sub> | I <sub>OL</sub> =1μA, #1, #2    |       |      |      | 0.2  | V    |
|   | V <sub>OL3f</sub>  | I <sub>OL</sub> =1μA, #3        |       |      |      | 0.2  | V    |
| Output "H" Voltage                              | V <sub>OH12g</sub> | I <sub>OH</sub> =-10μA, #1, #2  | COM-n | 2.4  |      |      | V    |
|   | V <sub>OH3g</sub>  | I <sub>OH</sub> =-10μA, #3      |       | 4.3  |      |      | V    |
| Output "M" Voltage                              | V <sub>OM12g</sub> | I <sub>O/H</sub> =±10μA, #1, #2 |       | 1.1  |      | 1.5  | V    |
|   | V <sub>OM3g</sub>  | I <sub>O/H</sub> =±10μA, #3     |       | 2.05 |      | 2.45 | V    |
| Output "L" Voltage                              | V <sub>OL12g</sub> | I <sub>OL</sub> =10μA, #1       |       |      | 0.2  | V    |      |
|   | V <sub>OL3g</sub>  | I <sub>OL</sub> =10μA, #3       |       |      | 0.2  | V    |      |
| <b>1/2 bias, 1/3duty display mode</b>           |                    |                                 |       |      |      |      |      |
| Output "H" Voltage                              | V <sub>OH12h</sub> | I <sub>OH</sub> =-1μA, #1, #2   | SEG-n | 2.4  |      |      | V    |
|   | V <sub>OH3h</sub>  | I <sub>OH</sub> =-1μA, #3       |       | 4.3  |      |      | V    |
| Output "L" Voltage                              | V <sub>OL12h</sub> | I <sub>OL</sub> =1μA, #1, #2    |       |      |      | 0.2  | V    |
|   | V <sub>OL3h</sub>  | I <sub>OL</sub> =1μA, #3        |       |      |      | 0.2  | V    |
| Output "H" Voltage                              | V <sub>OH12i</sub> | I <sub>OH</sub> =-10μA, #1, #2  | COM-n | 2.4  |      |      | V    |
|   | V <sub>OH3i</sub>  | I <sub>OH</sub> =-10μA, #3      |       | 4.3  |      |      | V    |
| Output "M" Voltage                              | V <sub>OM12i</sub> | I <sub>O/H</sub> =±10μA, #1, #2 |       | 1.1  |      | 1.5  | V    |
|   | V <sub>OM3i</sub>  | I <sub>O/H</sub> =±10μA, #3     |       | 2.05 |      | 2.45 | V    |
| Output "L" Voltage                              | V <sub>OL12i</sub> | I <sub>OL</sub> =10μA, #1, #2   |       |      | 0.2  | V    |      |
|   | V <sub>OL3i</sub>  | I <sub>OL</sub> =10μA, #3       |       |      | 0.2  | V    |      |
| <b>1/3bias, 1/3duty display mode</b>            |                    |                                 |       |      |      |      |      |
| Output "H" Voltage                              | V <sub>OH12j</sub> | I <sub>OH</sub> =-1μA, #1, #2   | SEG-n | 3.85 |      |      | V    |
|   | V <sub>OH3j</sub>  | I <sub>OH</sub> =-1μA, #3       |       | 6.55 |      |      | V    |
| Output "M1" Voltage                             | V <sub>OM12j</sub> | I <sub>O/H</sub> =±1μA, #1, #2  |       | 2.9  |      | 2.4  | V    |
|   | V <sub>OM13j</sub> | I <sub>O/H</sub> =±1μA, #1, #2  |       | 4.7  |      | 4.3  | V    |
| Output "M2" Voltage                             | V <sub>OM22j</sub> | I <sub>O/H</sub> =±1μA, #1, #2  | 1.1   |      | 1.5  | V    |      |
|   | V <sub>OM23j</sub> | I <sub>O/H</sub> =±1μA, #1, #2  | 2.05  |      | 2.45 | V    |      |
| Output "L" Voltage                              | V <sub>OL2j</sub>  | I <sub>OL</sub> =1μA, #2        |       |      | 0.2  | V    |      |
|   | V <sub>OL3j</sub>  | I <sub>OL</sub> =1μA, #3        |       |      | 0.2  | V    |      |
| Output "H" Voltage                              | V <sub>OH2k</sub>  | I <sub>OH</sub> =-10μA, #2      | COM-n | 3.85 |      |      | V    |
|   | V <sub>OH3k</sub>  | I <sub>OH</sub> =-10μA, #3      |       | 6.55 |      |      | V    |
| Output "M1" Voltage                             | V <sub>OM12k</sub> | I <sub>O/H</sub> =±10μA, #1, #2 |       | 2.9  |      | 2.4  | V    |
|   | V <sub>OM13k</sub> | I <sub>O/H</sub> =±10μA, #3     |       | 4.7  |      | 4.3  | V    |
| Output "M2" Voltage                             | V <sub>OM22k</sub> | I <sub>O/H</sub> =±10μA, #1, #2 | 1.1   |      | 1.5  | V    |      |
|   | V <sub>OM23k</sub> | I <sub>O/H</sub> =±10μA, #3     | 2.05  |      | 2.45 | V    |      |
| Output "L" Voltage                              | V <sub>OL2k</sub>  | I <sub>OL</sub> =10μA, #2       |       |      | 0.2  | V    |      |
|   | V <sub>OL3k</sub>  | I <sub>OL</sub> =10μA, #3       |       |      | 0.2  | V    |      |

Note: #1: V<sub>SS1</sub>= -1.2V (Ag), #2: V<sub>SS2</sub>= -2.4V (Li), #3: V<sub>SS2</sub>= -4V (ExtV).

**Instruction Table**

| Instruction | Machine Code       | Function                    | Remark         | Flag |
|-------------|--------------------|-----------------------------|----------------|------|
| NOP         | 000 0000 0000 0000 | No Operation                |                |      |
| LCT Ly,Rx   | 000 00YY YYXX XXXX | (Ly) ← (Rx)                 | Ly=000- No Use |      |
| OPA Rx      | 000 0100 01XX XXXX | Port(A) ← (Rx)              |                |      |
| LCB Ly,Rx   | 000 01YY YYXX XXXX | (Ly) ← (Rx)                 | Ly=000- No Use |      |
| OPB Rx      | 000 1000 01XX XXXX | Port(B) ← (Rx)              |                |      |
| LCP Ly,Rx   | 000 10YY YYXX XXXX | abcd,efgh ← (Rx),(AC)       | LY=000- No Use |      |
| MRA Rx      | 000 1101 01XX XXXX | CF ← Rx3                    |                |      |
| OPP Rx      | 000 1110 00XX XXXX | Port(P) ← (Rx)              |                |      |
| OPP S Rx    | 000 1110 1DXX XXXX | P1,2,3,4 ← Rx0,Rx1,D,Pulse  |                |      |
| ADC Rx      | 001 0000 00XX XXXX | (AC) ← (Rx)+(AC)+(CF)       |                | CF   |
| ADC* Rx     | 001 0000 10XX XXXX | (AC),(Rx) ← (Rx)+(AC)+(CF)  |                | CF   |
| SBC Rx      | 001 0001 00XX XXXX | (AC) ← (Rx)+(AC)B+(CF)      |                | CF   |
| SBC* Rx     | 001 0001 10XX XXXX | (AC),(Rx) ← (Rx)+(AC)B+(CF) |                | CF   |
| ADD Rx      | 001 0010 00XX XXXX | (AC) ← (Rx)+(AC)            |                | CF   |
| ADD* Rx     | 001 0010 10XX XXXX | (AC),(Rx) ← (Rx)+(AC)       |                | CF   |
| SUB Rx      | 001 0011 00XX XXXX | (AC) ← (Rx)+(AC)B+1         |                | CF   |
| SUB* Rx     | 001 0011 10XX XXXX | (AC),(Rx) ← (Rx)+(AC)B+1    |                | CF   |
| ADN Rx      | 001 0100 00XX XXXX | (AC) ← (Rx)+(AC)            |                |      |
| ADN* Rx     | 001 0100 10XX XXXX | (AC),(Rx) ← (Rx)+(AC)       |                |      |
| AND Rx      | 001 0101 00XX XXXX | (AC) ← (Rx) AND (AC)        |                |      |
| AND* Rx     | 001 0101 10XX XXXX | (AC),(Rx) ← (Rx) AND (AC)   |                |      |
| EOR Rx      | 001 0110 00XX XXXX | (AC) ← (Rx) EOR (AC)        |                |      |
| EOR* Rx     | 001 0110 10XX XXXX | (AC),(Rx) ← (Rx) EOR (AC)   |                |      |
| OR Rx       | 001 0111 00XX XXXX | (AC) ← (Rx) OR (AC)         |                |      |
| OR* Rx      | 001 0111 10XX XXXX | (AC),(Rx) ← (Rx) OR (AC)    |                |      |
| ADCI Ry,D   | 001 1000 0DDD DYYY | (AC) ← (Ry)+(D)+(CF)        |                | CF   |
| ADCI* Ry,D  | 001 1000 1DDD DYYY | (AC),(Ry) ← (Ry)+(D)+(CF)   |                | CF   |
| SBCI Ry,D   | 001 1001 0DDD DYYY | (AC) ← (Ry)+(D)B+(CF)       |                | CF   |
| SBCI* Ry,D  | 001 1001 1DDD DYYY | (AC),(Ry) ← (Ry)+(D)B+(CF)  |                | CF   |
| ADDI Ry,D   | 001 1010 0DDD DYYY | (AC) ← (Ry)+(D)             |                | CF   |
| ADDI* Ry,D  | 001 1010 1DDD DYYY | (AC),(Ry) ← (Ry)+(D)        |                | CF   |
| SUBI Ry,D   | 001 1011 0DDD DYYY | (AC) ← (Ry)+(D)B+1          |                | CF   |
| SUBI* Ry,D  | 001 1011 1DDD DYYY | (AC),(Ry) ← (Ry)+(D)B+1     |                | CF   |
| ADNI Ry,D   | 001 1100 0DDD DYYY | (AC) ← (Ry)+(D)             |                |      |
| ADNI* Ry,D  | 001 1100 1DDD DYYY | (AC),(Ry) ← (Ry)+(D)        |                |      |
| ANDI Ry,D   | 001 1101 0DDD DYYY | (AC) ← (Ry) AND (D)         |                |      |
| ANDI* Ry,D  | 001 1101 1DDD DYYY | (AC),(Ry) ← (Ry) AND (D)    |                |      |
| EORI Ry,D   | 001 1110 0DDD DYYY | (AC) ← (Ry) EOR (D)         |                |      |
| EORI* Ry,D  | 001 1110 1DDD DYYY | (AC),(Ry) ← (Ry) EOR (D)    |                |      |
| ORI Ry,D    | 001 1111 0DDD DYYY | (AC) ← (Ry) OR (D)          |                |      |
| ORI* Ry,D   | 001 1111 1DDD DYYY | (AC),(Ry) ← (Ry) OR (D)     |                |      |
| IPS Rx      | 010 0000 00XX XXXX | (AC),(Rx) ← Port(S)         |                |      |
| IPM Rx      | 010 0000 10XX XXXX | (AC),(Rx) ← Port(M)         |                |      |
| IPA Rx      | 010 0001 00XX XXXX | (AC),(Rx) ← Port(A)         |                |      |
| IPA* Rx     | 010 0001 01XX XXXX | (AC),(Rx) ← Port(A)         | I/OA ← I/P     |      |
| IPB Rx      | 010 0001 10XX XXXX | (AC),(Rx) ← Port(B)         |                |      |

| Instruction  | Machine Code          | Function  | Remark  | Flag                 |
|--------------|-----------------------|---|---|----------------------|
| IPB* Rx      | 010 0001 11XX XXXX    | (AC),(Rx) ← Port(B)   | I/OB ← I/P  |                      |
| MSB Rx       | 010 0010 00XX XXXX    | (AC),(Rx) ← STS2  | B0: BCF<br>B1: SCF1(MPT)<br>B2: SCF2(HRF)<br>B3: SCF3(SPT)  |                      |
| STA Rx       | 010 0010 10XX XXXX    | (Rx) ← (AC)   |   |                      |
| SR0 Rx       | 010 0011 00XX XXXX    | ACn, Rxn ← Rx(n+1)<br>AC3, Rx3 ← 0  |   |                      |
| SR1 Rx       | 010 0011 01XX XXXX    | ACn, Rxn ← (Rx(n+1))<br>AC3, Rx3 ← 1  |   |                      |
| SL0 Rx       | 010 0011 10XX XXXX    | ACn, Rxn ← Rx(n-1)<br>AC0, Rx0 ← 0  |   |                      |
| SL1 Rx       | 010 0011 11XX XXXX    | ACn, Rxn ← Rx(n-1)<br>AC0, Rx0 ← 1  |   |                      |
| LDS Rx,D     | 010 01DD DDXX<br>XXXX | (AC),(Rx) ← (D)   |   |                      |
| MSC Rx       | 011 0000 00XX XXXX    | (AC),(Rx) ← STS3  | B0: SCF4(INT)<br>B1: SCF5(TMR)<br>B2: PH15<br>B3: SCF7(PDV) |                      |
| MAF Rx       | 011 0001 00XX XXXX    | (AC),(Rx) ← STS1  | TF2: ZERO<br>TF3: CF  |                      |
| LDA Rx       | 011 0111 10XX XXXX    | (AC) ← (Rx)   |   |                      |
| MRW<br>Ry,Rx | 011 100Y YYXX XXXX    | (AC),(Ry) ← (Rx)  |   |                      |
| MWR<br>Rx,Ry | 011 110Y YYXX XXXX    | (AC),(Rx) ← (Ry)  |   |                      |
| JB0 X        | 100 00XX XXXX XXXX    | (PC) ← X  | if (AC0)=1  |                      |
| JB1 X        | 100 01XX XXXX XXXX    | (PC) ← X  | if (AC1)=1  |                      |
| JB2 X        | 100 10XX XXXX XXXX    | (PC) ← X  | if (AC2)=1  |                      |
| JB3 X        | 100 11XX XXXX XXXX    | (PC) ← X  | if (AC3)=1  |                      |
| JNZ X        | 101 00XX XXXX XXXX    | (PC) ← X  | if (Zero)=0   |                      |
| JNC X        | 101 01XX XXXX XXXX    | (PC) ← X  | if (CF)=0   |                      |
| JZ X         | 101 10XX XXXX XXXX    | (PC) ← X  | if (Zero)=1   |                      |
| JC X         | 101 11XX XXXX XXXX    | (PC) ← X  | if (CF)=1   |                      |
| JMP X        | 110 00XX XXXX XXXX    | (PC) ← X  |   |                      |
| CALL X       | 110 01XX XXXX XXXX    | (STACK) ← (PC)+1<br>(PC ← X)  |   |                      |
| RTS          | 110 1000 0000 0000    | (PC) ← (STACK)  |   |                      |
| SMS X        | 111 0000 00X XXXX     | SEF4 ← X4<br>SEF0~3 ← X0~3  | M1~4 Enable<br>S1~4 Enable                                  | SCF1<br>SCF3<br>HRF0 |
| TMS X        | 111 0010 00XX XXXX    | TIMER ← X   |   | HRF1                 |
| SF X         | 111 0100 0XX0 XXXX    | X6: M-PORT Pull-Low<br>X5: S-PORT Pull-Low<br>X3: HALT After Light<br>X2: LIGHT ON<br>X1: BCF Set<br>X0: CF Set |   | BCF<br>CF            |
|              |                       | X6: M-PORT Low-L-H<br>X5: S-PORT Low-L-H  |   |                      |

| Instruction | Machine Code       | Function   | Remark | Flag      |      |
|-------------|--------------------|--|--------|-----------|------|
| RF X        | 111 0110 0XX0 0XXX | X2: LIGHT OFF<br>X1: BCF Reset<br>X0: CF Reset     |        | BCF<br>CF |      |
| ALM X       | 111 0111 XXXX XXXX | X7,X6  | 0,1    | 1,0       | 1,1  |
|             |                    | Signal   | DC     | 1K/2K     | 4K   |
|             |                    | Xn=1   | X5     | X4        | X3   |
|             |                    | Signal   | 1Hz    | 2Hz       | 4Hz  |
|             |                    | Xn=1   | X2     | X1        | X0   |
|             |                    | Signal   | 8Hz    | 16Hz      | 32Hz |
| SIE X       | 111 1000 XXX0 XXXX | X5~7: HEF1~3 is Enabled<br>X0~3: IEF0~3 is Enabled |        |           |      |
| SIE* X      | 111 1010 0000 XXXX | X0~3: IEF0~3 is Enabled                            |        |           |      |
| PLC X       | 111 110X 0000 XXXX | X0~3: Reset HRF0~3<br>X8: Reset PH11~15            |        |           |      |
| HALT        | 111 1111 1111 1111 |  |        |           |      |

### Symbol description

|                                  |                                |
|----------------------------------|--------------------------------|
| AC: Accumulator                  | CF: Carry Flag                 |
| ACn: Accumulator Bit N           | BCF: Backup Flag               |
| Rx: Memory of Address X          | IEFn: Interrupt Enable Flag    |
| Rxn: Memory Bit N of Address X   | HEFn: HALT Release Enable Flag |
| Ry: Memory of Working Register Y | HRFn: HALT Release Flag        |
| PC: Program Counter              | SEFn: Switch Enable Flag       |
| X: Address                       | SCFn: Start Condition Flag     |
| D: Immediate Data                | Ly: LCD Latch                  |