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# ML610Q438/ML610Q439

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8-bit Microcontroller with a Built-in LCD driver

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## GENERAL DESCRIPTION

This LSI is a high-performance 8-bit CMOS microcontroller into which rich peripheral circuits, such as synchronous serial port, UART, I<sup>2</sup>C bus interface (master), melody driver, battery level detect circuit, RC oscillation type A/D converter, and LCD driver, are incorporated around 8-bit CPU nX-U8/100.

The CPU nX-U8/100 is capable of efficient instruction execution in 1-instruction 1-clock mode by 3-stage pipe line architecture parallel processing. The Flash ROM that is installed as program memory achieves low-voltage low-power consumption operation (read operation) equivalent to mask ROM and is most suitable for battery-driven applications.

The on-chip debug function that is installed enables program debugging and programming.

## FEATURES

- CPU
  - 8-bit RISC CPU (CPU name: nX-U8/100)
  - Instruction system: 16-bit instructions
  - Instruction set: Transfer, arithmetic operations, comparison, logic operations, multiplication/division, bit manipulations, bit logic operations, jump, conditional jump, call return stack manipulations, arithmetic shift, and so on
  - On-Chip debug function
  - Minimum instruction execution time
    - 30.5  $\mu$ s (@32.768 kHz system clock)
    - 0.244  $\mu$ s (@4.096 MHz system clock)
- Internal memory
  - Internal 128KByte Flash ROM (64K $\times$ 16 bits) (including unusable 1KByte TEST area)
  - Internal 6KByte Data RAM (6144 $\times$ 8 bits), 1KByte Display Allocation RAM (1024  $\times$  8bit)
  - Internal 192-byte RAM for display
- Interrupt controller
  - 2 non-maskable interrupt sources (Internal source: 1, External source: 1)
  - 27 maskable interrupt sources (Internal sources: 19, External sources: 8)
- Time base counter
  - Low-speed time base counter  $\times$ 1 channel
    - Frequency compensation (Compensation range: Approx.  $-488$ ppm to  $+488$ ppm. Compensation accuracy: Approx. 0.48ppm)
  - High-speed time base counter  $\times$ 1 channel
- Watchdog timer
  - Non-maskable interrupt and reset
  - Free running
  - Overflow period: 4 types selectable (125ms, 500ms, 2s, and 8s)
- Timers
  - 8 bits  $\times$  4 channels (16-bit configuration available)
- 1 kHz timer
  - 10 Hz/1 Hz interrupt function

- Capture
  - Time base capture  $\times$  2 channels (4096 Hz to 32 Hz)
- PWM
  - Resolution 16 bits  $\times$  3 channel
- Synchronous serial port
  - Master/slave selectable
  - LSB first/MSB first selectable
  - 8-bit length/16-bit length selectable
  - Timer interrupt is used as a serial clock and selection is possible
- UART
  - TXD/RXD  $\times$  1 channel
  - Bit length, parity/no parity, odd parity/even parity, 1 stop bit/2 stop bits
  - Positive logic/negative logic selectable
  - Built-in baud rate generator
- I<sup>2</sup>C bus interface
  - Master function only
  - Fast mode (400 kbps@4MHz), standard mode (100 kbps@1MHz, 50kbps@500kHz)
- Melody driver
  - Scale: 29 types (Melody sound frequency: 508 Hz to 32.768 kHz)
  - Tone length: 63 types
  - Tempo: 15 types
  - Buzzer output mode (4 output modes, 8 frequencies, 16 duty levels)
- RC oscillation type A/D converter
  - 24-bit counter
  - Time division  $\times$  2 channels
- Successive approximation type A/D converter
  - 12-bit A/D converter
  - Input  $\times$  2 channels
- General-purpose ports
  - Non-maskable interrupt input port  $\times$  1 channel
  - Input-only port  $\times$  10 channels (including secondary functions)
  - Output-only port  $\times$  3 channels (including secondary functions)
  - Input/output port  
20 channels (including secondary functions)
- LCD driver
  - Dot matrix can be supported.  
ML610Q438: 1344 dots max. (56 seg  $\times$  24 com)  
ML610Q439: 1024 dots max. (64 seg  $\times$  16 com)
  - 1/1 to 1/24 duty
  - 1/3 or 1/4 bias (built-in bias generation circuit)
  - Frame frequency selectable (approx. 64 Hz, 73 Hz, 85 Hz, and 102 Hz)
  - Bias voltage multiplying clock selectable (8 types)
  - Contrast adjustment (1/3 bias: 32 steps, 1/4 bias: 20 steps)
  - LCD drive stop mode, LCD display mode, all LCDs on mode, and all LCDs off mode selectable
  - Programmable display allocation function (available only when 1/1~1/8 duty is selected)
  - The metal option of only ML610Q439  
Type B : 16com  $\times$  64seg (seg63 to seg0: segment port)  
Type C : 16com  $\times$  56seg (seg63 to seg56: output port, seg55 to seg0: segment port)  
Type D : 16com  $\times$  48seg (seg63 to seg48: output port, seg47 to seg0: segment port)

Type E : 16com x 40seg (seg63 to seg40: output port, seg39 to seg0: segment port)

Type F : 16com x 32seg (seg63 to seg32: output port, seg31 to seg0: segment port)

- Reset
  - Reset through the RESET\_N pin
  - Power-on reset generation when powered on
  - Reset when oscillation stop of the low-speed clock is detected
  - Reset by the watchdog timer (WDT) overflow
- Power supply voltage detect function
  - Judgment voltages: One of 16 levels
  - Judgment accuracy:  $\pm 2\%$  (Typ.)
- Clock
  - Low-speed clock: (This LSI can not guarantee the operation without low-speed clock)  
Crystal oscillation (32.768 kHz)
  - High-speed clock:  
Built-in RC oscillation (2M/500kHz)  
Built-in PLL oscillation (8.192 MHz  $\pm 2.5\%$ ), crystal/ceramic oscillation (4.096 MHz), external clock
  - Selection of high-speed clock mode by software:  
Built-in RC oscillation, built-in PLL oscillation, crystal/ceramic oscillation, external clock
- Power management
  - HALT mode: Instruction execution by CPU is suspended (peripheral circuits are in operating states).
  - STOP mode: Stop of low-speed oscillation and high-speed oscillation (Operations of CPU and peripheral circuits are stopped.)
  - Clock gear: The frequency of high-speed system clock can be changed by software (1/1, 1/2, 1/4, or 1/8 of the oscillation clock)
  - Block Control Function: Power down (reset registers and stop clock supply) the circuits of unused peripherals.
- Shipment
  - Chip (Die)  
ML610Q438-xxxWA (Blank product: ML610Q438-NNNWA)  
ML610Q438P-xxxWA (Blank product: ML610Q438P-NNNWA)  
ML610Q439-xxxWA (Blank product: ML610Q439-NNNWA)  
ML610Q439P-xxxWA (Blank product: ML610Q439P-NNNWA)
  - 144-pin plastic LQFP  
ML610Q438-xxxTCZ03A (Blank product: ML610Q438-NNNTCZ03A)  
ML610Q438P-xxxTCZ03A (Blank product: ML610Q438P-NNNTCZ03A)  
ML610Q439-xxxTCZ03A (Blank product: ML610Q439-NNNTCZ03A)  
ML610Q439P-xxxTCZ03A (Blank product: ML610Q439P-NNNTCZ03A)  
xxx: ROM code number
- Guaranteed operating range
  - Operating temperature:  $-20^{\circ}\text{C}$  to  $70^{\circ}\text{C}$  (P version :  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ )
  - Operating voltage:  $V_{\text{DD}} = 1.1\text{V}$  to  $3.6\text{V}$ ,  $AV_{\text{DD}} = 2.2\text{V}$  to  $3.6\text{V}$

## BLOCK DIAGRAM

### ML610Q438 Block Diagram

Figure 1 show the block diagram of the ML610Q438.

"\*" indicates the secondary function of each port.

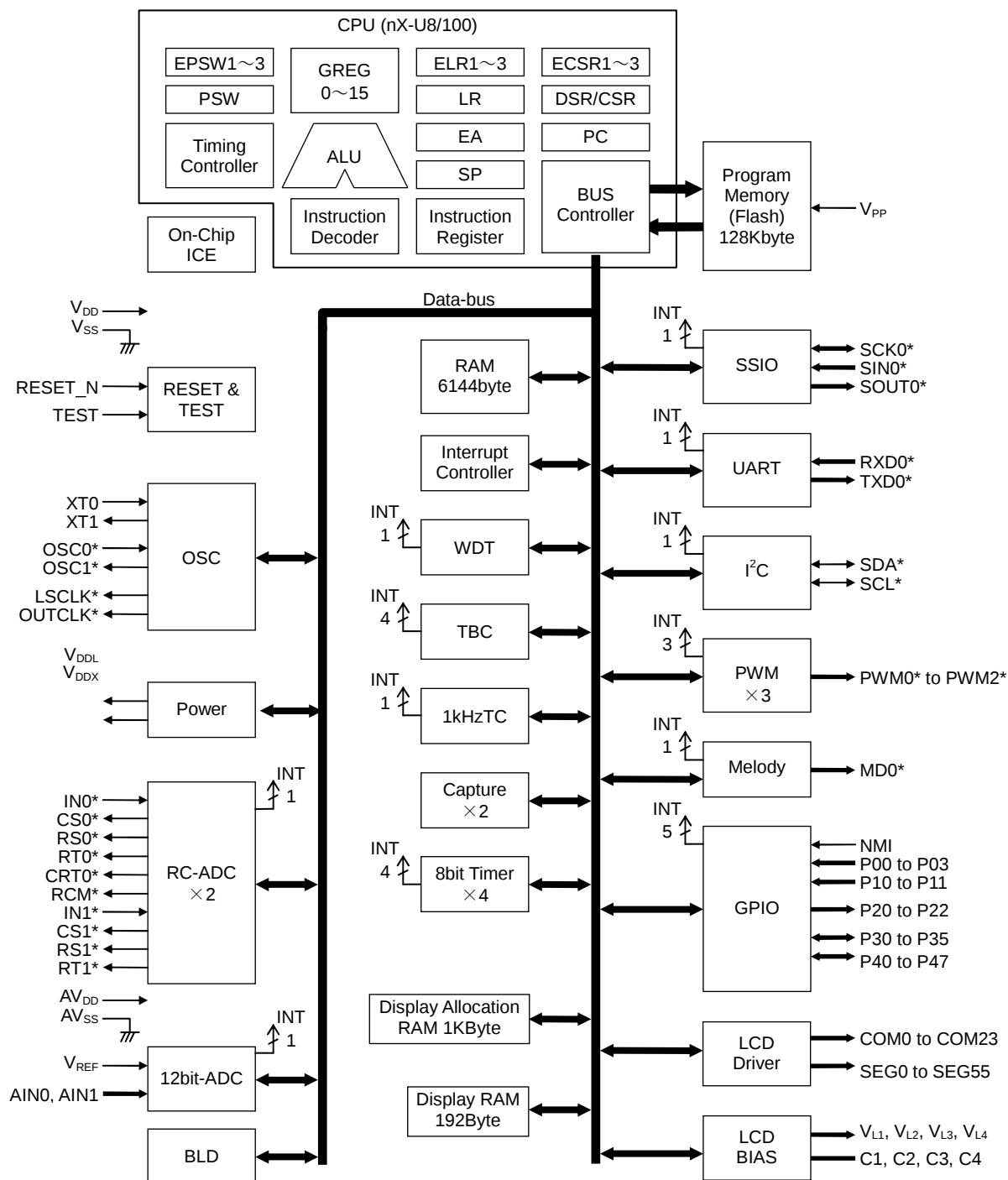


Figure 1 ML610Q438 Block Diagram

## ML610Q439 Block Diagram

Figure 2 show the block diagram of the ML610Q439.

"\*" indicates the secondary function of each port.

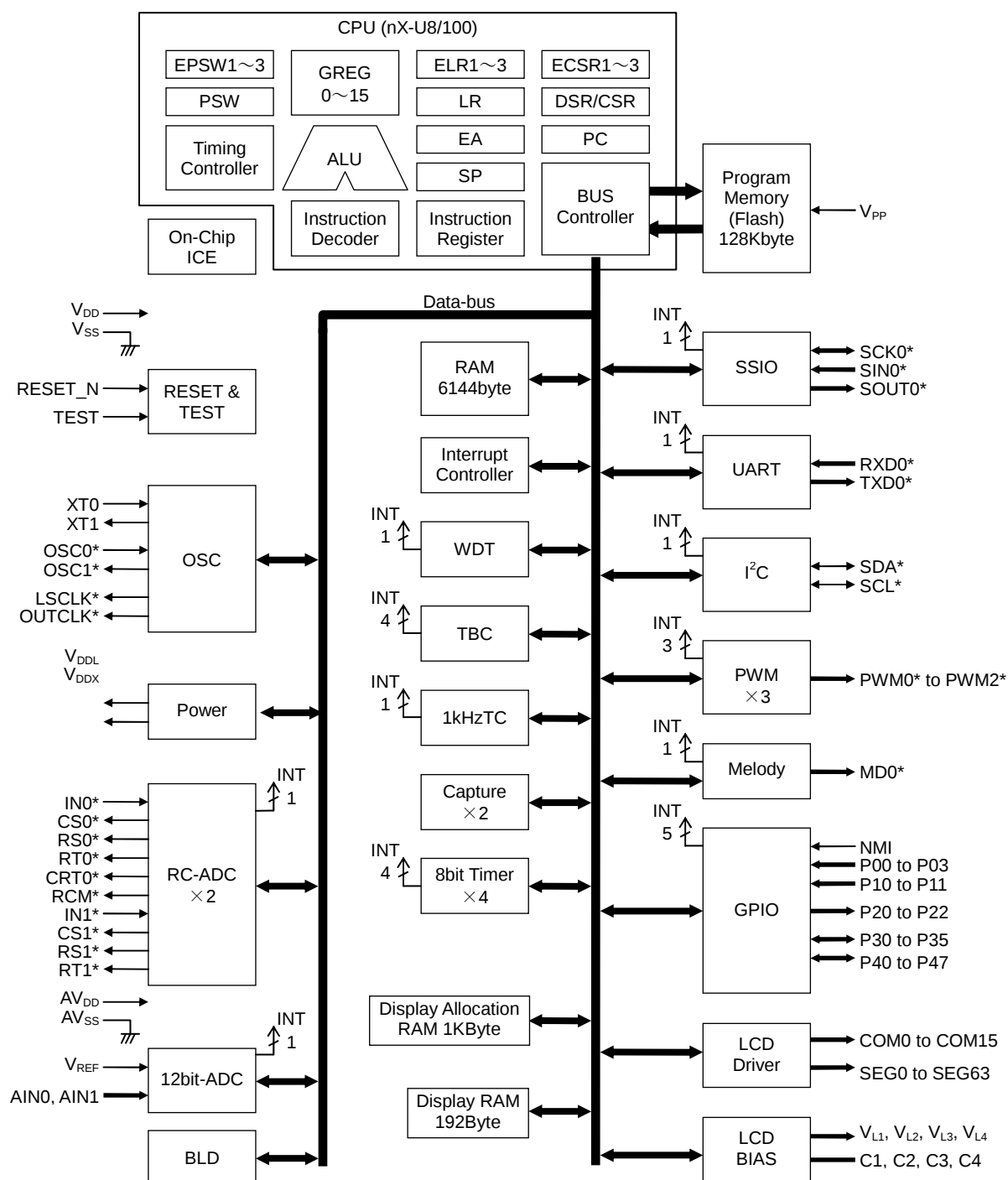
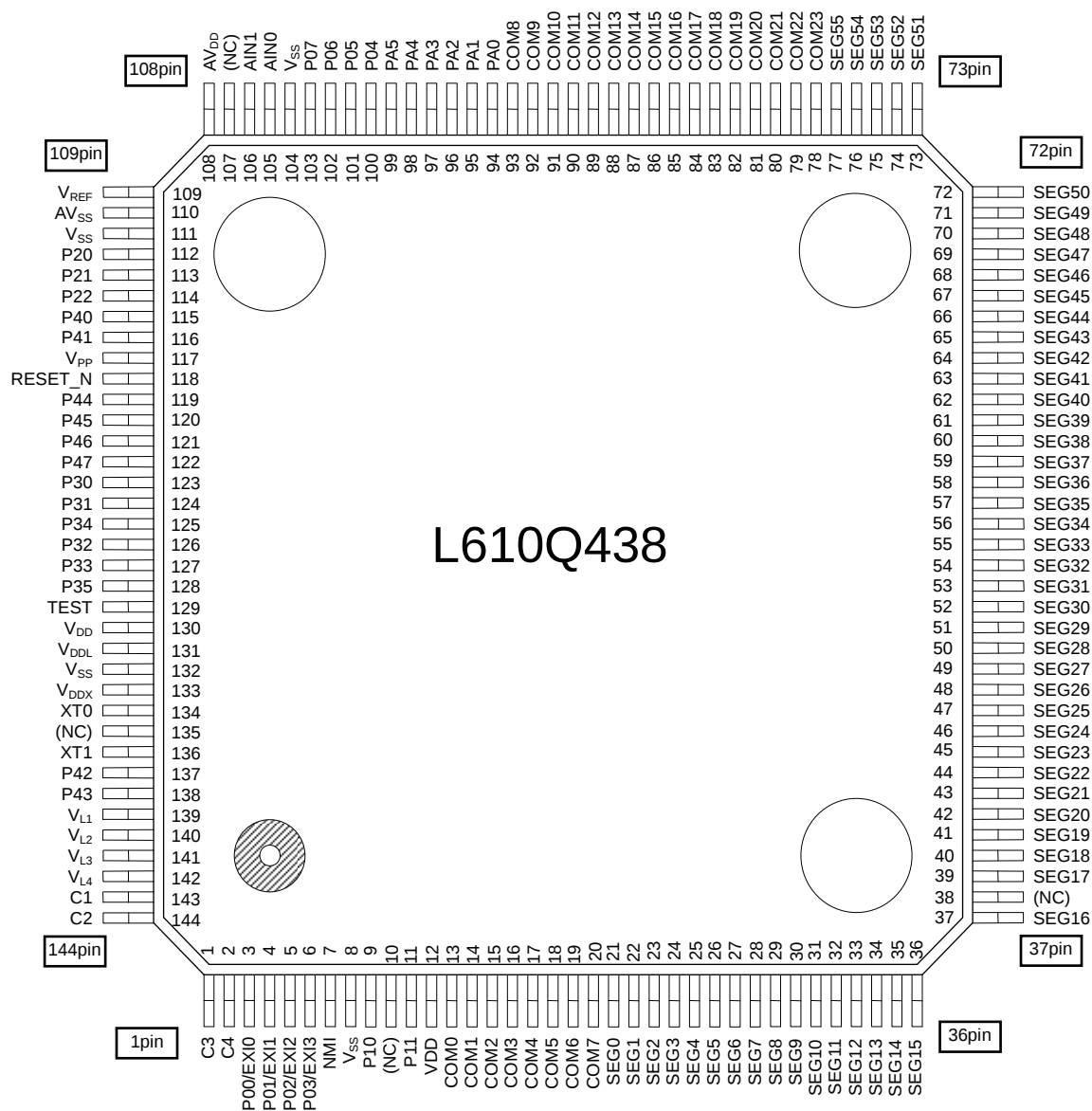


Figure 2 ML610Q439 Block Diagram

## PIN CONFIGURATION

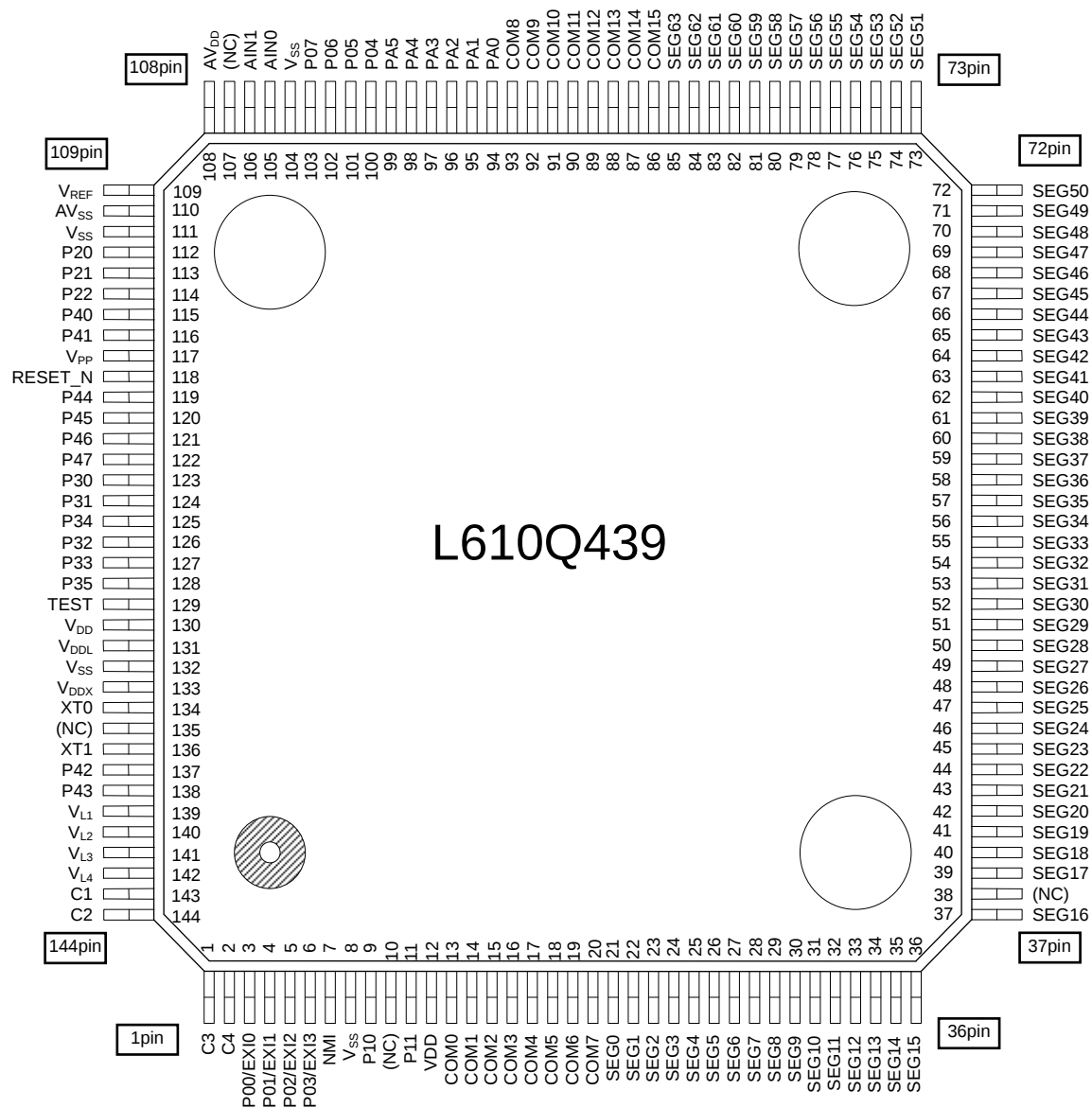
## ML610Q438 LQFP144 Pin Layout



(NC): No Connection

Figure 3 ML610Q438 LQFP144 Pin Configuration

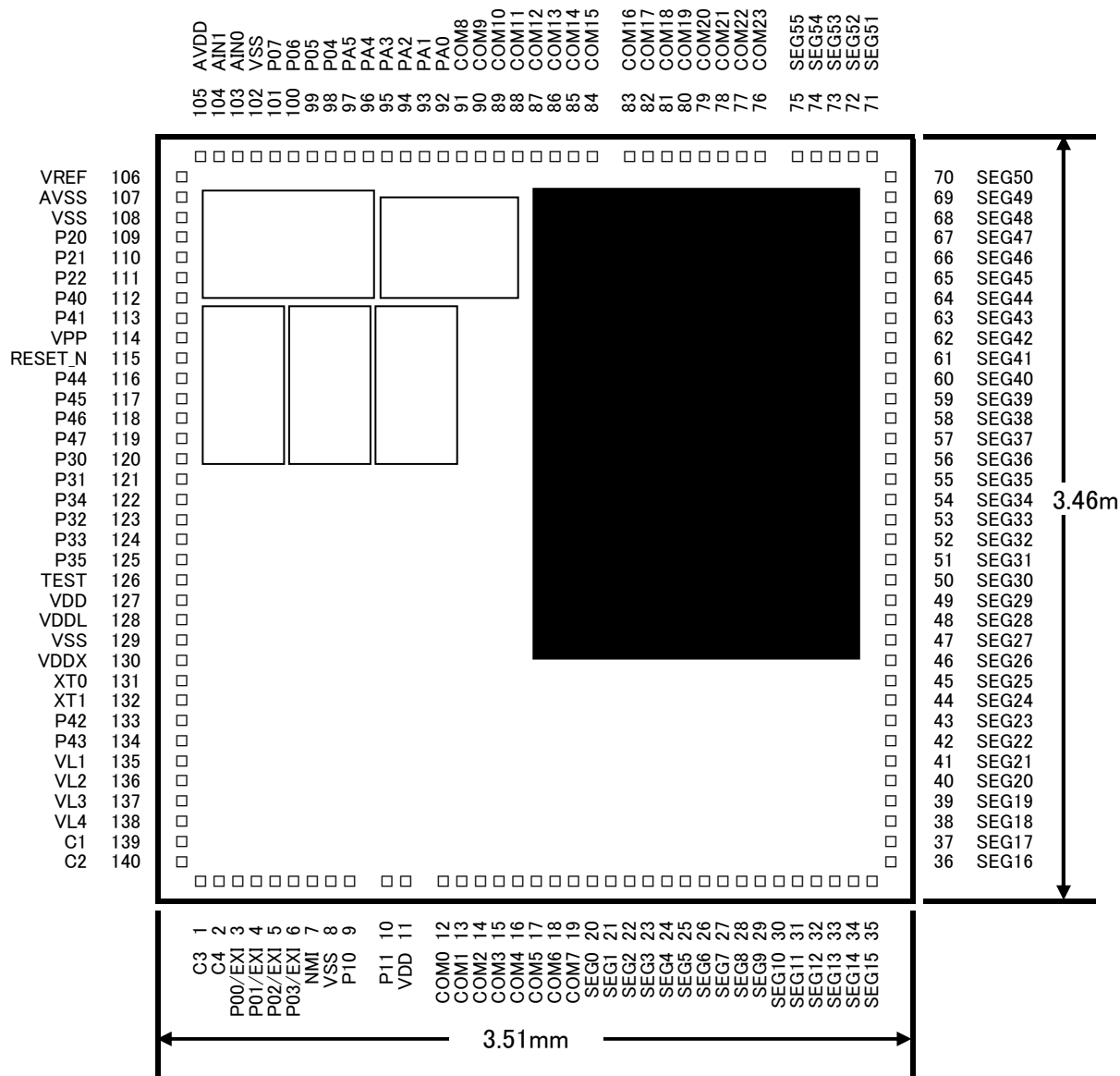
## ML610Q439 LQFP144 Pin Layout



(NC): No Connection

Figure 4 ML610Q439 LQFP144 Pin Configuration

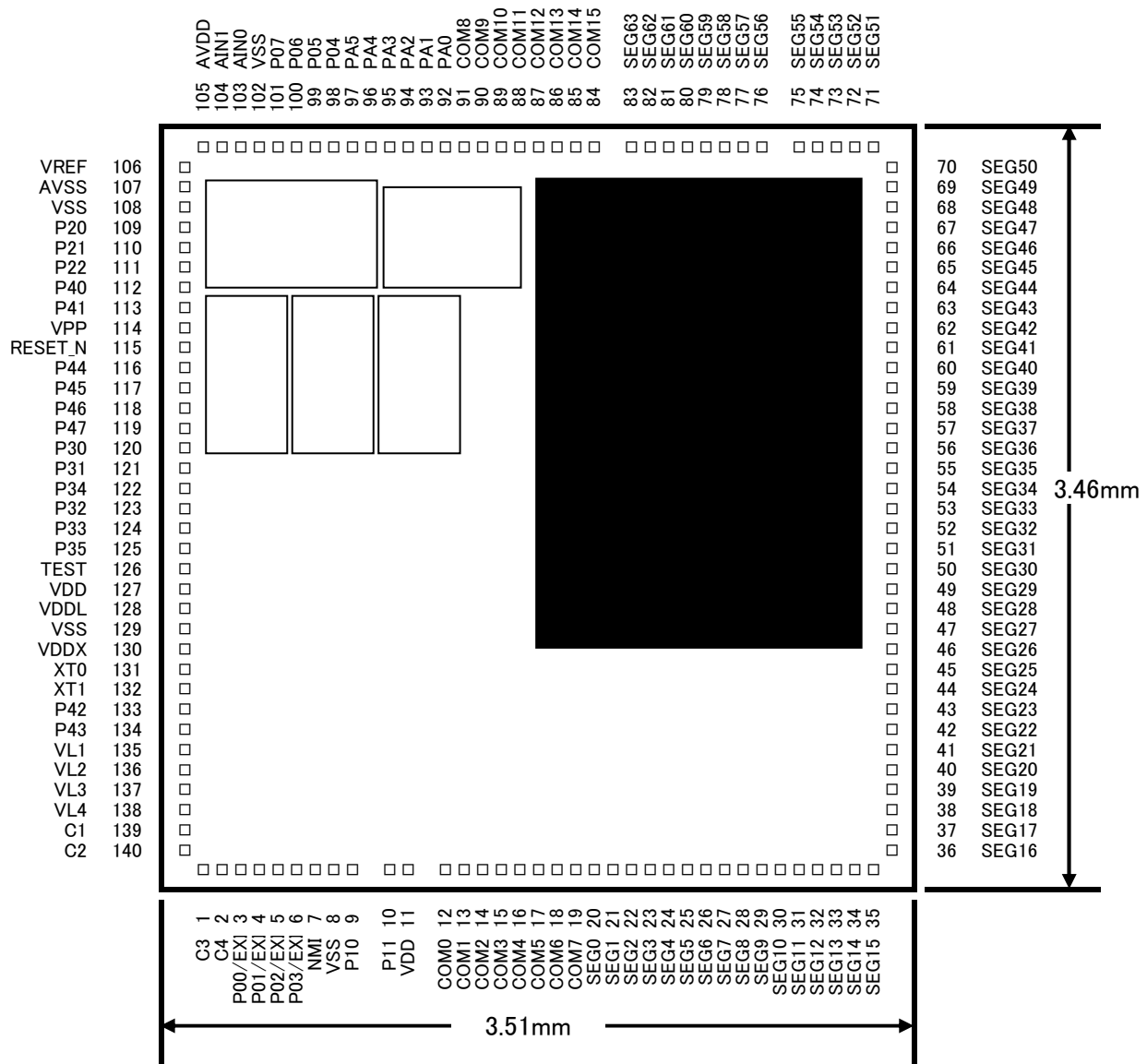
## ML610Q438 Chip Pin Layout &amp; Dimension



Chip size: 3.51 mm × 3.46 mm  
 PAD count: 140 pins  
 Minimum PAD pitch: 80 μm  
 PAD aperture: 80 μm × 80 μm  
 Chip thickness: 350 μm  
 Voltage of the rear side of chip: V<sub>SS</sub> level

Figure 5 ML610Q438 Chip Layout &amp; Dimension

## ML610Q439 Chip Pin Layout & Dimension



|                                   |                       |
|-----------------------------------|-----------------------|
| Chip size:                        | 3.51 mm × 3.46 mm     |
| PAD count:                        | 140 pins              |
| Minimum PAD pitch:                | 80 μm                 |
| PAD aperture:                     | 80 μm × 80 μm         |
| Chip thickness:                   | 350 μm                |
| Voltage of the rear side of chip: | V <sub>SS</sub> level |

### Figure 6 ML610Q439 Chip Layout & Dimension

## ML610Q438 Pad Coordinates

Table 1 ML610Q438 Pad Coordinates

Chip Center: X=0,Y=0

| PAD No. | Pad Name             | X (μm) | Y (μm) | PAD No. | Pad Name | X (μm) | Y (μm) | PAD No. | Pad Name | X (μm) | Y (μm) |
|---------|----------------------|--------|--------|---------|----------|--------|--------|---------|----------|--------|--------|
| 1       | C3                   | -1485  | -1624  | 48      | SEG28    | 1649   | -400   | 95      | PA3      | -525   | 1624   |
| 2       | C4                   | -1405  | -1624  | 49      | SEG29    | 1649   | -320   | 96      | PA4      | -605   | 1624   |
| 3       | P00/EXI0             | -1315  | -1624  | 50      | SEG30    | 1649   | -240   | 97      | PA5      | -685   | 1624   |
| 4       | P01/EXI1             | -1235  | -1624  | 51      | SEG31    | 1649   | -160   | 98      | P04      | -765   | 1624   |
| 5       | P02/EXI2 /RXD0/P2 CK | -1155  | -1624  | 52      | SEG32    | 1649   | -80    | 99      | P05      | -845   | 1624   |
| 6       | P03/EXI3             | -1075  | -1624  | 53      | SEG33    | 1649   | 0      | 100     | P06      | -925   | 1624   |
| 7       | NMI                  | -995   | -1624  | 54      | SEG34    | 1649   | 80     | 101     | P07      | -1005  | 1624   |
| 8       | VSS                  | -865   | -1624  | 55      | SEG35    | 1649   | 160    | 102     | VSS      | -1106  | 1624   |
| 9       | P10                  | -785   | -1624  | 56      | SEG36    | 1649   | 240    | 103     | AIN0     | -1186  | 1624   |
| 10      | P11                  | -625   | -1624  | 57      | SEG37    | 1649   | 320    | 104     | AIN1     | -1366  | 1624   |
| 11      | VDD                  | -545   | -1624  | 58      | SEG38    | 1649   | 400    | 105     | AVDD     | -1446  | 1624   |
| 12      | COM0                 | -445   | -1624  | 59      | SEG39    | 1649   | 480    | 106     | VREF     | -1649  | 1430   |
| 13      | COM1                 | -365   | -1624  | 60      | SEG40    | 1649   | 560    | 107     | AVSS     | -1649  | 1270   |
| 14      | COM2                 | -285   | -1624  | 61      | SEG41    | 1649   | 640    | 108     | VSS      | -1649  | 1190   |
| 15      | COM3                 | -205   | -1624  | 62      | SEG42    | 1649   | 720    | 109     | P20      | -1649  | 1095   |
| 16      | COM4                 | -125   | -1624  | 63      | SEG43    | 1649   | 800    | 110     | P21      | -1649  | 1015   |
| 17      | COM5                 | -45    | -1624  | 64      | SEG44    | 1649   | 880    | 111     | P22      | -1649  | 935    |
| 18      | COM6                 | 35     | -1624  | 65      | SEG45    | 1649   | 960    | 112     | P40      | -1649  | 855    |
| 19      | COM7                 | 115    | -1624  | 66      | SEG46    | 1649   | 1040   | 113     | P41      | -1649  | 775    |
| 20      | SEG0                 | 235    | -1624  | 67      | SEG47    | 1649   | 1120   | 114     | VPP      | -1649  | 695    |
| 21      | SEG1                 | 315    | -1624  | 68      | SEG48    | 1649   | 1200   | 115     | RESET_N  | -1649  | 615    |
| 22      | SEG2                 | 395    | -1624  | 69      | SEG49    | 1649   | 1280   | 116     | P44      | -1649  | 535    |
| 23      | SEG3                 | 475    | -1624  | 70      | SEG50    | 1649   | 1360   | 117     | P45      | -1649  | 455    |
| 24      | SEG4                 | 555    | -1624  | 71      | SEG51    | 1515   | 1624   | 118     | P46      | -1649  | 375    |
| 25      | SEG5                 | 635    | -1624  | 72      | SEG52    | 1435   | 1624   | 119     | P47      | -1649  | 295    |
| 26      | SEG6                 | 715    | -1624  | 73      | SEG53    | 1355   | 1624   | 120     | P30      | -1649  | 215    |
| 27      | SEG7                 | 795    | -1624  | 74      | SEG54    | 1275   | 1624   | 121     | P31      | -1649  | 135    |
| 28      | SEG8                 | 875    | -1624  | 75      | SEG55    | 1195   | 1624   | 122     | P34      | -1649  | 55     |
| 29      | SEG9                 | 955    | -1624  | 76      | COM23    | 1095   | 1624   | 123     | P32      | -1649  | -25    |
| 30      | SEG10                | 1035   | -1624  | 77      | COM22    | 1015   | 1624   | 124     | P33      | -1649  | -105   |
| 31      | SEG11                | 1115   | -1624  | 78      | COM21    | 935    | 1624   | 125     | P35      | -1649  | -185   |
| 32      | SEG12                | 1195   | -1624  | 79      | COM20    | 855    | 1624   | 126     | TEST     | -1649  | -265   |
| 33      | SEG13                | 1275   | -1624  | 80      | COM19    | 775    | 1624   | 127     | VDD      | -1649  | -345   |
| 34      | SEG14                | 1355   | -1624  | 81      | COM18    | 695    | 1624   | 128     | VDDL     | -1649  | -425   |
| 35      | SEG15                | 1435   | -1624  | 82      | COM17    | 615    | 1624   | 129     | VSS      | -1649  | -505   |
| 36      | SEG16                | 1649   | -1360  | 83      | COM16    | 535    | 1624   | 130     | VDDX     | -1649  | -585   |
| 37      | SEG17                | 1649   | -1280  | 84      | COM15    | 375    | 1624   | 131     | XT0      | -1649  | -665   |
| 38      | SEG18                | 1649   | -1200  | 85      | COM14    | 295    | 1624   | 132     | XT1      | -1649  | -825   |
| 39      | SEG19                | 1649   | -1120  | 86      | COM13    | 215    | 1624   | 133     | P42      | -1649  | -905   |
| 40      | SEG20                | 1649   | -1040  | 87      | COM12    | 135    | 1624   | 134     | P43      | -1649  | -985   |
| 41      | SEG21                | 1649   | -960   | 88      | COM11    | 55     | 1624   | 135     | VL1      | -1649  | -1080  |
| 42      | SEG22                | 1649   | -880   | 89      | COM10    | -25    | 1624   | 136     | VL2      | -1649  | -1160  |
| 43      | SEG23                | 1649   | -800   | 90      | COM9     | -105   | 1624   | 137     | VL3      | -1649  | -1240  |
| 44      | SEG24                | 1649   | -720   | 91      | COM8     | -185   | 1624   | 138     | VL4      | -1649  | -1320  |
| 45      | SEG25                | 1649   | -640   | 92      | PA0      | -285   | 1624   | 139     | C1       | -1649  | -1400  |
| 46      | SEG26                | 1649   | -560   | 93      | PA1      | -365   | 1624   | 140     | C2       | -1649  | -1480  |
| 47      | SEG27                | 1649   | -480   | 94      | PA2      | -445   | 1624   |         |          |        |        |

## ML610Q439 Pad Coordinates

Table 2 ML610Q439 Pad Coordinates

Chip Center: X=0,Y=0

| PAD No. | Pad Name             | X (μm) | Y (μm) | PAD No. | Pad Name | X (μm) | Y (μm) | PAD No. | Pad Name | X (μm) | Y (μm) |
|---------|----------------------|--------|--------|---------|----------|--------|--------|---------|----------|--------|--------|
| 1       | C3                   | -1485  | -1624  | 48      | SEG28    | 1649   | -400   | 95      | PA3      | -525   | 1624   |
| 2       | C4                   | -1405  | -1624  | 49      | SEG29    | 1649   | -320   | 96      | PA4      | -605   | 1624   |
| 3       | P00/EXI0             | -1315  | -1624  | 50      | SEG30    | 1649   | -240   | 97      | PA5      | -685   | 1624   |
| 4       | P01/EXI1             | -1235  | -1624  | 51      | SEG31    | 1649   | -160   | 98      | P04      | -765   | 1624   |
| 5       | P02/EXI2 /RXD0/P2 CK | -1155  | -1624  | 52      | SEG32    | 1649   | -80    | 99      | P05      | -845   | 1624   |
| 6       | P03/EXI3             | -1075  | -1624  | 53      | SEG33    | 1649   | 0      | 100     | P06      | -925   | 1624   |
| 7       | NMI                  | -995   | -1624  | 54      | SEG34    | 1649   | 80     | 101     | P07      | -1005  | 1624   |
| 8       | VSS                  | -865   | -1624  | 55      | SEG35    | 1649   | 160    | 102     | VSS      | -1106  | 1624   |
| 9       | P10                  | -785   | -1624  | 56      | SEG36    | 1649   | 240    | 103     | AIN0     | -1186  | 1624   |
| 10      | P11                  | -625   | -1624  | 57      | SEG37    | 1649   | 320    | 104     | AIN1     | -1366  | 1624   |
| 11      | VDD                  | -545   | -1624  | 58      | SEG38    | 1649   | 400    | 105     | AVDD     | -1446  | 1624   |
| 12      | COM0                 | -445   | -1624  | 59      | SEG39    | 1649   | 480    | 106     | VREF     | -1649  | 1430   |
| 13      | COM1                 | -365   | -1624  | 60      | SEG40    | 1649   | 560    | 107     | AVSS     | -1649  | 1270   |
| 14      | COM2                 | -285   | -1624  | 61      | SEG41    | 1649   | 640    | 108     | VSS      | -1649  | 1190   |
| 15      | COM3                 | -205   | -1624  | 62      | SEG42    | 1649   | 720    | 109     | P20      | -1649  | 1095   |
| 16      | COM4                 | -125   | -1624  | 63      | SEG43    | 1649   | 800    | 110     | P21      | -1649  | 1015   |
| 17      | COM5                 | -45    | -1624  | 64      | SEG44    | 1649   | 880    | 111     | P22      | -1649  | 935    |
| 18      | COM6                 | 35     | -1624  | 65      | SEG45    | 1649   | 960    | 112     | P40      | -1649  | 855    |
| 19      | COM7                 | 115    | -1624  | 66      | SEG46    | 1649   | 1040   | 113     | P41      | -1649  | 775    |
| 20      | SEG0                 | 235    | -1624  | 67      | SEG47    | 1649   | 1120   | 114     | VPP      | -1649  | 695    |
| 21      | SEG1                 | 315    | -1624  | 68      | SEG48    | 1649   | 1200   | 115     | RESET_N  | -1649  | 615    |
| 22      | SEG2                 | 395    | -1624  | 69      | SEG49    | 1649   | 1280   | 116     | P44      | -1649  | 535    |
| 23      | SEG3                 | 475    | -1624  | 70      | SEG50    | 1649   | 1360   | 117     | P45      | -1649  | 455    |
| 24      | SEG4                 | 555    | -1624  | 71      | SEG51    | 1515   | 1624   | 118     | P46      | -1649  | 375    |
| 25      | SEG5                 | 635    | -1624  | 72      | SEG52    | 1435   | 1624   | 119     | P47      | -1649  | 295    |
| 26      | SEG6                 | 715    | -1624  | 73      | SEG53    | 1355   | 1624   | 120     | P30      | -1649  | 215    |
| 27      | SEG7                 | 795    | -1624  | 74      | SEG54    | 1275   | 1624   | 121     | P31      | -1649  | 135    |
| 28      | SEG8                 | 875    | -1624  | 75      | SEG55    | 1195   | 1624   | 122     | P34      | -1649  | 55     |
| 29      | SEG9                 | 955    | -1624  | 76      | SEG56    | 1095   | 1624   | 123     | P32      | -1649  | -25    |
| 30      | SEG10                | 1035   | -1624  | 77      | SEG57    | 1015   | 1624   | 124     | P33      | -1649  | -105   |
| 31      | SEG11                | 1115   | -1624  | 78      | SEG58    | 935    | 1624   | 125     | P35      | -1649  | -185   |
| 32      | SEG12                | 1195   | -1624  | 79      | SEG59    | 855    | 1624   | 126     | TEST     | -1649  | -265   |
| 33      | SEG13                | 1275   | -1624  | 80      | SEG60    | 775    | 1624   | 127     | VDD      | -1649  | -345   |
| 34      | SEG14                | 1355   | -1624  | 81      | SEG61    | 695    | 1624   | 128     | VDDL     | -1649  | -425   |
| 35      | SEG15                | 1435   | -1624  | 82      | SEG62    | 615    | 1624   | 129     | VSS      | -1649  | -505   |
| 36      | SEG16                | 1649   | -1360  | 83      | SEG63    | 535    | 1624   | 130     | VDDX     | -1649  | -585   |
| 37      | SEG17                | 1649   | -1280  | 84      | COM15    | 375    | 1624   | 131     | XT0      | -1649  | -665   |
| 38      | SEG18                | 1649   | -1200  | 85      | COM14    | 295    | 1624   | 132     | XT1      | -1649  | -825   |
| 39      | SEG19                | 1649   | -1120  | 86      | COM13    | 215    | 1624   | 133     | P42      | -1649  | -905   |
| 40      | SEG20                | 1649   | -1040  | 87      | COM12    | 135    | 1624   | 134     | P43      | -1649  | -985   |
| 41      | SEG21                | 1649   | -960   | 88      | COM11    | 55     | 1624   | 135     | VL1      | -1649  | -1080  |
| 42      | SEG22                | 1649   | -880   | 89      | COM10    | -25    | 1624   | 136     | VL2      | -1649  | -1160  |
| 43      | SEG23                | 1649   | -800   | 90      | COM9     | -105   | 1624   | 137     | VL3      | -1649  | -1240  |
| 44      | SEG24                | 1649   | -720   | 91      | COM8     | -185   | 1624   | 138     | VL4      | -1649  | -1320  |
| 45      | SEG25                | 1649   | -640   | 92      | PA0      | -285   | 1624   | 139     | C1       | -1649  | -1400  |
| 46      | SEG26                | 1649   | -560   | 93      | PA1      | -365   | 1624   | 140     | C2       | -1649  | -1480  |
| 47      | SEG27                | 1649   | -480   | 94      | PA2      | -445   | 1624   |         |          |        |        |

## PIN LIST

| PAD No.           |                   | Primary function   |     |                                                                   | Secondary function |     |          | Tertiary function |     |          |
|-------------------|-------------------|--------------------|-----|-------------------------------------------------------------------|--------------------|-----|----------|-------------------|-----|----------|
| Q439              | Q438              | Pin name           | I/O | Function                                                          | Pin name           | I/O | Function | Pin name          | I/O | Function |
| 8,102,<br>108,129 | 8,102,<br>108,129 | V <sub>SS</sub>    | —   | Negative power supply pin                                         | —                  | —   | —        | —                 | —   | —        |
| 11,127            | 11,127            | V <sub>DD</sub>    | —   | Positive power supply pin                                         | —                  | —   | —        | —                 | —   | —        |
| 128               | 128               | V <sub>DDL</sub>   | —   | Power supply pin for internal logic (internally generated)        | —                  | —   | —        | —                 | —   | —        |
| 130               | 130               | V <sub>DDX</sub>   | —   | Power supply pin for low-speed oscillation (internally generated) | —                  | —   | —        | —                 | —   | —        |
| 114               | 114               | V <sub>PP</sub>    | —   | Power supply pin for Flash ROM                                    | —                  | —   | —        | —                 | —   | —        |
| 107               | 107               | AV <sub>SS</sub>   | —   | Negative power supply pin for successive approximation type ADC   | —                  | —   | —        | —                 | —   | —        |
| 105               | 105               | AV <sub>DD</sub>   | —   | Positive power supply pin for successive approximation type ADC   | —                  | —   | —        | —                 | —   | —        |
| 135               | 135               | V <sub>L1</sub>    | —   | Power supply pin for LCD bias (internally generated)              | —                  | —   | —        | —                 | —   | —        |
| 136               | 136               | V <sub>L2</sub>    | —   | Power supply pin for LCD bias (internally generated)              | —                  | —   | —        | —                 | —   | —        |
| 137               | 137               | V <sub>L3</sub>    | —   | Power supply pin for LCD bias (internally generated)              | —                  | —   | —        | —                 | —   | —        |
| 138               | 138               | V <sub>L4</sub>    | —   | Power supply pin for LCD bias (internally generated)              | —                  | —   | —        | —                 | —   | —        |
| 139               | 139               | C1                 | —   | Capacitor connection pin for LCD bias generation                  | —                  | —   | —        | —                 | —   | —        |
| 140               | 140               | C2                 | —   | Capacitor connection pin for LCD bias generation                  | —                  | —   | —        | —                 | —   | —        |
| 1                 | 1                 | C3                 | —   | Capacitor connection pin for LCD bias generation                  | —                  | —   | —        | —                 | —   | —        |
| 2                 | 2                 | C4                 | —   | Capacitor connection pin for LCD bias generation                  | —                  | —   | —        | —                 | —   | —        |
| 126               | 126               | TEST               | I/O | Input/output pin for testing                                      | —                  | —   | —        | —                 | —   | —        |
| 115               | 115               | RESET <sub>N</sub> | I   | Reset input pin                                                   | —                  | —   | —        | —                 | —   | —        |
| 131               | 131               | XT0                | I   | Low-speed clock oscillation pin                                   | —                  | —   | —        | —                 | —   | —        |
| 132               | 132               | XT1                | O   | Low-speed clock oscillation pin                                   | —                  | —   | —        | —                 | —   | —        |
| 106               | 106               | V <sub>REF</sub>   | —   | Reference power supply pin for successive approximation type ADC  | —                  | —   | —        | —                 | —   | —        |
| 103               | 103               | AIN0               | I   | Successive approximation type ADC input                           | —                  | —   | —        | —                 | —   | —        |

| PAD No. |      | Primary function   |     |                                                                            | Secondary function |     |                                                       | Tertiary function |     |                         |
|---------|------|--------------------|-----|----------------------------------------------------------------------------|--------------------|-----|-------------------------------------------------------|-------------------|-----|-------------------------|
| Q439    | Q438 | Pin name           | I/O | Function                                                                   | Pin name           | I/O | Function                                              | Pin name          | I/O | Function                |
| 104     | 104  | AIN1               | I   | Successive approximation type ADC input                                    | —                  | —   | —                                                     | —                 | —   | —                       |
| 7       | 7    | NMI                | I   | Non-maskable interrupt pin                                                 | —                  | —   | —                                                     | —                 | —   | —                       |
| 3       | 3    | P00/EXI0/CAP0      | I   | Input port, External interrupt 0 input, Capture 0 input                    | —                  | —   | —                                                     | —                 | —   | —                       |
| 4       | 4    | P01/EXI1/CAP1      | I   | Input port, External interrupt 1 input, Capture 1 input                    | —                  | —   | —                                                     | —                 | —   | —                       |
| 5       | 5    | P02/EXI2/RXD0/P2CK | I   | Input port, External interrupt 2, UART0 receive, PWM2 external clock input | —                  | —   | —                                                     | —                 | —   | —                       |
| 6       | 6    | P03/EXI3           | I   | Input port, External interrupt 3                                           | —                  | —   | —                                                     | —                 | —   | —                       |
| 98      | 98   | P04/EXI4           | I/O | Input port, External interrupt 4                                           | —                  | —   | —                                                     | —                 | —   | —                       |
| 99      | 99   | P05/EXI5           | I/O | Input port, External interrupt 5                                           | —                  | —   | —                                                     | —                 | —   | —                       |
| 100     | 100  | P06/EXI6           | I/O | Input port, External interrupt 6                                           | —                  | —   | —                                                     | —                 | —   | —                       |
| 101     | 101  | P07/EXI7           | I/O | Input port, External interrupt 7                                           | —                  | —   | —                                                     | —                 | —   | —                       |
| 9       | 9    | P10                | I   | Input port                                                                 | OSC0               | I   | High-speed oscillation                                | —                 | —   | —                       |
| 10      | 10   | P11                | I   | Input port                                                                 | OSC1               | O   | High-speed oscillation                                | —                 | —   | —                       |
| 109     | 109  | P20/LED0           | O   | Output port                                                                | LSCLK              | O   | Low-speed clock output                                | PWM2              | O   | PWM2 output             |
| 110     | 110  | P21/LED1           | O   | Output port                                                                | OUTCLK             | O   | High-speed clock output                               | —                 | —   | —                       |
| 111     | 111  | P22/LED2           | O   | Output port                                                                | MD0                | O   | Melody output                                         | —                 | —   | —                       |
| 120     | 120  | P30                | I/O | Input/output port                                                          | IN0                | I   | RC type ADC0 oscillation input pin                    | PWM2              | O   | PWM2 output             |
| 121     | 121  | P31                | I/O | Input/output port                                                          | CS0                | O   | RC type ADC0 reference capacitor connection pin       | —                 | —   | —                       |
| 123     | 123  | P32                | I/O | Input/output port                                                          | RS0                | O   | RC type ADC0 reference resistor connection pin        | —                 | —   | —                       |
| 124     | 124  | P33                | I/O | Input/output port                                                          | RT0                | O   | RC type ADC0 resistor sensor connection pin           | —                 | —   | —                       |
| 122     | 122  | P34                | I/O | Input/output port                                                          | RCT0               | O   | RC type ADC0 resistor/capacitor sensor connection pin | PWM0              | O   | PWM0 output             |
| 125     | 125  | P35                | I/O | Input/output port                                                          | RCM                | O   | RC type ADC oscillation monitor                       | PWM1              | O   | PWM1 output             |
| 112     | 112  | P40                | I/O | Input/output port                                                          | SDA                | I/O | I2C data input/output                                 | SIN0              | I   | SSIO data input         |
| 113     | 113  | P41                | I/O | Input/output port                                                          | SCL                | I/O | I2C clock input/output                                | SCK0              | I/O | SSIO synchronous clock  |
| 133     | 133  | P42                | I/O | Input/output port                                                          | RXD0               | I   | UART data input                                       | SOUT0             | O   | SSIO data output        |
| 134     | 134  | P43                | I/O | Input/output port                                                          | TXD0               | O   | UART data output                                      | PWM0              | O   | PWM0 output             |
| 116     | 116  | P44/T02P0CK        | I/O | Input/output port, Timer 0/Timer 2/PWM0 external clock input               | IN1                | I   | RC type ADC1 oscillation input pin                    | SIN0              | I   | SSIO0 data input        |
| 117     | 117  | P45/T13P1CK        | I/O | Input/output port, Timer 1/Timer 3/PWM1 external clock input               | CS1                | O   | RC type ADC1 reference capacitor connection pin       | SCK0              | I/O | SSIO0 synchronous clock |
| 118     | 118  | P46/T46P2CK        | I/O | Input/output port, PWM2 external clock input                               | RS1                | O   | RC type ADC1 reference resistor connection pin        | SOUT0             | O   | SSIO0 data output       |

| PAD No. |      | Primary function |     |                   | Secondary function |     |                                             | Tertiary function |     |             |
|---------|------|------------------|-----|-------------------|--------------------|-----|---------------------------------------------|-------------------|-----|-------------|
| Q439    | Q438 | Pin name         | I/O | Function          | Pin name           | I/O | Function                                    | Pin name          | I/O | Function    |
| 119     | 119  | P47              | I/O | Input/output port | RT1                | O   | RC type ADC1 resistor sensor connection pin | PWM1              | O   | PWM1 output |
| 92      | 92   | PA0              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 93      | 93   | PA1              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 94      | 94   | PA2              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 95      | 95   | PA3              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 96      | 96   | PA4              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 97      | 97   | PA5              | I/O | Input/output port | —                  | —   | —                                           | —                 | —   | —           |
| 12      | 12   | COM0             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 13      | 13   | COM1             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 14      | 14   | COM2             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 15      | 15   | COM3             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 16      | 16   | COM4             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 17      | 17   | COM5             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 18      | 18   | COM6             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 19      | 19   | COM7             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 91      | 91   | COM8             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 90      | 90   | COM9             | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 89      | 89   | COM10            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 88      | 88   | COM11            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 87      | 87   | COM12            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 86      | 86   | COM13            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 85      | 85   | COM14            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 84      | 84   | COM15            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 83   | COM16            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 82   | COM17            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 81   | COM18            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 80   | COM19            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 79   | COM20            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 78   | COM21            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 77   | COM22            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| —       | 76   | COM23            | O   | LCD common pin    | —                  | —   | —                                           | —                 | —   | —           |
| 20      | 20   | SEG0             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 21      | 21   | SEG1             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 22      | 22   | SEG2             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 23      | 23   | SEG3             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 24      | 24   | SEG4             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 25      | 25   | SEG5             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 26      | 26   | SEG6             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 27      | 27   | SEG7             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 28      | 28   | SEG8             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 29      | 29   | SEG9             | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 30      | 30   | SEG10            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 31      | 31   | SEG11            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 32      | 32   | SEG12            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 33      | 33   | SEG13            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 34      | 34   | SEG14            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 35      | 35   | SEG15            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |
| 36      | 36   | SEG16            | O   | LCD segment pin   | —                  | —   | —                                           | —                 | —   | —           |

| PAD No. |      | Primary function |     |                 | Secondary function |     |          | Tertiary function |     |          |
|---------|------|------------------|-----|-----------------|--------------------|-----|----------|-------------------|-----|----------|
| Q439    | Q438 | Pin name         | I/O | Function        | Pin name           | I/O | Function | Pin name          | I/O | Function |
| 37      | 37   | SEG17            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 38      | 38   | SEG18            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 39      | 39   | SEG19            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 40      | 40   | SEG20            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 41      | 41   | SEG21            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 42      | 42   | SEG22            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 43      | 43   | SEG23            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 44      | 44   | SEG24            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 45      | 45   | SEG25            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 46      | 46   | SEG26            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 47      | 47   | SEG27            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 48      | 48   | SEG28            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 49      | 49   | SEG29            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 50      | 50   | SEG30            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 51      | 51   | SEG31            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 52      | 52   | SEG32            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 53      | 53   | SEG33            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 54      | 54   | SEG34            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 55      | 55   | SEG35            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 56      | 56   | SEG36            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 57      | 57   | SEG37            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 58      | 58   | SEG38            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 59      | 59   | SEG39            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 60      | 60   | SEG40            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 61      | 61   | SEG41            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 62      | 62   | SEG42            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 63      | 63   | SEG43            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 64      | 64   | SEG44            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 65      | 65   | SEG45            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 66      | 66   | SEG46            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 67      | 67   | SEG47            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 68      | 68   | SEG48            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 69      | 69   | SEG49            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 70      | 70   | SEG50            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 71      | 71   | SEG51            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 72      | 72   | SEG52            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 73      | 73   | SEG53            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 74      | 74   | SEG54            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 75      | 75   | SEG55            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 76      | —    | SEG56            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 77      | —    | SEG57            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 78      | —    | SEG58            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 79      | —    | SEG59            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 80      | —    | SEG60            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 81      | —    | SEG61            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 82      | —    | SEG62            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |
| 83      | —    | SEG63            | O   | LCD segment pin | —                  | —   | —        | —                 | —   | —        |

## PIN DESCRIPTION

| Pin name                          | I/O | Description                                                                                                                                                                                                                                              | Primary/<br>Secondary/<br>Tertiary | Logic    |
|-----------------------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|----------|
| System                            |     |                                                                                                                                                                                                                                                          |                                    |          |
| RESET_N                           | I   | Reset input pin. When this pin is set to a “L” level, system reset mode is set and the internal section is initialized. When this pin is set to a “H” level subsequently, program execution starts. A pull-up resistor is internally connected.          | —                                  | Negative |
| XT0                               | I   | Crystal connection pin for low-speed clock.                                                                                                                                                                                                              | —                                  | —        |
| XT1                               | O   | A 32.768 kHz crystal oscillator (see measuring circuit 1) is connected to this pin. Capacitors CDL and CGL are connected across this pin and V <sub>SS</sub> as required.                                                                                | —                                  | —        |
| OSC0                              | I   | Crystal/ceramic connection pin for high-speed clock.                                                                                                                                                                                                     | Secondary                          | —        |
| OSC1                              | O   | A crystal or ceramic is connected to this pin (4.1 MHz max.). Capacitors CDH and CGH (see measuring circuit 1) are connected across this pin and V <sub>SS</sub> .<br>This pin is used as the secondary function of the P10 pin(OSC0) and P11 pin(OSC1). | Secondary                          | —        |
| LSCLK                             | O   | Low-speed clock output pin. This pin is used as the secondary function of the P20 pin.                                                                                                                                                                   | Secondary                          | —        |
| OUTCLK                            | O   | High-speed clock output pin. This pin is used as the secondary function of the P21 pin.                                                                                                                                                                  | Secondary                          | —        |
| General-purpose input port        |     |                                                                                                                                                                                                                                                          |                                    |          |
| P00-P07                           | I   | General-purpose input port.<br>Since these pins have secondary functions, the pins cannot be used as a port when the secondary functions are used.                                                                                                       | Primary                            | Positive |
| P10-P11                           | I   | General-purpose input port.<br>Since these pins have secondary functions, the pins cannot be used as a port when the secondary functions are used.                                                                                                       | Primary                            | Positive |
| General-purpose output port       |     |                                                                                                                                                                                                                                                          |                                    |          |
| P20-P22                           | O   | General-purpose output port.<br>Since these pins have secondary functions, the pins cannot be used as a port when the secondary functions are used.                                                                                                      | Primary                            | Positive |
| General-purpose input/output port |     |                                                                                                                                                                                                                                                          |                                    |          |
| P30-P35                           | I/O | General-purpose input/output port.<br>Since these pins have secondary functions, the pins cannot be used as a port when the secondary functions are used.                                                                                                | Primary                            | Positive |
| P40-P47                           | I/O | General-purpose input/output port.<br>Since these pins have secondary functions, the pins cannot be used as a port when the secondary functions are used.                                                                                                | Primary                            | Positive |
| PA0-PA5                           | I/O | General-purpose input/output port.                                                                                                                                                                                                                       | Primary                            | Positive |
| UART                              |     |                                                                                                                                                                                                                                                          |                                    |          |
| TXD0                              | O   | UART data output pin. This pin is used as the secondary function of the P43 pin.                                                                                                                                                                         | Secondary                          | Positive |
| RXD0                              | I   | UART data input pin. This pin is used as the secondary function of the P42 or the primary function of the P02 pin.                                                                                                                                       | Primary/Secondary                  | Positive |

| Pin name                            | I/O | Description                                                                                                                                                                                                                                  | Primary/<br>Secondary/<br>Tertiary | Logic             |
|-------------------------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------|
| <b>I<sup>2</sup>C bus interface</b> |     |                                                                                                                                                                                                                                              |                                    |                   |
| SDA                                 | I/O | I <sup>2</sup> C data input/output pin. This pin is used as the secondary function of the P40 pin. This pin has an NMOS open drain output. When using this pin as a function of the I <sup>2</sup> C, externally connect a pull-up resistor. | Secondary                          | Positive          |
| SCL                                 | O   | I <sup>2</sup> C clock output pin. This pin is used as the secondary function of the P41 pin. This pin has an NMOS open drain output. When using this pin as a function of the I <sup>2</sup> C, externally connect a pull-up resistor.      | Secondary                          | Positive          |
| <b>Synchronous serial (SSIO)</b>    |     |                                                                                                                                                                                                                                              |                                    |                   |
| SCK0                                | I/O | Synchronous serial clock input/output pin. This pin is used as the tertiary function of the P41 or P45 pin.                                                                                                                                  | Tertiary                           | —                 |
| SIN0                                | I   | Synchronous serial data input pin. This pin is used as the tertiary function of the P40 or P44 pin.                                                                                                                                          | Tertiary                           | Positive          |
| SOUT0                               | O   | Synchronous serial data output pin. This pin is used as the tertiary function of the P42 or P46 pin.                                                                                                                                         | Tertiary                           | Positive          |
| <b>PWM</b>                          |     |                                                                                                                                                                                                                                              |                                    |                   |
| PWM0                                | O   | PWM0 output pin. This pin is used as the tertiary function of the P43 or P34 pin.                                                                                                                                                            | Tertiary                           | Positive          |
| TOP0CK                              | I   | PWM0 external clock input pin. This pin is used as the primary function of the P44 pin.                                                                                                                                                      | Primary                            | —                 |
| PWM1                                | O   | PWM1 output pin. This pin is used as the tertiary function of the P47 or P35 pin.                                                                                                                                                            | Tertiary                           | Positive          |
| T1P1CK                              | I   | PWM1 external clock input pin. This pin is used as the primary function of the P45 pin.                                                                                                                                                      | Primary                            | —                 |
| PWM2                                | O   | PWM2 output pin. This pin is used as the tertiary function of the P20 or P30 pin.                                                                                                                                                            | Tertiary                           | Positive          |
| P2CK                                | I   | PWM2 external clock input pin. This pin is used as the primary function of the P02 pin.                                                                                                                                                      | Primary                            | —                 |
| <b>External interrupt</b>           |     |                                                                                                                                                                                                                                              |                                    |                   |
| NMI                                 | I   | External non-maskable interrupt input pin. An interrupt is generated on both edges.                                                                                                                                                          | Primary                            | Positive/negative |
| EXIO-7                              | I   | External maskable interrupt input pins. Interrupt enable and edge selection can be performed for each bit by software. These pins are used as the primary functions of the P00-P07 pins.                                                     | Primary                            | Positive/negative |
| <b>Capture</b>                      |     |                                                                                                                                                                                                                                              |                                    |                   |
| CAP0                                | I   | Capture trigger input pins. The value of the time base counter is captured in the register synchronously with the interrupt edge selected by software.                                                                                       | Primary                            | Positive/negative |
| CAP1                                | I   | These pins are used as the primary functions of the P00 pin(CAP0) and P01 pin(CAP1).                                                                                                                                                         | Primary                            | Positive/negative |
| <b>Timer</b>                        |     |                                                                                                                                                                                                                                              |                                    |                   |
| TOP0CK                              | I   | External clock input pin used for Timer 0. This pin is used as the primary function of the P44 pin.                                                                                                                                          | Primary                            | —                 |
| T1P1CK                              | I   | External clock input pin used for Timer 1. This pin is used as the primary function of the P45 pin.                                                                                                                                          | Primary                            | —                 |
| <b>Melody</b>                       |     |                                                                                                                                                                                                                                              |                                    |                   |
| MD0                                 | O   | Melody/buzzer signal output pin. This pin is used as the secondary function of the P22 pin.                                                                                                                                                  | Secondary                          | Positive/negative |
| <b>LED drive</b>                    |     |                                                                                                                                                                                                                                              |                                    |                   |
| LED0-2                              | O   | Nch open drain output pins to drive LED.                                                                                                                                                                                                     | Primary                            | Positive/negative |

| Pin name                                    | I/O | Description                                                                                                                                                                                                                                        | Primary/<br>Secondary/<br>Tertiary | Logic |
|---------------------------------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------|
| RC oscillation type A/D converter           |     |                                                                                                                                                                                                                                                    |                                    |       |
| IN0                                         | I   | Channel 0 oscillation input pin. This pin is used as the secondary function of the P30 pin.                                                                                                                                                        | Secondary                          | —     |
| CS0                                         | O   | Channel 0 reference capacitor connection pin. This pin is used as the secondary function of the P31 pin.                                                                                                                                           | Secondary                          | —     |
| RS0                                         | O   | This pin is used as the secondary function of the P32 pin which is the reference resistor connection pin of Channel 0.                                                                                                                             | Secondary                          | —     |
| RT0                                         | O   | Resistor sensor connection pin of Channel 0 for measurement. This pin is used as the secondary function of the P34 pin.                                                                                                                            | Secondary                          | —     |
| CRT0                                        | O   | Resistor/capacitor sensor connection pin of Channel 0 for measurement. This pin is used as the secondary function of the P33 pin.                                                                                                                  | Secondary                          | —     |
| RCM                                         | O   | RC oscillation monitor pin. This pin is used as the secondary function of the P35 pin.                                                                                                                                                             | Secondary                          | —     |
| IN1                                         | I   | Oscillation input pin of Channel 1. This pin is used as the secondary function of the P44 pin.                                                                                                                                                     | Secondary                          | —     |
| CS1                                         | O   | Reference capacitor connection pin of Channel 1. This pin is used as the secondary function of the P45 pin.                                                                                                                                        | Secondary                          | —     |
| RS1                                         | O   | Reference resistor connection pin of Channel 1. This pin is used as the secondary function of the P46 pin.                                                                                                                                         | Secondary                          | —     |
| RT1                                         | O   | Resistor sensor connection pin for measurement of Channel 1. This pin is used as the secondary function of the P47 pin.                                                                                                                            | Secondary                          | —     |
| Successive approximation type A/D converter |     |                                                                                                                                                                                                                                                    |                                    |       |
| AV <sub>SS</sub>                            | —   | Negative power supply pin for successive approximation type A/D converter.                                                                                                                                                                         | —                                  | —     |
| AV <sub>DD</sub>                            | —   | Positive power supply pin for successive approximation type A/D converter.                                                                                                                                                                         | —                                  | —     |
| V <sub>REF</sub>                            | —   | Reference power supply pin for successive approximation type A/D converter.                                                                                                                                                                        | —                                  | —     |
| AIN0                                        | I   | Channel 0 analog input for successive approximation type A/D converter.                                                                                                                                                                            | —                                  | —     |
| AIN1                                        | I   | Channel 1 analog input for successive approximation type A/D converter.                                                                                                                                                                            | —                                  | —     |
| LCD drive signal                            |     |                                                                                                                                                                                                                                                    |                                    |       |
| COM0-15                                     | O   | Common output pins.                                                                                                                                                                                                                                | —                                  | —     |
| COM8-23                                     | O   | Common output pins.<br>These pins are for the ML610Q438, but are not provided in the ML610Q439.                                                                                                                                                    | —                                  | —     |
| SEG0-57                                     | O   | Segment output pin.                                                                                                                                                                                                                                | —                                  | —     |
| SEG58-63                                    | O   | Segment output pins.<br>These pins are for the ML610Q439, but are not provided in the ML610Q438.                                                                                                                                                   | —                                  | —     |
| LCD driver power supply                     |     |                                                                                                                                                                                                                                                    |                                    |       |
| V <sub>L1</sub>                             | —   | Power supply pins for LCD bias (internally generated). Capacitors Ca, Cb, Cc, and Cd (see measuring circuit 1) are connected between V <sub>SS</sub> and V <sub>L1</sub> , V <sub>L2</sub> , V <sub>L3</sub> , and V <sub>L4</sub> , respectively. | —                                  | —     |
| V <sub>L2</sub>                             | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| V <sub>L3</sub>                             | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| V <sub>L4</sub>                             | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| C1                                          | —   | Power supply pins for LCD bias (internally generated). Capacitors C12 and C34 (see measuring circuit 1) are connected between C1 and C2 and between C3 and C4, respectively.                                                                       | —                                  | —     |
| C2                                          | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| C3                                          | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| C4                                          | —   |                                                                                                                                                                                                                                                    | —                                  | —     |
| For testing                                 |     |                                                                                                                                                                                                                                                    |                                    |       |
| TEST                                        | I/O | Input/output pin for testing. A pull-down resistor is internally connected.                                                                                                                                                                        | —                                  | —     |
| Power supply                                |     |                                                                                                                                                                                                                                                    |                                    |       |
| V <sub>SS</sub>                             | —   | Negative power supply pin.                                                                                                                                                                                                                         | —                                  | —     |

|                  |   |                                                                                                                                                                            |   |   |
|------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| V <sub>DD</sub>  | — | Positive power supply pin.                                                                                                                                                 | — | — |
| V <sub>DDL</sub> | — | Positive power supply pin (internally generated) for internal logic. Capacitors CL0 and CL1 (see measuring circuit 1) are connected between this pin and V <sub>SS</sub> . | — | — |
| V <sub>DDX</sub> | — | Plus-side power supply pin (internally generated) for low-speed oscillation. Capacitor Cx (see measuring circuit 1) is connected between this pin and V <sub>SS</sub> .    | — | — |
| V <sub>PP</sub>  | — | Power supply pin for programming Flash ROM. A pull-up resistor is internally connected.                                                                                    | — | — |

## TERMINATION OF UNUSED PINS

Table 3 shows methods of terminating the unused pins.

**Table 3 Termination of Unused Pins**

| Pin                                                                   | Recommended pin termination        |
|-----------------------------------------------------------------------|------------------------------------|
| V <sub>PP</sub>                                                       | Open                               |
| AV <sub>DD</sub>                                                      | V <sub>SS</sub>                    |
| AV <sub>SS</sub>                                                      | V <sub>SS</sub>                    |
| V <sub>REF</sub>                                                      | V <sub>SS</sub>                    |
| AIN0, AIN1                                                            | Open                               |
| V <sub>L1</sub> , V <sub>L2</sub> , V <sub>L3</sub> , V <sub>L4</sub> | Open                               |
| C1, C2, C3, C4                                                        | Open                               |
| RESET_N                                                               | Open                               |
| TEST                                                                  | Open                               |
| NMI                                                                   | Open                               |
| P00 to P07                                                            | V <sub>DD</sub> or V <sub>SS</sub> |
| P10 to P11                                                            | V <sub>DD</sub>                    |
| P20 to P22                                                            | Open                               |
| P30 to P35                                                            | Open                               |
| P40 to P47                                                            | Open                               |
| PA0 to PA5                                                            | Open                               |
| COM0 to 23                                                            | Open                               |
| SEG0 to 63                                                            | Open                               |

Note:

It is recommended to set the unused input ports and input/output ports to the inputs with pull-down resistors/pull-up resistors or the output mode since the supply current may become excessively large if the pins are left open in the high impedance input setting.

The main difference points of ML610Q438 and ML610Q439

**Table 4 The main difference points of ML610Q438 and ML610Q439.**

| Function | ML610Q438     | ML610Q439     |
|----------|---------------|---------------|
| LCD COM  | COM23 to COM0 | COM15 to COM0 |
| LCD SEG  | SEG55 to SEG0 | SEG63 to SEG0 |

## ELECTRICAL CHARACTERISTICS

## ABSOLUTE MAXIMUM RATINGS

(V<sub>SS</sub> = AV<sub>SS</sub> = 0V)

| Parameter              | Symbol            | Condition          | Rating                       | Unit |
|------------------------|-------------------|--------------------|------------------------------|------|
| Power supply voltage 1 | V <sub>DD</sub>   | Ta = 25°C          | −0.3 to +4.6                 | V    |
| Power supply voltage 2 | AV <sub>DD</sub>  | Ta = 25°C          | −0.3 to +4.6                 | V    |
| Power supply voltage 3 | V <sub>PP</sub>   | Ta = 25°C          | −0.3 to +9.5                 | V    |
| Power supply voltage 4 | V <sub>DDL</sub>  | Ta = 25°C          | −0.3 to +3.6                 | V    |
| Power supply voltage 5 | V <sub>DDX</sub>  | Ta = 25°C          | −0.3 to +3.6                 | V    |
| Power supply voltage 6 | V <sub>L1</sub>   | Ta = 25°C          | −0.3 to +1.75                | V    |
| Power supply voltage 7 | V <sub>L2</sub>   | Ta = 25°C          | −0.3 to +3.5                 | V    |
| Power supply voltage 8 | V <sub>L3</sub>   | Ta = 25°C          | −0.3 to +5.25                | V    |
| Power supply voltage 9 | V <sub>L4</sub>   | Ta = 25°C          | −0.3 to +7.0                 | V    |
| Input voltage          | V <sub>IN</sub>   | Ta = 25°C          | −0.3 to V <sub>DD</sub> +0.3 | V    |
| Output voltage         | V <sub>OUT</sub>  | Ta = 25°C          | −0.3 to V <sub>DD</sub> +0.3 | V    |
| Output current 1       | I <sub>OUT1</sub> | Port3−A, Ta = 25°C | −12 to +11                   | mA   |
| Output current 2       | I <sub>OUT2</sub> | Port2, Ta = 25°C   | −12 to +20                   | mA   |
| Power dissipation      | PD                | Ta = 25°C          | 122                          | mW   |
| Storage temperature    | T <sub>STG</sub>  | —                  | −55 to +150                  | °C   |

## RECOMMENDED OPERATING CONDITIONS

(V<sub>SS</sub> = AV<sub>SS</sub> = 0V)

| Parameter                                                                       | Symbol                            | Condition                     | Range         | Unit             |
|---------------------------------------------------------------------------------|-----------------------------------|-------------------------------|---------------|------------------|
| Operating temperature                                                           | T <sub>OP</sub>                   | ML610Q438/Q439                | −20 to +70    | °C               |
|                                                                                 |                                   | ML610Q438P/Q439P              |               |                  |
| Operating voltage                                                               | V <sub>DD</sub>                   | —                             | 1.1 to 3.6    | V                |
|                                                                                 | AV <sub>DD</sub>                  | —                             | 2.2 to 3.6    | AV <sub>DD</sub> |
| Operating frequency (CPU)                                                       | f <sub>OP</sub>                   | V <sub>DD</sub> = 1.1 to 3.6V | 30k to 36k    | Hz               |
|                                                                                 |                                   | V <sub>DD</sub> = 1.3 to 3.6V | 30k to 650k   |                  |
|                                                                                 |                                   | V <sub>DD</sub> = 1.8 to 3.6V | 30k to 4.2M   |                  |
| Low-speed crystal oscillation frequency                                         | f <sub>XTL</sub>                  | —                             | 32.768k       | Hz               |
| Low-speed crystal oscillation external capacitor                                | C <sub>DL</sub>                   | —                             | 0 to 12       | pF               |
|                                                                                 | C <sub>GL</sub>                   | —                             | 0 to 12       |                  |
| High-speed crystal/ceramic oscillation frequency                                | f <sub>XTH</sub>                  | —                             | 4.0M / 4.096M | Hz               |
| High-speed crystal oscillation external capacitor                               | C <sub>DH</sub>                   | —                             | 24            | pF               |
|                                                                                 | C <sub>GH</sub>                   | —                             | 24            |                  |
| Capacitor externally connected to V <sub>DDL</sub> pin                          | C <sub>L0</sub>                   | —                             | 1.0±30%       | μF               |
|                                                                                 | C <sub>L1</sub>                   | —                             | 0.1±30%       |                  |
| Capacitor externally connected to V <sub>DDX</sub> pin                          | C <sub>X</sub>                    | —                             | 0.1±30%       | μF               |
| Capacitors externally connected to V <sub>L1</sub> , 2, 3, 4 pins               | C <sub>a, b, c, d</sub>           | —                             | 1.0±30%       | μF               |
| Capacitors externally connected across C1 and C2 pins and across C3 and C4 pins | C <sub>12</sub> , C <sub>34</sub> | —                             | 1.0±30%       | μF               |

## OPERATING CONDITIONS OF FLASH ROM

(V<sub>SS</sub> = AV<sub>SS</sub> = 0V)

| Parameter             | Symbol           | Condition                    | Range       | Unit   |
|-----------------------|------------------|------------------------------|-------------|--------|
| Operating temperature | T <sub>OP</sub>  | At write/erase <sup>*1</sup> | 0 to +40    | °C     |
| Operating voltage     | V <sub>DD</sub>  | At write/erase <sup>*1</sup> | 2.75 to 3.6 | V      |
|                       | V <sub>DDL</sub> | At write/erase <sup>*1</sup> | 2.5 to 2.75 |        |
|                       | V <sub>PP</sub>  | At write/erase <sup>*1</sup> | 7.7 to 8.3  |        |
| Write cycles          | C <sub>EP</sub>  | —                            | 80          | cycles |
| Data retention        | Y <sub>DR</sub>  | —                            | 10          | years  |

<sup>\*1</sup>: In addition the power supply to VDD pin and VPP pin, within the range 2.5V to 2.75V has to be supplied to VDDL pin when programming and erasing Flash ROM.

## DC CHARACTERISTICS (1/5)

(V<sub>DD</sub> = 1.1 to 3.6V, AV<sub>DD</sub> = 2.2 to 3.6V, V<sub>SS</sub> = AV<sub>SS</sub> = 0V, Ta = -20 to +70°C, Ta = -40 to +85°C for P version, unless otherwise specified ) (1/5)

| Parameter                                   | Symbol            | Condition                                          |                   | Rating    |       |           | Unit | Measuring circuit |
|---------------------------------------------|-------------------|----------------------------------------------------|-------------------|-----------|-------|-----------|------|-------------------|
|                                             |                   |                                                    |                   | Min.      | Typ.  | Max.      |      |                   |
| 500kHz RC oscillation frequency             | f <sub>RC</sub>   | V <sub>DD</sub> = 1.3 to 3.6V                      | Ta = 25°C         | Typ. -10% | 500   | Typ. +10% | kHz  | 1                 |
|                                             |                   |                                                    | Ta = -20 to +70°C | Typ. -25% | 500   | Typ. +25% | kHz  |                   |
| PLL oscillation frequency*4                 | f <sub>PLL</sub>  | LSCLK = 32.768kHz<br>V <sub>DD</sub> = 1.8 to 3.6V |                   | -2.5%     | 8.192 | +2.5%     | MHz  |                   |
| Low-speed crystal oscillation start time*2  | T <sub>XTL</sub>  | —                                                  |                   | —         | 0.3   | 2         | s    |                   |
| 500kHz RC oscillation start time            | T <sub>RC</sub>   | —                                                  |                   | —         | 50    | 500       | μs   |                   |
| High-speed crystal oscillation start time*3 | T <sub>XTH</sub>  | V <sub>DD</sub> = 1.8 to 3.6V                      |                   | —         | 2     | 20        | ms   |                   |
| PLL oscillation start time                  | T <sub>PLL</sub>  | V <sub>DD</sub> = 1.8 to 3.6V                      |                   | —         | 1     | 10        |      |                   |
| Low-speed oscillation stop detect time*1    | T <sub>STOP</sub> | —                                                  |                   | 0.2       | 3     | 20        |      |                   |
| Reset pulse width                           | P <sub>RST</sub>  | —                                                  |                   | 200       | —     | —         | μs   |                   |
| Reset noise elimination pulse width         | P <sub>NRST</sub> | —                                                  |                   | —         | —     | 0.3       |      |                   |
| Power-on reset activation power rise time   | T <sub>POR</sub>  | —                                                  |                   | —         | —     | 10        | ms   |                   |

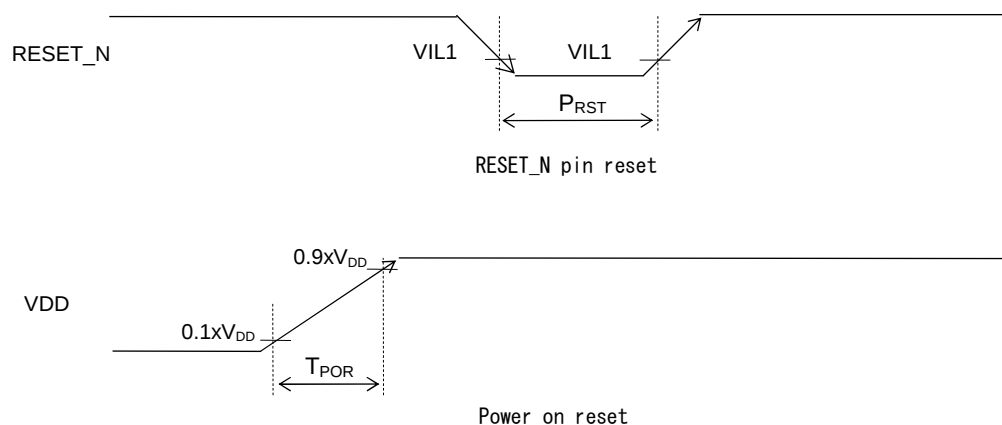
<sup>\*1</sup>: When low-speed crystal oscillation stops for a duration more than the low-speed oscillation stop detect time, the system is reset to shift to system reset mode.

<sup>\*2</sup> : Use 32.768KHz Crystal Resonator DT-26 (Load capacitance 6pF) (KDS: DAISHINKU CORP.)

<sup>\*3</sup> : Use 4.096MHz Crystal Oscillator CHC49SFWB (Kyocera).

<sup>\*4</sup> : 1024 clock average.

## RESET



**DC CHARACTERISTICS (2/5)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^\circ C$ ,  $T_a = -40$  to  $+85^\circ C$  for P version, unless otherwise specified) (2/5)

| Parameter                        | Symbol          | Condition                                                                              |                           | Rating       |                   |             | Unit  | Measuring circuit |
|----------------------------------|-----------------|----------------------------------------------------------------------------------------|---------------------------|--------------|-------------------|-------------|-------|-------------------|
|                                  |                 |                                                                                        |                           | Min.         | Typ.              | Max.        |       |                   |
| $V_{L1}$ voltage                 | $V_{L1}$        | $V_{DD} = 3.0V$ ,<br>$T_j = 25^\circ C$                                                | CN4-0 = 00H               | 0.89         | 0.94              | 0.99        | V     | 1                 |
|                                  |                 |                                                                                        | CN4-0 = 01H               | 0.91         | 0.96              | 1.01        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 02H               | 0.93         | 0.98              | 1.03        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 03H               | 0.95         | 1.00              | 1.05        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 04H               | 0.97         | 1.02              | 1.07        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 05H               | 0.99         | 1.04              | 1.09        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 06H               | 1.01         | 1.06              | 1.11        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 07H               | 1.03         | 1.08              | 1.13        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 08H               | 1.05         | 1.10              | 1.15        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 09H               | 1.07         | 1.12              | 1.17        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0AH               | 1.09         | 1.14              | 1.19        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0BH               | 1.11         | 1.16              | 1.21        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0CH               | 1.13         | 1.18              | 1.23        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0DH               | 1.15         | 1.20              | 1.25        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0EH               | 1.17         | 1.22              | 1.27        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 0FH               | 1.19         | 1.24              | 1.29        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 10H               | 1.21         | 1.26              | 1.31        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 11H               | 1.23         | 1.28              | 1.33        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 12H               | 1.25         | 1.30              | 1.35        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 13H               | 1.27         | 1.32              | 1.37        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 14H <sup>*1</sup> | 1.29         | 1.34              | 1.39        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 15H <sup>*1</sup> | 1.31         | 1.36              | 1.41        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 16H <sup>*1</sup> | 1.33         | 1.38              | 1.43        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 17H <sup>*1</sup> | 1.35         | 1.40              | 1.45        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 18H <sup>*1</sup> | 1.37         | 1.42              | 1.47        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 19H <sup>*1</sup> | 1.39         | 1.44              | 1.49        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1AH <sup>*1</sup> | 1.41         | 1.46              | 1.51        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1BH <sup>*1</sup> | 1.43         | 1.48              | 1.53        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1CH <sup>*1</sup> | 1.45         | 1.50              | 1.55        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1DH <sup>*1</sup> | 1.47         | 1.52              | 1.57        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1EH <sup>*1</sup> | 1.49         | 1.54              | 1.59        |       |                   |
|                                  |                 |                                                                                        | CN4-0 = 1FH <sup>*1</sup> | 1.51         | 1.56              | 1.61        |       |                   |
| $V_{L1}$ temperature deviation   | $\Delta V_{L1}$ | $V_{DD} = 3.0V$                                                                        |                           | —            | -1.5              | —           | mV/°C |                   |
| $V_{L1}$ voltage dependency      | $\Delta V_{L1}$ | $V_{DD} = 1.3$ to $3.6V$                                                               |                           | —            | 5                 | 20          | mV/V  |                   |
| $V_{L2}$ voltage                 | $V_{L2}$        | $V_{DD} = 3.0V$ , $T_j = 25^\circ C$<br>300k $\Omega$ load ( $V_{L4} - V_{SS}$ )       |                           | Typ.<br>-10% | $V_{L1} \times 2$ | Typ.<br>+4% | V     |                   |
| $V_{L3}$ voltage                 | $V_{L3}$        | $V_{DD} = 3.0V$ ,<br>$T_j = 25^\circ C$<br>300k $\Omega$ load<br>( $V_{L4} - V_{SS}$ ) | 1/3 bias                  | Typ.<br>-10% | $V_{L1} \times 2$ | Typ.<br>+4% |       |                   |
|                                  |                 |                                                                                        | 1/4 bias                  |              | $V_{L1} \times 3$ |             |       |                   |
| $V_{L4}$ voltage                 | $V_{L4}$        |                                                                                        | 1/3 bias                  | Typ.<br>-10% | $V_{L1} \times 3$ | Typ.<br>+5% |       |                   |
|                                  |                 |                                                                                        | 1/4 bias                  |              | $V_{L1} \times 4$ |             |       |                   |
| LCD bias voltage generation time | $T_{BIAS}$      | —                                                                                      |                           | —            | —                 | 600         | ms    |                   |

\*1: When using 1/4 bias, the  $V_{L1}$  voltage is set to typ. 1.32 V (same voltage as in CN4-0 = 13H).

**DC CHARACTERISTICS (3/5)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^{\circ}C$ ,  $T_a = -40$  to  $+85^{\circ}C$  for P version, unless otherwise specified) (3/5)

| Parameter                                   | Symbol           | Condition                                                                                                                                    |                               | Rating      |      |             | Unit           | Measuring circuit |
|---------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------|------|-------------|----------------|-------------------|
|                                             |                  |                                                                                                                                              |                               | Min.        | Typ. | Max.        |                |                   |
| BLD threshold voltage                       | $V_{BLD}$        | $V_{DD} = 1.35$ to $3.6V$                                                                                                                    | LD2-0 = 0H                    | Typ.<br>-2% | 1.35 | Typ.<br>+2% | V              | 1                 |
|                                             |                  |                                                                                                                                              | LD2-0 = 1H                    |             | 1.4  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 2H                    |             | 1.45 |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 3H                    |             | 1.5  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 4H                    |             | 1.6  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 5H                    |             | 1.7  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 6H                    |             | 1.8  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 7H                    |             | 1.9  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 8H                    |             | 2.0  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 9H                    |             | 2.1  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0AH                   |             | 2.2  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0BH                   |             | 2.3  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0CH                   |             | 2.4  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0DH                   |             | 2.5  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0EH                   |             | 2.7  |             |                |                   |
|                                             |                  |                                                                                                                                              | LD2-0 = 0FH                   |             | 2.9  |             |                |                   |
| BLD threshold voltage temperature deviation | $\Delta V_{BLD}$ | $V_{DD} = 1.35$ to $3.6V$                                                                                                                    |                               | —           | ~0   | —           | %/ $^{\circ}C$ | 1                 |
| Supply current 1                            | IDD1             | CPU: In STOP state.<br>Low-speed/high-speed oscillation: stopped.                                                                            | $T_a = 25^{\circ}C$           | —           | 0.15 | 0.50        | $\mu A$        |                   |
|                                             |                  |                                                                                                                                              | $T_a = -20$ to $+70^{\circ}C$ | —           | —    | 2.50        |                |                   |
| Supply current 2                            | IDD2             | CPU: In HALT state (LTBC, RTC: Operating <sup>*3*5</sup> ).<br>High-speed oscillation: Stopped.<br>LCD/BIAS circuits: Stopped.               | $T_a = 25^{\circ}C$           | —           | 0.5  | 1.3         | $\mu A$        |                   |
|                                             |                  |                                                                                                                                              | $T_a = -20$ to $+70^{\circ}C$ | —           | —    | 3.5         |                |                   |
| Supply current 3                            | IDD3             | CPU: In 32.768kHz operating state. <sup>*1*3</sup><br>High-speed oscillation: Stopped.<br>LCD/BIAS circuits: Operating. <sup>*2</sup>        | $T_a = 25^{\circ}C$           | —           | 5    | 7           | $\mu A$        |                   |
|                                             |                  |                                                                                                                                              | $T_a = -20$ to $+70^{\circ}C$ | —           | —    | 12          |                |                   |
| Supply current 4                            | IDD4             | CPU: In 500kHz CR operating state.<br>LCD/BIAS circuits: Operating. <sup>*2*3</sup>                                                          | $T_a = 25^{\circ}C$           | —           | 70   | 85          | $\mu A$        |                   |
|                                             |                  |                                                                                                                                              | $T_a = -20$ to $+70^{\circ}C$ | —           | —    | 100         |                |                   |
| Supply current 5                            | IDD5             | CPU: In 4.096MHz operating state.<br>PLL: In oscillating state.<br>LCD/BIAS circuits: Operating. <sup>*2*3</sup><br>$V_{DD} = 1.8$ to $3.6V$ | $T_a = 25^{\circ}C$           | —           | 0.8  | 1.0         | mA             |                   |
|                                             |                  |                                                                                                                                              | $T_a = -20$ to $+70^{\circ}C$ | —           | —    | 1.2         |                |                   |

<sup>\*1</sup>: CPU operating rate is 100% (No HALT state).

<sup>\*2</sup>: All SEGs: off waveform, No LCD panel load, 1/3 bias, 1/3 duty, Frame frequency: Approx. 64 Hz, Bias voltage multiplying clock: 1/128 LSCLK (256Hz)

<sup>\*3</sup>: Use 32.768KHz Crystal Resonator DT-26 (Load capacitance 6pF) (KDS: DAISHINKU CORP.)

<sup>\*4</sup>: Use 4.096MHz Crystal Oscillator CHC49SFWB (Kyocera).

<sup>\*5</sup>: Significant bits of BLKCON0~BLKCON4 registers are all "1".

**DC CHARACTERISTICS (4/5)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^\circ C$ ,  $T_a = -40$  to  $+85^\circ C$  for P version, unless otherwise specified) (4/5)

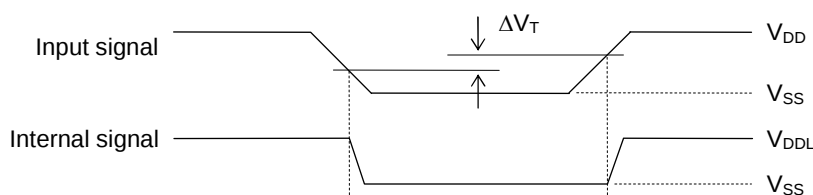
| Parameter                                                                                                 | Symbol | Condition                                                                            |                          | Rating                   |      |                | Unit    | Measuring circuit |
|-----------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------|--------------------------|--------------------------|------|----------------|---------|-------------------|
|                                                                                                           |        |                                                                                      |                          | Min.                     | Typ. | Max.           |         |                   |
| Output voltage 1<br>(P20–P22/2 <sup>nd</sup> function is selected)<br>(P30–P36)<br>(P40–P47)<br>(PA0–PA5) | VOH1   | IOH1 = $-0.5mA$ , $V_{DD} = 1.8$ to $3.6V$                                           |                          | $V_{DD} - 0.5$           | —    | —              | V       | 2                 |
|                                                                                                           |        | IOH1 = $-0.1mA$ , $V_{DD} = 1.3$ to $3.6V$                                           |                          | $V_{DD} - 0.3$           | —    | —              |         |                   |
|                                                                                                           |        | IOH1 = $-0.03mA$ , $V_{DD} = 1.1$ to $3.6V$                                          |                          | $V_{DD} - 0.3$           | —    | —              |         |                   |
|                                                                                                           | VOL1   | IOL1 = $+0.5mA$ , $V_{DD} = 1.8$ to $3.6V$                                           |                          | —                        | —    | 0.5            |         |                   |
|                                                                                                           |        | IOL1 = $+0.1mA$ , $V_{DD} = 1.3$ to $3.6V$                                           |                          | —                        | —    | 0.5            |         |                   |
|                                                                                                           |        | IOL1 = $+0.03mA$ , $V_{DD} = 1.1$ to $3.6V$                                          |                          | —                        | —    | 0.3            |         |                   |
| Output voltage 2<br>(P20–P22/2 <sup>nd</sup> function is Not selected)                                    | VOH2   | IOH1 = $-0.5mA$ , $V_{DD} = 1.8$ to $3.6V$                                           |                          | $V_{DD} - 0.5$           | —    | —              |         |                   |
|                                                                                                           |        | IOH1 = $-0.1mA$ , $V_{DD} = 1.3$ to $3.6V$                                           |                          | $V_{DD} - 0.3$           | —    | —              |         |                   |
|                                                                                                           |        | IOH1 = $-0.03mA$ , $V_{DD} = 1.1$ to $3.6V$                                          |                          | $V_{DD} - 0.3$           | —    | —              |         |                   |
|                                                                                                           | VOL2   | IOL2 = $+5mA$ , $V_{DD} = 1.8$ to $3.6V$                                             |                          | —                        | —    | 0.5            |         |                   |
| Output voltage 3<br>(P40–P41)                                                                             | VOL3   | IOL3 = $+3mA$ , $V_{DD} = 2.0$ to $3.6V$<br>(when I <sup>2</sup> C mode is selected) |                          | —                        | —    | 0.4            |         |                   |
| Output voltage 4<br>(COM0–23)<br>(SEG0–63)                                                                | VOH4   | IOH4 = $-0.2mA$ , $V_{L1} = 1.2V$                                                    |                          | $V_{L4} - 0.2$           | —    | —              |         |                   |
|                                                                                                           | VOMH4  | IOMH4 = $+0.2mA$ , $V_{L1} = 1.2V$                                                   |                          | —                        | —    | $V_{L3} + 0.2$ |         |                   |
|                                                                                                           | VOMH4S | IOMH4S = $-0.2mA$ , $V_{L1} = 1.2V$                                                  |                          | $V_{L3} - 0.2$           | —    | —              |         |                   |
|                                                                                                           | VOM4   | IOM4 = $+0.2mA$ , $V_{L1} = 1.2V$                                                    |                          | —                        | —    | $V_{L2} + 0.2$ |         |                   |
|                                                                                                           | VOM4S  | IOM4S = $-0.2mA$ , $V_{L1} = 1.2V$                                                   |                          | $V_{L2} - 0.2$           | —    | —              |         |                   |
|                                                                                                           | VOML4  | IOML4 = $+0.2mA$ , $V_{L1} = 1.2V$                                                   |                          | —                        | —    | $V_{L1} + 0.2$ |         |                   |
|                                                                                                           | VOML4S | IOML4S = $-0.2mA$ , $V_{L1} = 1.2V$                                                  |                          | $V_{L1} - 0.2$           | —    | —              |         |                   |
|                                                                                                           | VOL4   | IOL4 = $+0.2mA$ , $V_{L1} = 1.2V$                                                    |                          | —                        | —    | 0.2            |         |                   |
| Output leakage<br>(P20–P22)<br>(P30–P35)<br>(P40–P47)<br>(PA0–PA5)                                        | IOOH   | VOH = $V_{DD}$ (in high-impedance state)                                             |                          | —                        | —    | 1              | $\mu A$ | 3                 |
|                                                                                                           | IOOL   | VOL = $V_{SS}$ (in high-impedance state)                                             |                          | -1                       | —    | —              |         |                   |
| Input current 1<br>(RESET_N)                                                                              | IIH1   | $V_{IH1} = V_{DD}$                                                                   |                          | 0                        | —    | 1              | $\mu A$ | 4                 |
|                                                                                                           | IIL1   | $V_{IL1} = V_{SS}$                                                                   | $V_{DD} = 1.8$ to $3.6V$ | -600                     | -300 | -20            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.3$ to $3.6V$ | -600                     | -300 | -10            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.1$ to $3.6V$ | -600                     | -300 | -2             |         |                   |
| Input current 1<br>(TEST)                                                                                 | IIH1   | $V_{IH1} = V_{DD}$                                                                   | $V_{DD} = 1.8$ to $3.6V$ | 20                       | 300  | 600            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.3$ to $3.6V$ | 10                       | 300  | 600            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.1$ to $3.6V$ | 2                        | 300  | 600            |         |                   |
|                                                                                                           | IIL1   | $V_{IL1} = V_{SS}$                                                                   |                          | -1                       | —    | —              |         |                   |
| Input current 2<br>(NMI)<br>(P00–P03)<br>(P04–P07)                                                        | IIH2   | $V_{IH2} = V_{DD}$<br>(when pulled-down)                                             | $V_{DD} = 1.8$ to $3.6V$ | 2                        | 30   | 200            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.3$ to $3.6V$ | 0.2                      | 30   | 200            |         |                   |
|                                                                                                           |        |                                                                                      | $V_{DD} = 1.1$ to $3.6V$ | 0.01                     | 30   | 200            |         |                   |
|                                                                                                           | IIL2   | $V_{IL2} = V_{SS}$                                                                   |                          | $V_{DD} = 1.8$ to $3.6V$ | -200 | -30            | -2      |                   |

|                                                  |       |                                              |                                        |      |     |       |  |  |
|--------------------------------------------------|-------|----------------------------------------------|----------------------------------------|------|-----|-------|--|--|
| (P10–P11)<br>(P30–P35)<br>(P40–P47)<br>(PA0–PA5) |       | (when pulled-up)                             | $V_{DD} = 1.3 \text{ to } 3.6\text{V}$ | –200 | –30 | –0.2  |  |  |
|                                                  |       |                                              | $V_{DD} = 1.1 \text{ to } 3.6\text{V}$ | –200 | –30 | –0.01 |  |  |
|                                                  | I1H2Z | $V_{IH2} = V_{DD}$ (in high-impedance state) |                                        | —    | —   | 1     |  |  |
|                                                  | I1L2Z | $V_{IL2} = V_{SS}$ (in high-impedance state) |                                        | –1   | —   | —     |  |  |

**DC CHARACTERISTICS (5/5)**

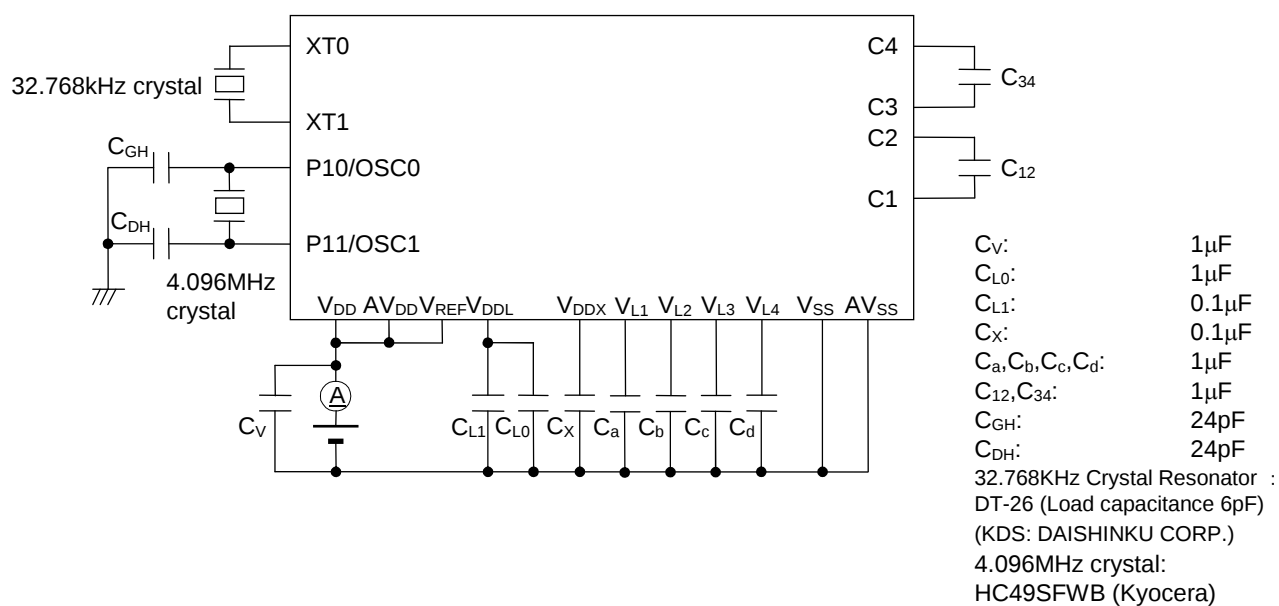
( $V_{DD} = 1.1 \text{ to } 3.6\text{V}$ ,  $AV_{DD} = 2.2 \text{ to } 3.6\text{V}$ ,  $V_{SS} = AV_{SS} = 0\text{V}$ ,  $T_a = -20 \text{ to } +70^\circ\text{C}$ ,  $T_a = -40 \text{ to } +85^\circ\text{C}$  for P version, unless otherwise specified) (5/5)

| Parameter                                                                                                                                   | Symbol       | Condition                                                                 | Rating               |                      |                     | Unit | Measuring circuit |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------|----------------------|----------------------|---------------------|------|-------------------|
|                                                                                                                                             |              |                                                                           | Min.                 | Typ.                 | Max.                |      |                   |
| Input voltage 1<br>(RESET_N)<br>(TEST)<br>(NMI)<br>(P00–P03)<br>(P04–P07)<br>(P10–P11)<br>(P31–P35)<br>(P40–P43)<br>(P45–P47)<br>(PA0–PA5)  | VIH1         | $V_{DD} = 1.3 \text{ to } 3.6\text{V}$                                    | $0.7 \times V_{DD}$  | —                    | $V_{DD}$            | V    | 5                 |
|                                                                                                                                             |              | $V_{DD} = 1.1 \text{ to } 3.6\text{V}$                                    | $0.7 \times V_{DD}$  | —                    | $V_{DD}$            |      |                   |
|                                                                                                                                             | VIL1         | $V_{DD} = 1.3 \text{ to } 3.6\text{V}$                                    | 0                    | —                    | $0.3 \times V_{DD}$ |      |                   |
|                                                                                                                                             |              | $V_{DD} = 1.1 \text{ to } 3.6\text{V}$                                    | 0                    | —                    | $0.2 \times V_{DD}$ |      |                   |
| Hysteresis width<br>(RESET_N)<br>(TEST)<br>(NMI)<br>(P00–P03)<br>(P04–P07)<br>(P10–P11)<br>(P31–P35)<br>(P40–P43)<br>(P45–P47)<br>(PA0–PA5) | $\Delta V_T$ | $V_{DD} = 2.0 \text{ to } 3.6\text{V}$                                    | $0.05 \times V_{DD}$ | $0.18 \times V_{DD}$ | $0.4 \times V_{DD}$ | V    | 5                 |
|                                                                                                                                             |              | $V_{DD} = 1.1 \text{ to } 3.6\text{V}$                                    | $0.02 \times V_{DD}$ | $0.18 \times V_{DD}$ | $0.4 \times V_{DD}$ |      |                   |
| Input voltage 2<br>(P30, P44)                                                                                                               | VIH2         | —                                                                         | $0.7 \times V_{DD}$  | —                    | $V_{DD}$            | V    | 5                 |
|                                                                                                                                             | VIL2         | —                                                                         | 0                    | —                    | $0.3 \times V_{DD}$ |      |                   |
| Input pin capacitance<br>(NMI)<br>(P00–P03)<br>(P04–P07)<br>(P10–P11)<br>(P30–P35)<br>(P40–P47)<br>(PA0–PA5)                                | CIN          | $f = 10\text{kHz}$<br>$V_{rms} = 50\text{mV}$<br>$T_a = 25^\circ\text{C}$ | —                    | —                    | 5                   | pF   | —                 |

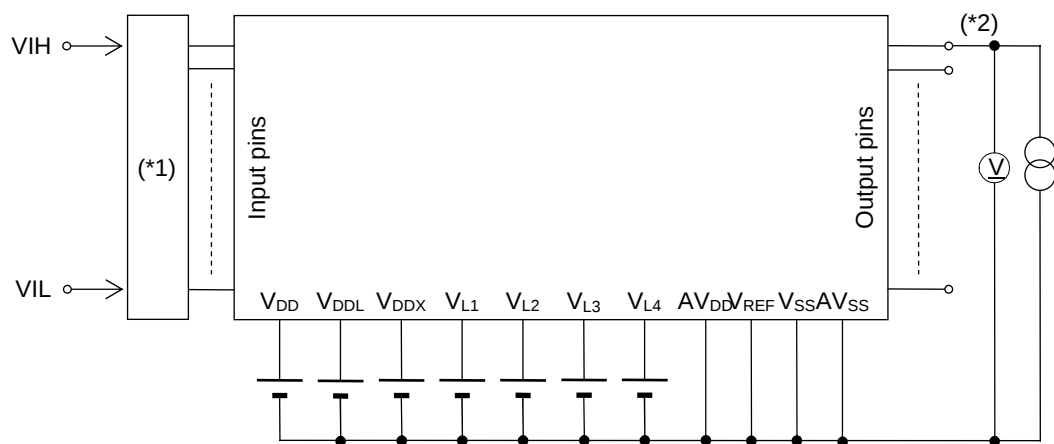
**HYSTERESIS WIDTH**

## MEASURING CIRCUITS

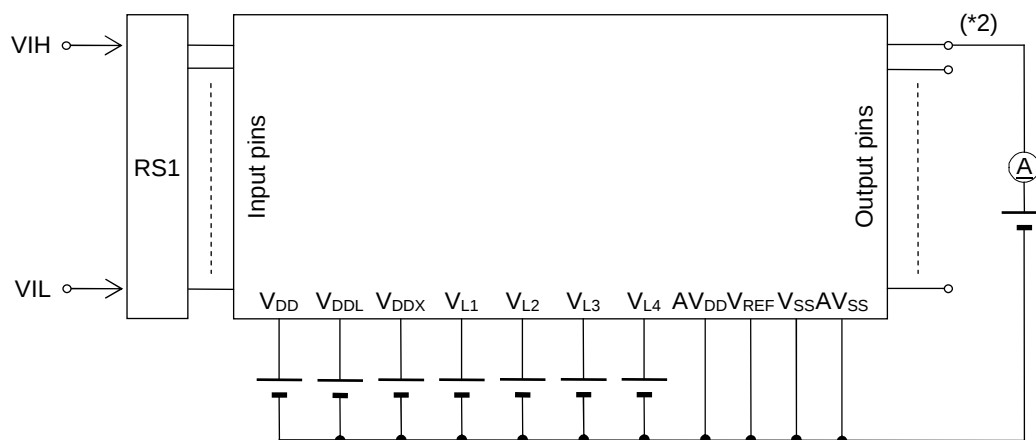
### MEASURING CIRCUIT 1



### MEASURING CIRCUIT 2



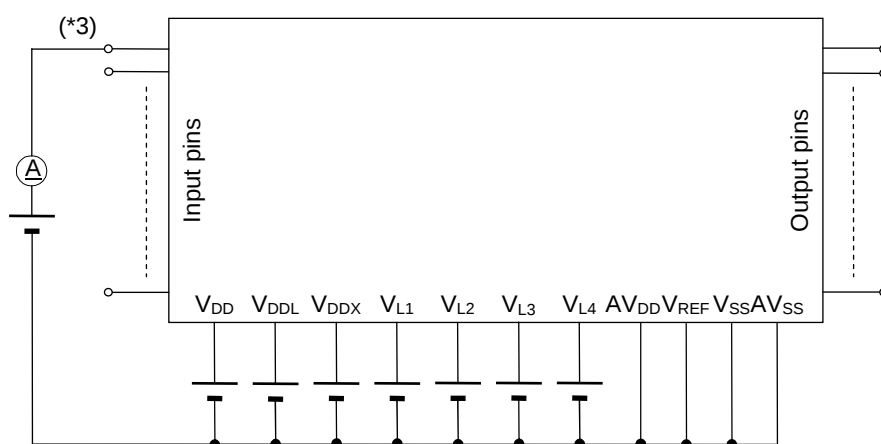
## MEASURING CIRCUIT 3



\*1: Input logic circuit to determine the specified measuring conditions.

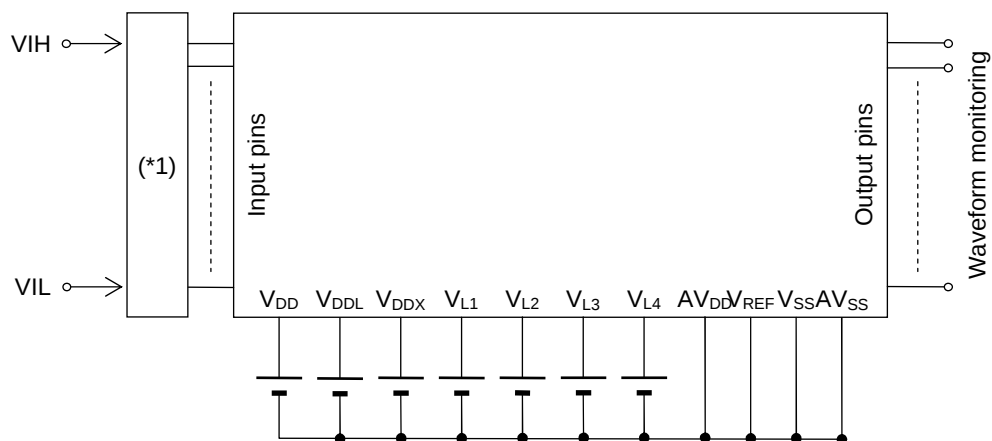
\*2: Measured at the specified output pins.

## MEASURING CIRCUIT 4



\*3: Measured at the specified output pins.

## MEASURING CIRCUIT 5

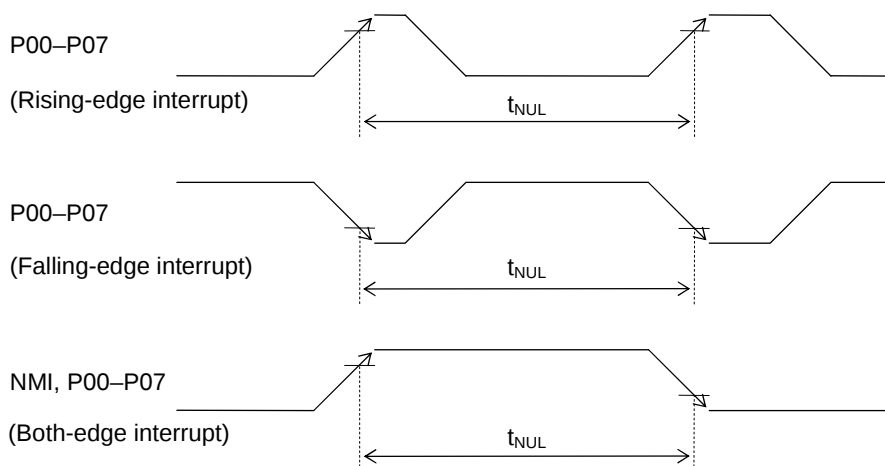


\*1: Input logic circuit to determine the specified measuring conditions.

**AC CHARACTERISTICS (External Interrupt)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^{\circ}C$ ,  $T_a = -40$  to  $+85^{\circ}C$  for P version, unless otherwise specified)

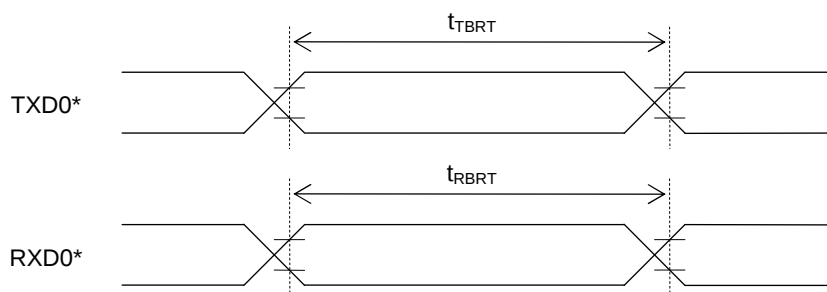
| Parameter                         | Symbol    | Condition                                                                      | Rating |      |       | Unit    |
|-----------------------------------|-----------|--------------------------------------------------------------------------------|--------|------|-------|---------|
|                                   |           |                                                                                | Min.   | Typ. | Max.  |         |
| External interrupt disable period | $T_{NUL}$ | Interrupt: Enabled (MIE = 1),<br>CPU: NOP operation<br>System clock: 32.768kHz | 76.8   | —    | 106.8 | $\mu s$ |

**AC CHARACTERISTICS (UART)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^{\circ}C$ ,  $T_a = -40$  to  $+85^{\circ}C$  for P version, unless otherwise specified)

| Parameter          | Symbol     | Condition | Rating            |            |                   | Unit |
|--------------------|------------|-----------|-------------------|------------|-------------------|------|
|                    |            |           | Min.              | Typ.       | Max.              |      |
| Transmit baud rate | $t_{TBRT}$ | —         | —                 | $BRT^{*1}$ | —                 | s    |
| Receive baud rate  | $t_{RBRT}$ | —         | $BRT^{*1}$<br>–3% | $BRT^{*1}$ | $BRT^{*1}$<br>+3% | s    |

\*1: Baud rate period (including the error of the clock frequency selected) set with the UART baud rate register (UA0BRTL,H) and the UART mode register 0 (UA0MOD0).



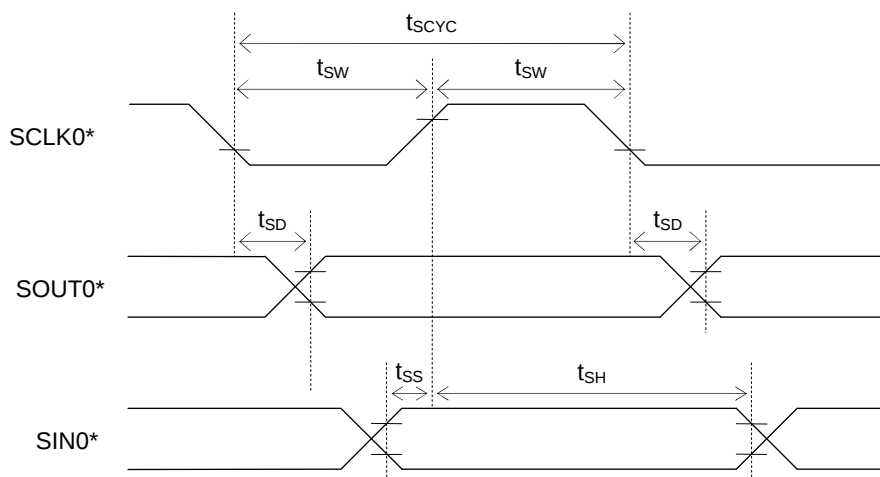
\*: Indicates the secondary function of the port.

**AC CHARACTERISTICS (Synchronous Serial Port)**

( $V_{DD} = 1.1$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^\circ C$ ,  $T_a = -40$  to  $+85^\circ C$  for P version, unless otherwise specified)

| Parameter                             | Symbol     | Condition                                                          | Rating                 |                        |                        | Unit    |
|---------------------------------------|------------|--------------------------------------------------------------------|------------------------|------------------------|------------------------|---------|
|                                       |            |                                                                    | Min.                   | Typ.                   | Max.                   |         |
| SCLK input cycle (slave mode)         | $t_{SCYC}$ | When high-speed oscillation is not active                          | 10                     | —                      | —                      | $\mu s$ |
|                                       |            | When high-speed oscillation is active ( $V_{DD} = 1.8$ to $3.6V$ ) | 1                      | —                      | —                      | $\mu s$ |
| SCLK output cycle (master mode)       | $t_{SCYC}$ | —                                                                  | —                      | $SCLK^{*1}$            | —                      | s       |
| SCLK input pulse width (slave mode)   | $t_{SW}$   | When high-speed oscillation is not active                          | 4                      | —                      | —                      | $\mu s$ |
|                                       |            | When high-speed oscillation is active ( $V_{DD} = 1.8$ to $3.6V$ ) | 0.4                    | —                      | —                      | $\mu s$ |
| SCLK output pulse width (master mode) | $t_{SW}$   | —                                                                  | $SCLK^{*1} \times 0.4$ | $SCLK^{*1} \times 0.5$ | $SCLK^{*1} \times 0.6$ | s       |
| SOUT output delay time (slave mode)   | $t_{SD}$   | —                                                                  | —                      | —                      | 180                    | ns      |
| SOUT output delay time (master mode)  | $t_{SD}$   | —                                                                  | —                      | —                      | 80                     | ns      |
| SIN input setup time (slave mode)     | $t_{SS}$   | —                                                                  | 80                     | —                      | —                      | ns      |
| SIN input setup time (master mode)    | $t_{SS}$   | —                                                                  | 180                    | —                      | —                      | ns      |
| SIN input hold time                   | $t_{SH}$   | —                                                                  | 80                     | —                      | —                      | ns      |

\*1: Clock period selected with S0CK3–0 of the serial port 0 mode register (SIO0MOD1)



\*: Indicates the secondary function of the port.

**AC CHARACTERISTICS (I<sup>2</sup>C Bus Interface: Standard Mode 100kHz)**

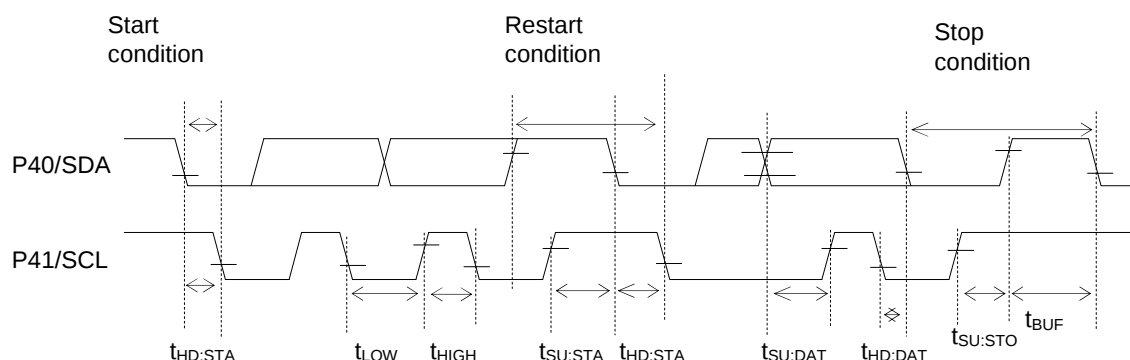
(V<sub>DD</sub> = 1.8 to 3.6V, AV<sub>DD</sub> = 2.2 to 3.6V, V<sub>SS</sub> = AV<sub>SS</sub> = 0V, Ta = -20 to +70°C, Ta = -40 to +85°C for P version, unless otherwise specified)

| Parameter                                  | Symbol              | Condition | Rating |      |      | Unit |
|--------------------------------------------|---------------------|-----------|--------|------|------|------|
|                                            |                     |           | Min.   | Typ. | Max. |      |
| SCL clock frequency                        | f <sub>SCL</sub>    | —         | 0      | —    | 100  | kHz  |
| SCL hold time<br>(start/restart condition) | t <sub>HD:STA</sub> | —         | 4.0    | —    | —    | μs   |
| SCL "L" level time                         | t <sub>LOW</sub>    | —         | 4.7    | —    | —    | μs   |
| SCL "H" level time                         | t <sub>HIGH</sub>   | —         | 4.0    | —    | —    | μs   |
| SCL setup time<br>(restart condition)      | t <sub>SU:STA</sub> | —         | 4.7    | —    | —    | μs   |
| SDA hold time                              | t <sub>HD:DAT</sub> | —         | 0      | —    | 3.45 | μs   |
| SDA setup time                             | t <sub>SU:DAT</sub> | —         | 0.25   | —    | —    | μs   |
| SDA setup time<br>(stop condition)         | t <sub>SU:STO</sub> | —         | 4.0    | —    | —    | μs   |
| Bus-free time                              | t <sub>BUF</sub>    | —         | 4.7    | —    | —    | μs   |

**AC CHARACTERISTICS (I<sup>2</sup>C Bus Interface: Fast Mode 400kHz)**

(V<sub>DD</sub> = 1.8 to 3.6V, AV<sub>DD</sub> = 2.2 to 3.6V, V<sub>SS</sub> = AV<sub>SS</sub> = 0V, Ta = -20 to +70°C, Ta = -40 to +85°C for P version, unless otherwise specified)

| Parameter                                  | Symbol              | Condition | Rating |      |      | Unit |
|--------------------------------------------|---------------------|-----------|--------|------|------|------|
|                                            |                     |           | Min.   | Typ. | Max. |      |
| SCL clock frequency                        | f <sub>SCL</sub>    | —         | 0      | —    | 400  | kHz  |
| SCL hold time<br>(start/restart condition) | t <sub>HD:STA</sub> | —         | 0.6    | —    | —    | μs   |
| SCL "L" level time                         | t <sub>LOW</sub>    | —         | 1.3    | —    | —    | μs   |
| SCL "H" level time                         | t <sub>HIGH</sub>   | —         | 0.6    | —    | —    | μs   |
| SCL setup time<br>(restart condition)      | t <sub>SU:STA</sub> | —         | 0.6    | —    | —    | μs   |
| SDA hold time                              | t <sub>HD:DAT</sub> | —         | 0      | —    | 0.9  | μs   |
| SDA setup time                             | t <sub>SU:DAT</sub> | —         | 0.1    | —    | —    | μs   |
| SDA setup time<br>(stop condition)         | t <sub>SU:STO</sub> | —         | 0.6    | —    | —    | μs   |
| Bus-free time                              | t <sub>BUF</sub>    | —         | 1.3    | —    | —    | μs   |



**AC CHARACTERISTICS (RC Oscillation A/D Converter)**

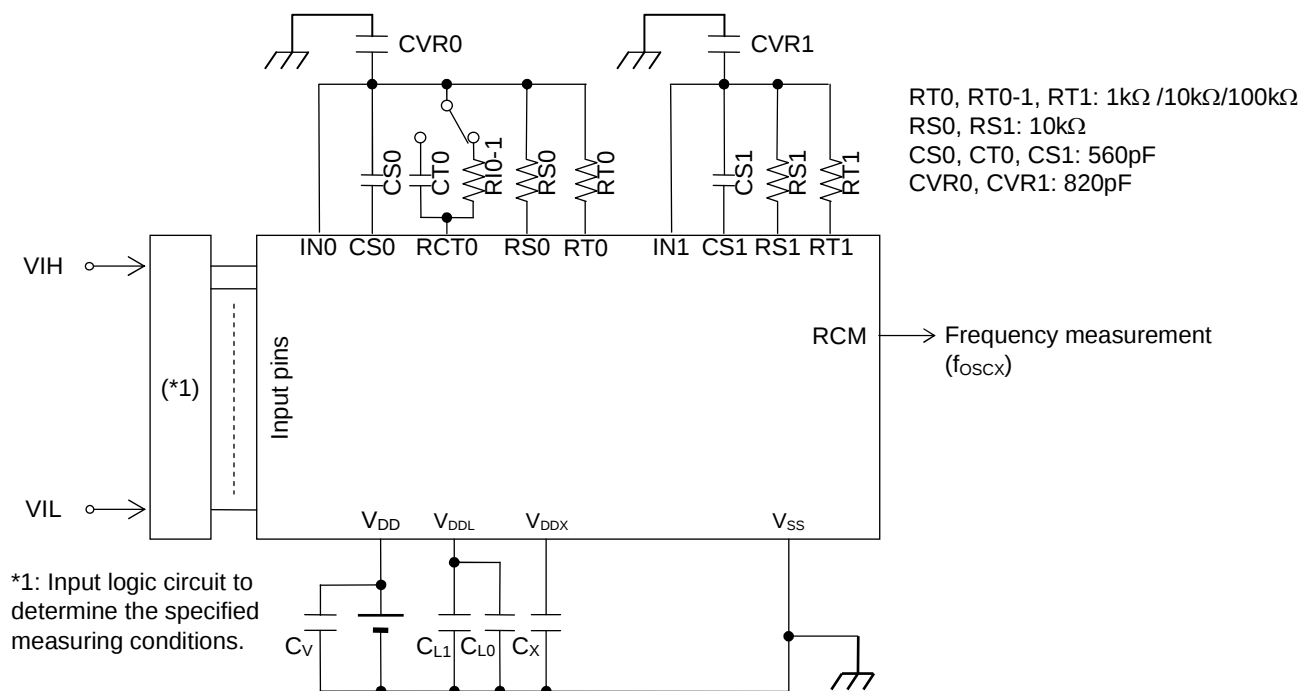
( $V_{DD} = 1.3$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^\circ C$ ,  $T_a = -40$  to  $+85^\circ C$  for P version, unless otherwise specified)

| Parameter                                             | Symbol                    | Condition                                | Rating |       |       | Unit       |
|-------------------------------------------------------|---------------------------|------------------------------------------|--------|-------|-------|------------|
|                                                       |                           |                                          | Min.   | Typ.  | Max.  |            |
| Resistors for oscillation                             | RS0, RS1, RT0, RT0-1, RT1 | CS0, CT0, CS1 $\geq 740pF$               | 1      | —     | —     | k $\Omega$ |
| Oscillation frequency<br>VDD = 1.5V                   | $f_{OSC1}$                | Resistor for oscillation = 1k $\Omega$   | 209.4  | 330.6 | 435.1 | kHz        |
|                                                       | $f_{OSC2}$                | Resistor for oscillation = 10k $\Omega$  | 41.29  | 55.27 | 64.16 | kHz        |
|                                                       | $f_{OSC3}$                | Resistor for oscillation = 100k $\Omega$ | 4.71   | 5.97  | 7.06  | kHz        |
| RS to RT oscillation frequency ratio *1<br>VDD = 1.5V | Kf1                       | RT0, RT0-1, RT1 = 1kHz                   | 5.567  | 5.982 | 6.225 | —          |
|                                                       | Kf2                       | RT0, RT0-1, RT1 = 10 kHz                 | 0.99   | 1     | 1.01  | —          |
|                                                       | Kf3                       | RT0, RT0-1, RT1 = 100 kHz                | 0.104  | 0.108 | 0.118 | —          |
| Oscillation frequency<br>VDD = 3.0V                   | $f_{OSC1}$                | Resistor for oscillation = 1k $\Omega$   | 407.3  | 486.7 | 594.6 | kHz        |
|                                                       | $f_{OSC2}$                | Resistor for oscillation = 10k $\Omega$  | 49.76  | 59.28 | 72.76 | kHz        |
|                                                       | $f_{OSC3}$                | Resistor for oscillation = 100k $\Omega$ | 5.04   | 5.993 | 7.04  | kHz        |
| RS to RT oscillation frequency ratio *1<br>VDD = 3.0V | Kf1                       | RT0, RT0-1, RT1 = 1kHz                   | 8.006  | 8.210 | 8.416 | —          |
|                                                       | Kf2                       | RT0, RT0-1, RT1 = 10 kHz                 | 0.99   | 1     | 1.01  | —          |
|                                                       | Kf3                       | RT0, RT0-1, RT1 = 100 kHz                | 0.100  | 0.108 | 0.115 | —          |

\*1: Kfx is the ratio of the oscillation frequency by the sensor resistor to the oscillation frequency by the reference resistor on the same conditions.

$$Kfx = \frac{f_{oscx}(RT0-CS0 \text{ oscillation})}{f_{oscx}(RS0-CS0 \text{ oscillation})}, \quad \frac{f_{oscx}(RT0-1-CS0 \text{ oscillation})}{f_{oscx}(RS0-CS0 \text{ oscillation})}, \quad \frac{f_{oscx}(RT1-CS1 \text{ oscillation})}{f_{oscx}(RS1-CS1 \text{ oscillation})}$$

(x = 1, 2, 3)



Note:

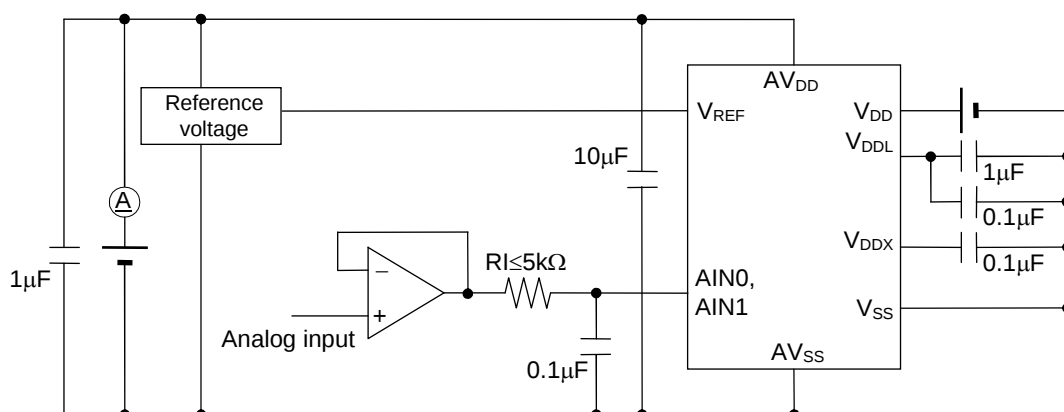
- Please have the shortest layout for the common node (wiring patterns which are connected to the external capacitors, resistors and IN0/IN1 pin), including CTR0/CTR1. Especially, do not have long wire between IN0/IN1 and RS0/RS1. The coupling capacitance on the wires may occur incorrect A/D conversion. Also, please do not have signals which may be a source of noise around the node.
- When RT0/RT1 (Thermistor and etc.) requires long wiring due to the restricted placement, please have VSS(GND) trace next to the signal.
- Please make wiring to components (capacitor, resistor and etc.) necessary for objective measurement. Wiring to reserved components may affect to the A/D conversion operation by noise the components itself may have.

**Electrical Characteristics of Successive Approximation Type A/D Converter**

( $V_{DD} = 1.8$  to  $3.6V$ ,  $AV_{DD} = 2.2$  to  $3.6V$ ,  $V_{SS} = AV_{SS} = 0V$ ,  $T_a = -20$  to  $+70^{\circ}C$ ,  $T_a = -40$  to  $+85^{\circ}C$  for P version, unless otherwise specified)

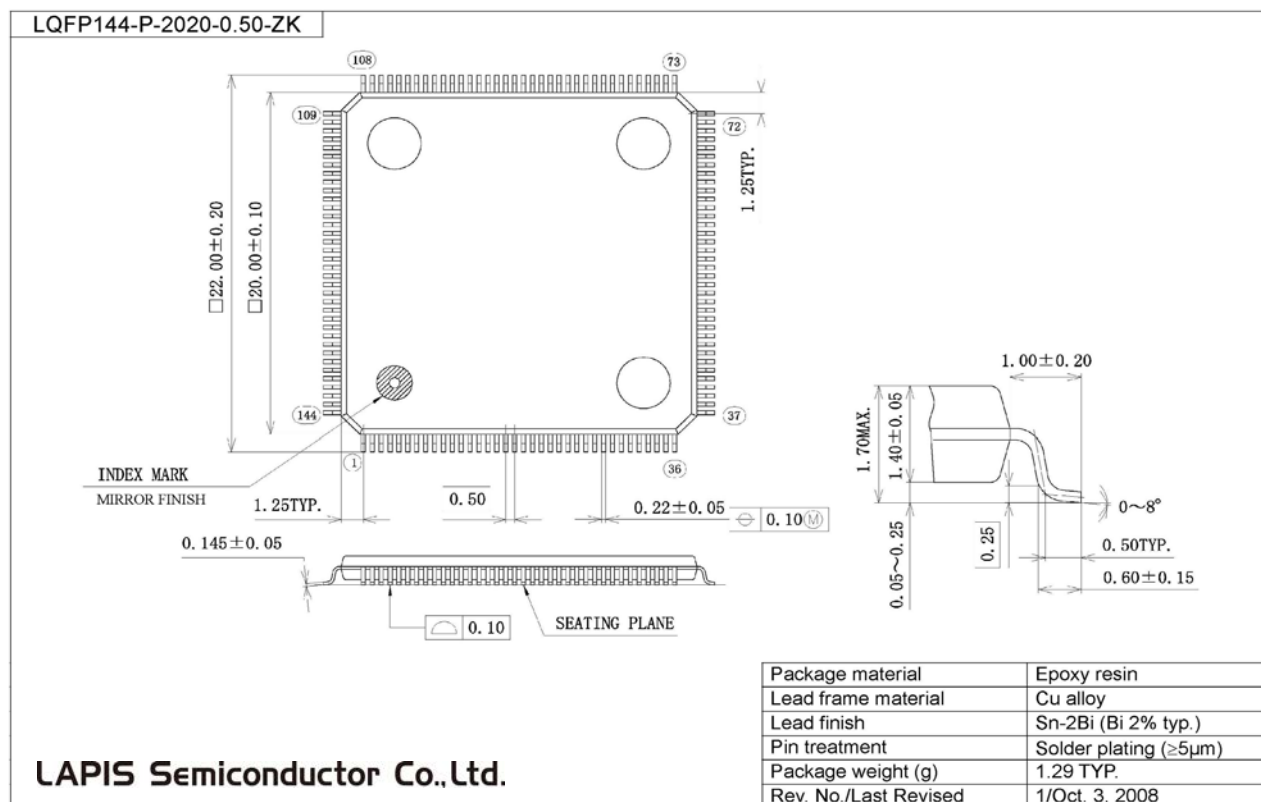
| Parameter                        | Symbol     | Condition                              | Rating |      |           | Unit      |
|----------------------------------|------------|----------------------------------------|--------|------|-----------|-----------|
|                                  |            |                                        | Min.   | Typ. | Max.      |           |
| Resolution                       | n          | —                                      | —      | —    | 12        | bit       |
| Integral non-linearity error     | IDL        | $2.7V \leq V_{REF} \leq 3.6V$          | -4     | —    | +4        | LSB       |
|                                  |            | $2.2V \leq V_{REF} \leq 2.7V$          | -6     | —    | +6        |           |
| Differential non-linearity error | DNL        | $2.7V \leq V_{REF} \leq 3.6V$          | -3     | —    | +3        |           |
|                                  |            | $2.2V \leq V_{REF} \leq 2.7V$          | -5     | —    | +5        |           |
| Zero-scale error                 | $V_{OFF}$  | —                                      | -6     | —    | +6        | V         |
| Full-scale error                 | FSE        | —                                      | -6     | —    | +6        |           |
| Reference voltage                | $V_{REF}$  | —                                      | 2.2    | —    | $AV_{DD}$ |           |
| Conversion time                  | $t_{CONV}$ | SACK = 0<br>(HSCLK = 375kHz to 625kHz) | —      | 25   | —         | $\phi/CH$ |
|                                  |            | SACK = 1<br>(HSCLK = 1.5MHz to 4.2MHz) | —      | 112  | —         |           |

$\phi$ : Period of high-speed clock (HSCLK)



## Package Dimensions

(Unit: mm)



### Notes for Mounting the Surface Mount Type Package

The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact our responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

**Revision History**

| Document No.   | Date         | Page             |                 | Description                    |
|----------------|--------------|------------------|-----------------|--------------------------------|
|                |              | Previous Edition | Current Edition |                                |
| FEDL610Q439-01 | Aug. 24,2010 | —                | —               | Formally edition 1.0           |
| FEDL610Q439-02 | Feb. 2,2011  | 34               | 34              | Change of a Package Dimensions |
| FEDL610Q439-03 | Jun. 7,2011  | 3                | 3               | Add the P persion              |

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