

# ML610471/472/473/Q471/Q472/Q473

8-bit Microcontroller with a Built-in LCD driver

## GENERAL DESCRIPTION

This LSI is a high performance CMOS 8-bit microcontroller equipped with an 8-bit CPU nX-U8/100 and integrated with peripheral functions such as the UART, RC oscillation type A/D converter, and LCD driver.

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. Additionally, it adopts the low-/high-speed dual clock system, standby mode, and process that prohibits leak current at high temperatures, and is most suitable for battery-driven applications.

MTP version (ML610Q471/ML610Q472/ML610Q473) can rewrite programs on-board, which can contribute to reduction in product development TAT. The flash memory incorporated into this MTP version implements the mask ROM-equivalent low-voltage operation (1.25V or higher) and low-power consumption (typically 5uA at low-speed operation), enabling volume production by the MTP version.

For industrial use, ML610471P/ML610472P/ML610473P/ML610Q471P/ML610Q472P/ML610Q473P with the extended operating ambient temperature ranging from -40°C to 85°C are available.

## FEATURES

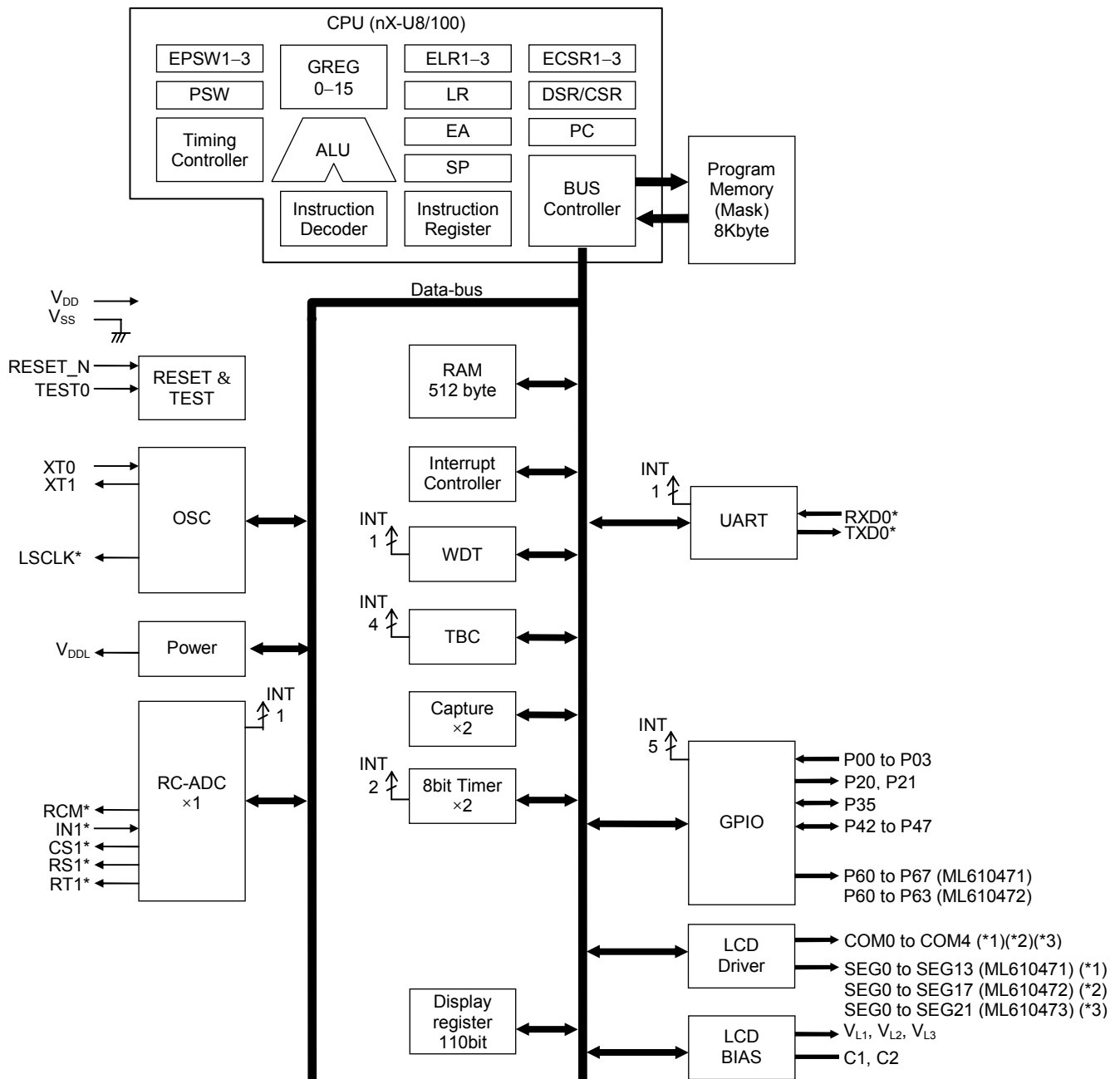
- CPU
  - 8-bit RISC CPU (CPU name: nX-U8/100)
  - Instruction system: 16-bit length instruction
  - Instruction set: Transfer, arithmetic operations, comparison, logic operations, multiplication/division, bit manipulations, bit logic operations, jump, conditional jump, call return stack manipulations, arithmetic shift, and so on
  - Flash Memory rewrite function (MTP version only)
  - Minimum instruction execution time
    - 30.5  $\mu$ s (@ 32.768 kHz system clock)
    - 2  $\mu$ s (@ 500 kHz system clock)
- Internal memory
  - ML610471/ML610472/ML610473
    - Internal 8KByte Mask ROM (4K x 16 bits) (including unusable 256Byte TEST area)
    - Internal 512Byte RAM (512 x 8 bits)
  - ML610Q471/ML610Q472/ML610Q473
    - Internal 8KByte Flash ROM (4K x 16 bits) (including unusable 256Byte TEST area)
    - Internal 512Byte RAM (512 x 8 bits)
- Interrupt controller
  - 1 non-maskable interrupt source:
    - Internal source: 1 (Watchdog Timer)
  - 12 maskable interrupt sources:
    - Internal source: 8 (Timer 2, Timer 3, UART0, RC Oscillation type A/D converter, TBC128Hz, TBC32Hz, TBC16Hz, TBC2Hz)
    - External source: 4 (P00, P01, P02, P03)
- Time base counter
  - Low-speed time base counter x 1 channel
    - Frequency compensation (Compensation range: Approx. -488ppm to +488ppm. Compensation accuracy: Approx. 0.48ppm)
  - High-speed time base counter x 1 channel
- Watchdog timer
  - Non-maskable interrupt and reset
  - Free running
  - Overflow period: 4 types selectable (125ms, 500ms, 2s, 8s)

- Timers
  - 8 bits x 2 channels [also available is 16-bit configuration (using Timers 2 and 3) x 1 channels]
  - Clock frequency measurement function mode (16-bit configuration using Timers 2 and 3 x 1 channel only)
- Capture
  - Time base capture x 2 channels (4096 Hz to 32 Hz)
- UART
  - TXD/RXD x 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
- RC oscillation type A/D converter
  - 16-bit counter
  - Time division x 1 channels
- General-purpose ports
  - Input-only port: 4 channels (including secondary functions)
  - Output-only port
    - Chip or 64-pin plastic TQFP
      - ML610471/ML610Q471: 10 channels (including secondary functions)
      - ML610472/ML610Q472: 6 channels (including secondary functions)
      - ML610473/ML610Q473: 2 channels (including secondary functions)
    - 48-pin plastic TQFP
      - ML610471/ML610Q471: 9 channels (including secondary functions)
      - ML610472/ML610Q472: 5 channels (including secondary functions)
      - ML610473/ML610Q473: 1 channels (including secondary functions)
  - Input/output port
    - Chip or 64-pin plastic TQFP: 7 channels (including secondary functions)
    - 48-pin plastic TQFP: 6 channels (including secondary functions)
- LCD driver
  - Number of segments
    - ML610471/ML610Q471:
      - Up to 55 dots (select among 11 segments x 5 commons, 12 segments x 4 commons, 13 segments x 3 commons, and 14 segments x 2 commons)
    - ML610472/ML610Q472:
      - Up to 75 dots (select among 15 segments x 5 commons, 16 segments x 4 commons, 17 segments x 3 commons, and 18 segments x 2 commons)
    - ML610473/ML610Q473:
      - Up to 95 dots (select among 19 segments x 5 commons, 20 segments x 4 commons, 21 segments x 3 commons, and 22 segments x 2 commons)
  - 1/1 to 1/5 duty
  - 1/2 or 1/3 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)
  - LCD drive stop mode, LCD display mode, all LCDs on mode, and all LCDs off mode selectable
- Reset
  - Reset through the RESET\_N pin
  - Power-on reset generation when powered on
  - Reset by the watchdog timer (WDT) overflow
- Clock
  - Low-speed clock (Operation of this LSI is not guaranteed under a condition with no supply of low-speed crystal oscillation clock)
    - Crystal oscillation (32.768 kHz)
  - High-speed clock
    - Built-in RC oscillation (500 kHz)

- Power management
    - HALT mode: Suspends the instruction execution by CPU (peripheral circuits are in operating states)
    - STOP mode: Stops the low-speed oscillation and high-speed oscillation (Operations of CPU and peripheral circuits are stopped.)
    - High-speed 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: Completely stops the operation of any function block circuit that is not used (resets registers and stops clock)
  - Shipment
    - Chip (Die)
      - ML610471-xxxWA / ML610Q471-xxxWA
      - ML610472-xxxWA / ML610Q472-xxxWA
      - ML610473-xxxWA / ML610Q473-xxxWA
      - ML610471P-xxxWA / ML610Q471P-xxxWA
      - ML610472P-xxxWA / ML610Q472P-xxxWA
      - ML610473P-xxxWA / ML610Q473P-xxxWA
    - 48-pin plastic TQFP
      - ML610471-xxxTPZ03A / ML610Q471-xxxTPZ0AAL
      - ML610472-xxxTPZ03A / ML610Q472-xxxTPZ0AAL
      - ML610473-xxxTPZ03A / ML610Q473-xxxTPZ0AAL
      - ML610471P-xxxTPZ03A / ML610Q471P-xxxTPZ0AAL
      - ML610472P-xxxTPZ03A / ML610Q472P-xxxTPZ0AAL
      - ML610473P-xxxTPZ03A / ML610Q473P-xxxTPZ0AAL
    - 64-pin plastic TQFP
      - ML610471-xxxTBZ03A / ML610Q471-xxxTBZ0ARL
      - ML610472-xxxTBZ03A / ML610Q472-xxxTBZ0ARL
      - ML610473-xxxTBZ03A / ML610Q473-xxxTBZ0ARL
      - ML610471P-xxxTBZ03A / ML610Q471P-xxxTBZ0ARL
      - ML610472P-xxxTBZ03A / ML610Q472P-xxxTBZ0ARL
      - ML610473P-xxxTBZ03A / ML610Q473P-xxxTBZ0ARL
- xxx: ROM code number (xxx of the blank product is NNN, MTP version only)  
 Q: MTP version  
 P: Wide range temperature version (P version)  
 WA: Chip (Die)  
 TPZ0AAL: 48pin plastic TQFP  
 TBZ0ARL: 64pin plastic TQFP
- Guaranteed Operation Range
    - Operating temperature: -20°C to +70°C (P version: -40°C to +85°C)
    - Operating voltage:  $V_{DD} = 1.25V$  to  $3.6V$

## BLOCK DIAGRAM

## ML610471/ML610472/ML610473



\* Secondary function or Tertiary function

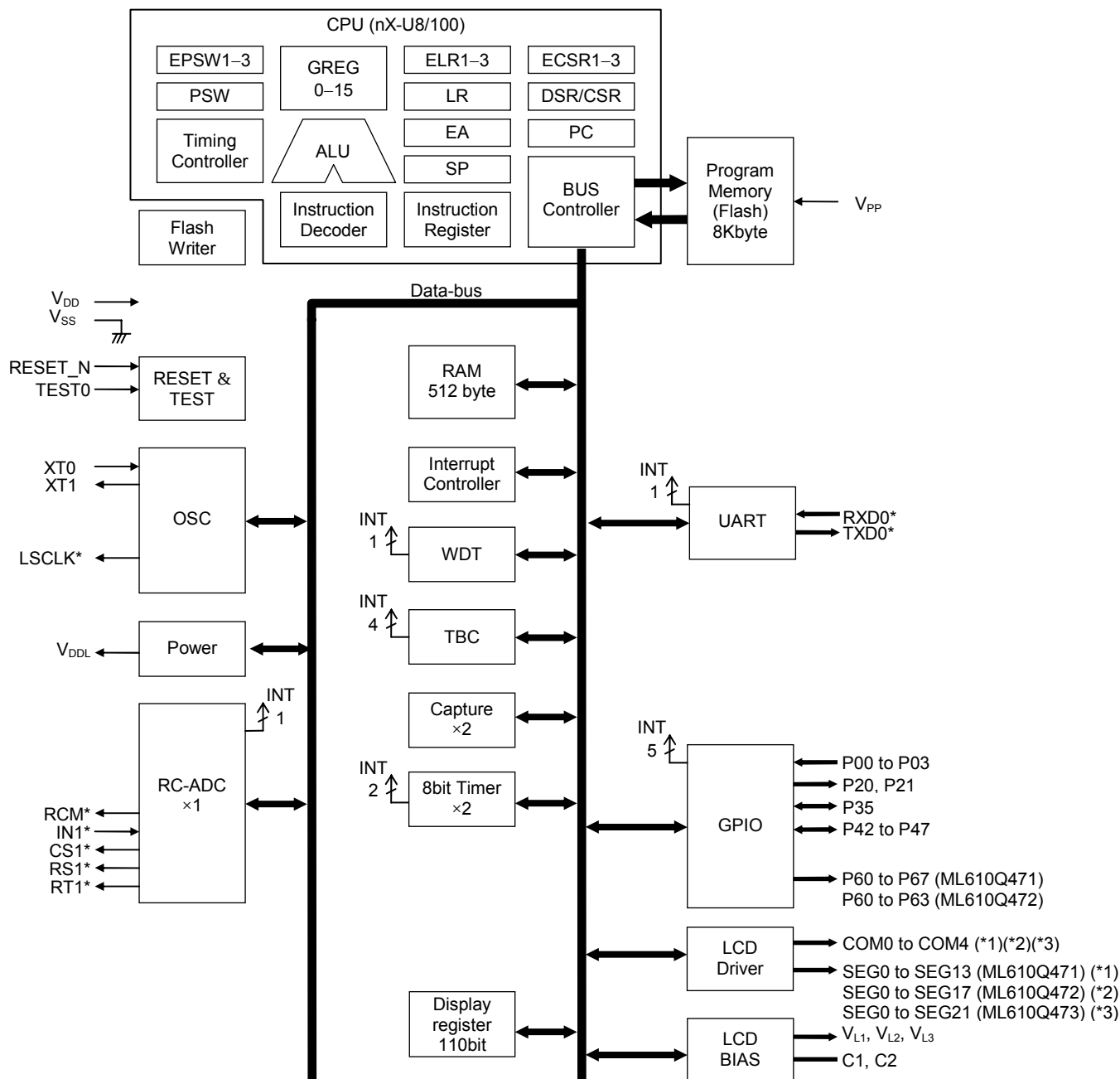
(\*1) Select among 11 segments x 5 commons, 12 segments x 4 commons, 13 segments x 3 commons, and 14 segments x 2 commons with the register

(\*2) Select among 15 segments x 5 commons, 16 segments x 4 commons, 17 segments x 3 commons, and 18 segments x 2 commons with the register

(\*3) Select among 19 segments x 5 commons, 20 segments x 4 commons, 21 segments x 3 commons, and 22 segments x 2 commons with the register

Figure 1 ML610471/ML610472/ML610473 Block Diagram

## ML610Q471/ML610Q472/ML610Q473



\* Secondary function or Tertiary function

(\*1) Select among 11 segments x 5 commons, 12 segments x 4 commons, 13 segments x 3 commons, and 14 segments x 2 commons with the register

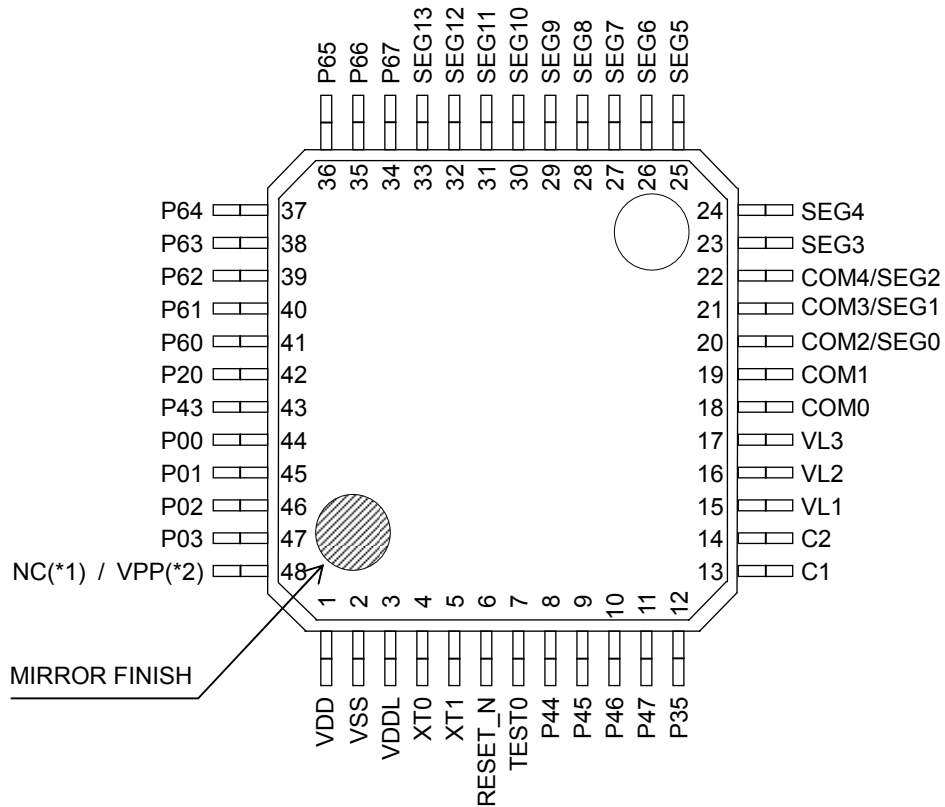
(\*2) Select among 15 segments x 5 commons, 16 segments x 4 commons, 17 segments x 3 commons, and 18 segments x 2 commons with the register

(\*3) Select among 19 segments x 5 commons, 20 segments x 4 commons, 21 segments x 3 commons, and 22 segments x 2 commons with the register

Figure 2 ML610Q471/ML610Q472/ML610Q473 Block Diagram

## PACKAGE PIN/CHIP PAD LAYOUT

## ML610471/ML610Q471 48pin TQFP Package Pin Layout



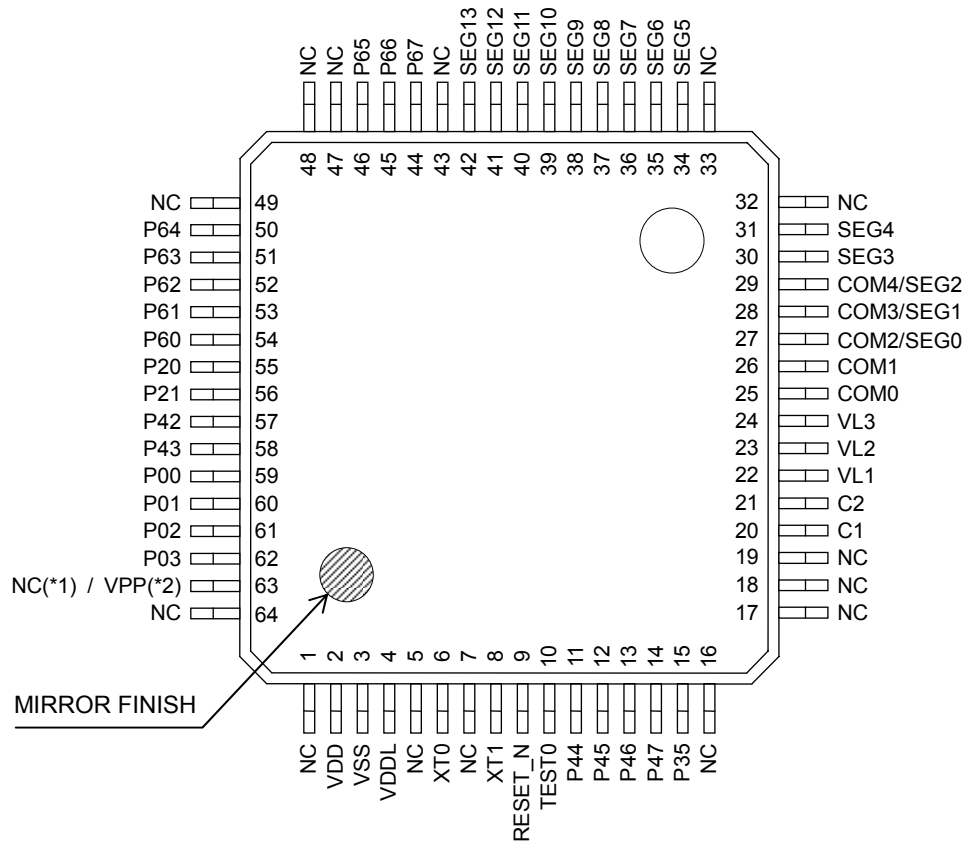
(NC): No Connection

(\*1) : ML610471

(\*2) : ML610Q471

Figure 3 ML610471/ML610Q471 48pin TQFP Package Pin Layout

## ML610471/ML610Q471 64pin TQFP Package Pin Layout



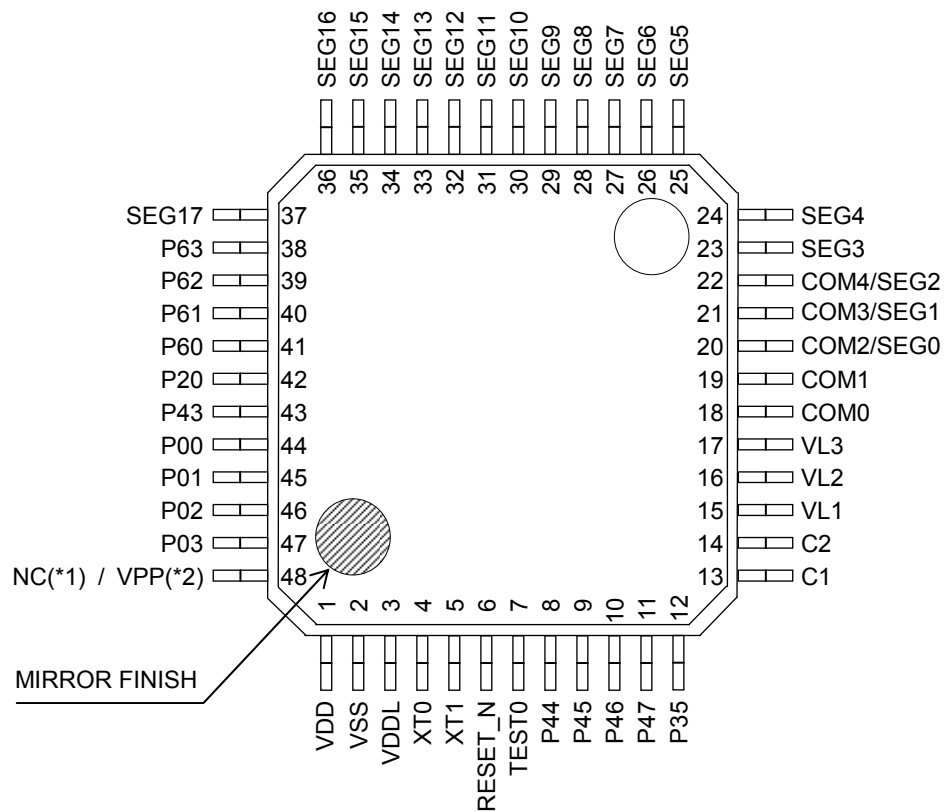
(NC): No Connection

(\*1) : ML610471

(\*2) : ML610Q471

Figure 4 ML610471/ML610Q471 64pin TQFP Package Pin Layout

## ML610472/ML610Q472 48pin TQFP Pin Layout



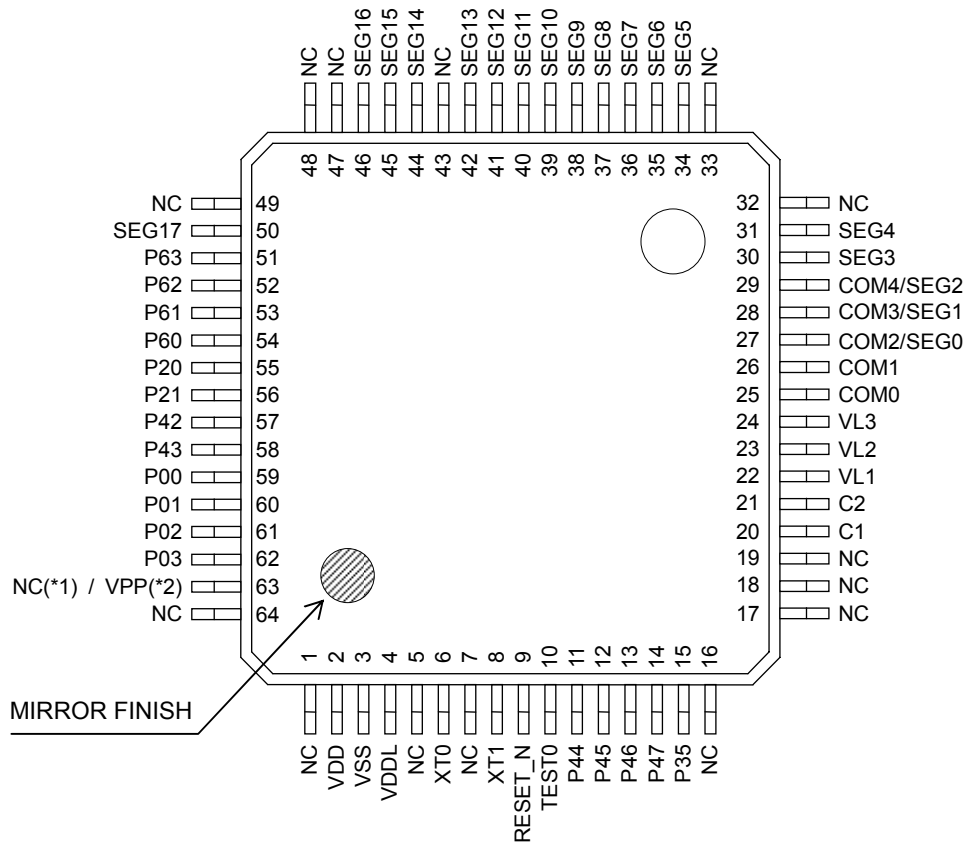
(NC): No Connection

(\*1) : ML610472

(\*2) : ML610Q472

Figure 5 ML610472/ML610Q472 48pin TQFP Package Pin Layout

## ML610472/ML610Q472 64pin TQFP Pin Layout



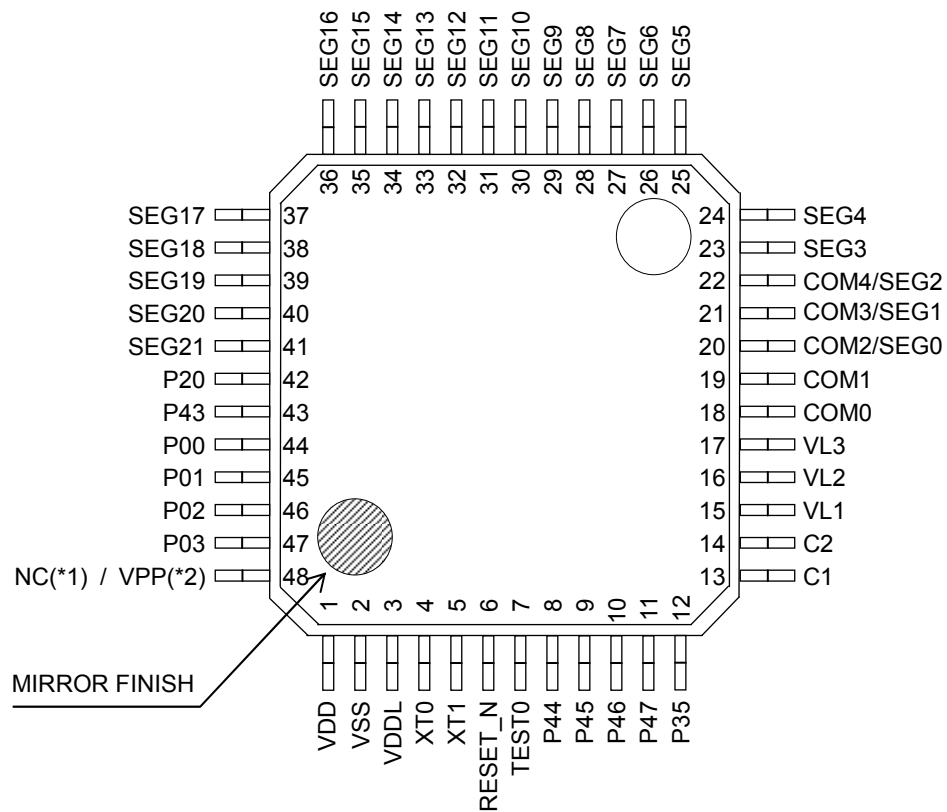
(NC): No Connection

(\*1) : ML610472

(\*2) : ML610Q472

Figure 6 ML610472/ML610Q472 64pin TQFP Package Pin Layout

## ML610473/ML610Q473 48pin TQFP Pin Layout



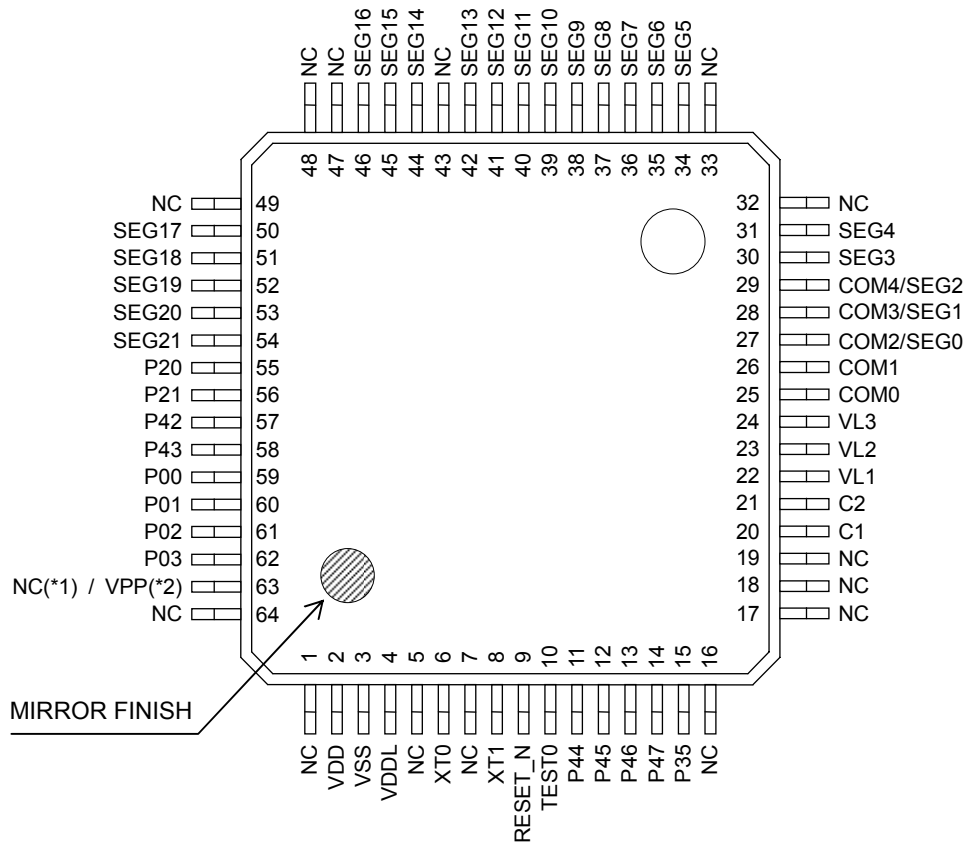
(NC): No Connection

(\*1) : ML610473

(\*2) : ML610Q473

Figure 7 ML610473/ML610Q473 48pin TQFP Package Pin Layout

## ML610473/ML610Q473 64pin TQFP Pin Layout



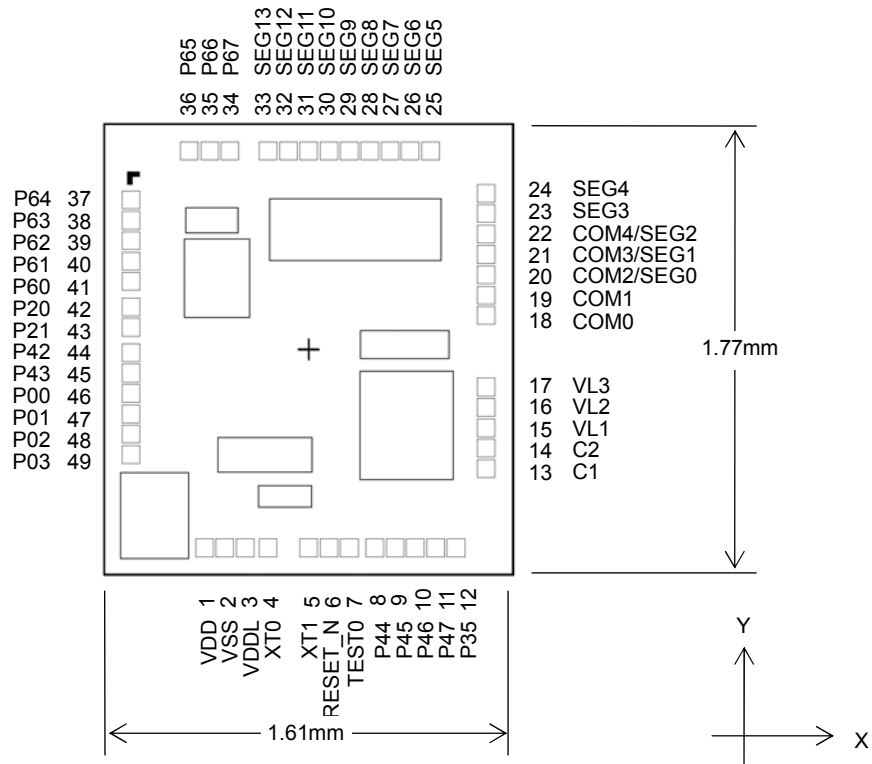
(NC): No Connection

(\*1) : ML610473

(\*2) : ML610Q473

Figure 8 ML610473/ML610Q473 64pin TQFP Package Pin Layout

## ML610471 Chip Pad Layout &amp; Dimension



Chip size: 1.61 mm × 1.77 mm

PAD count: 49 pins

Minimum PAD pitch: 80μm

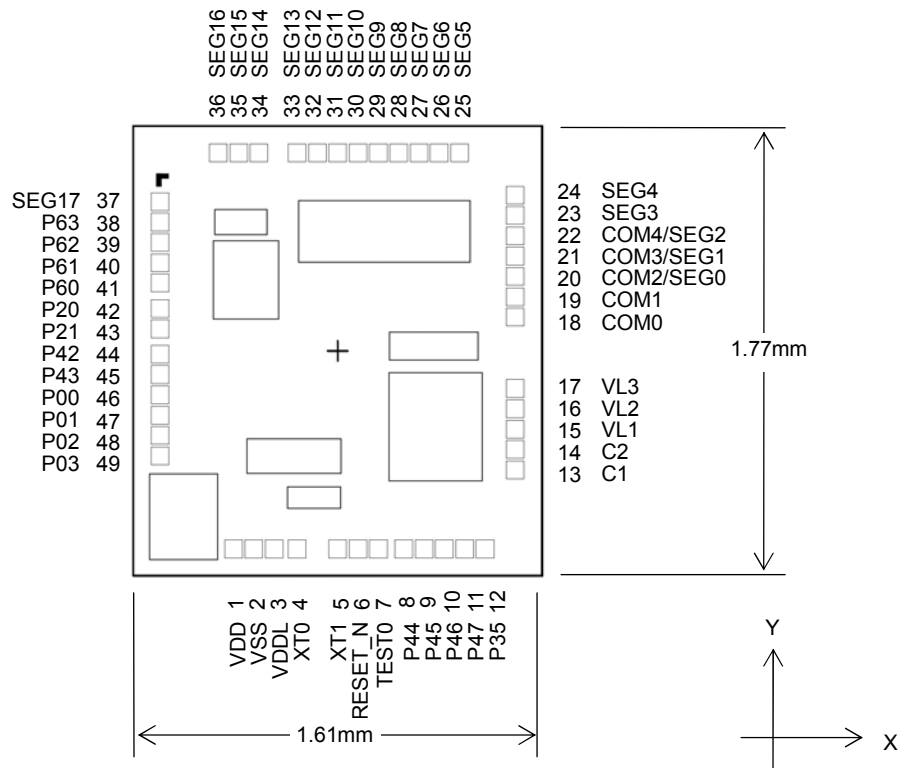
PAD aperture: 70μm×70μm

Chip thickness: 350μm

Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 9 ML610471 Chip Pin Layout & Dimension

## ML610472 Chip Pad Layout &amp; Dimension



Chip size: 1.61 mm × 1.77 mm

PAD count: 49 pins

Minimum PAD pitch: 80μm

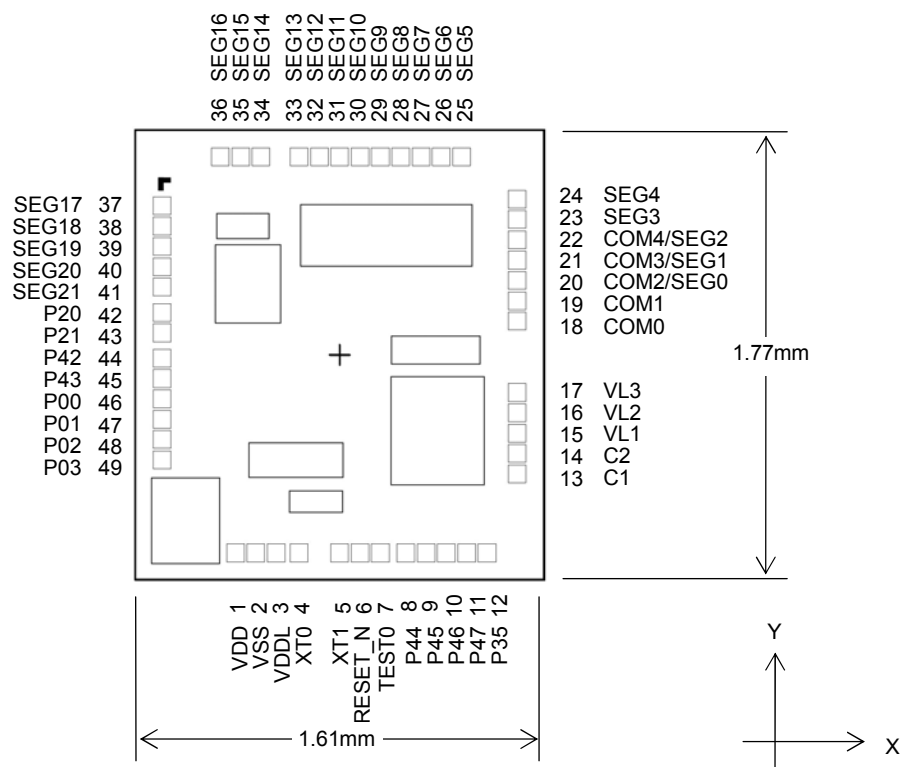
PAD aperture: 70μm×70μm

Chip thickness: 350μm

Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 10 ML610472 Chip Pin Layout & Dimension

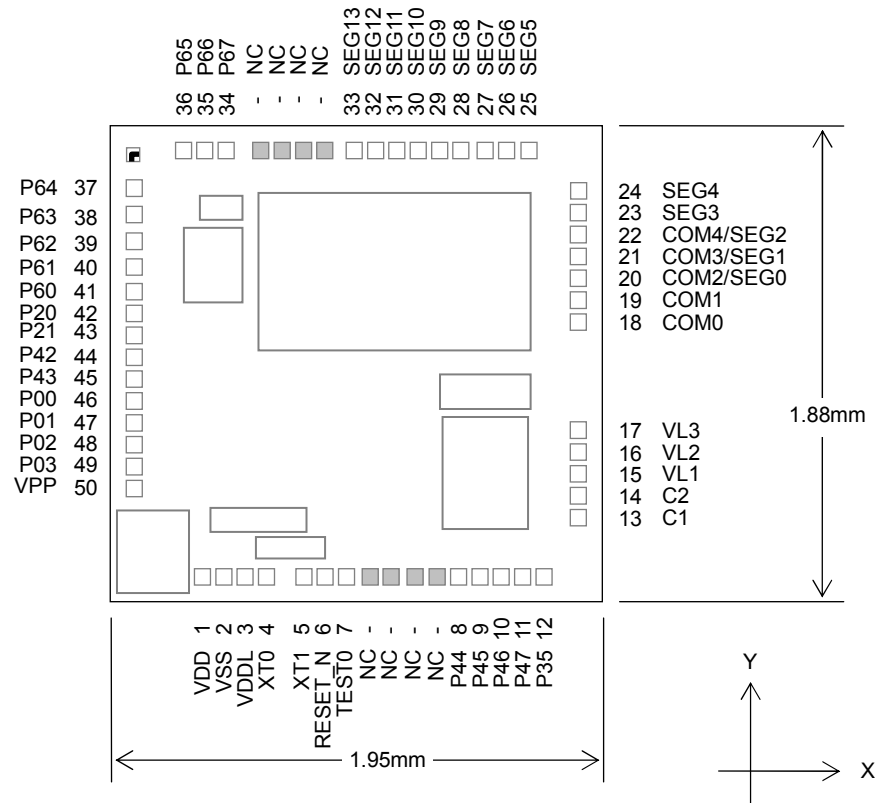
## ML610473 Chip Pad Layout &amp; Dimension



Chip size: 1.61 mm × 1.77 mm  
 PAD count: 49 pins  
 Minimum PAD pitch: 80 μm  
 PAD aperture: 70 μm×70 μm  
 Chip thickness: 350 μm  
 Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 11 ML610473 Chip Pin Layout &amp; Dimension

## ML610Q471 Chip Pad Layout &amp; Dimension

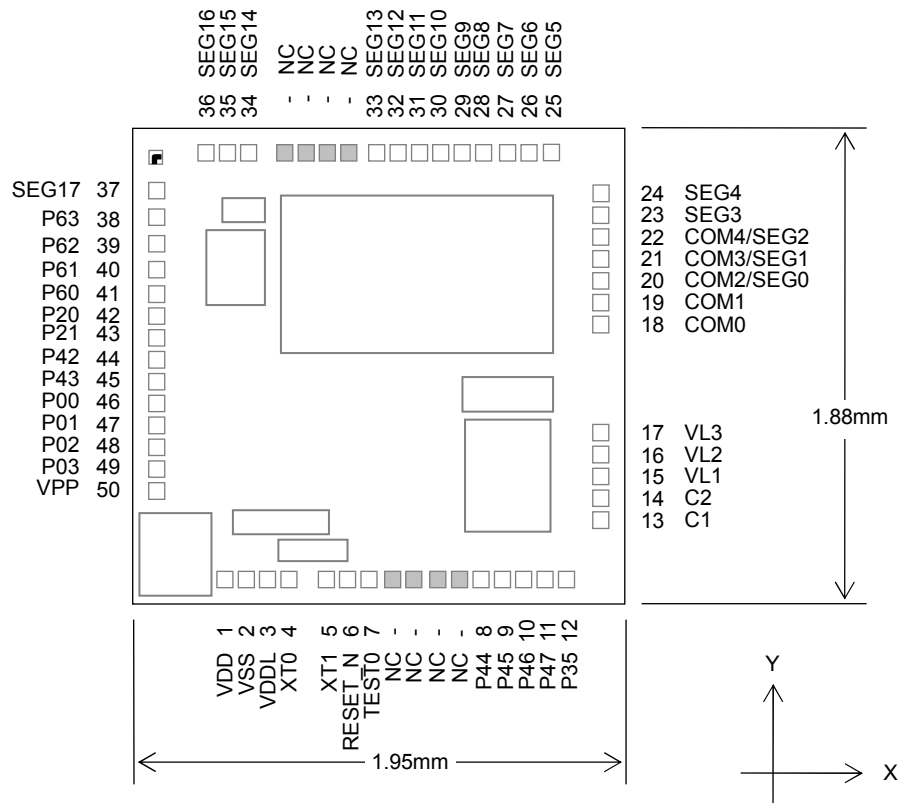


(NC): No Connection

Chip size: 1.95 mm × 1.88 mm  
 PAD count: 50 pins  
 Minimum PAD pitch: 80μm  
 PAD aperture: 70μm×70μm  
 Chip thickness: 350μm  
 Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 12 ML610Q471 Chip Pin Layout &amp; Dimension

## ML610Q472 Chip Pad Layout &amp; Dimension



(NC): No Connection

Chip size: 1.95 mm × 1.88 mm

PAD count: 50 pins

Minimum PAD pitch: 80μm

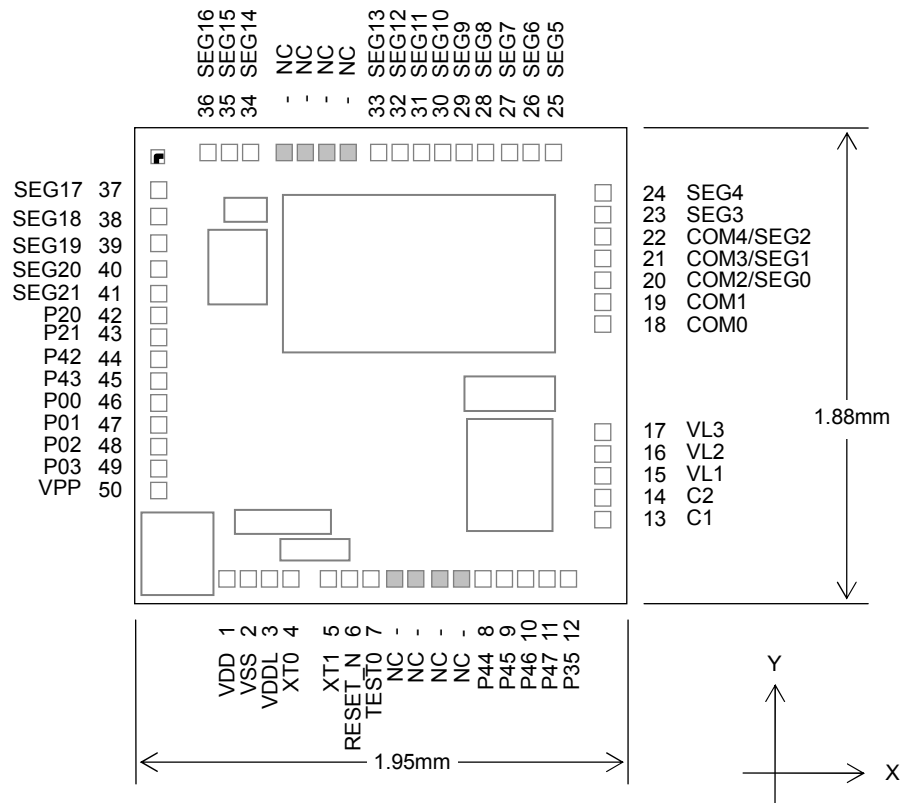
PAD aperture: 70μm×70μm

Chip thickness: 350μm

Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 13 ML610Q472 Chip Pin Layout &amp; Dimension

## ML610Q473 Chip Pad Layout &amp; Dimension



(NC): No Connection

Chip size: 1.95 mm × 1.88 mm  
 PAD count: 50 pins  
 Minimum PAD pitch: 80 μm  
 PAD aperture: 70 μm × 70 μm  
 Chip thickness: 350 μm  
 Voltage of the rear side of chip: V<sub>SS</sub> level.

Figure 14 ML610Q473 Chip Pin Layout &amp; Dimension

## PAD COORDINATES

## ML610471/ML610472/ML610473 Pad Coordinates

Table 1 ML610471/ML610472/ML610473 Pad Coordinates

Chip Center: X=0,Y=0

| PAD No. | Pad Name  | ML610471/2/3 |        |
|---------|-----------|--------------|--------|
|         |           | X (μm)       | Y (μm) |
| 1       | VDD       | -410         | -779   |
| 2       | VSS       | -330         | -779   |
| 3       | VDDL      | -250         | -779   |
| 4       | XT0       | -160         | -779   |
| 5       | XT1       | 0            | -779   |
| 6       | RESET_N   | -80          | -779   |
| 7       | TEST0     | 160          | -779   |
| 8       | P44       | 260          | -779   |
| 9       | P45       | 340          | -779   |
| 10      | P46       | 420          | -779   |
| 11      | P47       | 500          | -779   |
| 12      | P35       | 580          | -779   |
| 13      | C1        | 699          | -468   |
| 14      | C2        | 699          | -388   |
| 15      | VL1       | 699          | -308   |
| 16      | VL2       | 699          | -228   |
| 17      | VL3       | 699          | -148   |
| 18      | COM0      | 699          | 133    |
| 19      | COM1      | 699          | 213    |
| 20      | COM2/SEG0 | 699          | 293    |
| 21      | COM3/SEG1 | 699          | 373    |
| 22      | COM4/SEG2 | 699          | 453    |
| 23      | SEG3      | 699          | 533    |
| 24      | SEG4      | 699          | 613    |
| 25      | SEG5      | 480          | 779    |
| 26      | SEG6      | 400          | 779    |
| 27      | SEG7      | 320          | 779    |
| 28      | SEG8      | 240          | 779    |
| 29      | SEG9      | 160          | 779    |

| PAD No. | Pad Name                 | ML610471/2/3 |        |
|---------|--------------------------|--------------|--------|
|         |                          | X (μm)       | Y (μm) |
| 30      | SEG10                    | 80           | 779    |
| 31      | SEG11                    | 0            | 779    |
| 32      | SEG12                    | -80          | 779    |
| 33      | SEG13                    | -160         | 779    |
| 34      | P67 <sup>(*)</sup>       | -310         | 779    |
|         | SEG14 <sup>(*)</sup> (*) |              |        |
| 35      | P66 <sup>(*)</sup>       | -390         | 779    |
|         | SEG15 <sup>(*)</sup> (*) |              |        |
| 36      | P65 <sup>(*)</sup>       | -470         | 779    |
|         | SEG16 <sup>(*)</sup> (*) |              |        |
| 37      | P64 <sup>(*)</sup>       | -699         | 587    |
|         | SEG17 <sup>(*)</sup> (*) |              |        |
| 38      | P63 <sup>(*)</sup> (*)   | -699         | 507    |
|         | SEG18 <sup>(*)</sup>     |              |        |
| 39      | P62 <sup>(*)</sup> (*)   | -699         | 427    |
|         | SEG19 <sup>(*)</sup>     |              |        |
| 40      | P61 <sup>(*)</sup> (*)   | -699         | 347    |
|         | SEG20 <sup>(*)</sup>     |              |        |
| 41      | P60 <sup>(*)</sup> (*)   | -699         | 267    |
|         | SEG21 <sup>(*)</sup>     |              |        |
| 42      | P20                      | -699         | 167    |
| 43      | P21                      | -699         | 87     |
| 44      | P42                      | -699         | -13    |
| 45      | P43                      | -699         | -93    |
| 46      | P00                      | -699         | -173   |
| 47      | P01                      | -699         | -253   |
| 48      | P02                      | -699         | -333   |
| 49      | P03                      | -699         | -413   |

(\*) Pad for ML610471. (\*\*) Pad for ML610472. (\*\*\*) Pad for ML610473.

## ML610Q471/ML610Q472/ML610Q473 Pad Coordinates

Table 2 ML610Q471/ML610Q472/ML610Q473 Pad Coordinates

Chip Center: X=0,Y=0

| PAD No. | Pad Name  | ML610Q471/2/3 |        |
|---------|-----------|---------------|--------|
|         |           | X (μm)        | Y (μm) |
| 1       | VDD       | -580          | -834   |
| 2       | VSS       | -500          | -834   |
| 3       | VDDL      | -420          | -834   |
| 4       | XT0       | -330          | -834   |
| 5       | XT1       | -170          | -834   |
| 6       | RESET_N   | -90           | -834   |
| 7       | TEST0     | -10           | -834   |
| 8       | P44       | 430           | -834   |
| 9       | P45       | 510           | -834   |
| 10      | P46       | 590           | -834   |
| 11      | P47       | 670           | -834   |
| 12      | P35       | 750           | -834   |
| 13      | C1        | 869           | -523   |
| 14      | C2        | 869           | -443   |
| 15      | VL1       | 869           | -363   |
| 16      | VL2       | 869           | -283   |
| 17      | VL3       | 869           | -203   |
| 18      | COM0      | 869           | 175    |
| 19      | COM1      | 869           | 255    |
| 20      | COM2/SEG0 | 869           | 335    |
| 21      | COM3/SEG1 | 869           | 415    |
| 22      | COM4/SEG2 | 869           | 495    |
| 23      | SEG3      | 869           | 575    |
| 24      | SEG4      | 869           | 655    |
| 25      | SEG5      | 650           | 834    |
| 26      | SEG6      | 570           | 834    |
| 27      | SEG7      | 490           | 834    |
| 28      | SEG8      | 410           | 834    |
| 29      | SEG9      | 330           | 834    |

| PAD No. | Pad Name                              | ML610Q471/2/3 |        |
|---------|---------------------------------------|---------------|--------|
|         |                                       | X (μm)        | Y (μm) |
| 30      | SEG10                                 | 250           | 834    |
| 31      | SEG11                                 | 170           | 834    |
| 32      | SEG12                                 | 90            | 834    |
| 33      | SEG13                                 | 10            | 834    |
| 34      | P67 <sup>(*)1</sup>                   | -480          | 834    |
|         | SEG14 <sup>(*)2</sup> <sup>(*)3</sup> |               |        |
| 35      | P66 <sup>(*)1</sup>                   | -560          | 834    |
|         | SEG15 <sup>(*)2</sup> <sup>(*)3</sup> |               |        |
| 36      | P65 <sup>(*)1</sup>                   | -640          | 834    |
|         | SEG16 <sup>(*)2</sup> <sup>(*)3</sup> |               |        |
| 37      | P64 <sup>(*)1</sup>                   | -869          | 642    |
|         | SEG17 <sup>(*)2</sup> <sup>(*)3</sup> |               |        |
| 38      | P63 <sup>(*)1</sup> <sup>(*)2</sup>   | -869          | 562    |
|         | SEG18 <sup>(*)3</sup>                 |               |        |
| 39      | P62 <sup>(*)1</sup> <sup>(*)2</sup>   | -869          | 482    |
|         | SEG19 <sup>(*)3</sup>                 |               |        |
| 40      | P61 <sup>(*)1</sup> <sup>(*)2</sup>   | -869          | 402    |
|         | SEG20 <sup>(*)3</sup>                 |               |        |
| 41      | P60 <sup>(*)1</sup> <sup>(*)2</sup>   | -869          | 322    |
|         | SEG21 <sup>(*)3</sup>                 |               |        |
| 42      | P20                                   | -869          | 222    |
| 43      | P21                                   | -869          | 142    |
| 44      | P42                                   | -869          | 42     |
| 45      | P43                                   | -869          | -38    |
| 46      | P00                                   | -869          | -118   |
| 47      | P01                                   | -869          | -198   |
| 48      | P02                                   | -869          | -278   |
| 49      | P03                                   | -869          | -358   |
| 50      | VPP                                   | -869          | -438   |

(\*)1 Pad for ML610Q471. (\*)2 Pad for ML610Q472. (\*)3 Pad for ML610Q473.

## PIN LIST

| PIN No.           |                   | PAD No.<br>(MASK) | PAD No.<br>(FLASH) | Primary function   |     |                                                                                                               | Secondary function |     |                                                         |
|-------------------|-------------------|-------------------|--------------------|--------------------|-----|---------------------------------------------------------------------------------------------------------------|--------------------|-----|---------------------------------------------------------|
| 48 <sup>(*)</sup> | 64 <sup>(*)</sup> |                   |                    | Pin name           | I/O | Function                                                                                                      | Pin name           | I/O | Function                                                |
| 2                 | 3                 | 2                 | 2                  | VSS                | —   | Negative power supply pin                                                                                     | —                  | —   | —                                                       |
| 1                 | 2                 | 1                 | 1                  | VDD                | —   | Positive power supply pin                                                                                     | —                  | —   | —                                                       |
| 3                 | 4                 | 3                 | 3                  | VDDL               | —   | Power supply pin for internal logic (internally generated)                                                    | —                  | —   | —                                                       |
| 48                | 63                | —                 | 50                 | VPP <sup>(*)</sup> | —   | Power supply pin for Flash ROM                                                                                | —                  | —   | —                                                       |
| 15                | 22                | 15                | 15                 | VL1                | —   | Power supply pin for LCD bias (internally generated or connected to positive power supply pin) <sup>(*)</sup> | —                  | —   | —                                                       |
| 16                | 23                | 16                | 16                 | VL2                | —   | Power supply pin for LCD bias (internally generated or connected to positive power supply pin) <sup>(*)</sup> | —                  | —   | —                                                       |
| 17                | 24                | 17                | 17                 | VL3                | —   | Power supply pin for LCD bias (internally generated)                                                          | —                  | —   | —                                                       |
| 13                | 20                | 13                | 13                 | C1                 | —   | Capacitor connection pin for LCD bias generation                                                              | —                  | —   | —                                                       |
| 14                | 21                | 14                | 14                 | C2                 | —   | Capacitor connection pin for LCD bias generation                                                              | —                  | —   | —                                                       |
| 7                 | 10                | 7                 | 7                  | TEST0              | I/O | Test pin                                                                                                      | —                  | —   | —                                                       |
| 6                 | 9                 | 6                 | 6                  | RESET_N            | I   | Reset input pin                                                                                               | —                  | —   | —                                                       |
| 4                 | 6                 | 4                 | 4                  | XT0                | I   | Low-speed clock oscillation pin                                                                               | —                  | —   | —                                                       |
| 5                 | 8                 | 5                 | 5                  | XT1                | O   | Low-speed clock oscillation pin                                                                               | —                  | —   | —                                                       |
| 44                | 59                | 46                | 46                 | P00/EXI0/CAP0      | I   | Input port, External interrupt, Capture 0 input                                                               | —                  | —   | —                                                       |
| 45                | 60                | 47                | 47                 | P01/EXI1/CAP1      | I   | Input port, External interrupt, Capture 1 input                                                               | —                  | —   | —                                                       |
| 46                | 61                | 48                | 48                 | P02/EXI2/RXD0      | I   | Input port, External interrupt, UART0 received data                                                           | —                  | —   | —                                                       |
| 47                | 62                | 49                | 49                 | P03/EXI3           | I   | Input port, External interrupt                                                                                | —                  | —   | —                                                       |
| 42                | 55                | 42                | 42                 | P20/LED0           | O   | Output port                                                                                                   | LSCLK              | O   | Low-speed clock output                                  |
| —                 | 56                | 43                | 43                 | P21/LED1           | O   | Output port                                                                                                   | OUTCLK             | O   | High-speed clock output                                 |
| 12                | 15                | 12                | 12                 | P35                | I/O | Input/output port                                                                                             | RCM                | O   | RC type ADC oscillation monitor                         |
| —                 | 57                | 44                | 44                 | P42                | I/O | Input/output port                                                                                             | RXD0               | —   | UART0 received data                                     |
| 43                | 58                | 45                | 45                 | P43                | I/O | Input/output port                                                                                             | TXD0               | O   | UART data output                                        |
| 8                 | 11                | 8                 | 8                  | P44/T2CK           | I/O | Input/output port, Timer 2 external clock input                                                               | IN1                | I   | RC type ADC1 oscillation input pin                      |
| 9                 | 12                | 9                 | 9                  | P45/T3CK           | I/O | Input/output port, Timer 3 external clock input                                                               | CS1                | O   | RC type ADC1 reference capacitor connection pin         |
| 10                | 13                | 10                | 10                 | P46                | I/O | Input/output port                                                                                             | RS1                | O   | RC type ADC1 reference resistor connection pin          |
| 11                | 14                | 11                | 11                 | P47                | I/O | Input/output port                                                                                             | RT1                | O   | RC type ADC1 measurement resistor sensor connection pin |

(\*) 48pin TQFP. (\*\*) 64pin TQFP

(\*) Pad for ML610Q471/ML610Q472/ML610Q473

| PIN No.           |                   | PAD No.<br>(MASK) | PAD No.<br>(FLASH) | Primary function            |     |                        | Secondary function |     |          |
|-------------------|-------------------|-------------------|--------------------|-----------------------------|-----|------------------------|--------------------|-----|----------|
| 48 <sup>(*)</sup> | 64 <sup>(*)</sup> |                   |                    | Pin name                    | I/O | Function               | Pin name           | I/O | Function |
| 18                | 25                | 18                | 18                 | COM0                        | O   | LCD common pin         | —                  | —   | —        |
| 19                | 26                | 19                | 19                 | COM1                        | O   | LCD common pin         | —                  | —   | —        |
| 20                | 27                | 20                | 20                 | COM2/<br>SEG0               | O   | LCD common/segment pin | —                  | —   | —        |
| 21                | 28                | 21                | 21                 | COM3/<br>SEG1               | O   | LCD common/segment pin | —                  | —   | —        |
| 22                | 29                | 22                | 22                 | COM4/<br>SEG2               | O   | LCD common/segment pin | —                  | —   | —        |
| 23                | 30                | 23                | 23                 | SEG3                        | O   | LCD segment pin        | —                  | —   | —        |
| 24                | 31                | 24                | 24                 | SEG4                        | O   | LCD segment pin        | —                  | —   | —        |
| 25                | 34                | 25                | 25                 | SEG5                        | O   | LCD segment pin        | —                  | —   | —        |
| 26                | 35                | 26                | 26                 | SEG6                        | O   | LCD segment pin        | —                  | —   | —        |
| 27                | 36                | 27                | 27                 | SEG7                        | O   | LCD segment pin        | —                  | —   | —        |
| 28                | 37                | 28                | 28                 | SEG8                        | O   | LCD segment pin        | —                  | —   | —        |
| 29                | 38                | 29                | 29                 | SEG9                        | O   | LCD segment pin        | —                  | —   | —        |
| 30                | 39                | 30                | 30                 | SEG10                       | O   | LCD segment pin        | —                  | —   | —        |
| 31                | 40                | 31                | 31                 | SEG11                       | O   | LCD segment pin        | —                  | —   | —        |
| 32                | 41                | 32                | 32                 | SEG12                       | O   | LCD segment pin        | —                  | —   | —        |
| 33                | 42                | 33                | 33                 | SEG13                       | O   | LCD segment pin        | —                  | —   | —        |
| 34                | 44                | 34                | 34                 | P67 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG14 <sup>(*)</sup><br>(*) |     | LCD segment pin        | —                  | —   | —        |
| 35                | 45                | 35                | 35                 | P66 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG15 <sup>(*)</sup><br>(*) |     | LCD segment pin        | —                  | —   | —        |
| 36                | 46                | 36                | 36                 | P65 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG16 <sup>(*)</sup><br>(*) |     | LCD segment pin        | —                  | —   | —        |
| 37                | 50                | 37                | 37                 | P64 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG17 <sup>(*)</sup><br>(*) |     | LCD segment pin        | —                  | —   | —        |
| 38                | 51                | 38                | 38                 | P63 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG18 <sup>(*)</sup>        |     | LCD segment pin        | —                  | —   | —        |
| 39                | 52                | 39                | 39                 | P62 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG19 <sup>(*)</sup>        |     | LCD segment pin        | —                  | —   | —        |
| 40                | 53                | 40                | 40                 | P61 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG20 <sup>(*)</sup>        |     | LCD segment pin        | —                  | —   | —        |
| 41                | 54                | 41                | 41                 | P60 <sup>(*)</sup>          | O   | Output port            | —                  | —   | —        |
|                   |                   |                   |                    | SEG21 <sup>(*)</sup>        |     | LCD segment pin        | —                  | —   | —        |

(\*) 48pin TQFP. (\*\*) 64pin TQFP,

(\*) Pad for ML610Q471/ML610Q472/ML610Q473

(\*) Pad for ML610471/ML610Q471

(\*) Pad for ML610472/ML610Q472

(\*) Pad for ML610473/ML610Q473.

## PIN DESCRIPTION

| Pin name                          | I/O | Description                                                                                                                                                                                                                                     | Primary/<br>Secondary | 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.<br>A 32.768 kHz crystal resonator is connected to this pin. Capacitors                                                                                                                              | —                     | —                     |
| XT1                               | O   | C <sub>DL</sub> and C <sub>GL</sub> are connected across this pin and VSS. (see appendix C measuring circuit 1)                                                                                                                                 | —                     | —                     |
| LSCLK                             | O   | Low-speed clock output. Assigned to 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 to P03                        | I   | General-purpose input port.                                                                                                                                                                                                                     | Primary               | Positive              |
| General-purpose output port       |     |                                                                                                                                                                                                                                                 |                       |                       |
| P20, P21                          | O   | General-purpose output port.<br>This cannot be used as the general output port when used as the secondary function.                                                                                                                             | Primary               | Positive              |
| General-purpose input/output port |     |                                                                                                                                                                                                                                                 |                       |                       |
| P35                               | I/O | General-purpose input/output port.<br>This cannot be used as the general input/output port when used as the secondary function.                                                                                                                 | Primary               | Positive              |
| P42 to P47                        | I/O | General-purpose input/output port.<br>This cannot be used as the general input/output port when used as the secondary function.                                                                                                                 | Primary               | Positive              |
| P60 to P63                        | O   | General-purpose output port.<br>Incorporated only into ML610471/610Q471/ML610472/ML610Q472, and not into ML610473/ML610Q473.                                                                                                                    | Primary               | Positive              |
| P64 to P67                        | O   | General-purpose output port.<br>Incorporated only into ML610473/ML610Q473, and not into ML610471/ML610Q471/ML610472/ ML610Q472.                                                                                                                 | 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               | Positive              |
| External interrupt                |     |                                                                                                                                                                                                                                                 |                       |                       |
| EXI0-3                            | 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 to P03 pins.                                                     | Primary/<br>Secondary | Positive/<br>negative |

| Pin name                          | I/O | Description                                                                                                                                                                                                                                 | Primary/<br>Secondary | Logic                 |
|-----------------------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| Capture                           |     |                                                                                                                                                                                                                                             |                       |                       |
| 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. These pins are used as the primary functions of the P00 pin(CAP0) and P01 pin(CAP1). | Primary               | Positive/<br>negative |
| CAP1                              | I   |                                                                                                                                                                                                                                             | Primary               | Positive/<br>negative |
| Timer                             |     |                                                                                                                                                                                                                                             |                       |                       |
| T2CK                              | I   | External clock input pin used for Timer 2. This pin is used as the primary function of the P44 pin.                                                                                                                                         | Primary               | —                     |
| T3CK                              | I   | External clock input pin used for Timer 3. This pin is used as the primary function of the P45 pin.                                                                                                                                         | Primary               | —                     |
| LED drive                         |     |                                                                                                                                                                                                                                             |                       |                       |
| LED0-1                            | O   | N-channel open drain output pins to drive LED. This pin is used as the primary function of the P20 pin and P21 pin.                                                                                                                         | Primary               | Positive<br>/negative |
| RC oscillation type A/D converter |     |                                                                                                                                                                                                                                             |                       |                       |
| 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             | —                     |

| Pin name                | I/O | Description                                                                                                                                                                                                                                                                         | Primary/<br>Secondary | Logic    |
|-------------------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------|
| LCD drive signal        |     |                                                                                                                                                                                                                                                                                     |                       |          |
| COM0 to COM4            | O   | Common output pins. COM2, COM3, and COM4 can be switched to SEG0, SEG1, and SEG2, respectively, through the register setting. To change the setting, switch between COM4 and SEG2 for one pin and switch between COM3, COM4 and SEG1, SEG2 for two pins.                            | —                     | —        |
| SEG0 to SEG13           | O   | Segment output pin. The SEG0, SEG1, and SEG2 pins are for switching the register setting with the COM2, COM3, and COM4.                                                                                                                                                             | —                     | —        |
| SEG14 to SEG17          | O   | Segment output pin. Incorporated into ML610472/ML610Q472/ML610473/ML610Q473, not into ML610471/ML610Q471.                                                                                                                                                                           | —                     | —        |
| SEG18 to SEG21          | O   | Segment output pin. Incorporated into ML610473/ML610Q473, not into ML610471/ML610Q471/ML610472/ML610Q472.                                                                                                                                                                           | —                     | —        |
| LCD driver power supply |     |                                                                                                                                                                                                                                                                                     |                       |          |
| VL1                     | —   | Power supply pin for LCD bias (internally generated) or power supply connection pin. Depending on LCD Bias setting and V <sub>DD</sub> voltage level, V <sub>DD</sub> or V <sub>DDL</sub> or capacitor is connected. For details of the connection method, see measuring circuit 1. | —                     | —        |
| VL2                     | —   |                                                                                                                                                                                                                                                                                     | —                     | —        |
| VL3                     | —   |                                                                                                                                                                                                                                                                                     | —                     | —        |
| C1                      | —   | Power supply pins for LCD bias (internally generated). Capacitor C <sub>12</sub> (see measuring circuit 1) is connected between C1 and C2.                                                                                                                                          | —                     | —        |
| C2                      | —   |                                                                                                                                                                                                                                                                                     | —                     | —        |
| Test                    |     |                                                                                                                                                                                                                                                                                     |                       |          |
| TEST0                   | I/O | Pin for testing. A pull-down resistor is internally connected.                                                                                                                                                                                                                      | —                     | Positive |
| Power supply            |     |                                                                                                                                                                                                                                                                                     |                       |          |
| VSS                     | —   | Negative power supply pin.                                                                                                                                                                                                                                                          | —                     | —        |
| VDD                     | —   | Positive power supply pin.                                                                                                                                                                                                                                                          | —                     | —        |
| VDDL                    | —   | Positive power supply pin (internally generated) for internal logic. Capacitors C <sub>L0</sub> and C <sub>L1</sub> (see measuring circuit 1) are connected between this pin and VSS.                                                                                               | —                     | —        |
| VPP                     | —   | Power supply pin for programming Flash ROM. A pull-down resistor is internally connected. This pin is only for ML610Q471/ML610Q472/ML610Q473.                                                                                                                                       | —                     | —        |

**TERMINATION OF UNUSED PINS**

Table 2 shows methods of terminating the unused pins.

**Table 2 Termination of Unused Pins**

| Pin           | Recommended pin handling      |
|---------------|-------------------------------|
| VPP           | Open                          |
| VL1           | Open                          |
| VL2           | Open                          |
| VL3           | Open                          |
| C1, C2        | Open                          |
| RESET_N       | Open                          |
| TEST0         | Pull down(1k $\Omega$ to VSS) |
| P00 to P03    | VDD or VSS                    |
| P20, P21      | Open                          |
| P35           | Open                          |
| P42 to P47    | Open                          |
| P60 to P67    | Open                          |
| COM0 to COM4  | Open                          |
| SEG0 to SEG21 | 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.

## ELECTRICAL CHARACTERISTICS

## Absolute Maximum Ratings

(V<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 | V <sub>PP</sub>   | Ta=25°C              | -0.3 to +9.5                 | V    |
| Power supply voltage 3 | V <sub>DDL</sub>  | Ta=25°C              | -0.3 to +3.6                 | V    |
| Power supply voltage 4 | V <sub>L1</sub>   | Ta=25°C              | -0.3 to +2.0                 | V    |
| Power supply voltage 5 | V <sub>L2</sub>   | Ta=25°C              | -0.3 to +4.0                 | V    |
| Power supply voltage 6 | V <sub>L3</sub>   | Ta=25°C              | -0.3 to +6.0                 | 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> | Port 3 to 6, Ta=25°C | -12 to +11                   | mA   |
| Output current 2       | I <sub>OUT2</sub> | Port 2, Ta=25°C      | -12 to +20                   | mA   |
| Power dissipation      | PD                | Ta=25°C              | 0.9                          | W    |
| Storage temperature    | T <sub>STG</sub>  | —                    | -55 to +150                  | °C   |

## Recommended Operating conditions

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

| Parameter                                          | Symbol             | Condition                      | Range                             | Unit |
|----------------------------------------------------|--------------------|--------------------------------|-----------------------------------|------|
| Operating temperature                              | T <sub>OP</sub>    | without P version              | -20 to +70                        | °C   |
|                                                    |                    | P version                      | -40 to +85                        |      |
| Operating voltage                                  | V <sub>DD</sub>    | f <sub>OP</sub> =30k to 625kHz | 1.25 to 3.6                       | V    |
| Operating frequency (CPU)                          | f <sub>OP</sub>    | V <sub>DD</sub> =1.25 to 3.6V  | 30k to 625k                       | Hz   |
| Low-speed crystal oscillation frequency            | f <sub>XTL</sub>   | —                              | 32.768k                           | Hz   |
| Low-speed crystal oscillation external capacitance | C <sub>DL</sub>    | —                              | 3 to 18                           | pF   |
|                                                    | C <sub>GL</sub>    | —                              | 3 to 18                           |      |
| V <sub>DD</sub> pin external capacitance           | C <sub>V</sub>     | —                              | 1.0±30% to 2.2±30%* <sup>1</sup>  | μF   |
| V <sub>DDL</sub> pin external capacitance          | C <sub>L</sub>     | —                              | 0.47±30% to 2.2±30%* <sup>2</sup> | μF   |
| V <sub>L1</sub> , 2, or 3 pin external capacitance | C <sub>a,b,c</sub> | —                              | 0.1±30%                           | μF   |
| Pin-to-pin (C1 to C2) external capacitance         | C <sub>12</sub>    | —                              | 0.47±30%                          | μF   |

\*<sup>1</sup>: Please select as C<sub>V</sub> is larger than C<sub>L</sub> or same as C<sub>L</sub>.\*<sup>2</sup>: When the load of V<sub>DD</sub> is small and the power rise time is too short, it may happen that the power-on reset is not generated. In this case please select C<sub>L</sub> with larger capacitance

## Operating conditions of FlashROM

(VSS=0V)

| Parameter             | Symbol    | Condition                    | Range       | Unit   |
|-----------------------|-----------|------------------------------|-------------|--------|
| Operating temperature | $T_{OP}$  | At write/erase               | 0 to +40    | °C     |
| Operating voltage     | $V_{DD}$  | At write/erase               | 2.75 to 3.6 | V      |
|                       | $V_{DDL}$ | At write/erase <sup>*1</sup> | 2.5 to 2.75 |        |
|                       | $V_{PP}$  | At write/erase               | 7.7 to 8.3  |        |
| Rewrite count         | $C_{EP}$  | —                            | 80          | cycles |
| Data retention        | $Y_{DR}$  | —                            | 10          | years  |

<sup>\*1</sup>: When writing to and erasing on the flash Memory, the voltage in the specified range needs to be supplied to the  $V_{DDL}$  pin.  
The  $V_{PP}$  pin has an internal pull-down resistor.

## DC Characteristics (1/6)

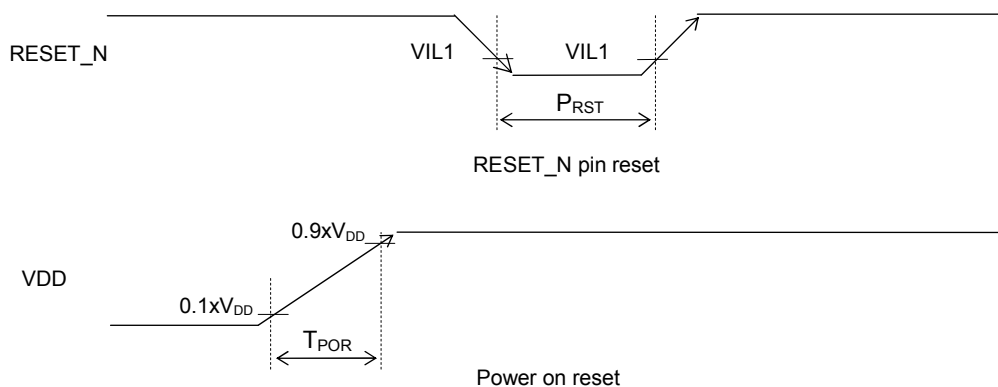
(VDD=1.25 to 3.6V, VSS=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

| Parameter                                                 | Symbol            | Condition                        |         | Rating       |      |              | Unit | Measur-<br>ement<br>circuit |
|-----------------------------------------------------------|-------------------|----------------------------------|---------|--------------|------|--------------|------|-----------------------------|
|                                                           |                   |                                  |         | Min.         | Typ. | Max.         |      |                             |
| 500kHz RC oscillation<br>frequency                        | f <sub>RC</sub>   | V <sub>DD</sub> =1.25<br>to 3.6V | Ta=25°C | Typ.<br>-10% | 500  | Typ.<br>+10% | kHz  | 1                           |
|                                                           |                   |                                  | *2      | Typ.<br>-25% | 500  | Typ.<br>+25% | kHz  |                             |
| Low-speed crystal<br>oscillation start time* <sup>1</sup> | T <sub>XTL</sub>  | —                                |         | —            | 0.6  | 2            | s    |                             |
| 500kHz RC oscillation start<br>time                       | T <sub>RC</sub>   | —                                |         | —            | —    | 3            | μs   |                             |
| Reset pulse width                                         | P <sub>RST</sub>  | —                                |         | 200          | —    | —            | μs   |                             |
| Reset noise elimination<br>pulse width                    | P <sub>NRST</sub> | —                                |         | —            | —    | 0.3          |      |                             |
| Power-on reset generated<br>power rise time               | T <sub>POR</sub>  | —                                |         | —            | —    | 10           | ms   |                             |

<sup>\*1</sup>: 32.768kHz crystal resonator DT-26 (Load capacitance 6pF) (made by KDS:DAISHINKU CORP.) is used ( $C_{GL}=C_{DL}=12\text{pF}$ ).

<sup>\*2</sup>: Recommended operating temperature ( $T_a=-20$  to  $70^{\circ}\text{C}$ ,  $T_a=-40$  to  $85^{\circ}\text{C}$  for P version)

## RESET



**DC Characteristics (2/6)**

(VDD=1.25 to 3.6V, VSS=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

| Parameter                                 | Symbol            | Condition             | Rating |      |      | Unit  | Measur<br>ement<br>circuit |
|-------------------------------------------|-------------------|-----------------------|--------|------|------|-------|----------------------------|
|                                           |                   |                       | Min.   | Typ. | Max. |       |                            |
| V <sub>DDL</sub> voltage                  | V <sub>DDL</sub>  | fop=30k to 625kHz     | 1.1    | 1.2  | 1.3  | V     | 1                          |
| V <sub>DDL</sub> temperature deviation *1 | ΔV <sub>DDL</sub> | V <sub>DD</sub> =3.0V | —      | -1   | —    | mV/°C |                            |
| V <sub>DDL</sub> voltage dependency *1    | ΔV <sub>DDL</sub> | —                     | —      | 5    | 20   | mV/V  |                            |

\*1: The maximum V<sub>DDL</sub> voltage becomes the V<sub>DD</sub> voltage level when the V<sub>DDL</sub> voltage determined by the temperature and voltage deviations mathematically exceeds the V<sub>DD</sub> voltage.

**DC Characteristics for ML610471/472/473 (3/6)**

(VDD=3.0V, VSS=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

| Parameter             | Symbol | Condition                                                                                                                           | Rating  |      |      | Unit | Measur<br>ement<br>circuit |
|-----------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------|---------|------|------|------|----------------------------|
|                       |        |                                                                                                                                     | Min.    | Typ. | Max. |      |                            |
| Supply current 1      | IDD1   | CPU: In STOP state.<br>Low-speed/High-speed oscillation:<br>stopped.                                                                | Ta=25°C | —    | 0.3  | 0.8  | 1                          |
|                       |        |                                                                                                                                     | *5      | —    | —    | 3    |                            |
| Supply current 2      | IDD2   | CPU: In HALT state.<br>(LTBC, WDT: Operating)*3*4.<br>High-speed 500kHz oscillation:<br>Stopped.<br>LCD/BIAS circuits: Operating *6 | Ta=25°C | —    | 0.8  | 1.8  |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 4    |                            |
| Supply current 3      | IDD3   | CPU: In 32.768kHz operating<br>state.*1*3<br>High-speed 500kHz oscillation:<br>Stopped,<br>LCD/BIAS circuits: Operating *2          | Ta=25°C | —    | 3    | 6    |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 9    |                            |
| Supply current<br>4-1 | IDD4-1 | CPU: In 500kHz RC operating<br>state.<br>LCD/BIAS circuits: Operating.*2                                                            | Ta=25°C | —    | 50   | 70   |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 80   |                            |

\*1: When the CPU operating rate is 100% (no HALT state).

\*2: 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)

\*3: 32.768KHz crystal resonator DT-26 (Load capacitance 6pF) (made by KDS:DAISHINKU CORP.) is used (C<sub>GL</sub>=C<sub>DL</sub>=6pF)

\*4: Significant bits of BLKCON0 to BLKCON4 registers are all "1" except DLCD bit on BLKCON4.

\*5: Recommended operating temperature (Ta=-20 to 70°C, Ta=-40 to 85°C for P version)

\*6: LCD stop mode, 1/3 bias, Bias voltage multiplying clock: 1/128 LSCLK (256Hz)

**DC Characteristics for ML610Q471/Q472/Q473 (4/6)**

(VDD=3.0V, VSS=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

| Parameter             | Symbol | Condition                                                                                                                           | Rating  |      |      | Unit | Measur<br>ement<br>circuit |
|-----------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------|---------|------|------|------|----------------------------|
|                       |        |                                                                                                                                     | Min.    | Typ. | Max. |      |                            |
| Supply current 1      | IDD1   | CPU: In STOP state.<br>Low-speed/High-speed oscillation:<br>stopped.                                                                | Ta=25°C | —    | 0.3  | 1.25 | 1                          |
|                       |        |                                                                                                                                     | *5      | —    | —    | 5.5  |                            |
| Supply current 2      | IDD2   | CPU: In HALT state.<br>(LTBC, WDT: Operating)*3*4.<br>High-speed 500kHz oscillation:<br>Stopped.<br>LCD/BIAS circuits: Operating *6 | Ta=25°C | —    | 0.8  | 3.2  |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 8.5  |                            |
| Supply current 3      | IDD3   | CPU: In 32.768kHz operating<br>state.*1*3<br>High-speed 500kHz oscillation:<br>Stopped,<br>LCD/BIAS circuits: Operating *2          | Ta=25°C | —    | 4.7  | 7.5  |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 13   |                            |
| Supply current<br>4-1 | IDD4-1 | CPU: In 500kHz RC operating<br>state.<br>LCD/BIAS circuits: Operating.*2                                                            | Ta=25°C | —    | 70   | 100  |                            |
|                       |        |                                                                                                                                     | *5      | —    | —    | 120  |                            |

\*1: When the CPU operating rate is 100% (no HALT state).

\*2: 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)

\*3: 32.768KHz crystal resonator DT-26 (Load capacitance 6pF) (made by KDS:DAISHINKU CORP.) is used (C<sub>GL</sub>=C<sub>DL</sub>=6pF)

\*4: Significant bits of BLKCON0 to BLKCON4 registers are all "1" except DLCD bit on BLKCON4.

\*5: Recommended operating temperature (Ta=-20 to 70°C, Ta=-40 to 85°C for P version)

\*6: LCD stop mode, 1/3 bias, Bias voltage multiplying clock: 1/128 LSCLK (256Hz)

## DC Characteristics (5/6)

(V<sub>DD</sub>=1.25 to 3.6V, V<sub>SS</sub>=0V, T<sub>a</sub>=-20 to +70°C, T<sub>a</sub>=-40 to +85°C for P version, unless otherwise specified)

| Parameter                                                                                                                                                                          | Symbol | Condition                                                                  | Rating                  |      |                         | Unit | Measur<br>ement<br>circuit |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------|-------------------------|------|-------------------------|------|----------------------------|
|                                                                                                                                                                                    |        |                                                                            | Min.                    | Typ. | Max.                    |      |                            |
| Output voltage 1<br>(P20, P21<br>(N-channel open<br>drain output<br>mode is not<br>selected))<br>(P35)<br>(P42 to P47)<br>(P60 to P63) <sup>*2</sup><br>(P60 to P67) <sup>*1</sup> | VOH1   | IOH1=-0.5mA, V <sub>DD</sub> =1.8 to 3.6V                                  | V <sub>DD</sub><br>-0.5 | —    | —                       | V    | 2                          |
|                                                                                                                                                                                    |        | IOH1=-0.03mA, V <sub>DD</sub> =1.25 to 3.6V                                | V <sub>DD</sub><br>-0.3 | —    | —                       |      |                            |
|                                                                                                                                                                                    | VOL1   | IOL1=+0.5mA, V <sub>DD</sub> =1.8 to 3.6V                                  | —                       | —    | 0.5                     |      |                            |
|                                                                                                                                                                                    |        | IOL1=+0.1mA, V <sub>DD</sub> =1.25 to 3.6V                                 | —                       | —    | 0.3                     |      |                            |
| Output voltage 2<br>(P20, P21<br>(N-channel open<br>drain output<br>mode is<br>selected))                                                                                          | VOL2   | IOL2=+5mA, V <sub>DD</sub> =1.8 to 3.6V                                    | —                       | —    | 0.5                     |      |                            |
| Output voltage 3<br>(COM0 to 4)<br>(SEG0 to 13) <sup>*1</sup><br>(SEG0 to 17) <sup>*2</sup><br>(SEG0 to 21) <sup>*3</sup>                                                          | VOH3   | IOH3=-0.05mA, VL1=1.2V                                                     | V <sub>L3</sub><br>-0.2 | —    | —                       |      |                            |
|                                                                                                                                                                                    | VOML3  | IOML3=+0.05mA, VL1=1.2V                                                    | —                       | —    | V <sub>L2</sub><br>+0.2 |      |                            |
|                                                                                                                                                                                    | VOML3S | IOML3S=-0.05mA, VL1=1.2V                                                   | V <sub>L2</sub><br>-0.2 | —    | —                       |      |                            |
|                                                                                                                                                                                    | VOLM3  | IOLM3=+0.05mA, VL1=1.2V                                                    | —                       | —    | V <sub>L1</sub><br>+0.2 |      |                            |
|                                                                                                                                                                                    | VOLM3S | IOLM3S=-0.05mA, VL1=1.2V                                                   | V <sub>L1</sub><br>-0.2 | —    | —                       |      |                            |
|                                                                                                                                                                                    | VOL3   | IOL3=+0.05mA, VL1=1.2V                                                     | —                       | —    | 0.2                     |      |                            |
| Output leakage<br>(P20, P21)<br>(P35)<br>(P42 to P47)<br>(P60 to P63) <sup>*2</sup><br>(P60 to P67) <sup>*1</sup>                                                                  | IOOH   | VOH=V <sub>DD</sub> (in high-impedance state)                              | —                       | —    | 1                       | μA   | 3                          |
|                                                                                                                                                                                    | IOOL   | VOL=V <sub>SS</sub> (in high-impedance state)                              | -1                      | —    | —                       |      |                            |
| Input current 1<br>(RESET_N)                                                                                                                                                       | IIH1   | VIH1=V <sub>DD</sub>                                                       | —                       | —    | 1                       | μA   | 4                          |
|                                                                                                                                                                                    | IIL1   | VIL1=V <sub>SS</sub>                                                       | -600                    | -300 | -2                      |      |                            |
| Input current 2<br>(TEST0)                                                                                                                                                         | IIH2   | VIH2=V <sub>DD</sub>                                                       | 2                       | 300  | 600                     |      |                            |
|                                                                                                                                                                                    | IIL2   | VIL2=V <sub>SS</sub>                                                       | -1                      | —    | —                       |      |                            |
| Input current 3<br>(P00 to P03)<br>(P35)<br>(P42 to P47)                                                                                                                           | IIH3   | VIH3=V <sub>DD</sub> , V <sub>DD</sub> =1.8 to 3.6V<br>(when pulled-down)  | 2                       | 30   | 200                     |      |                            |
|                                                                                                                                                                                    |        | VIH3=V <sub>DD</sub> , V <sub>DD</sub> =1.25 to 3.6V<br>(when pulled-down) | 0.01                    | 30   | 200                     |      |                            |
|                                                                                                                                                                                    | IIL3   | VIL3=V <sub>SS</sub> , V <sub>DD</sub> =1.8 to 3.6V<br>(when pulled-up)    | -200                    | -30  | -2                      |      |                            |
|                                                                                                                                                                                    |        | VIL3=V <sub>SS</sub> , V <sub>DD</sub> =1.25 to 3.6V<br>(when pulled-up)   | -200                    | -30  | -0.01                   |      |                            |
|                                                                                                                                                                                    | IIH3Z  | VIH3=V <sub>DD</sub> (in high-impedance state)                             | —                       | —    | 1                       |      |                            |
|                                                                                                                                                                                    | IIL3Z  | VIL3=V <sub>SS</sub> (in high-impedance state)                             | -1                      | —    | —                       |      |                            |

\*1: Characteristics for ML610471/ML610Q471.

\*2: Characteristics for ML610472/ML610Q472.

\*3: Characteristics for ML610473/ML610Q473.

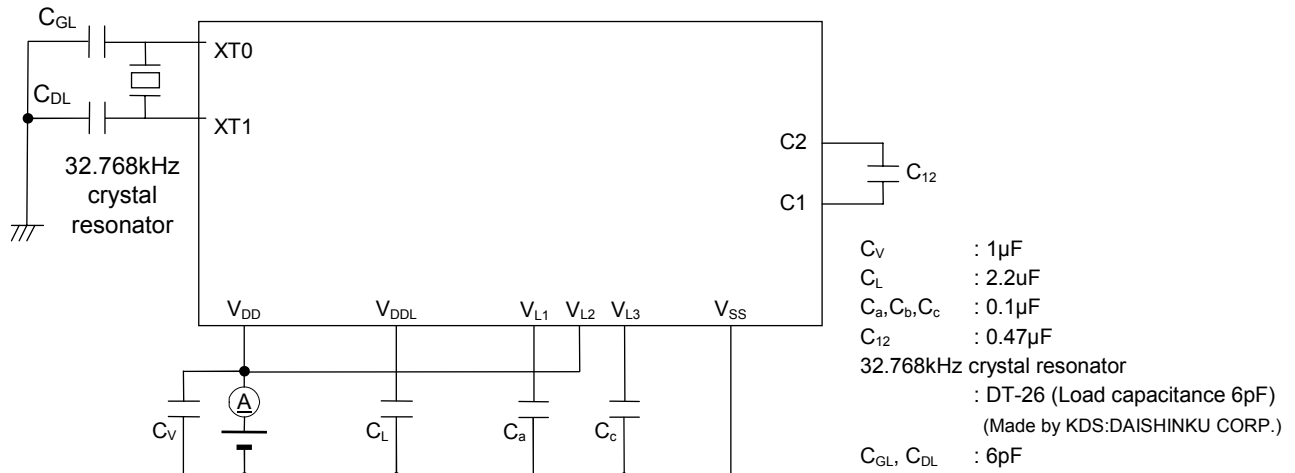
**DC Characteristics (6/6)**

(VDD=1.25 to 3.6V, VSS=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

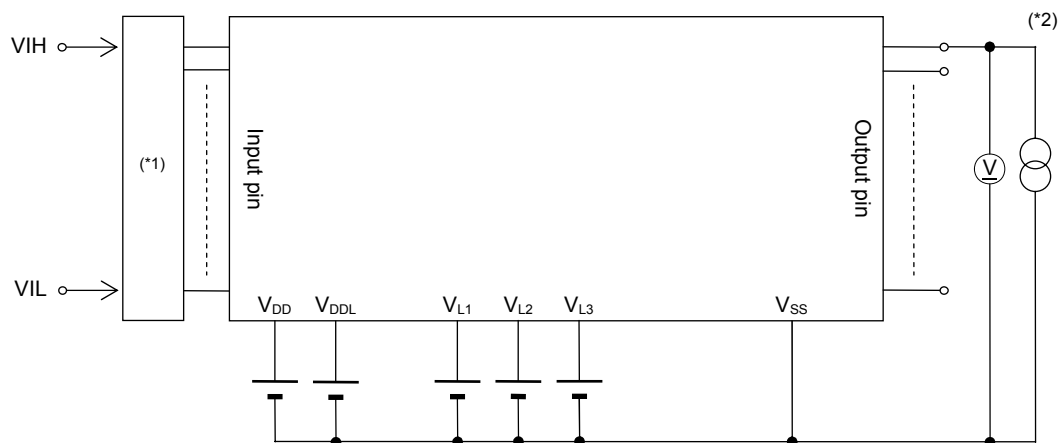
| Parameter                                                                        | Symbol | Condition                                    | Rating                  |      |                         | Unit | Measur<br>ement<br>circuit |
|----------------------------------------------------------------------------------|--------|----------------------------------------------|-------------------------|------|-------------------------|------|----------------------------|
|                                                                                  |        |                                              | Min.                    | Typ. | Max.                    |      |                            |
| Input voltage 1<br>(RESET_N)<br>(TEST0)<br>(P00 to P03)<br>(P35)<br>(P42 to P47) | VIH1   | —                                            | 0.7<br>×V <sub>DD</sub> | —    | V <sub>DD</sub>         | V    | 5                          |
|                                                                                  | VIL1   | V <sub>DD</sub> =1.25 to 3.6V                | 0                       | —    | 0.2<br>×V <sub>DD</sub> |      |                            |
| Input pin<br>capacitance<br>(P00 to P03)<br>(P35)<br>(P42 to P47)                | CIN    | f=10kHz<br>V <sub>rms</sub> =50mV<br>Ta=25°C | —                       | —    | 5                       | pF   | —                          |

## Measuring Circuits

### Measuring Circuit 1



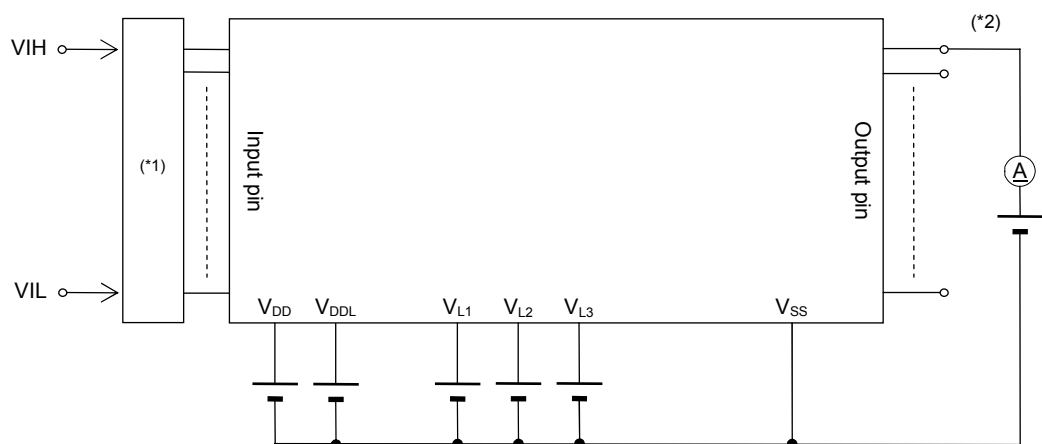
### Measuring Circuit 2



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

\*2: Repeats for the specified output pin

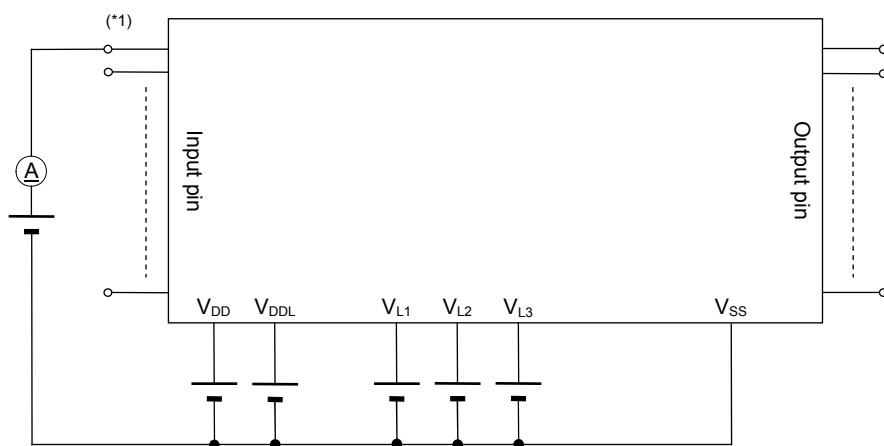
## Measuring Circuit 3



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

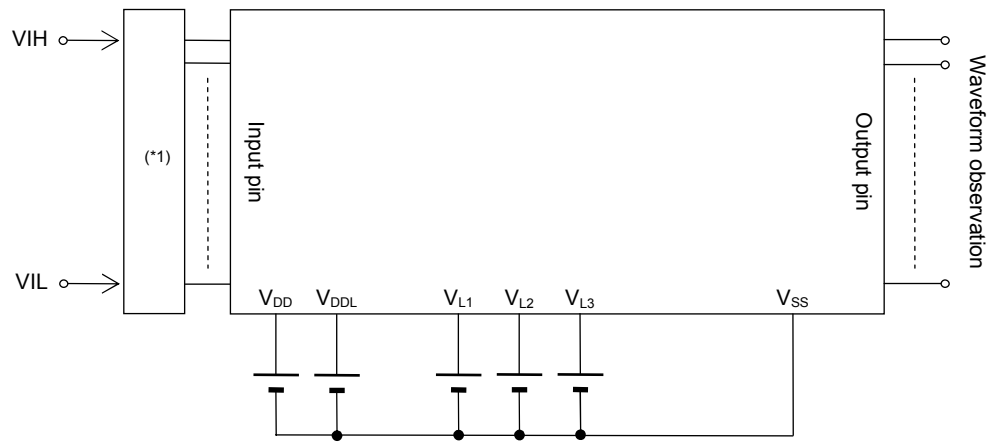
\*2: Repeats for the specified output pin

## Measuring Circuit 4



\*1: Repeats for the specified input pin

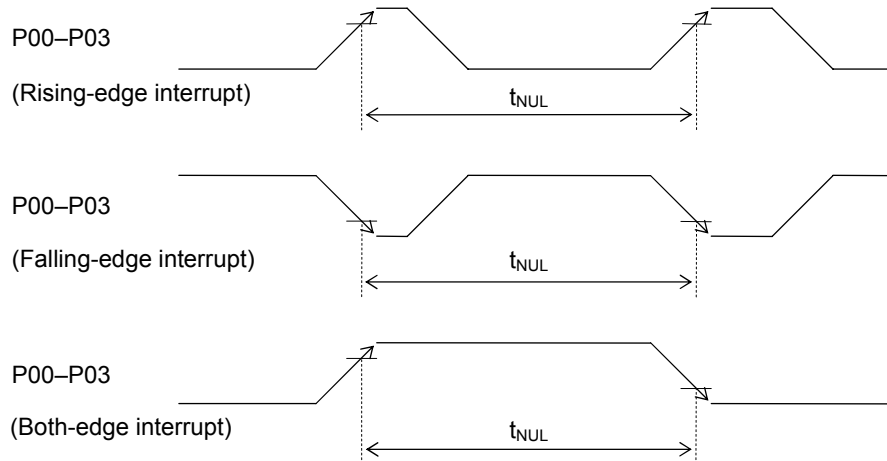
## Measuring Circuit 5



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

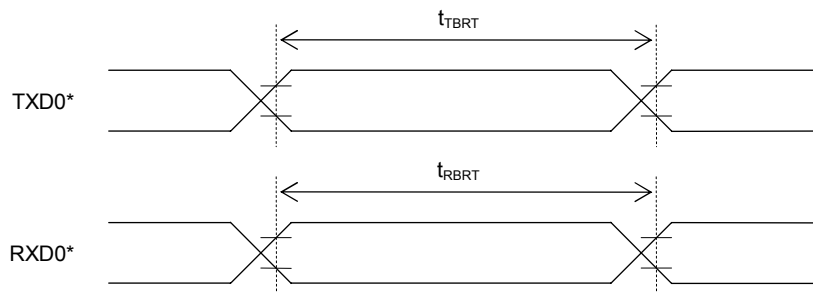
**AC Characteristics (External Interrupt)**(V<sub>DD</sub>=1.25 to 3.6V, V<sub>SS</sub>=0V, Ta=-20 to +70°C, Ta=-40 to +85°C for P version, unless otherwise specified)

| Parameter                         | Symbol           | Condition                                                                      | Rating |      |       | Unit |
|-----------------------------------|------------------|--------------------------------------------------------------------------------|--------|------|-------|------|
|                                   |                  |                                                                                | Min.   | Typ. | Max.  |      |
| External interrupt disable period | T <sub>NUL</sub> | Interrupt: Enabled (MIE = 1),<br>CPU: NOP operation<br>System clock: 32.768kHz | 76.8   | —    | 106.8 | μs   |

**AC Characteristics (UART)**(V<sub>DD</sub>=1.25 to 3.6V, V<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.                     |      |
| Transmit baud rate | t <sub>TBRT</sub> | —         | —                        | BRT* <sup>1</sup> | —                        | s    |
| Receive baud rate  | t <sub>RBRT</sub> | —         | BRT* <sup>1</sup><br>-3% | BRT* <sup>1</sup> | BRT* <sup>1</sup><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).



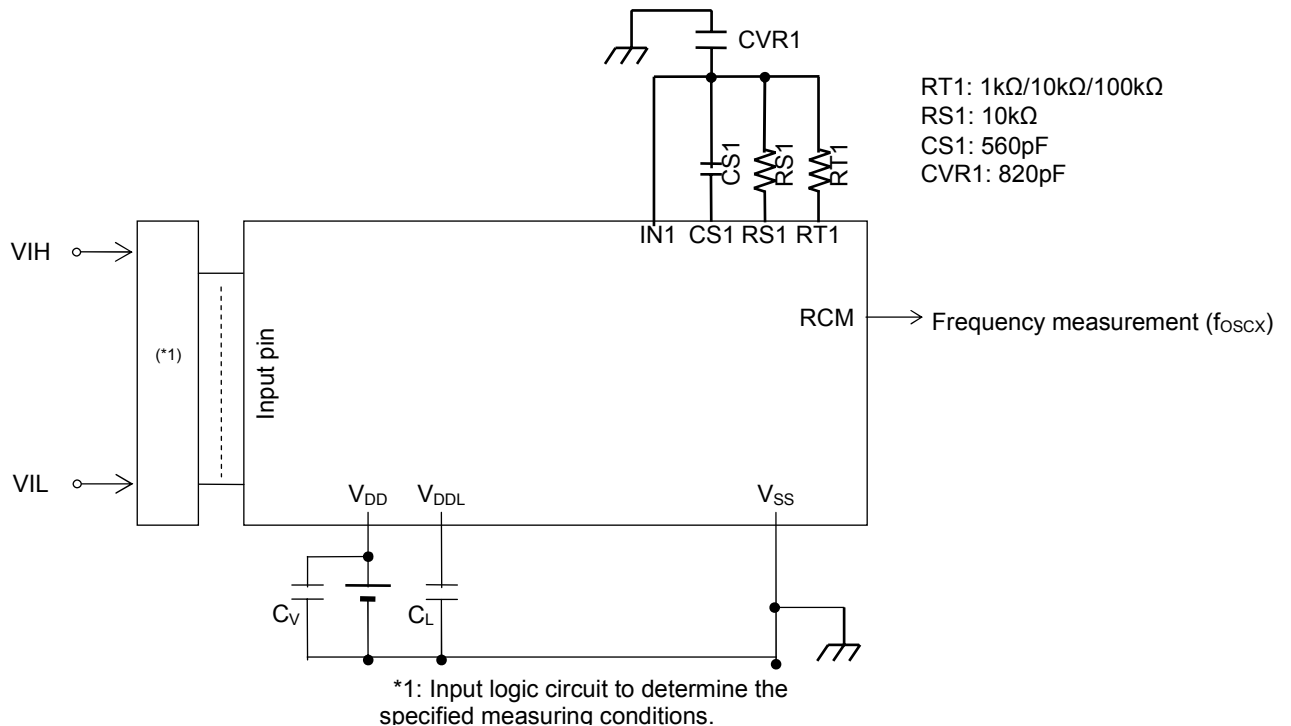
\*: Indicates the secondary function of the port.

**AC Characteristics (RC Oscillation A/D Converter)**Condition for  $V_{DD}=1.8$  to  $3.6V$  $(V_{DD}=1.8$  to  $3.6V$ ,  $V_{SS}=0V$ ,  $T_a=-20$  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.  |            |
| Oscillation resistor                                          | RS1,RT1    | CS0, CT0, CS1 $\geq$ 740pF             | 1      | —     | —     | k $\Omega$ |
| Oscillation frequency<br>$V_{DD} = 3.0V$                      | $f_{OSC1}$ | Resistor for oscillation=1k $\Omega$   | 457.3  | 525.2 | 575.1 | kHz        |
|                                                               | $f_{OSC2}$ | Resistor for oscillation=10k $\Omega$  | 53.48  | 58.18 | 62.43 | kHz        |
|                                                               | $f_{OSC3}$ | Resistor for oscillation=100k $\Omega$ | 5.43   | 5.89  | 6.32  | kHz        |
| RS to RT oscillation<br>frequency ratio *1<br>$V_{DD} = 3.0V$ | Kf1        | RT1=1k $\Omega$                        | 7.972  | 9.028 | 9.782 | —          |
|                                                               | Kf2        | RT1=10k $\Omega$                       | 0.981  | 1     | 1.019 | —          |
|                                                               | Kf3        | RT1=100k $\Omega$                      | 0.099  | 0.101 | 0.104 | —          |

\*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.

$$Kfx = \frac{f_{OSCx}(RT1-CS1 \text{ oscillation})}{f_{OSCx}(RS1-CS1 \text{ oscillation})}, \quad (x = 1, 2, 3)$$

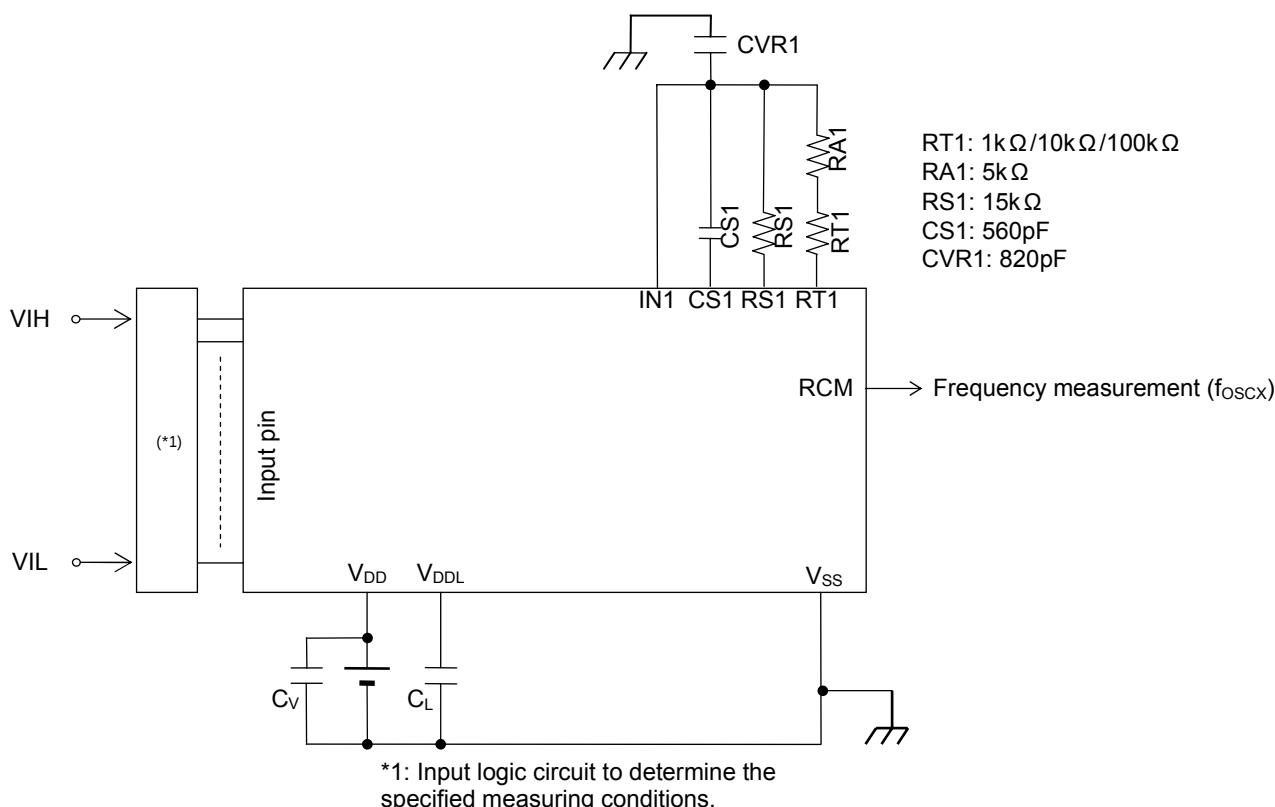


Condition for  $V_{DD}=1.25$  to  $3.6V$  $(V_{DD}=1.25$  to  $3.6V$ ,  $V_{SS}=0V$ ,  $T_a=-20$  to  $+70^{\circ}C$ ,  $T_a=-40$  to  $+85^{\circ}C$  for P version, unless otherwise specified)

| Parameter                                                                | Symbol            | Condition                              | Rating |       |       | Unit       |
|--------------------------------------------------------------------------|-------------------|----------------------------------------|--------|-------|-------|------------|
|                                                                          |                   |                                        | Min.   | Typ.  | Max.  |            |
| Oscillation resistor                                                     | RS1,RT1           | CS1 $\geq$ 740pF                       | 1      | —     | —     | k $\Omega$ |
| Oscillation frequency<br>$V_{DD} = 1.5V$                                 | f <sub>OSC1</sub> | Resistor for oscillation=6k $\Omega$   | 81.93  | 93.16 | 101.2 | kHz        |
|                                                                          | f <sub>OSC2</sub> | Resistor for oscillation=15k $\Omega$  | 35.32  | 38.75 | 41.48 | kHz        |
|                                                                          | f <sub>OSC3</sub> | Resistor for oscillation=105k $\Omega$ | 5.22   | 5.65  | 6.03  | kHz        |
| RS to RT oscillation<br>frequency ratio <sup>*1</sup><br>$V_{DD} = 1.5V$ | Kf1               | RT1=1k $\Omega$                        | 2.139  | 2.381 | 2.632 | —          |
|                                                                          | Kf2               | RT1=10k $\Omega$                       | 0.973  | 1     | 1.028 | —          |
|                                                                          | Kf3               | RT1=100k $\Omega$                      | 0.142  | 0.147 | 0.152 | —          |
| Oscillation frequency<br>$V_{DD} = 3.0V$                                 | f <sub>OSC1</sub> | Resistor for oscillation=6k $\Omega$   | 85.28  | 94.58 | 103.3 | kHz        |
|                                                                          | f <sub>OSC2</sub> | Resistor for oscillation=15k $\Omega$  | 35.72  | 38.87 | 41.78 | kHz        |
|                                                                          | f <sub>OSC3</sub> | Resistor for oscillation=105k $\Omega$ | 5.189  | 5.622 | 6.012 | kHz        |
| RS to RT oscillation<br>frequency ratio <sup>*1</sup><br>$V_{DD} = 3.0V$ | Kf1               | RT1=1k $\Omega$                        | 2.227  | 2.432 | 2.626 | —          |
|                                                                          | Kf2               | RT1=10k $\Omega$                       | 0.982  | 1     | 1.018 | —          |
|                                                                          | Kf3               | RT1=100k $\Omega$                      | 0.141  | 0.145 | 0.149 | —          |

\*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.

$$Kfx = \frac{f_{OSCx}(RT1-CS1 \text{ oscillation})}{f_{OSCx}(RS1-CS1 \text{ oscillation})} \quad (x = 1, 2, 3)$$



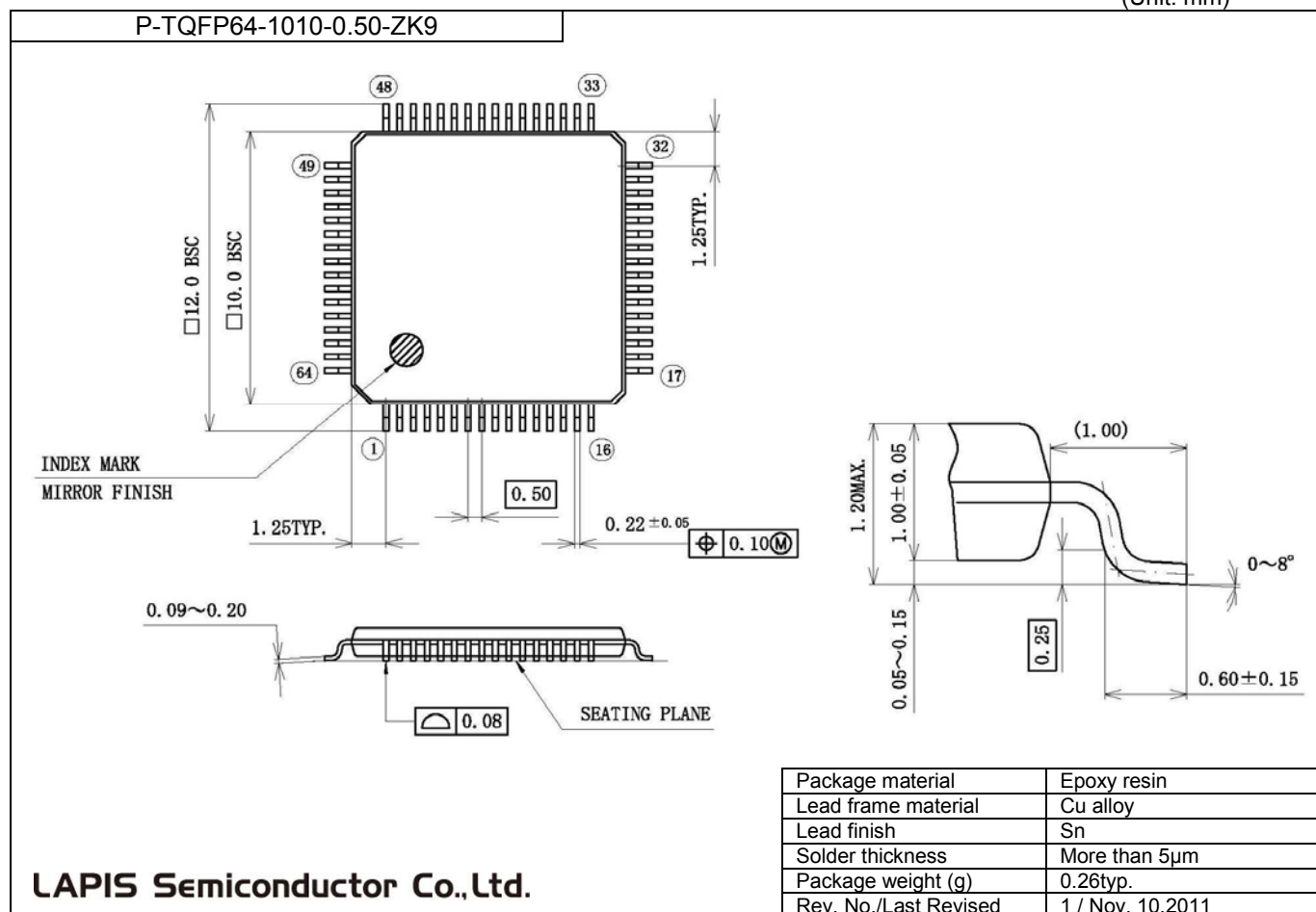
Note:

- Please have the shortest layout for the common node (wiring patterns which are connected to the external capacitors, resistors and IN1 pin), including CVR1. Especially, do not have long wiring between IN1 and 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 RT1 (Thermistor and etc.) requires long wiring due to the restricted placement, please have  $V_{SS}(GND)$  trace next to the signal.
- Please make wiring to components (capacitor, resistor, and so on) necessary for objective measurement. Wiring to reserved components may affect to the A/D conversion operation by noise the components itself may have.

## PACKAGE DIMENSIONS

## 64pin TQFP Package

(Unit: mm)

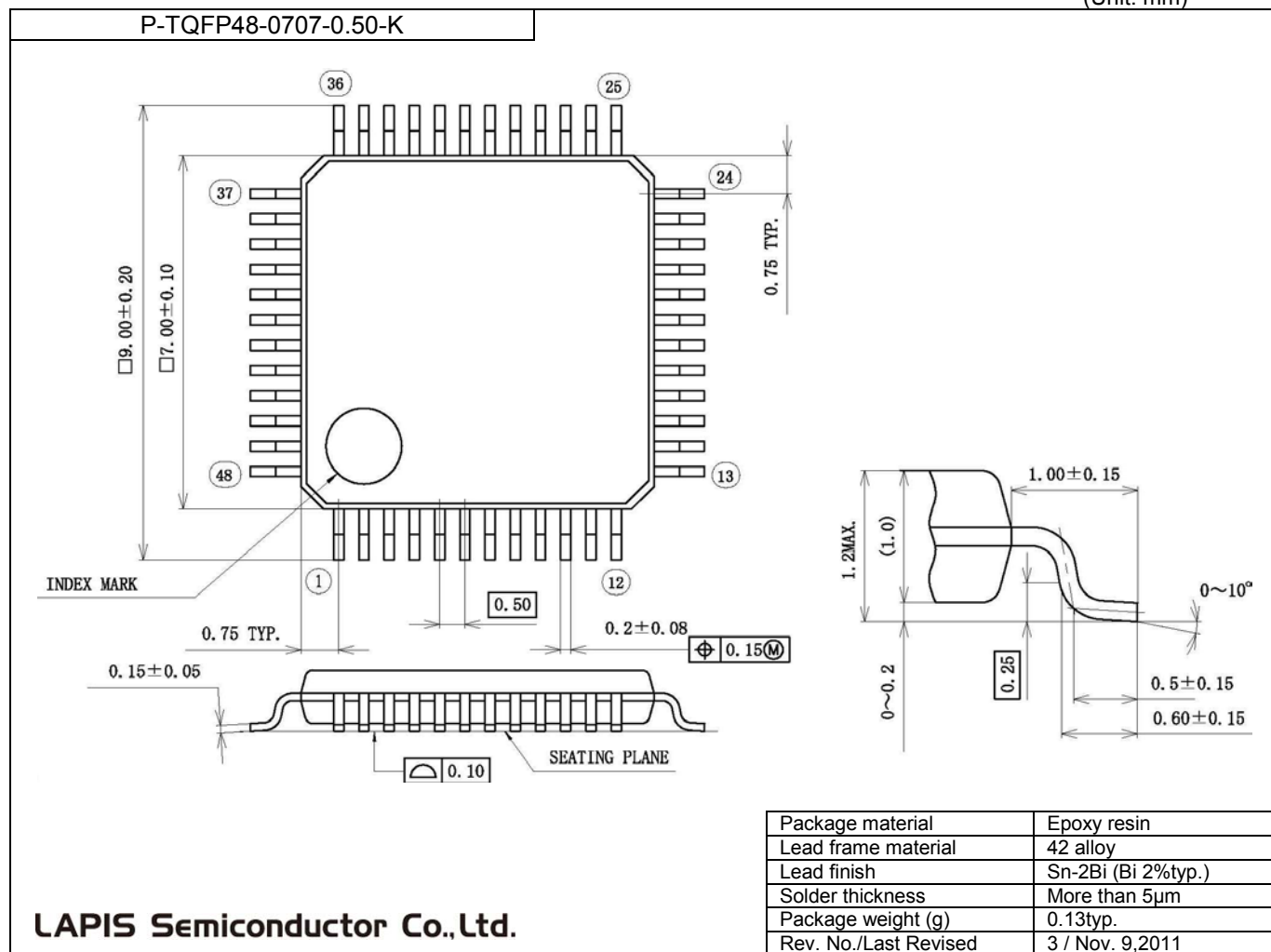


## Notes for Mounting the Surface Mount Type Package

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 ROHM's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

## 48 pin TQFP Package

(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 ROHM's 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 |                                                                                                                |
| FEDL610473-01 | Apr.25,2011 | –                | –               | Formally edition 1                                                                                             |
| FEDL610473-02 | May.10,2011 | 1,2,3            | 1,2,3           | Add Mask ROM version(ML610471/ML610472/ML610473)                                                               |
|               |             | –                | 4               | Add Block Diagram (Mask ROM version)                                                                           |
|               |             | –                | 12,13,14        | Add Chip Pad Layout and Dimensions (Mask ROM version)                                                          |
|               |             | 15,16            | 20,21           | Add Pad No of Mask ROM version into PIN list.                                                                  |
| FEDL610473-03 | Sep.13,2011 | 3                | 3               | The package name of TQFP48 was changed.                                                                        |
|               |             | 15-17,<br>19-21  | 15-17,<br>19-21 | The pads number were changed.                                                                                  |
|               |             | 28               | 29              | Add DC Characteristics<br>(ML610471/ML610472/ML610473)                                                         |
| FEDL610473-04 | Sep.28,2011 | 15-17            | 15-17           | The figures were revised.                                                                                      |
| FEDL610473-05 | Mar.27,2012 | 26,32            | 26,32           | The value of capacitor CL was changed to 2.2uF.                                                                |
| FEDL610473-06 | Jul.18,2012 | 25               | 25              | The pull down register(1kΩ to VSS) was added.                                                                  |
|               |             | 26               | 26              | The notes about C <sub>V</sub> , C <sub>L</sub> were added.                                                    |
|               |             | 38,39            | 38,39           | The package dimension was changed.                                                                             |
| FEDL610473-07 | Jan. 7,2013 | 2                | 2               | The difference of the number of the port between chip, 48-pin plastic TQFP and 64-pin plastic TQFP were added. |

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