Dear customer

ROHM Co., Ltd. ("ROHM"), on the 1st day of April, 2024,
has absorbed into merger with 100%-owned subsidiary of LAPIS Technology Co., Ltd.

Therefore, all references to "LAPIS Technology Co., Ltd.", "LAPIS Technology"
and/or "LAPIS" in this document shall be replaced with "ROHM Co., Ltd."
Furthermore, there are no changes to the documents relating to our products other than
the company name, the company trademark, logo, etc.

Thank you for your understanding.

ROHM Co., Ltd.
April 1, 2024

FEDL610Q306-03
Issue Date: Aug. 7, 2023

ML610Q305/306

8-bit Microcontroller with Voice Output Function

GENERAL DESCRIPTION

Ÿ **Please see the "Notes" and the "Notes for product usage" in this document.**

Equipped with a 8-bit CPU nX-U8/100, the ML610Q305/306 is a high-performance 8-bit CMOS microcontroller that integrates a wide variety of peripherals such as timer, synchronous serial port, successive approximation type 10-bit A/D converter and voice output function. The nX-U8/100 CPU is capable of executing instructions efficiently on a one-instruction-per-clock-pulse basis through parallel processing by the 3-stage pipelined architecture. The ML610Q305/306 is also equipped with a flash memory* that has achieved low voltage and low power consumption (at read) equivalent to mask ROM, so it is best suited to battery-driven applications such as alarm and portable devices. In addition, it has an on-chip debugging function, which allows software debugging/rewriting with the LSI mounted on the board.

*: This product uses SuperFlash® technology licensed from Silicon Storage Technology, Inc. SuperFlash® is a registered trademark of Silicon Storage Technology, Inc.

FEATURES

· CPU
- 8-bit RISC CPU (CPU name: nX-U8/100)
- Instruction system: 16-bit instructions
- Instruction set: Transfer, arithmetic operations, comparison, logic operations, multiplication/division, bit manipulations, bit logic operations, jump, conditional jump, call return stack manipulations, arithmetic shift, and so on
- On-Chip debug function
- Minimum instruction execution time
  Approx 30.5 ms (@32.768kHz system clock)
  Approx 0.244 ms (@4.096 MHz system clock)@V_{DD}=2.0 to 5.5V
  Approx 0.122 ms (@8.192 MHz system clock)@V_{DD}=2.2 to 5.5V

· Internal memory
- Has 96-Kbyte flash ROM(48K ´ 16-bits) built in. (1 K byte of test domain that it cannot be used is included)
- Has 2-Kbyte flash ROM built in. (area in which self rewriting is possible (512byte ´ 4))
- Internal 1Kbyte RAM (1K ´ 8 bits)

· Interrupt controller
- 2 non-maskable interrupt sources
  Internal source: 1(Watchdog timer)
  External source: 1(NMI)
- 24 maskable interrupt sources
  Internal source: 16(SSIO0, SSIO1, UART, I^2C bus master/slave interface, Timer 0, Timer 1, Timer 2, Timer 3, A/D converter, Voice sound reproduction, Speaker pin short detection, TBC128Hz, TBC32Hz, TBC16Hz, TBC2Hz)
  External source: 8(P80, P81, P82, P83, P84, P85, P86, P87)

· Time base counter
- Low-speed time base counter ´ 1 channel
- High-speed time base counter ´ 1 channel

· Watchdog timer
- Generates a non-maskable interrupt upon the first overflow and a system reset occurs upon the second
- Free running
- Overflow period: 4 types selectable (125ms, 500ms, 2s, and 8s at 32.768kHz)

•Timers
- 8 bits × 4ch (16-bit configuration available)

•Voice output function
- Voice synthesis method: 4-bit ADPCM2 / non-linear 8-bit PCM / straight 8-bit PCM / straight 16-bit PCM / HQ-ADPCM
- Sampling frequency: 8kHz, 16kHz, 32 kHz, 10.7kHz, 21.3 kHz, 6.4kHz, 12.8kHz, 25.6 kHz

•Successive approximation type A/D converter
- 10-bit A/D converter
- Input: 3ch (ch0-2:External input) (for ML610Q305) / 4ch (ch0-3:External input) (for ML610Q306)
- Conversion time: 24.4 μs per channel at 4.096MHz V_{DD}≥2.2V
- Conversion time: 12.2 μs per channel at 8.192MHz V_{DD}≥2.5V
- Continuous conversion / Single conversion selectable

•Synchronous serial port
- 2ch
- Master/slave selectable
- LSB first/MSB first selectable
- 8-bit length/16-bit length selectable

•UART
- Half-duplex × 1ch
- TXD/RXD
- Bit length, parity/no parity, odd parity/even parity, 1 stop bit/2 stop bits
- Positive logic/negative logic selectable
- Built-in baud rate generator

•I^2C bus interface
- Master function: standard mode (100 kbps) and Fast mode (400 kbps)
- Slave function: standard mode (100 kbps) and Fast mode (400 kbps)

•General-purpose ports
- Input-only port × 1ch
- Output-only port × 3ch (including secondary functions)
- Input/output port × 12ch (including secondary functions) (P40 to P42 uses also as an A/D converter input port.) (for ML610Q305)
  × 15ch (including secondary functions) (P40 to P43 uses also as an A/D converter input port.) (for ML610Q306)

•Speaker amplifier(D-class) output power
- 1.0W(at 5.0V)/0.45W(at 3.0V)
- Disconnection detection circuit
- Speaker pin short detection circuit

•Reset
- Reset through the RESET_N pin
- Power-on reset generation when powered on
- Reset by the watchdog timer (WDT) overflow
- PLL oscillation stop detection reset
- Low level detection (LLD) reset

•Clock
- Low-speed clock
  Built-in RC oscillation (32.768 kHz)
- High-speed clock
  Built-in PLL oscillation (Approx. 1.024MHz / 2.048MHz / 4.096MHz / 8.192MHz)

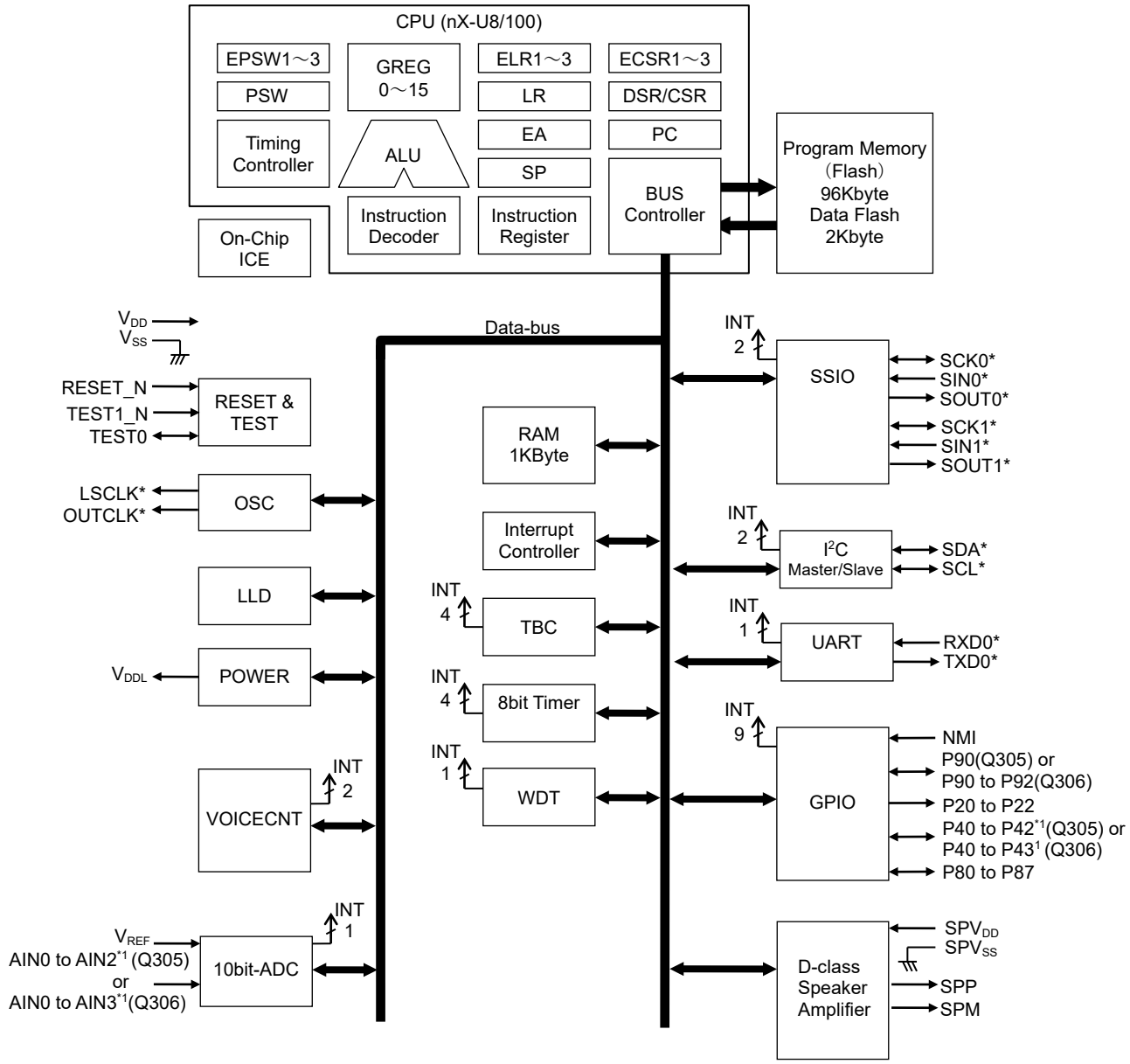
•Power management
- STOP mode: Stop of oscillation (Operations of CPU and peripheral circuits are stopped.)
- HALT mode: Instruction execution by CPU is suspended (peripheral circuits are in operating states).
- Clock gear: The frequency of high-speed system clock can be changed by software (1/2, 1/4, 1/8, or 1/16 of the oscillation clock)
- Block control function: Operation of an intact functional block circuit is powerd down. (register reset and clock stop)

•Shipment
- 32-pin WQFN（P-WQFN32-0505-0.50-A63）
  ML610Q305-xxxGD (blank product: ML610Q305-NNNGD)
- 32-pin TQFP（P-TQFP32-0707-0.80-ZK6 or P-TQFP32-0707-0.80-Z6K6）
  ML610Q305-xxxTB (blank product: ML610Q305-NNNTB)
- 36-pin WQFN（P-WQFN36-0606-0.50-A63）
  ML610Q306-xxxGD (blank product: ML610Q306-NNNGD)
  xxx: ROM code number

•Guaranteed operating range
- Operating temperature: –40°C to 85°C
- Operating voltage: V_{DD} = 2.0V to 5.5V, SPV_{DD} = 2.0V to 5.5V

BLOCK DIAGRAM

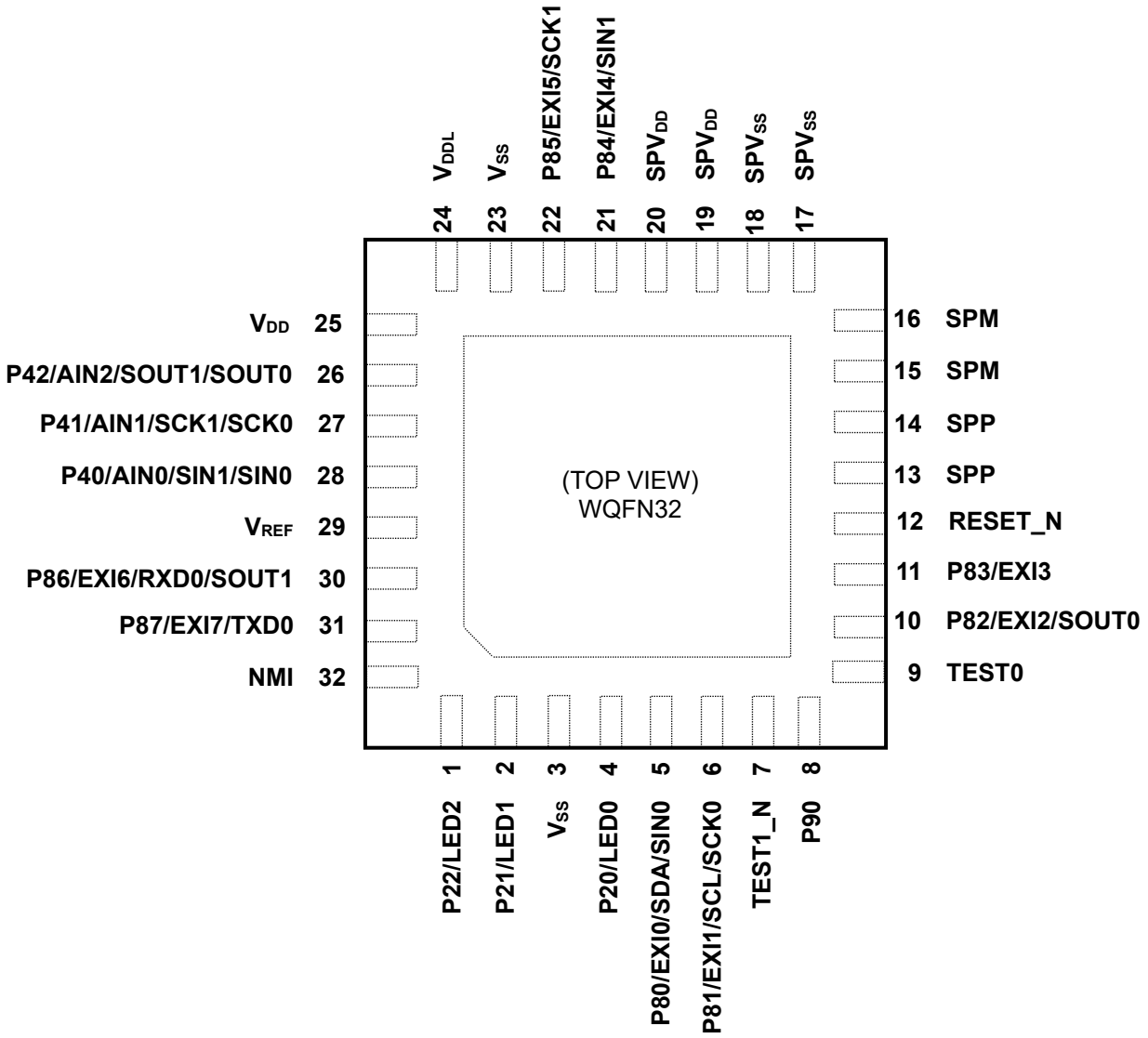
ML610Q305/306 Block Diagram



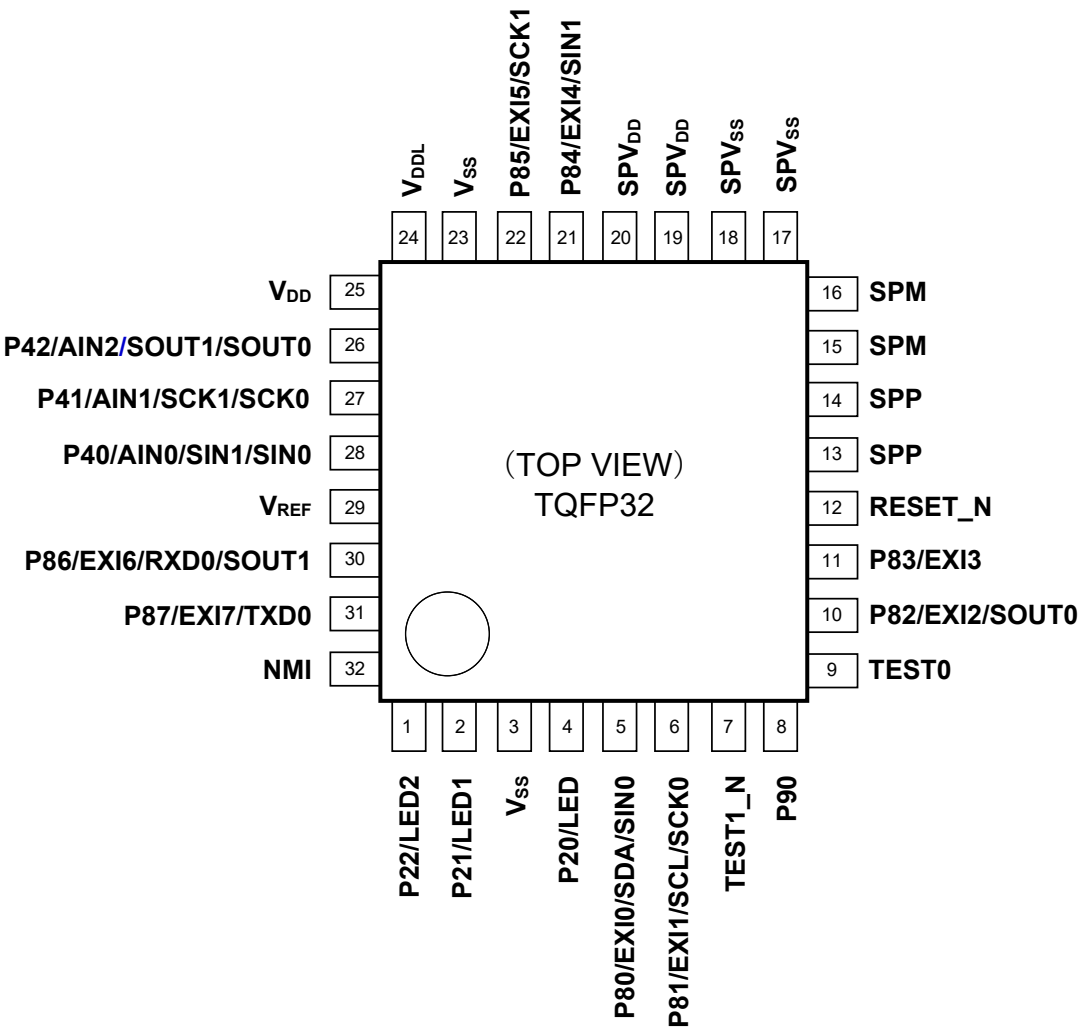
* : Secondary or tertiary function
*1: Select I/O port or A/D converter input terminal

PIN CONFIGURATION

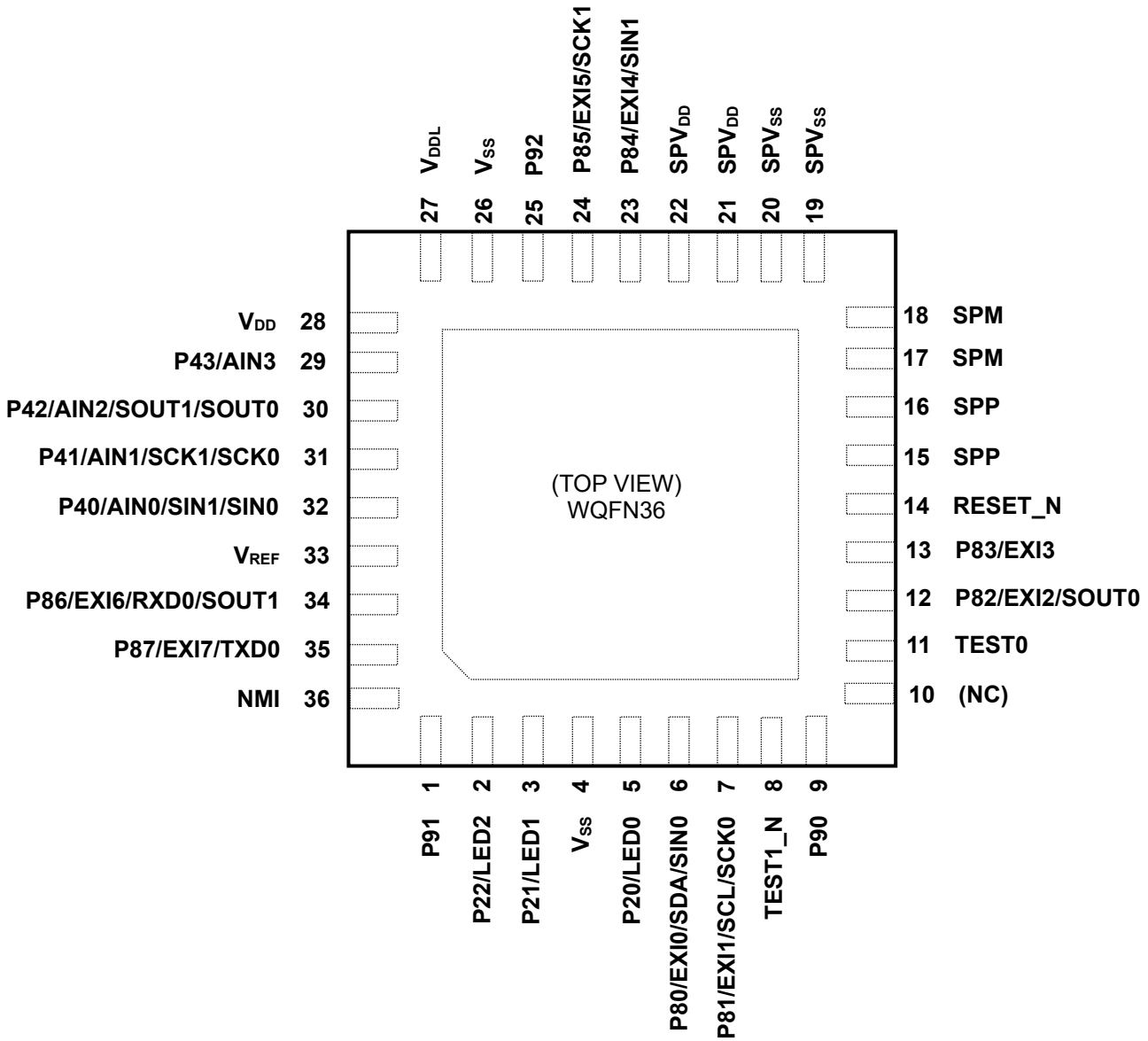
Pin Layout of ML610Q305 32pin WQFN Package(Top View)



Pin Layout of ML610Q305 32pin TQFP Package(Top View)



Pin Layout of ML610Q306 36pin WQFN Package(Top View)



（NC）: No Connection

LIST OF PIN

In the I/O column, "—" denotes a power pin, "I" an input pin, "O" an output pin, and "I/O" an input/output pin.

36pin WQFN	32pin WQFN /TQFP	Primary function			Secondary/Tertiary function			
		Pin name	I/O	Description	Secondary/ Tertiary	Pin name	I/O	Description
15, 16	13, 14	SPP	O	Positive output pin of the built-in speaker amplifier	—	—	—	—
17, 18	15, 16	SPM	O	Negative output pin of the built-in speaker	—	—	—	—
19, 20	17, 18	SPVss	—	Negative power supply pin for built-in speaker amplifier	—	—	—	—
21, 22	19, 20	SPV_{DD}	—	Positive power supply pin for built-in speaker amplifier	—	—	—	—
4, 26	3, 23	V_{SS}	—	Negative power supply pin	—	—	—	—
27	24	V_{DDL}	—	Power supply for internal logic (internally generated)	—	—	—	—
28	25	V_{DD}	—	Positive power supply pin	—	—	—	—
33	29	V_{REF}	—	Reference power supply pin for successive-approximation type ADC	—	—	—	—
14	12	RESET_N	I	Reset input pin	—	—	—	—
11	9	TEST0	I/O	Input/output pin for testing	—	—	—	—
8	7	TEST1_N	I	Input pin for testing	—	—	—	—
36	32	NMI	I	Input port, non-maskable interrupt	—	—	—	—
5	4	P20/LED0	O	Output port / LED port	Secondary	LSCLK	O	Low-speed clock output
3	2	P21/LED1	O	Output port / LED port	Secondary	OUTCLK	O	high-speed clock output
2	1	P22/LED2	O	Output port / LED port	—	—	—	—
9	8	P90	I/O	Input port/Output port	—	—	—	—
1	—	P91	I/O	Input port/Output port	—	—	—	—
25	—	P92	I/O	Input port/Output port	—	—	—	—
32	28	P40/AIN0	I/O	Input port/Output port /Successive-approximation type ADC input0	Secondary	SIN1	I	SSIO1 data input
					Tertiary	SIN0	I	SSIO0 data input
31	27	P41/AIN1	I/O	Input port/Output port /Successive-approximation type ADC input1	Secondary	SCK1	I/O	SSIO1 clock input/output
					Tertiary	SCK0	I/O	SSIO0 clock input/output
30	26	P42/AIN2	I/O	Input port/Output port /Successive-approximation type ADC input2	Secondary	SOUT1	O	SSIO1 data output
					Tertiary	SOUT0	O	SSIO0 data output
29	—	P43/AIN3	I/O	Input port/Output port /Successive-approximation type ADC input3	—	—	—	—
6	5	P80/EXI0	I/O	Input port/Output port / External interrupt	Secondary	SDA	I/O	I^2C data input/ output
					Tertiary	SIN0	I	SSIO0 data input
7	6	P81/EXI1	I/O	Input port/Output port / External interrupt	Secondary	SCL	I/O	I^2C clock input/output
					Tertiary	SCK0	I/O	SSIO0 clock input/output
12	10	P82/EXI2	I/O	Input port/Output port / External interrupt	Tertiary	SOUT0	O	SSIO0 data output
13	11	P83/EXI3	I/O	Input port/Output port / External interrupt	—	—	—	—
23	21	P84/EXI4	I/O	Input port/Output port / External interrupt	Tertiary	SIN1	I	SSIO1 data input
24	22	P85/EXI5	I/O	Input port/Output port / External interrupt	Tertiary	SCK1	I/O	SSIO1 clock input/output
34	30	P86/EXI6	I/O	Input port/Output port / External interrupt	Secondary	RXD0	I	UART0 data input
					Tertiary	SOUT1	O	SSIO1 data output
35	31	P87/EXI7	I/O	Input port/Output port / External interrupt	Secondary	TXD0	O	UART0 data output

Note:

The function which is not chosen is lost when either a secondary function or a tertiary function is chosen. However, when using it as an input, read-out of an input data is possible at a port n data register (PnD).

PIN DESCRIPTION

In the I/O column, "—" denotes a power pin, "I" an input pin, "O" an output pin, and "I/O" an input/output pin.

Pin name	I/O	Description	Primary/ Secondary/ Tertiary	Logic
Power supply				
V_{SS}	—	Negative power supply pin	—	—
V_{DD}	—	Positive power supply pin	—	—
V_{DDL}	—	Positive power supply pin for internal logic (internally generated) Connect the capacitor C_L(1uF)(Refer to Measuring circuit 1) to V_{SS}	—	—
SPV_{SS}	—	Negative power supply pin for built-in speaker amplifier	—	—
SPV_{DD}	—	Positive power supply pin for built-in speaker amplifier	—	—
V_{REF}	—	Reference power supply pin for successive-approximation type ADC	—	—
Test				
TEST0	I/O	Input/output pin for testing. Has a pull-down resistor built in.	—	Positive
TEST1_N	I	Input pin for testing. Has a pull-up resistor built in.	—	Negative
System				
RESET_N	I	Reset input pin. When this pin is set to a "L" level, the device is placed in system reset mode and the internal circuit is initialized. If after that this pin is set to a "H" level, program execution starts. This pin has a pull-up resistor built in.	—	Negative
LSCLK	O	Low-speed clock output. This function is allocated to the secondary function of the P20 pin.	Secondary	—
OUTCLK	O	High-speed clock output. This function is allocated to the secondary function of the P21 pin.	Secondary	—
General-purpose Output port				
P20 to P22	O	General-purpose output ports. Provided with a secondary function. Cannot be used as ports if their secondary function is used.	Primary	Positive
General-purpose Input/output port				
P40 to P42	I/O	General-purpose input/output ports. Provided with a tertiary function. Cannot be used as ports if their tertiary function is used.	Primary	Positive
P43	I/O	General-purpose input/output port. (built into ML610Q306)	Primary	Positive
P80 to P87	I/O	General-purpose input/output ports. Provided with a secondary function or a tertiary function. Cannot be used as ports if their secondary function or tertiary function is used.	Primary	Positive
P90	I/O	General-purpose input/output ports.	Primary	Positive
P91 to P92	I/O	General-purpose input/output port. (built into ML610Q306)	Primary	Positive

Pin name	I/O	Description	Primary/ Secondary/ Tertiary	Logic
I^2C bus interface				
SDA	I/O	I^2C data input/output pin. This pin is used as the secondary function of the P80 pin. This pin has an Nch open drain output. When using this pin as a function of the I^2C, externally connect a pull-up resistor.	Secondary	Positive
SCL	I/O	I^2C clock output pin. This pin is used as the secondary function of the P81 pin. This pin has an Nch open drain output. When using this pin as a function of the I^2C, externally connect a pull-up resistor.	Secondary	Positive
Synchronous serial (SSIO)				
SIN0	I	Synchronous serial data input pin. Allocated to the tertiary function of the P40 pin and P80 pin.	Tertiary	Positive
SCK0	I/O	Synchronous serial clock input/output pin. Allocated to the tertiary function of the P41 pin and P81 pin.	Tertiary	—
SOUT0	O	Synchronous serial data output pin. Allocated to the tertiary function of the P42 pin and P82 pin.	Tertiary	Positive
SIN1	I	Synchronous serial data input pin. Allocated to the tertiary function of the P84 pin and the secondary function of the P40 pin.	Secondary/ Tertiary	Positive
SCK1	I/O	Synchronous serial clock input/output pin. Allocated to the tertiary function of the P85 pin and the secondary function of the P41 pin.	Secondary/ Tertiary	—
SOUT1	O	Synchronous serial data output pin. Allocated to the tertiary function of the P86 pin and the secondary function of the P42 pin.	Secondary/ Tertiary	Positive
UART				
TXD0	O	UART data output pin. Allocated to the secondary function of the P87 pin.	Secondary	Positive
RXD0	I	UART data input pin. Allocated to the secondary function of the P86 pin.	Secondary	Positive
External interrupt				
NMI	I	External non-maskable interrupt input pin. The interrupt occurs on both the rising and falling edges.	Primary	Positive/ Negative
EXI0 to 7	I	External maskable interrupt input pins. It is possible, for each bit, to specify whether the interrupt is enabled and select the interrupt edge by software. Allocated to the primary function of the P80 to P87 pins.	Primary	Positive/ Negative
LED drive				
LED0 to 2	O	Pins for LED driving. Allocated to the primary function of the P20 to P22 pins.	Primary	Positive/ Negative
Voice output function				
SPP	O	Positive output pin of the internal speaker amplifier.	—	—
SPM	O	Negative output pin of the internal speaker amplifier.	—	—
Successive-approximation type A/D converter				
AIN0 to 2	I	Analog inputs to Ch0 to Ch2 of the successive-approximation type A/D converter. Allocated to the primary function of the P40 to P42 pins.	Primary	—
AIN3	I	Analog inputs to Ch3 of the successive-approximation type A/D converter.(built into ML610Q306) Allocated to the primary function of the P43 pins.	Primary	—

TERMINATION OF UNUSED PINS

How to Terminate Unused Pins

Pin	Recommended pin termination
RESET_N	Open
TEST0	Open
TEST1_N	Open or connect to V_{DD} *
V_{REF}	Connect to V_{DD}
P40 to P42 (AIN0 to AIN2)	Open
P43(AIN3) (built into ML610Q306)	Open
SPV_{DD}	Connect to V_{DD}
SPV_{SS}	Connect to V_{SS}
SPP	Open
SPM	Open
P20 to P22	Open
P80 to P87	Open
P90	Open
P91 to P92(built into ML610Q306)	Open
NMI	Open or connect to V_{DD} *

*: TEST1_N pin (Typ.10kΩ) and NMI pin (Typ.100kΩ) have the built-in pull-up resistor. It is recommened to connect to V_{DD} or be pulled up by around 1kΩ resistor in a severe enviroment such as noise.

Notes:
- The unused input ports or unused input/output ports should not be configured as high-impedance inputs and left open. If the corresponding pins are configured as high-impedance inputs and left open, because the input buffer of both Nch and Pch MOS transistor turn on, the supply current may become excessively large. Therefore, it is recommended to configure those pins as either inputs with a pull-down resistor/pull-up resistor or outputs.
- When the power is turned on, the state of the general-purpose port is undefined. Therefore, there is a possibility of outputting high-level or low-level.If the undefined state at the power-on is a problem, take measures with the peripheral components on the user board.

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

(V_{SS}= SPV_{SS}=0V)

Parameter	Symbol	Condition	Rating	Unit
Power supply voltage 1	V_{DD}	Ta=25°C	−0.3 to +6.5	V
Power supply voltage 2	SPV_{DD}	Ta=25°C	−0.3 to +6.5	V
Power supply voltage 3	V_{DDL}	Ta=25°C	−0.3 to +2.0	V
Reference supply voltage	V_{REF}	Ta=25°C	−0.3 to V_{DD}+0.3	V
Input voltage	V_{IN}	Ta=25°C	−0.3 to V_{DD}+0.3	V
Output voltage	V_{OUT}	Ta=25°C	−0.3 to V_{DD}+0.3	V
Output current 1 (P40 to P42, P43[*1], P80 to P87, P90, P91 to P92[*1])	I_{OUT1}	Ta=25°C	−12 to +11	mA
Output current 2 (P20 to P22)	I_{OUT2}	Ta=25°C When setting Nch open drain mode.	−12 to +20	mA
Power dissipation	PD	Ta=25°C	1.0	W
Storage temperature	T_{STG}	—	−55 to +150	°C

[*1] :P43, P91 to P92 are built into ML610Q306

Recommended Operating Conditions

(V_{SS}= SPV_{SS}=0V)

Parameter	Symbol	Condition	Range	Unit
Operating temperature	T_{OP}	—	−40 to +85	°C
Operating voltage	V_{DD}	—	2.0 to 5.5	V
	SPV_{DD}	—	2.0 to 5.5	
Reference supply voltage	V_{REF}	$V_{DD} \geq V_{REF}$	2.2 to V_{DD}	V
Operating frequency (CPU)	f_{OP}	V_{DD} = 2.0 to 5.5V	27k to 4.2M	Hz
		V_{DD} = 2.2 to 5.5V	4.2M to 8.4M	
Capacitor externally connected to V_{DD} pin	C_V	—	More than 1.0±30%	µF
Capacitor externally connected to V_{DDL} pin	C_L	—	1.0±30%	µF

Operating Conditions of Flash Memory

(V_{SS}= SPV_{SS}=0V)

Parameter	Symbol	Condition		Range	Unit
Operating temperature	T_{OP}	At write/erase (Data flash area)		-40 to +70	°C
		At write/erase (Program code area)		0 to +40	
Operating voltage	V_{DD}	At write/erase		2.2 to 5.5	V
Maximum rewrite count*1	C_{EPD}	Data flash area(512Byte x 4)		10,000	cycles
	C_{EPP}	Program code area		100	
Erase unit	—	Chip erase		All program and data area	—
	—	Block erase	Program area	16	KB
			Data area	2	
	—	Sector erase		512	B
Erase time(Maximum)	—	Chip/Block/Sector erase		50	ms
Program unit	—	—		1word(2Bytes)	—
Program time(Maximum)	—	1word(2Bytes)		40	µs
Write cycles	Y_{DR}	—		15	years

*1 : It means one erase and one program. Even when erasing is interrupted, it counts as one time.

DC Characteristics (Supply Current)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition		Rating			Unit	Measuring circuit
				Min.	Typ.	Max.		
Supply current 1	IDD1	CPU: In STOP state. Low-speed/high-speed oscillation: stopped	Ta≤+50°C	—	0.5	3.0	µA	1
			Ta≤+85°C	—	0.5	8.0		
Supply current 2	IDD2	CPU: In HALT state (LTBC,WDT: Operating) High-speed oscillation: Stopped	Ta≤+50°C	—	2.0	5.0		
			Ta≤+85°C	—	2.0	10		
Supply current 3	IDD3	CPU: Running at 32.768 kHz*1 High-speed oscillation: Stopped		—	15	30		
Supply current 4	IDD4	CPU: Running at 4.096MHz CR oscillating mode	V_{DD}=SPV_{DD}= 3.0V	—	1.0	2.5	mA	
			V_{DD}=SPV_{DD}= 5.0V	—	1.0	2.5		
		CPU: Running at 8.192MHz CR oscillating mode	V_{DD}=SPV_{DD}= 3.0V	—	2.0	3.5		
			V_{DD}=SPV_{DD}= 5.0V	—	2.0	3.5		
Supply current 5	IDD5	CPU: Running at 4.096MHz CR oscillating mode During voice playback of 1KHz,2.98db,SIN-wave (no output load)	V_{DD}=SPV_{DD}= 3.0V	—	2.0	5.0		
			V_{DD}=SPV_{DD}= 5.0V	—	4.0	8.0		
		CPU: Running at 8.192MHz CR oscillating mode During voice playback of 1KHz,2.98db,SIN-wave (no output load)	V_{DD}=SPV_{DD}= 3.0V	—	3.0	6.0		
			V_{DD}=SPV_{DD}= 5.0V	—	5.0	9.0		

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

DC Characteristics (VOHL, IOHL, IIHL)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition		Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Output voltage 1 (P20 to P22) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	VOH1	IOH1=−0.5mA (When one port is selected as output mode)		V_{DD} −0.5	—	—	V	2
	VOL1	IOL1=+0.5mA (When one port is selected as output mode)		—	—	0.5		
Output voltage 2 (P20 to P22)	VOL2	(When one port is selected as Nch open drain mode)	IOL2=+5mA V_{DD}≥2.2V	—	—	0.5		
			IOL2=+8mA V_{DD}≥2.3V	—	—	0.5		
Output voltage 3 (P80 to P81)	VOL3	IOL3=+3mA (I^2C bus input/output mode, When one port is selected as output)		—	—	0.4		
Output leakage (P20 to P22) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	IOOH	VOH=V_{DD} (in high-impedance state)		—	—	1.0	μA	3
	IOOL	VOL=V_{SS} (in high-impedance state)		−1.0	—	—		
Input current 1 (RESET_N) (TEST1_N)	IIH1	VIH1=V_{DD}		0	—	1.0	μA	4
	IIL1	VIL1=V_{SS}		−1500	−300	−20		
Input current 2 (NMI) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	IIH2	VIH2=V_{DD} (when pulled-down)		2	30	250		
	IIL2	VIL2=V_{SS} (when pulled-up)		−250	−30	−2		
	IIH2Z	VIH2=V_{DD} (in high-impedance state)		—	—	1.0		
	IIL2Z	VIL2=V_{SS} (in high-impedance state)		−1.0	—	—		
Input current 3 (TEST0)	IIH3	VIH3=V_{DD}		20	300	1500		
	IIL3	VIL3=V_{SS}		−1.0	—	—		

[*1] P43, P91 to P92 are built into ML610Q306

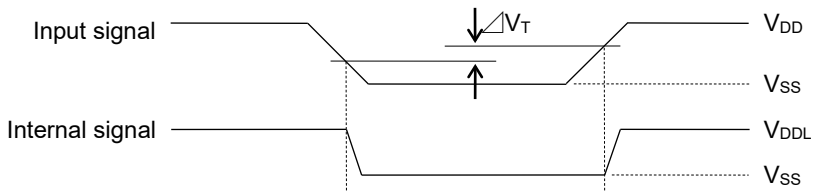
DC Characteristics (VIHL)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit	Measuring circuit
			Min.	Typ.	Max.		
Input voltage 1 (RESET_N) (TEST0) (TEST1_N) (NMI) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	VIH1	—	0.7×V_{DD}	—	V_{DD}	V	5
	VIL1	—	0	—	0.3×V_{DD}		
Hysteresis width (RESET_N) (TEST0) (TEST1_N) (NMI) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	⊿V_T	—	0.05×V_{DD}	—	0.4×V_{DD}		
Input pin capacitance (NMI) (P40 to P42, P43[*1]) (P80 to P87) (P90, P91 to P92[*1])	CIN	f=10kHz V_{rms}=50mV Ta=25°C	—	—	10	pF	—

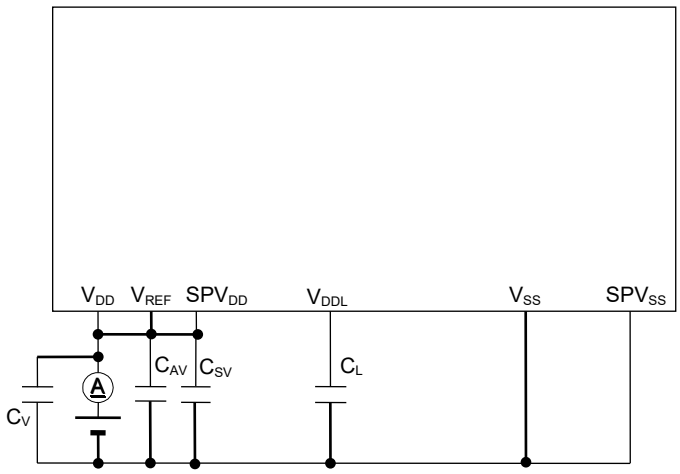
[*1] : P43, P91 to P92 are built into ML610Q306

Hysteresis Width



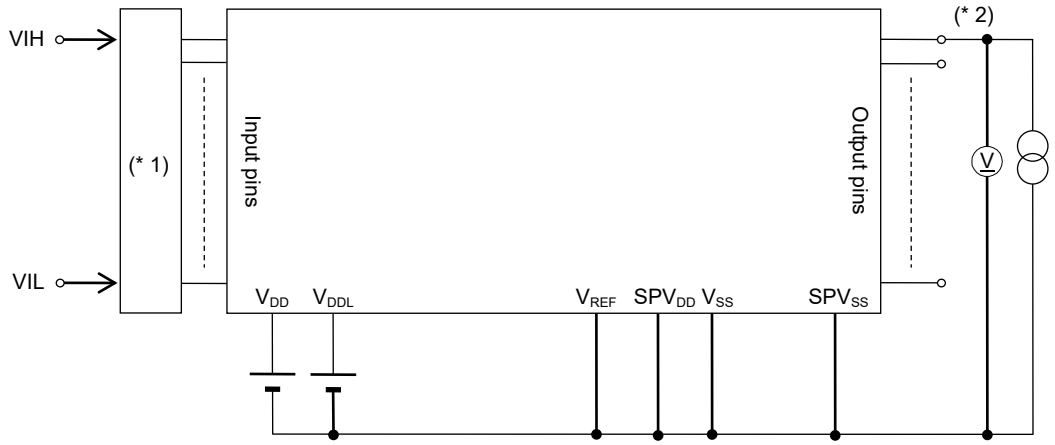
Measuring circuit

・Measuring circuit 1



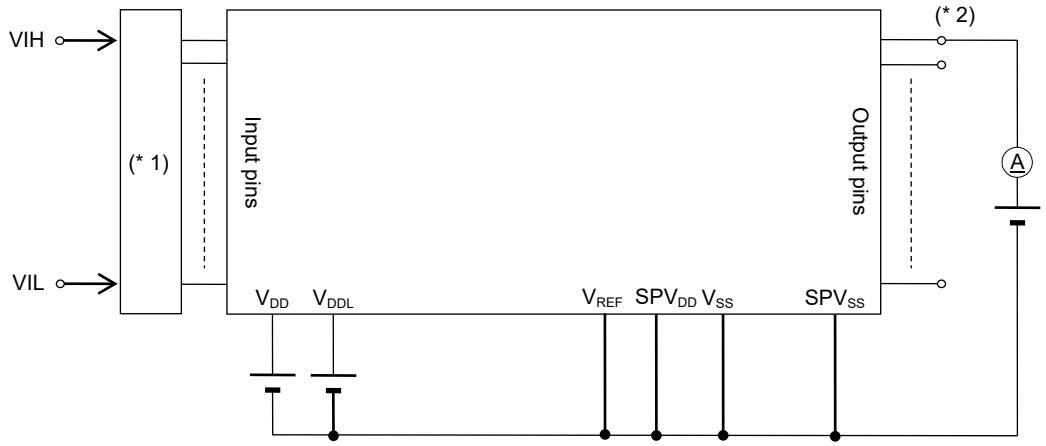
C_V : 1.0μF
C_{SV} : 1.0μF
C_{AV} : 1.0μF
C_L : 1.0μF

・Measuring circuit 2



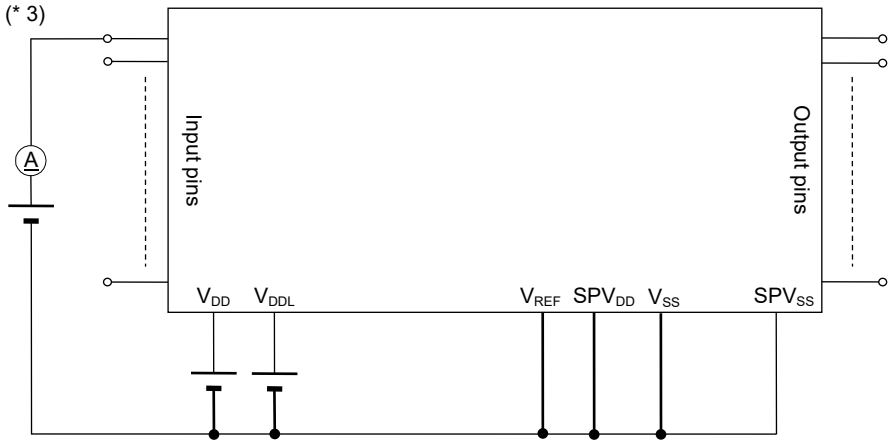
(* 1) Input logic circuit to determine the specified measuring conditions.
(* 2) Measured at the specified output pins.

・Measuring circuit 3



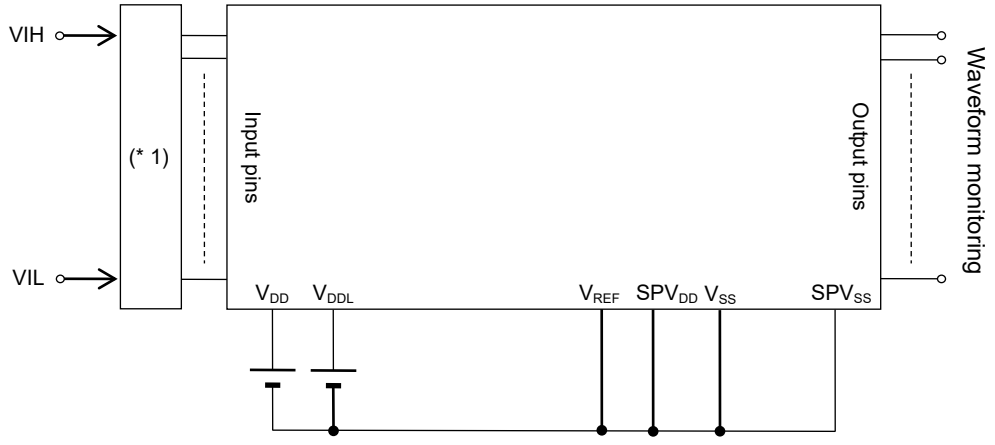
(* 1) Input logic circuit to determine the specified measuring conditions.
(* 2) Measured at the specified output pins.

・Measuring circuit 4



(* 3) Measured at the specified output pins.

・Measuring circuit 5



(* 1) Input logic circuit to determine the specified measuring conditions.

AC Characteristics (Oscillation Circuit)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit	Measuring Circuit
			Min.	Typ.	Max.		
Built-in low-speed RC oscillation frequency	f_{LCR}	Ta = −10 to +50°C	Typ -1.5%	32.768	Typ +1.5%	kHz	1
		Ta = −40 to +85°C	Typ -3.0%		Typ +3.0%		
PLL oscillation frequency	f_{HPLL}	Ta = −10 to +50°C	Typ -1.5%	4.096 or 8.192	Typ +1.5%	MHz	
		Ta = −40 to +85°C	Typ -3.0%		Typ +3.0%		

AC Characteristics (Speaker amp)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

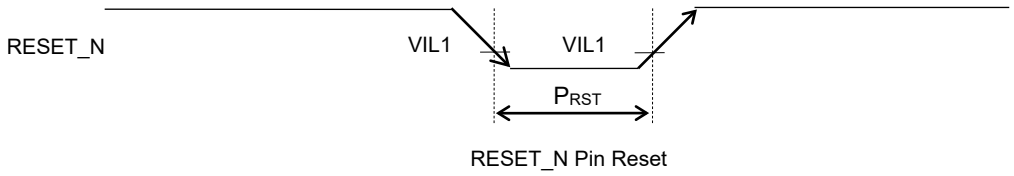
Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
SPM, SPP output load resistance	R_{LSP}	—	6.4	8	—	Ω
Speaker amp output power	P_{SPO1}	SPV_{DD}=3.0V, f=1kHz R_{SPO}=8Ω, THD≥10%	—	0.45	—	W
	P_{SPO2}	SPV_{DD}=5.0V, f=1kHz R_{SPO}=8Ω, THD≥10%	—	1.0	—	

AC Characteristics (Power on, Reset Sequence)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit	Measuring circuit
			Min.	Typ.	Max.		
Time until it starts SPV_{DD} after starting V_{DD}	t_{VDD}	—	0	—	—	ns	1
Reset *1 pulse width	P_{RST}	—	100	—	—	µs	
Reset *1 noise elimination pulse width	P_{NRST}	—	—	—	0.4		
Power-on rising slope	S_{POR}	—	0.1	—	—	V/ms	

*1 : reset from RESET_N pin



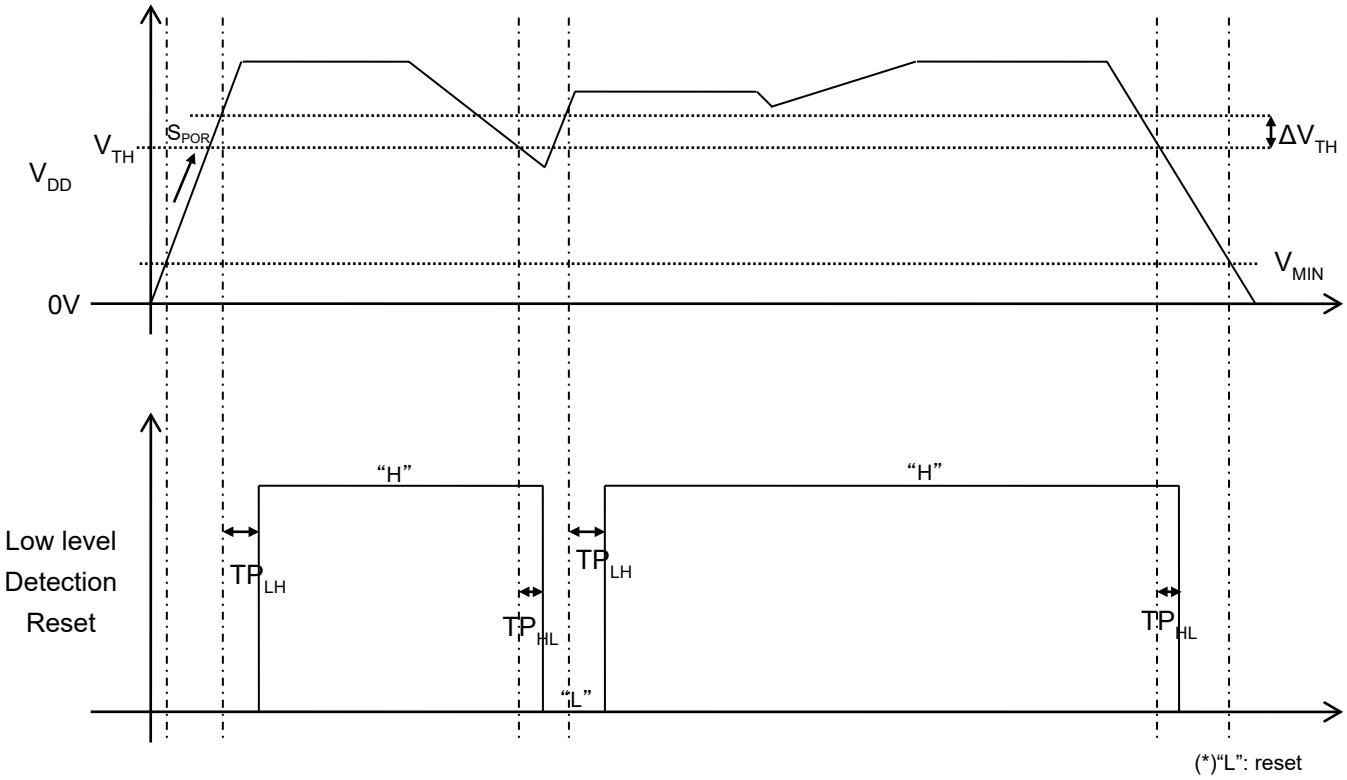
RESET_N Pin Reset

Power-on rising slope

AC Characteristics (Low Level Detection Reset)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

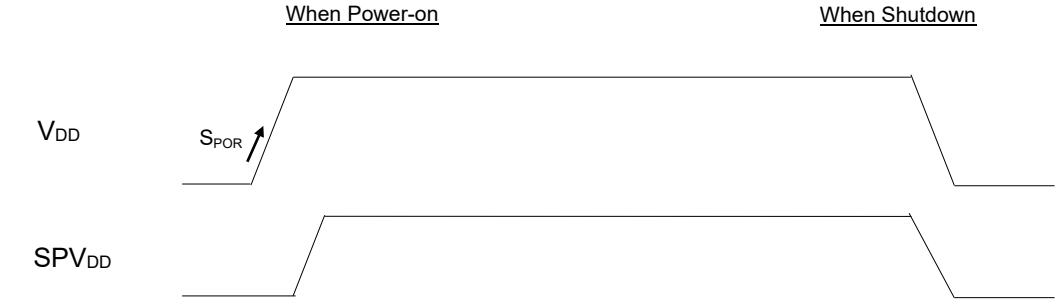
Parameter	Symbol	Condition	Rating			Unit	Measuring circuit
			Min.	Typ.	Max.		
Detection voltage	V_{TH}	LLD1-0=3H	Typ. -5%	1.9	Typ. +5%	V	1
		LLD1-0=2H	Typ. -5%	2.1	Typ. +5%		
		LLD1-0=1H	Typ. -5%	2.3	Typ. +5%		
		LLD1-0=0H	Typ. -5%	2.5	Typ. +5%		
Hysteresis width	Δ_{TH}	—	0.05	0.1	0.15	V	
Output delay when power rising	TP_{LH}	—	—	10	200	μs	
Output delay when power falling	TP_{HL}	—	—	10	200	μs	
Low level detection reset operating voltage	V_{MIN}	—	1.0	—	—	V	



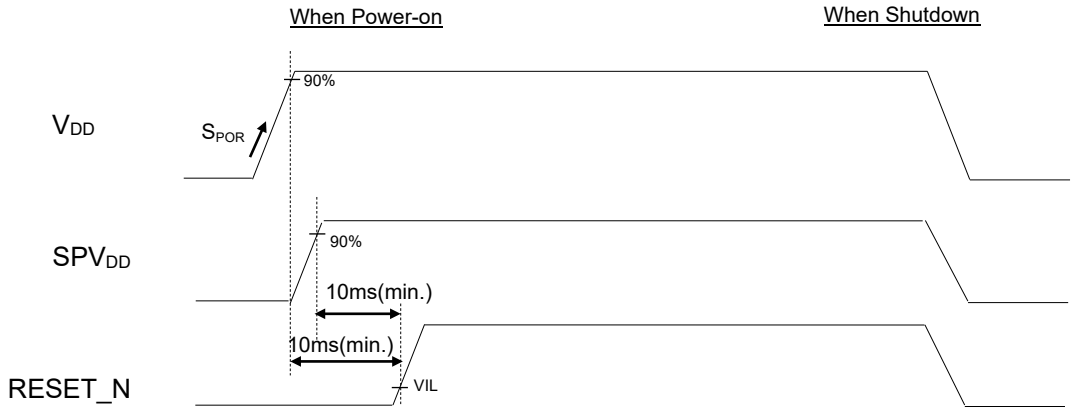
Note:
When the detection voltage of Low Level Detection Reset (V_{TH}) is set to 1.9V(LLD1-0=3H), Low Level Detection Reset is not asserted in the voltage lange from lower minimum recommended operating volatge (V_{DD}=2.0V) to upper detection voltage (V_{TH}=1.9V). During power shutdown sequence, if this voltage lange is kept, depending on the LSI operationg condition, the internal regulated power supply circuit (VRL) can not keep the operationg votage, and the program may NOT operate properly. Therefore, please take measures, such as, setting Low Level Detection Reset (V_{TH}) to except 1.9V (LLD1-0 =3H), and reset generation from RESET_N pin for fail-safe

Power-on/Shutdown Sequence

・When the power-on rising slope is 0.1V/ms(Min.)



・When the power-on rising slope is less than 0.1V/ms(Min.)



Recommended power-on/shutdown sequence
There are no ristrictions of order, slope time, time lag in turnning on/off V_{DD} and SPV_{DD}.

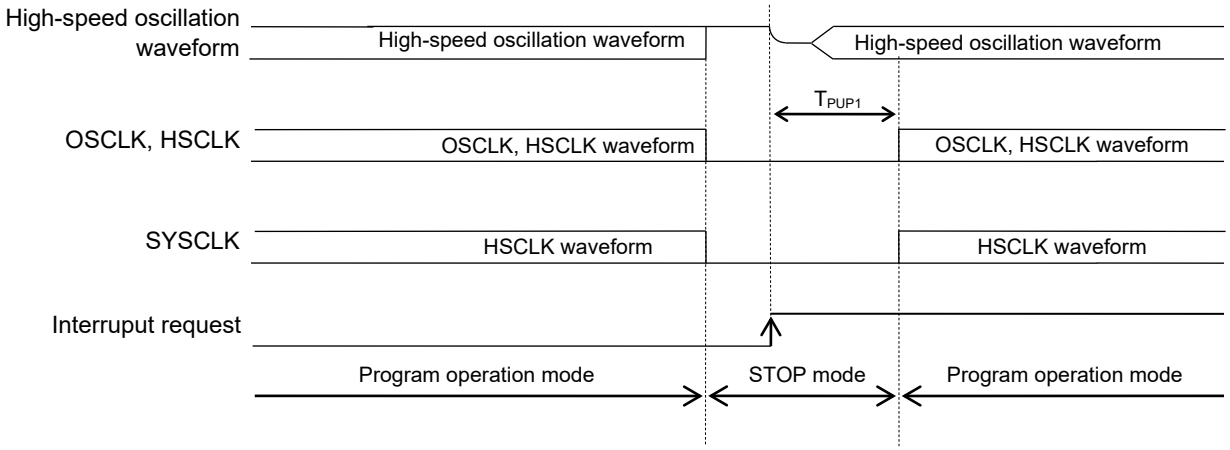
Notes:

- When the power is turned on, the state of the general-purpose port is undefined. Therefore, there is a possibility of outputting high-level or low-level.If the undefined state at the power-on is a problem, take measures with the peripheral components on the user board.
- When power-on reset is generated because of instantaneous power failure etc., or, when the glitch which is narrower than output delay when power falling (TP_{HL}) is generated on V_{DD} power, or, When V_{DD} power is decreased below low level detection reset operating voltage (V_{MIN}) before output delay when power falling (TP_{HL}) is passed, the LSI may NOT get reset, and the program may NOT operate properly. Therefore, please take measures, such as, power voltage drop prevention by bypass capacitors, and reset generation from RESET_N pin for fail-safe.

AC Characteristics (Oscillation stable time after STOP release)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

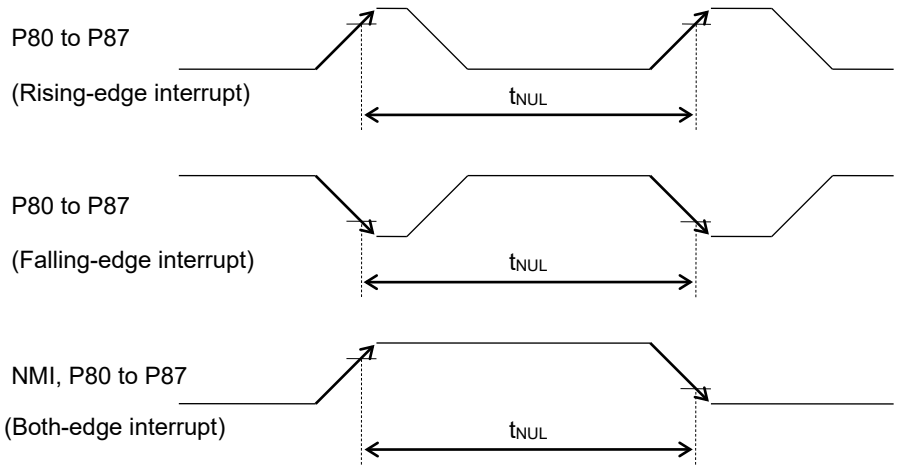
Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Oscillation stable time after STOP release	T_{PUP1}	—	—	—	2	ms



AC Characteristics (External Interrupt)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
External interrupt disable period	T_{NUL}	Interrupt: Enabled (MIE=1) CPU: NOP operation	2.5×sysclk	—	3.5×sysclk	µs

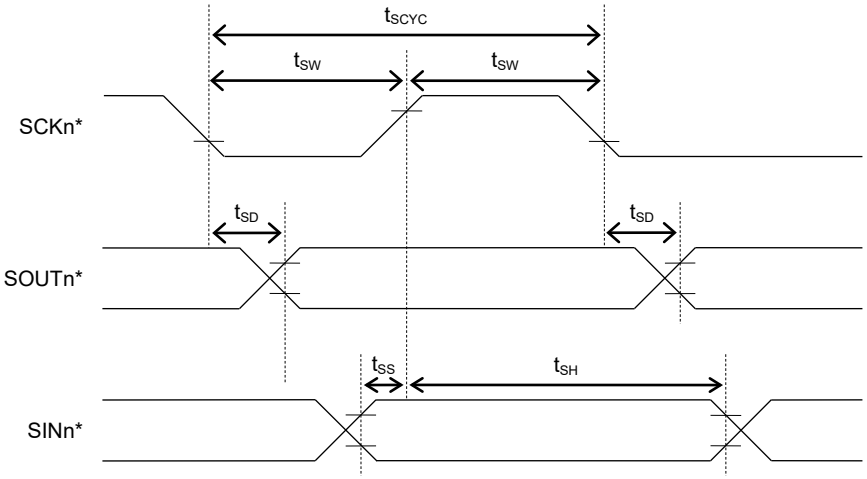


AC Characteristics (Synchronous Serial Port)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
SCK input cycle (slave mode)	t_{SCYC}	When high-speed oscillation is not active	10	—	—	µs
		When high-speed oscillation is active	500	—	—	ns
SCK output cycle (master mode)	t_{SCYC}	VDD≥2.4V	—	4	—	MHz
		VDD≥2.0V	—	2	—	
SCK input pulse width (slave mode)	t_{SW}	When high-speed oscillation is not active	4	—	—	µs
		When high-speed oscillation is active	200	—	—	ns
SCK output pulse width (master mode)	t_{SW}	—	SCK*1 ×0.4	SCK*1 ×0.5	SCK*1 ×0.6	s
SOUT output delay time (slave mode)	t_{SD}	—	—	—	180	ns
SOUT output delay time (master mode)	t_{SD}	—	—	—	80	ns
SIN input setup time (slave mode)	t_{SS}	—	50	—	—	ns
SIN input hold time	t_{SH}	—	50	—	—	ns

*1: Clock period selected with SnCK3–0 of the serial port n mode register (SIOnMOD1) (n=0,1)



*: Indicates the secondary function of the port. n=0, 1

AC Characteristics (I^2C Bus Interface: Standard Mode 100kbps)

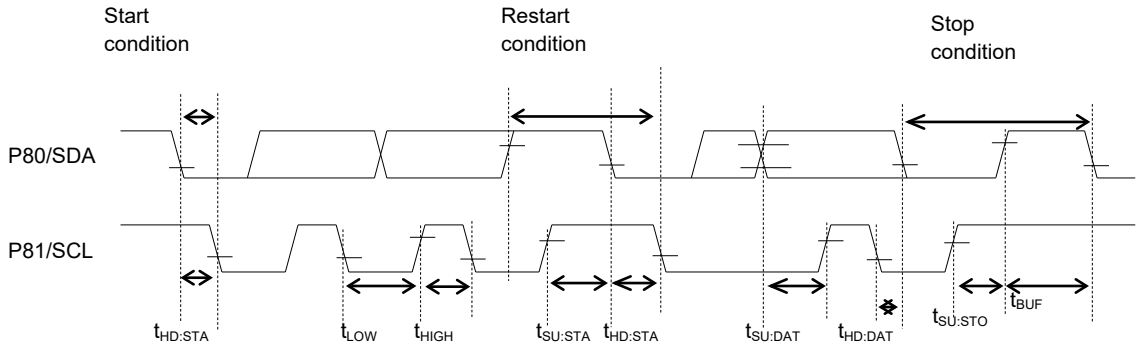
(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
SCL clock frequency	f_{SCL}	—	0	—	100	kHz
SCL hold time (start/restart condition)	$t_{HD:STA}$	—	4.0	—	—	µs
SCL "L" level time	t_{LOW}	—	4.7	—	—	µs
SCL "H" level time	t_{HIGH}	—	4.0	—	—	µs
SCL setup time (restart condition)	$t_{SU:STA}$	—	4.7	—	—	µs
SDA hold time	$t_{HD:DAT}$	—	0	—	—	µs
SDA setup time	$t_{SU:DAT}$	—	0.25	—	—	µs
SDA setup time (stop condition)	$t_{SU:STO}$	—	4.0	—	—	µs
Bus-free time	t_{BUF}	—	4.7	—	—	µs

AC Characteristics (I^2C Bus Interface: Fast Mode 400kbps)

(V_{DD}= 2.0 to 5.5V, SPV_{DD}=2.0 to 5.5V, V_{SS}= SPV_{SS}=0V, Ta=−40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
SCL clock frequency	f_{SCL}	—	0	—	400	kHz
SCL hold time (start/restart condition)	$t_{HD:STA}$	—	0.6	—	—	µs
SCL "L" level time	t_{LOW}	—	1.3	—	—	µs
SCL "H" level time	t_{HIGH}	—	0.6	—	—	µs
SCL setup time (restart condition)	$t_{SU:STA}$	—	0.6	—	—	µs
SDA hold time	$t_{HD:DAT}$	—	0	—	—	µs
SDA setup time	$t_{SU:DAT}$	—	0.1	—	—	µs
SDA setup time (stop condition)	$t_{SU:STO}$	—	0.6	—	—	µs
Bus-free time	t_{BUF}	—	1.3	—	—	µs

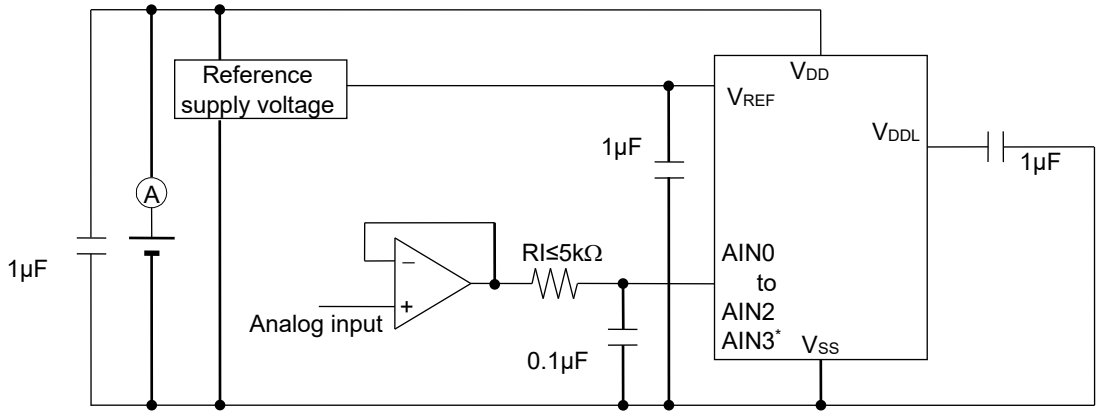


Electrical Characteristics of Successive Approximation Type A/D Converter

(V_{DD}=SPV_{DD}=2.2 to 5.5V, V_{REF}=2.2 to 5.5V, V_{SS}=SPV_{SS}=0V, Ta=–40 to +85°C, unless otherwise specified)

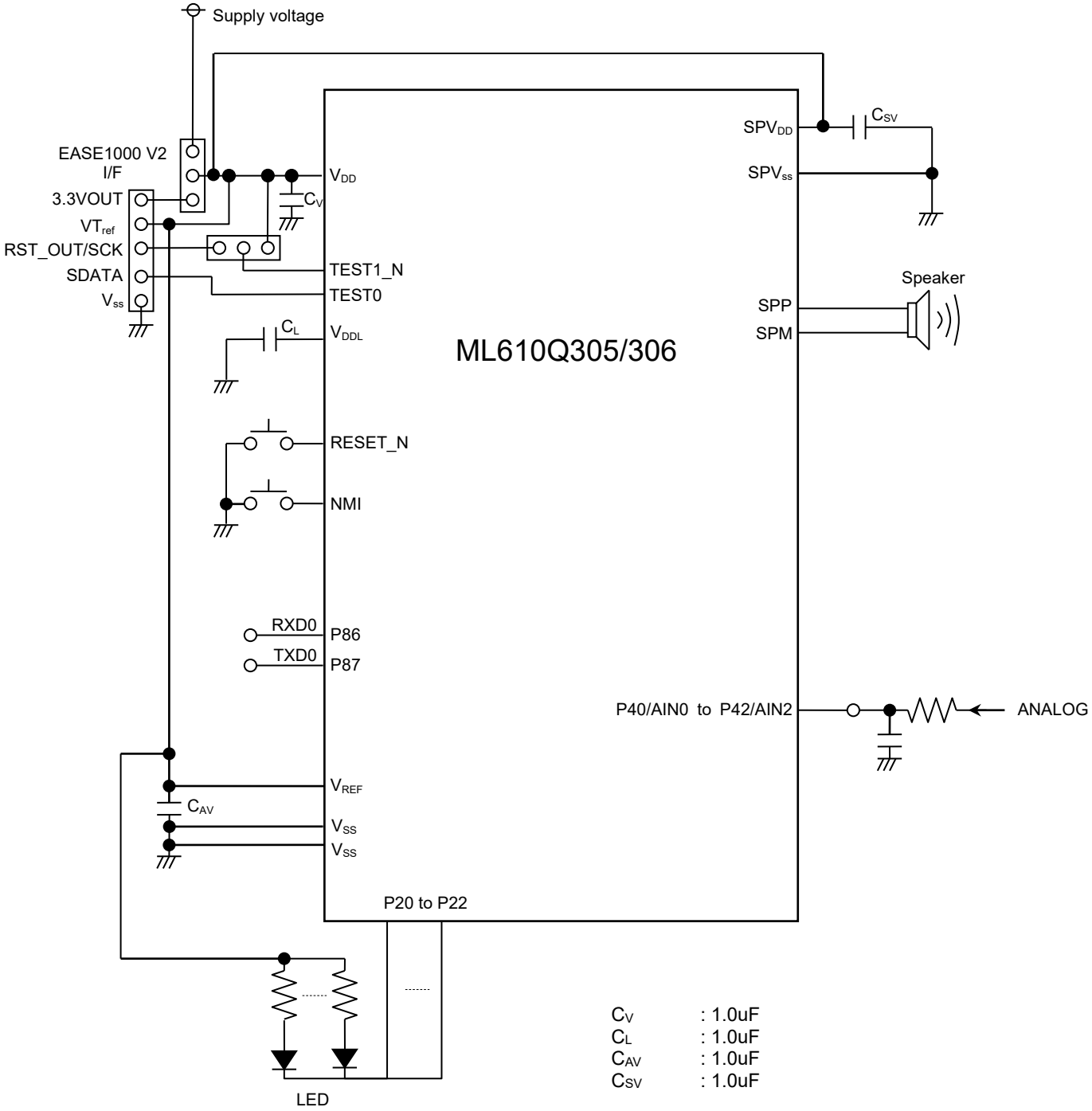
Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Resolution	n	—	—	—	10	bit
Integral non-linearity error	IDL	2.7V≤V_{REF}≤5.5V	–4	—	+4	LSB
		2.2V≤V_{REF}≤2.7V	–5	—	+5	
Differential non-linearity error	DNL	2.7V≤V_{REF}≤5.5V	–3	—	+3	
		2.2V≤V_{REF}≤2.7V	–4	—	+4	
Zero-scale error	V_{OFF}	R_I≤5kΩ	–4	—	+4	
Full-scale error	FSE	R_I≤5kΩ	–4	—	+4	
Prefilter resistance	R_I	—	—	—	5k	Ω
Reference supply voltage	V_{REF}	—	2.2	—	V_{DD}	V
Conversion time	t_{CONV}	HSCLK=4M to 8.4MHz	—	102	—	ϕ/CH

ϕ: Period of high-speed clock (HSCLK)



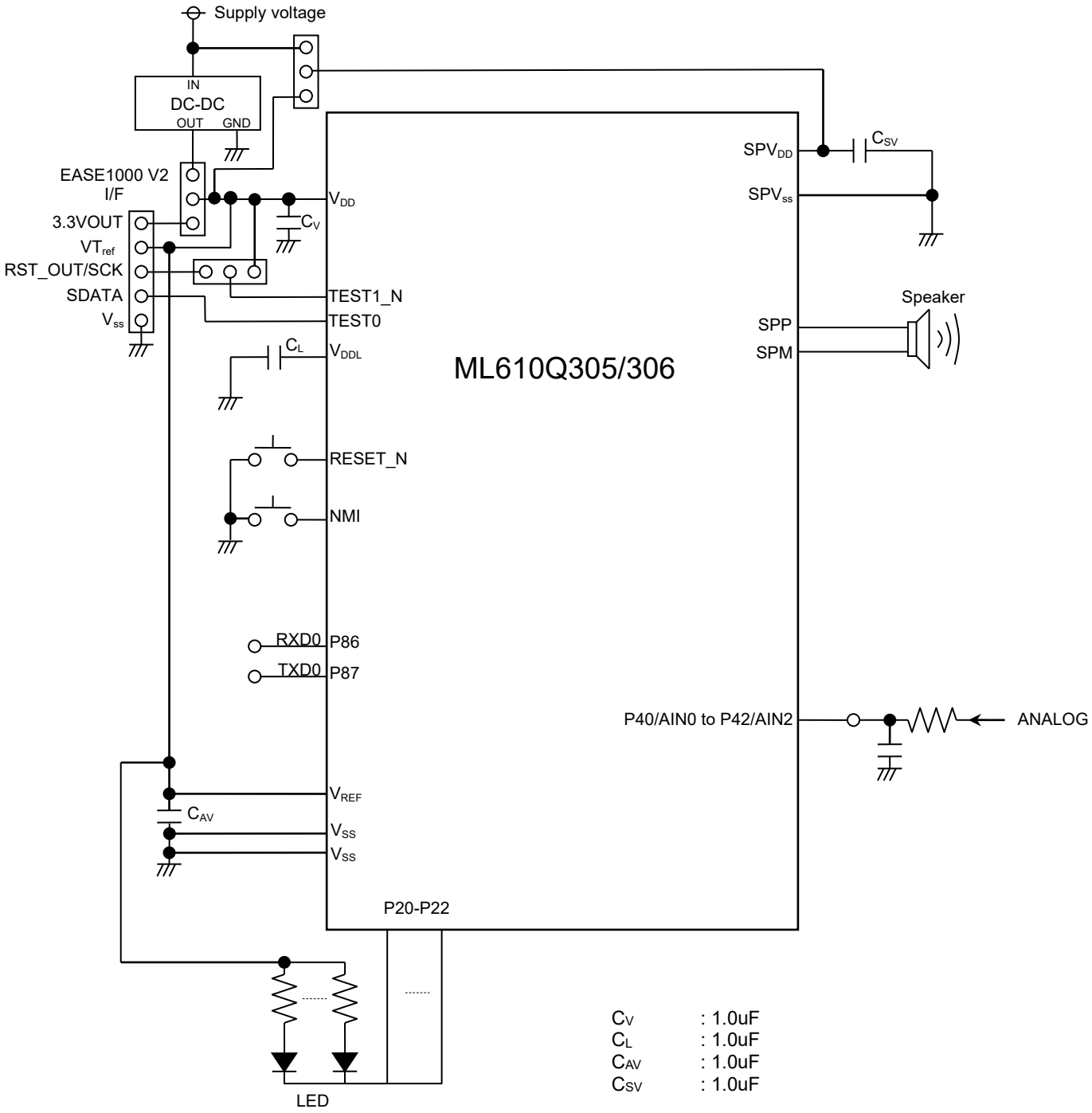
* AIN3 is built into ML610Q306

Example of Application Circuit



V_{DD} and SPV_{DD} are supplied from same power supply

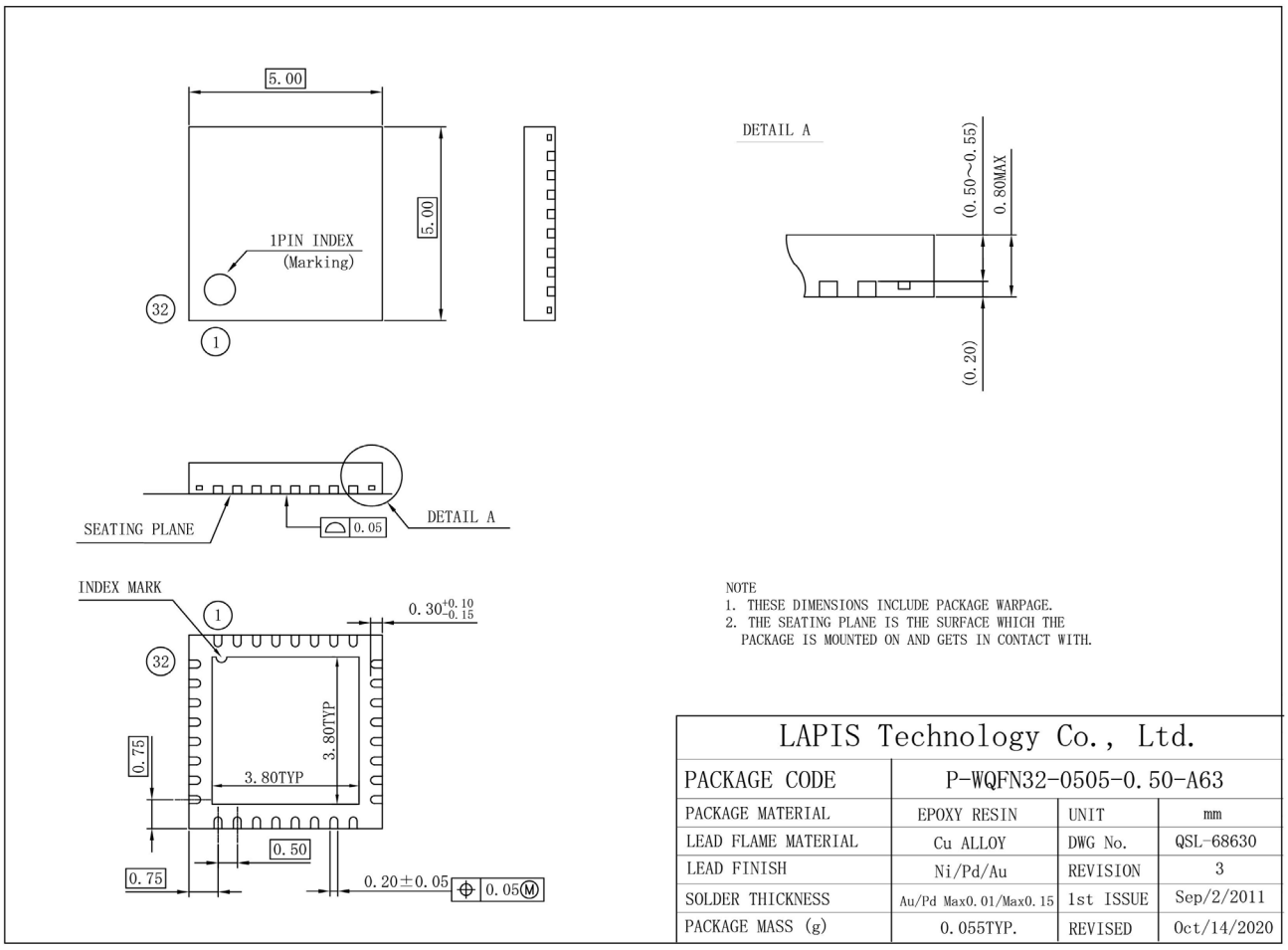
Note:
Design the PCB layout having the shortest wiring distance between V_{DDL} pin and V_{DDL} pin's external capacitor (C_L), and between V_{DDL} pin's external capacitor (C_L) and V_{SS} for noise reduction purpose.



V_{DD} is supplied through DC-DC converter from SPV_{DD}

Note:
Design the PCB layout having the shortest wiring distance between V_{DDL} pin and V_{DDL} pin's external capacitor (C_L), and between V_{DDL} pin's external capacitor (C_L) and V_{SS} for noise reduction purpose.

PACKAGE DIMENSIONS (32pin WQFN)



LAPIS Technology Co., Ltd.			
PACKAGE CODE	P-WQFN32-0505-0.50-A63		
PACKAGE MATERIAL	EPOXY RESIN	UNIT	mm
LEAD FLAME MATERIAL	Cu ALLOY	DWG No.	QSL-68630
LEAD FINISH	Ni/Pd/Au	REVISION	3
SOLDER THICKNESS	Au/Pd Max0.01/Max0.15	1st ISSUE	Sep/2/2011
PACKAGE MASS (g)	0.055TYP.	REVISED	Oct/14/2020

Notes for Mounting the Surface Mount Type Package

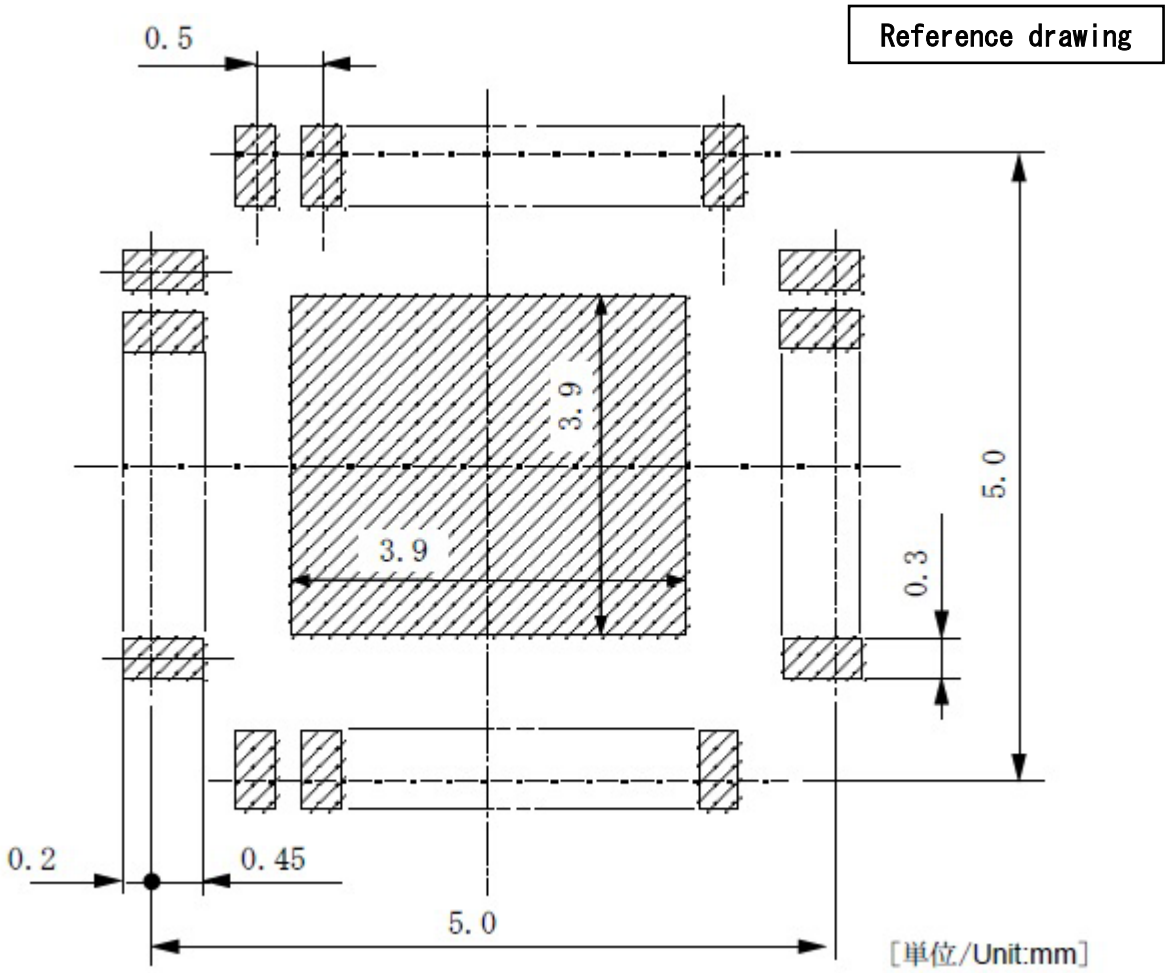
The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact a ROHM sales office for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature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

The heat resistance (example) of this LSI is shown below. Heat resistance (θ Ja) changes with the size and the number of layers of a substrate.

PCB	W/L/t=76.2 / 114.3 / 1.6(mm)
PCB Layer	JEDEC 4layers
Air cooling conditions	Calm(0m/sec)
Heat resistance(θJa)	32.2[°C/W] (back diepad contact)
Power consumption of Chip PMax	0.300[W]

TjMax of this LSI is 110 °C. TjMax is expressed with the following formulas.
TjMax = TaMax + θJa × PMax

Figure of soldering department terminal existence range (32pin WQFN)

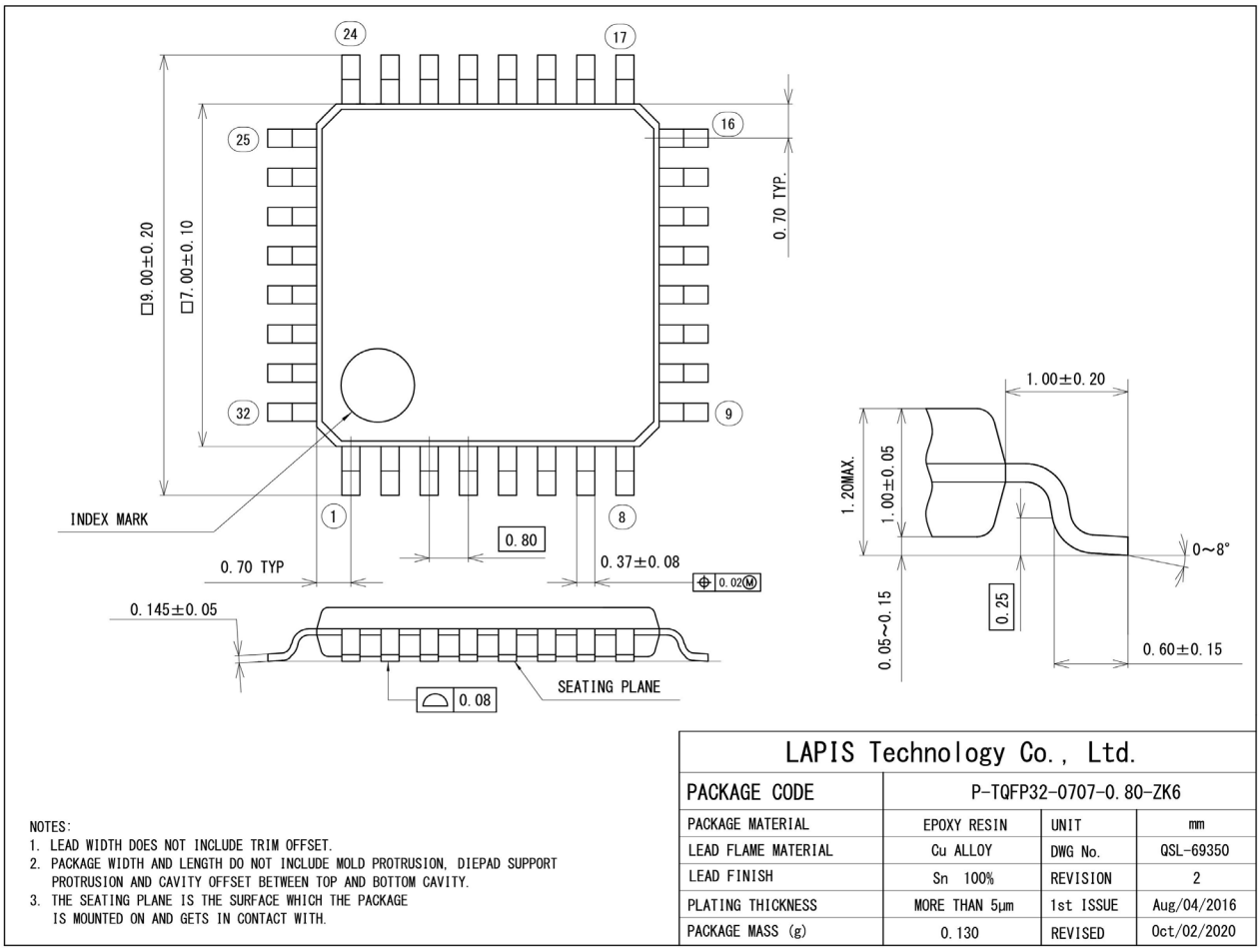


Attention of the layout of a mounting board

Please take into consideration enough that there are not ease of a mounting, the reliability of contact, leading about of a wiring, and a solder bridge generate in the case of layout of the foot pattern of a mounting board.

The optimal layout of a foot pattern changes by the board quality of material, the solder paste category to be used, thickness, the soldering methodology, etc. Therefore, since the span where the terminator of this package may exist is shown as a "soldering part terminator extent drawing", please give as reference data of a foot pattern design.

PACKAGE DIMENSIONS (32pin TQFP)



NOTES:
1. LEAD WIDTH DOES NOT INCLUDE TRIM OFFSET.
2. PACKAGE WIDTH AND LENGTH DO NOT INCLUDE MOLD PROTRUSION, DIEPAD SUPPORT PROTRUSION AND CAVITY OFFSET BETWEEN TOP AND BOTTOM CAVITY.
3. THE SEATING PLANE IS THE SURFACE WHICH THE PACKAGE IS MOUNTED ON AND GETS IN CONTACT WITH.

LAPIS Technology Co., Ltd.			
PACKAGE CODE	P-TQFP32-0707-0.80-ZK6		
PACKAGE MATERIAL	EPOXY RESIN	UNIT	mm
LEAD FLAME MATERIAL	Cu ALLOY	DWG No.	QSL-69350
LEAD FINISH	Sn 100%	REVISION	2
PLATING THICKNESS	MORE THAN 5μm	1st ISSUE	Aug/04/2016
PACKAGE MASS (g)	0.130	REVISED	Oct/02/2020

Notes for Mounting the Surface Mount Type Package

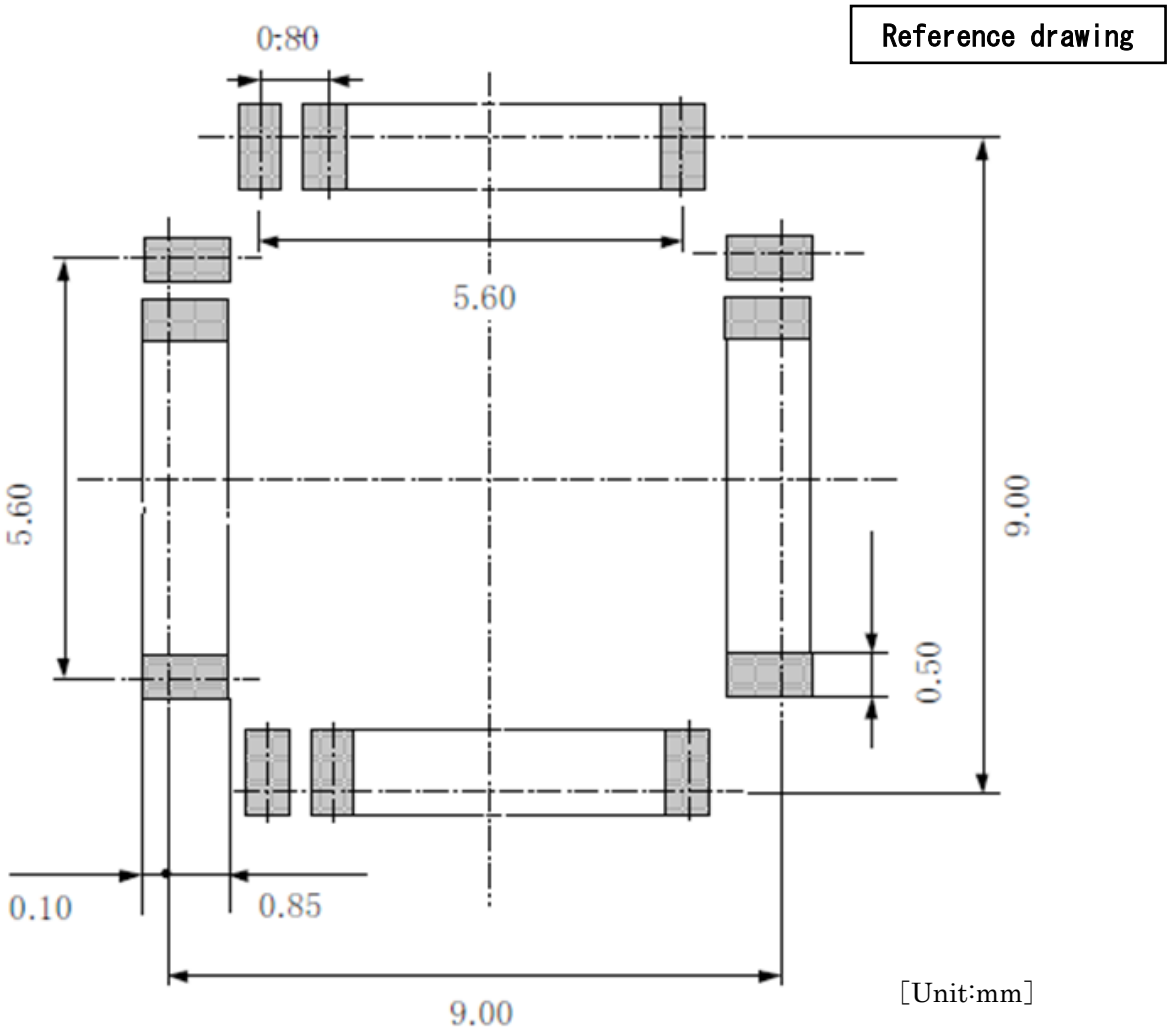
The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact a ROHM sales office for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature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

The heat resistance (example) of this LSI is shown below. Heat resistance (θ Ja) changes with the size and the number of layers of a substrate.

PCB	W/L/t=76.2 / 114.3 / 1.6(mm)
PCB Layer	JEDEC 4layers
Air cooling conditions	Calm(0m/sec)
Heat resistance(θJa)	58.5 [°C/W]
Power consumption of Chip PMax	0.300[W]

TjMax of this LSI is 110 °C. TjMax is expressed with the following formulas.
TjMax = TaMax + θJa × PMax

Figure of soldering department terminal existence range (32pin TQFP)

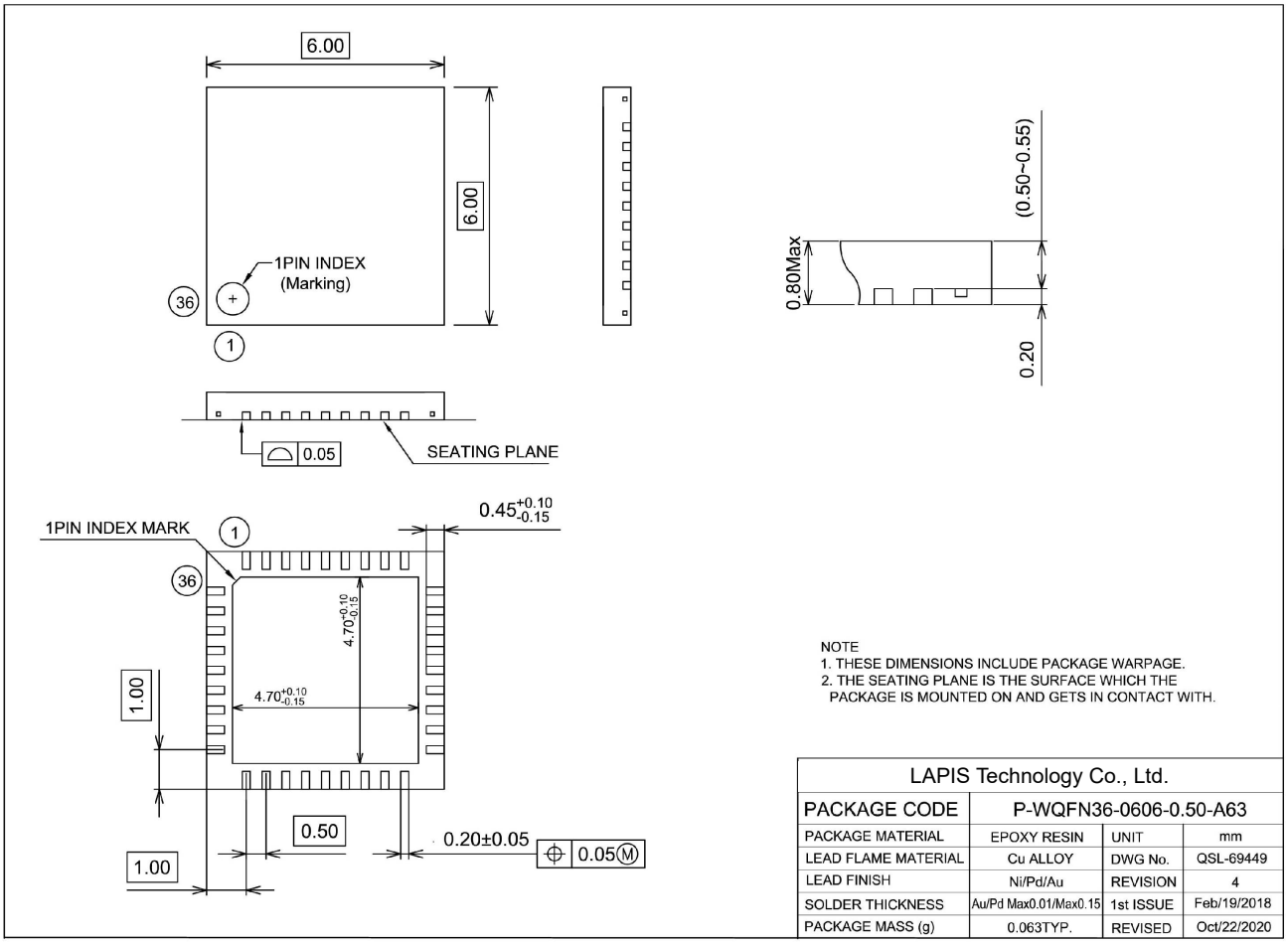


Attention of the layout of a mounting board

Please take into consideration enough that there are not ease of a mounting, the reliability of contact, leading about of a wiring, and a solder bridge generate in the case of layout of the foot pattern of a mounting board.

The optimal layout of a foot pattern changes by the board quality of material, the solder paste category to be used, thickness, the soldering methodology, etc. Therefore, since the span where the terminator of this package may exist is shown as a "soldering part terminator extent drawing", please give as reference data of a foot pattern design.

PACKAGE DIMENSIONS (36pin WQFN)



LAPIS Technology Co., Ltd.			
PACKAGE CODE	P-WQFN36-0606-0.50-A63		
PACKAGE MATERIAL	EPOXY RESIN	UNIT	mm
LEAD FLAME MATERIAL	Cu ALLOY	DWG No.	QSL-69449
LEAD FINISH	Ni/Pd/Au	REVISION	4
SOLDER THICKNESS	Au/Pd Max0.01/Max0.15	1st ISSUE	Feb/19/2018
PACKAGE MASS (g)	0.063TYP.	REVISED	Oct/22/2020

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 a ROHM sales office for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

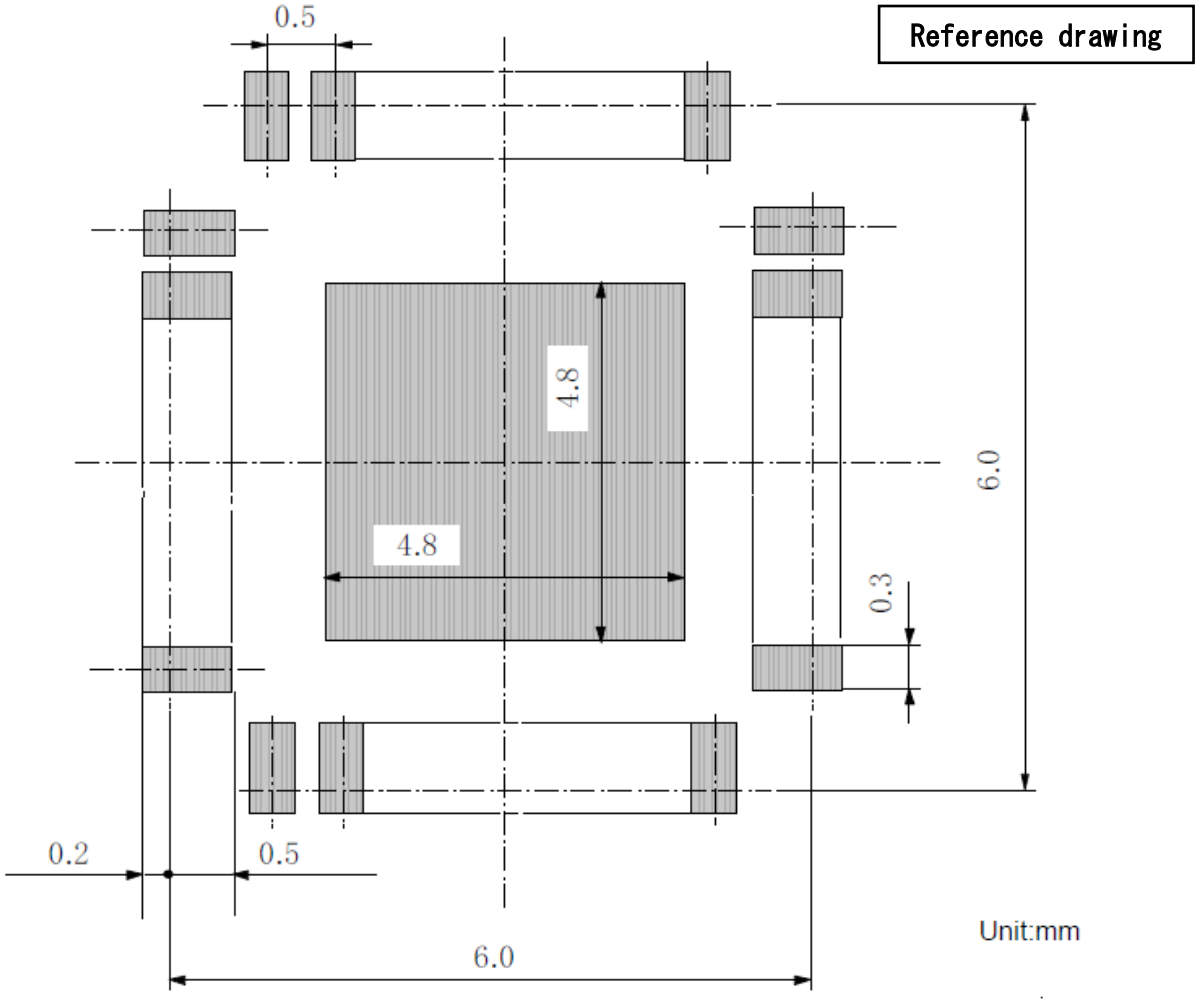
The heat resistance (example) of this LSI is shown below. Heat resistance (θ Ja) changes with the size and the number of layers of a substrate.

PCB	W/L/t=76.2 / 114.3 / 1.6（mm）
PCB Layer	JEDEC 4layers
Air cooling conditions	Calm（0m/sec）
Heat resistance（θJa）	30.0 [°C/W] (back diepad contact)
Power consumption of Chip PMax	0.300[W]

TjMax of this LSI is 110 °C. TjMax is expressed with the following formulas.

TjMax = TaMax + θJa × PMax

Figure of soldering department terminal existence range (36pin WQFN)



Attention of the layout of a mounting board

Please take into consideration enough that there are not ease of a mounting, the reliability of contact, leading about of a wiring, and a solder bridge generate in the case of layout of the foot pattern of a mounting board.

The optimal layout of a foot pattern changes by the board quality of material, the solder paste category to be used, thickness, the soldering methodology, etc. Therefore, since the span where the terminator of this package may exist is shown as a "soldering part terminator extent drawing", please give as reference data of a foot pattern design.

Revision History

Document No.	Date	Page		Description
		Previous Edition	Current Edition	
FEDL610Q306-01	Jun. 28, 2021	—	—	Formal edition 1
FEDL610Q306-02	Apr. 28, 2023	13	13	Added conditions for DC characteristics (IDD1)
		31	31	Updated the Figure of soldering department terminal existence range (32pin TQFP)
FEDL610Q306-03	Aug. 7, 2023	—	1	Added wording
		—	35	Added “Notes for product usage”

Notes for product usage

Notes on this page are applicable to the all LAPIS Technology microcontroller products.
For individual notes on each LAPIS Technology microcontroller product, refer to [Note] in the chapters of each user's manual.
The individual notes of each user's manual take priority over those contents in this page if they are different.

1. HANDLING OF UNUSED INPUT PINS

Fix the unused input pins to the power pin or GND to prevent to cause the device performing wrong operation or increasing the current consumption due to noise, etc. If the handlings for the unused pins are described in the chapters, follow the instruction.

2. STATE AT POWER ON

At the power on, the data in the internal registers and output of the ports are undefined until the power supply voltage reaches to the recommended operating condition and "L" level is input to the reset pin.
On LAPIS Technology microcontroller products that have the power on reset function, the data in the internal registers and output of the ports are undefined until the power on reset is generated.
Be careful to design the application system does not work incorrectly due to the undefined data of internal registers and output of the ports.

3. ACCESS TO UNUSED MEMORY

If reading from unused address area or writing to unused address area of the memory, the operations are not guaranteed.

4. CHARACTERISTICS DIFFERENCE BETWEEN THE PRODUCT

Electrical characteristics, noise tolerance, noise radiation amount, and the other characteristics are different from each microcontroller product.
When replacing from other product to LAPIS Technology microcontroller products, please evaluate enough the apparatus/system which implemented LAPIS Technology microcontroller products.

5. USE ENVIRONMENT

When using LAPIS Technology microcontroller products in a high humidity environment and an environment where dew condensation, take moisture-proof measures.

Notes

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