

LC87FBH08A

8-bit Microcontroller with 8K-byte Flash ROM and 256-byte RAM

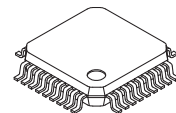


ON Semiconductor®

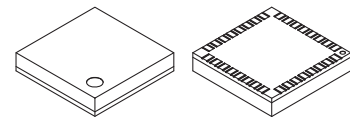
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Overview

The LC87FBH08A is an 8-bit microcontroller that, centered around a CPU running at a minimum bus cycle time of 83.3ns, integrates on a single chip a number of hardware features such as 8K-byte flash ROM (On-board-programmable), 256-byte RAM, an On-chip-debugger (flash versions only), sophisticated 16-bit timers/counters (may be divided into 8-bit timers), a 16-bit timer/counter (may be divided into 8-bit timers/counters or 8-bit PWMs), two 8-bit timers with a prescaler, a base timer serving as a time-of-day clock, a high-speed clock counter, a synchronous SIO interface, an asynchronous/synchronous SIO interface, a UART interface (full duplex), two 12-bit PWM channels, a 12-bit/8-bit 11-channel AD converter, a high-speed clock counter, a system clock frequency divider, an internal high-accuracy oscillator, a reference voltage generator circuit, an internal reset and a 20-source 10-vector interrupt feature.



LQFP36 7x7 / QFP36



VQLP32 4x4
[Build to order]

Features

■Flash ROM

- 8192 × 8 bits
- Capable of On-board programming with wide range (2.2 to 5.5V) of voltage source.
- Block-erasable in 128 byte units
- Writable in 2-byte units

■RAM

- 256 × 9 bits

■Minimum Bus Cycle

- 83.3ns (12MHz at $V_{DD}=2.7V$ to 5.5V, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)
- 100ns (10MHz at $V_{DD}=2.2V$ to 5.5V, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)
- 250ns (4MHz at $V_{DD}=1.8V$ to 5.5V, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)

Note: The bus cycle time here refers to the ROM read speed.

* This product is licensed from Silicon Storage Technology, Inc. (USA).

ORDERING INFORMATION

See detailed ordering and shipping information on page 32 of this data sheet.

LC87FBH08A

■ Minimum Instruction Cycle Time

- 250ns (12MHz at $V_{DD}=2.7V$ to $5.5V$, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)
- 300ns (10MHz at $V_{DD}=2.2V$ to $5.5V$, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)
- 750ns (4MHz at $V_{DD}=1.8V$ to $5.5V$, $T_a=-40^{\circ}C$ to $+85^{\circ}C$)

■ Ports

- Normal withstand voltage I/O ports
 - Ports I/O direction can be designated in 1-bit units 17 (P1n, P20, P21, P30, P31, P70 to P73 CF2/XT2)
 - Ports I/O direction can be designated in 4-bit units 8 (P0n)
- Dedicated oscillator ports/input ports 1 (CF1/XT1)
- Reset pin 1 (RES)
- Power pins 3 (VSS1, VSS2, VDD1)

■ Timers

- Timer 0: 16-bit timer/counter with a capture register.
 - Mode 0: 8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register) \times 2 channels
 - Mode 1: 8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register) + 8-bit counter (with an 8-bit capture register)
 - Mode 2: 16-bit timer with an 8-bit programmable prescaler (with a 16-bit capture register)
 - Mode 3: 16-bit counter (with a 16-bit capture register)
- Timer 1: 16-bit timer/counter that supports PWM/toggle outputs
 - Mode 0: 8-bit timer with an 8-bit prescaler (with toggle outputs) + 8-bit timer/counter with an 8-bit prescaler (with toggle outputs)
 - Mode 1: 8-bit PWM with an 8-bit prescaler \times 2 channels
 - Mode 2: 16-bit timer/counter with an 8-bit prescaler (with toggle outputs) (toggle outputs also possible from the lower-order 8 bits)
 - Mode 3: 16-bit timer with an 8-bit prescaler (with toggle outputs) (The lower-order 8 bits can be used as PWM)
- Timer 6: 8-bit timer with a 6-bit prescaler (with toggle outputs)
- Timer 7: 8-bit timer with a 6-bit prescaler (with toggle outputs)
- Base timer
 - 1) The clock is selectable from the subclock (32.768kHz crystal oscillation), system clock, and timer 0 prescaler output.
 - 2) Interrupts are programmable in 5 different time schemes

■ High-speed Clock Counter

- Can count clocks with a maximum clock rate of 20MHz (at a main clock of 10MHz).
- Can generate output real time.

■ SIO

- SIO0: 8-bit synchronous serial interface
 - 1) LSB first/MSB first mode selectable
 - 2) Built-in 8-bit baudrate generator (maximum transfer clock cycle = $4/3 t_{CYC}$)
 - 3) Automatic continuous data transmission (1 to 256 bits, specifiable in 1 bit units, suspension and resumption of data transmission possible in 1 byte units)
- SIO1: 8-bit asynchronous/synchronous serial interface
 - Mode 0: Synchronous 8-bit serial I/O (2- or 3-wire configuration, 2 to 512 t_{CYC} transfer clocks)
 - Mode 1: Asynchronous serial I/O (half-duplex, 8 data bits, 1 stop bit, 8 to 2048 t_{CYC} baudrates)
 - Mode 2: Bus mode 1 (start bit, 8 data bits, 2 to 512 t_{CYC} transfer clocks)
 - Mode 3: Bus mode 2 (start detect, 8 data bits, stop detect)

■ UART1

- Full duplex
- 7/8/9 bit data bits selectable
- 1 stop bit (2-bit in continuous data transmission)
- Built-in baudrate generator

LC87FBH08A

- AD converter: 12 bits/8 bits × 11 channels
 - Successive approximation
 - 12 bits/8 bits AD converter resolution selectable
 - Port input: 10 channels, Reference voltage input: 1 channel
- PWM: Multifrequency 12-bit PWM × 2 channels
- Reference voltage generator circuit (VREF17)
 - Capable of monitoring the power supply voltage by AD conversion of frequency variable RC oscillator circuit's reference voltage.
- Remote Control Receiver Circuit (sharing pins with P73, INT3, and T0IN)
 - Noise rejection function (noise filter time constant selectable from 1 tCYC, 32 tCYC, and 128 tCYC)
- Clock Output Function
 - Capable generating clock outputs with a frequency of 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 of the source clock selected as the system clock.
 - Capable of generating the source clock for the subclock.
- Watchdog Timer
 - Capable of generating an internal reset on an overflow of a timer running on the low-speed RC oscillator clock or subclock.
 - Operating mode at standby is selectable from 3 modes (continue counting/stop operation/stop counting with a count value held).

■ Interrupts

- 20 sources, 10 vector addresses
 - 1) Provides three levels (low (L), high (H), and highest (X)) of multiplex interrupt control. Any interrupt requests of the level equal to or lower than the current interrupt are not accepted.
 - 2) When interrupt requests to two or more vector addresses occur at the same time, the interrupt of the highest level takes precedence over the other interrupts. For interrupts of the same level, the interrupt into the smallest vector address takes precedence.

| No. | Vector Address | Level | Interrupt Source |
|-----|----------------|--------|-----------------------|
| 1 | 00003H | X or L | INT0 |
| 2 | 0000BH | X or L | INT1 |
| 3 | 00013H | H or L | INT2/T0L/INT4 |
| 4 | 0001BH | H or L | INT3/INT5/base timer |
| 5 | 00023H | H or L | T0H |
| 6 | 0002BH | H or L | T1L/T1H |
| 7 | 00033H | H or L | SIO0/UART1 receive |
| 8 | 0003BH | H or L | SIO1/UART1 transmit |
| 9 | 00043H | H or L | ADC/T6/T7/ PWM4, PWM5 |
| 10 | 0004BH | H or L | Port 0 |

- Priority levels X > H > L
- Of interrupts of the same level, the one with the smallest vector address takes precedence.

■ Subroutine Stack Levels: 128levels (The stack is allocated in RAM.)

■ High-speed Multiplication/Division Instructions

- 16 bits × 8 bits (5 tCYC execution time)
- 24 bits × 16 bits (12 tCYC execution time)
- 16 bits ÷ 8 bits (8 tCYC execution time)
- 24 bits ÷ 16 bits (12 tCYC execution time)

LC87FBH08A

■ Oscillation Circuits

- Internal oscillation circuits
 - Low-speed RC oscillation circuit (SRC): For system clock / For Watchdog timer (100kHz)
 - Medium-speed RC oscillation circuit (RC): For system clock (1MHz)
 - Frequency variable RC oscillation circuit (MRC): For system clock (8MHz \pm 1.5%, Ta=−10°C to +85°C)
- External oscillation circuits
 - Hi-speed CF oscillation circuit (CF): For system clock, with internal Rf
 - Low speed crystal oscillation circuit (X'tal): For low-speed system clock / For Watchdog timer, with internal Rf
 - 1) The CF and crystal oscillation circuits share the same pins. The active circuit is selected under program control.
 - 2) Both the CF and crystal oscillator circuits stop operation on a system reset. After reset is released, oscillation is stopped so start the oscillation operation by program.

■ System Clock Divider Function

- Can run on low current.
- The minimum instruction cycle selectable from 300ns, 600ns, 1.2 μ s, 2.4 μ s, 4.8 μ s, 9.6 μ s, 19.2 μ s, 38.4 μ s, and 76.8 μ s (at a main clock rate of 10MHz).

■ Internal Reset Function

- Power-on reset (POR) function
 - 1) POR reset is generated only at power-on time.
 - 2) The POR release level can be selected from 8 levels (1.67V, 1.97V, 2.07V, 2.37V, 2.57V, 2.87V, 3.86V, and 4.35V) through option configuration.
- Low-voltage detection reset (LVD) function
 - 1) LVD and POR functions are combined to generate resets when power is turned on and when power voltage falls below a certain level.
 - 2) The use or disuse of the LVD function and the low voltage threshold level (7 levels: 1.91V, 2.01V, 2.31V, 2.51V, 2.81V, 3.79V, 4.28V) can be selected by optional configuration.

■ Standby Function

- HALT mode: Halts instruction execution while allowing the peripheral circuits to continue operation.
 - 1) Oscillation is not halted automatically.
 - 2) There are four ways of resetting the HALT mode.
 - (1) Setting the reset pin to the low level
 - (2) System resetting by low-voltage detection
 - (3) System resetting by watchdog timer
 - (4) Occurrence of an interrupt
- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
 - 1) The CF, low-/medium-/ Frequency variable RC, and crystal oscillators automatically stop operation.
Note: The oscillation of the low-speed RC oscillator is also controlled directly by the watchdog timer and its standby-mode-time oscillation is also controlled.
 - 2) There are five ways of resetting the HOLD mode.
 - (1) Setting the reset pin to the lower level.
 - (2) System resetting by low-voltage detection
 - (3) System resetting by watchdog timer
 - (4) Having an interrupt source established at either INT0, INT1, INT2, INT4, INT5
* INT0 and INT1 HOLD mode reset is available only when level detection is set.
 - (5) Having an interrupt source established at port 0.

Continued on next page.

LC87FBH08A

Continued from preceding page.

- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer.
 - 1) The CF, low-/medium-/ Frequency variable RC oscillators automatically stop operation.
Note: The oscillation of the low-speed RC oscillator is also controlled directly by the watchdog timer and its standby-mode-time oscillation is also controlled.
 - 2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
 - 3) There are six ways of resetting the X'tal HOLD mode.
 - (1) Setting the reset pin to the low level.
 - (2) System resetting by watchdog timer or low-voltage detection.
 - (3) System resetting by watchdog timer or low-voltage detection.
 - (4) Having an interrupt source established at either INT0, INT1, INT2, INT4, INT5
* INT0 and INT1 HOLD mode reset is available only when level detection is set.
 - (5) Having an interrupt source established at port 0.
 - (6) Having an interrupt source established in the base timer circuit.
Note: Available only when X'tal oscillation is selected.

■ Onchip Debugger (flash versions only)

- Supports software debugging with the microcontroller mounted on the target board.
- Software break setting
- Stepwise execution of instructions
- Real time RAM data monitoring function
All the RAM data map contents can be monitored and rewritten on the screen when the program is running.
(Part of the SFR data cannot be rewritten.)
- Two channels of on-chip debugger pins are available to be compatible with small pin count devices.
DBGP0 (P0), DBGP1 (P1)

■ Data Security Function (flash versions only)

- Protects the program data stored in flash memory from unauthorized read or copy.
Note: This data security function does not necessarily provide absolute data security.

■ Package Form

- QFP36(7mm×7mm) : Pb-Free and Halogen Free type
- VQLP32(4mm×4mm) : Pb-Free and Halogen Free type (Build-to-order)

■ Development Tools

- On-chip-debugger : (1) TCB87 TypeB + LC87FBH08A
(2) TCB87 TypeC (3 wire version) + LC87FBH08A

■ Flash ROM Programming Boards

| Package | Programming boards |
|------------------|--------------------|
| QFP36 (7mm×7mm) | W87F24Q |
| VQLP32 (4mm×4mm) | (build-to-order) |

LC87FBH08A

■Flash ROM Programmer

| Maker | | Model | Supported version | Device |
|---|----------------------------|---|--------------------------------------|-----------|
| Flash Support Group, Inc. (FSG) | Single Programmer | AF9709/AF9709B/AF9709C (Including Ando Electric Co., Ltd. models) | Rev 03.28 or later | 87F008SU |
| | Gang Programmer | AF9723/AF9723B(Main body) (Including Ando Electric Co., Ltd. models) | - | - |
| | | AF9833(Unit) (Including Ando Electric Co., Ltd. models) | - | - |
| Flash Support Group, Inc. (FSG) + ON Semiconductor (Note 1) | In-circuit Programmer | AF9101/AF9103(Main body) (FSG models) | (Note 2) | - |
| | | SIB87(Inter Face Driver) (ON Semiconductor model) | | |
| ON Semiconductor | Single/Gang Programmer | SKK / SKK Type B / SKK Type C (SanyoFWS) | Application Version 1.07 or later | LC87FBH08 |
| | In-circuit/Gang Programmer | SKK-DBG Type B / SKK-DBG Type C (SanyoFWS) | Chip Data Version 2.38 or later | |

For information about AF-Series:

Flash Support Group, Inc.

TEL: +81-53-459-1050

E-mail: sales@j-fsg.co.jp

Note1: On-board-programmer from FSG (AF9101/AF9103) and serial interface driver from our company (SIB87) together can give a PC-less, standalone on-board-programming capabilities.

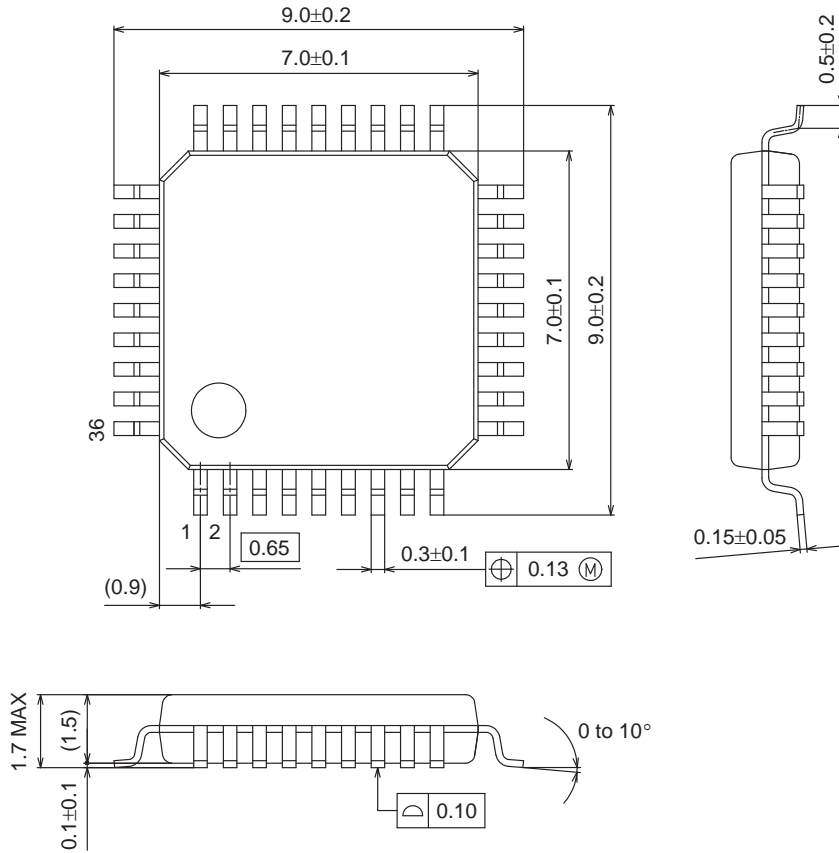
Note2: It needs a special programming devices and applications depending on the use of programming environment. Please ask FSG or our company for the information.

LC87FBH08A

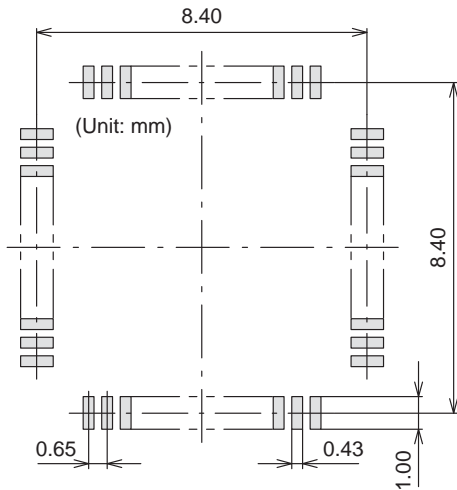
Package Dimensions

unit : mm

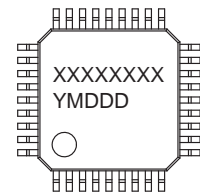
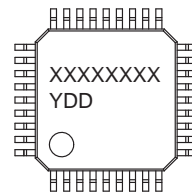
LQFP36 7x7 / QFP36
CASE 561AV
ISSUE A



SOLDERING FOOTPRINT*



GENERIC MARKING DIAGRAM*



XXXXX = Specific Device Code
Y = Year
DD = Additional Traceability Data

XXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present.

NOTE: The measurements are not to guarantee but for reference only.

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

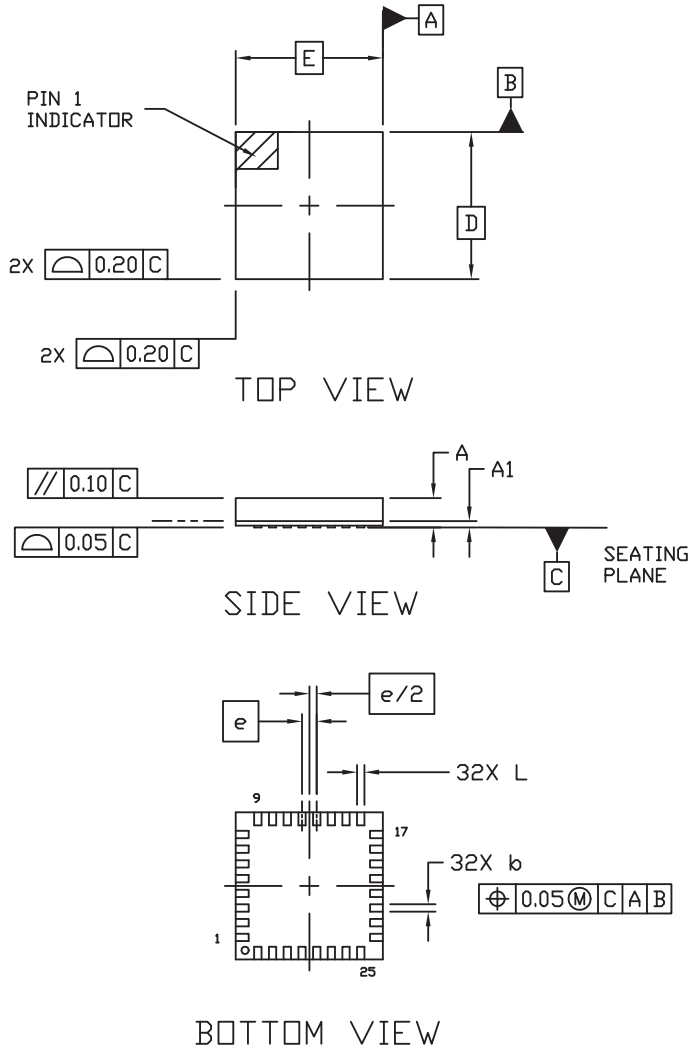
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Package Dimensions

unit : mm

[Build to order]

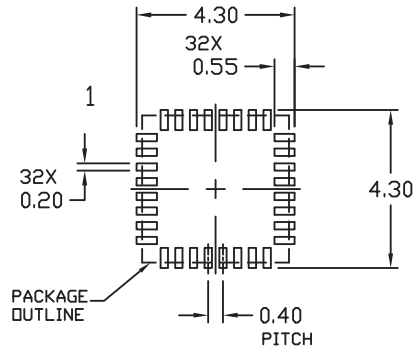
VQLP32 4x4
CASE 602AE
ISSUE A



NOTES:

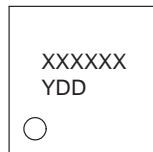
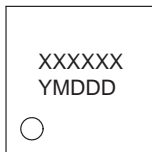
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS

| DIM | MILLIMETERS | |
|-----|-------------|------|
| | MIN. | MAX. |
| A | --- | 0.85 |
| A1 | --- | 0.05 |
| b | 0.15 | 0.25 |
| D | 4.00 BSC | |
| E | 4.00 BSC | |
| e | 0.40 BSC | |
| L | 0.30 | 0.40 |



RECOMMENDED MOUNTING FOOTPRINT

GENERIC MARKING DIAGRAM*



XXXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

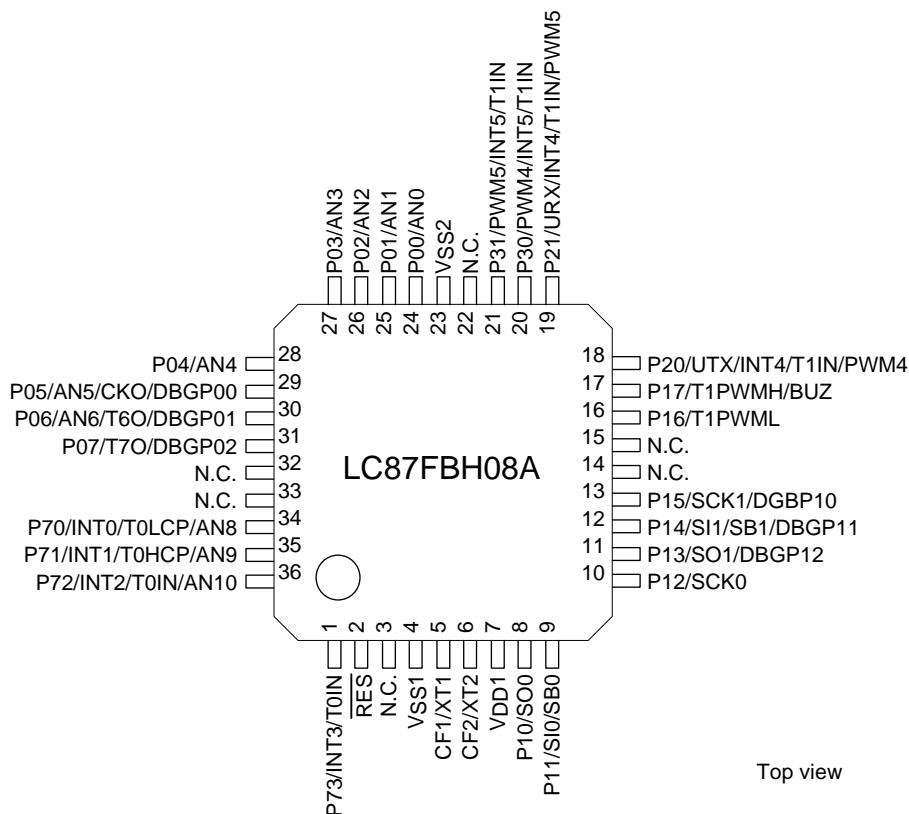
XXXXXX = Specific Device Code
Y = Year
DD = Additional Traceability Data

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present.

LC87FBH08A

Pin Assignment

LQFP36 7x7 / QFP36



| QFP36 | NAME |
|-------|------------------------|
| 1 | P73/INT3/T0IN |
| 2 | RES |
| 3 | N.C. |
| 4 | V _{SS1} |
| 5 | CF1/XT1 |
| 6 | CF2/XT2 |
| 7 | V _{DD1} |
| 8 | P10/SO0 |
| 9 | P11/SI0/SB0 |
| 10 | P12/SCK0 |
| 11 | P13/SO1/DBGP12 |
| 12 | P14/SI1/SB1/DBGP11 |
| 13 | P15/SCK1/DBGP10 |
| 14 | N.C. |
| 15 | N.C. |
| 16 | P16/T1PWML |
| 17 | P17/T1PVMH/BUZ |
| 18 | P20/UTX/INT4/T1IN/PWM4 |

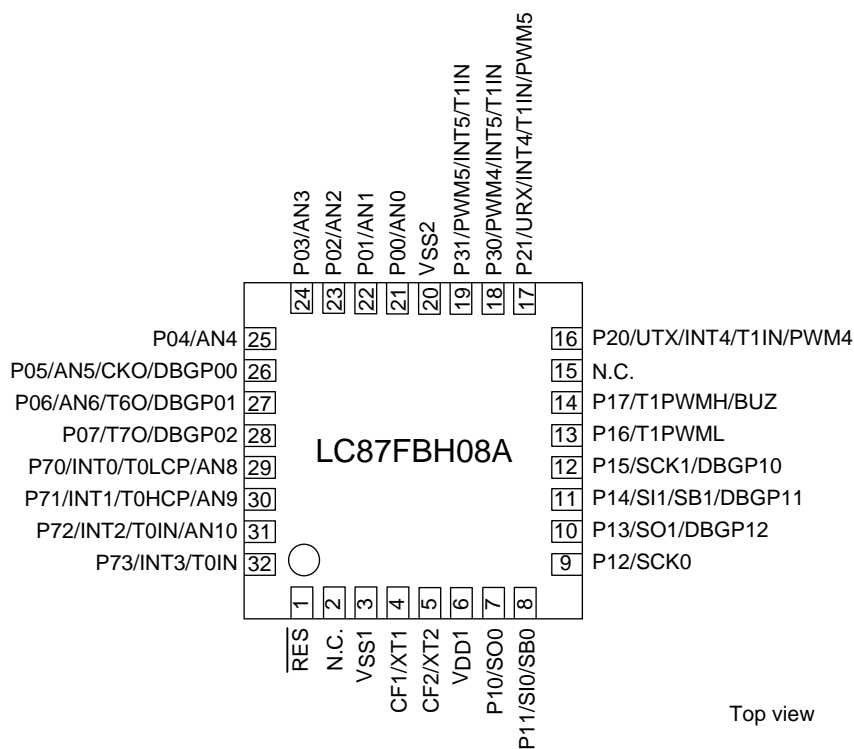
| QFP36 | NAME |
|-------|------------------------|
| 19 | P21/URX/INT4/T1IN/PWM5 |
| 20 | P30/PWM4/INT5/T1IN |
| 21 | P31/PWM5/INT5/T1IN |
| 22 | N.C. |
| 23 | V _{SS2} |
| 24 | P00/AN0 |
| 25 | P01/AN1 |
| 26 | P02/AN2 |
| 27 | P03/AN3 |
| 28 | P04/AN4 |
| 29 | P05/AN5/CKO/DBGP00 |
| 30 | P06/AN6/T6O/DBGP01 |
| 31 | P07/T7O/DBGP02 |
| 32 | N.C. |
| 33 | N.C. |
| 34 | P70/INT0/T0LCP/AN8 |
| 35 | P71/INT1/T0HCP/AN9 |
| 36 | P72/INT2/T0IN/AN10 |

Note: N.C. pins must be held open (disconnected).

LC87FBH08A

Pin Assignment

VQLP32 4x4 [Built to order]



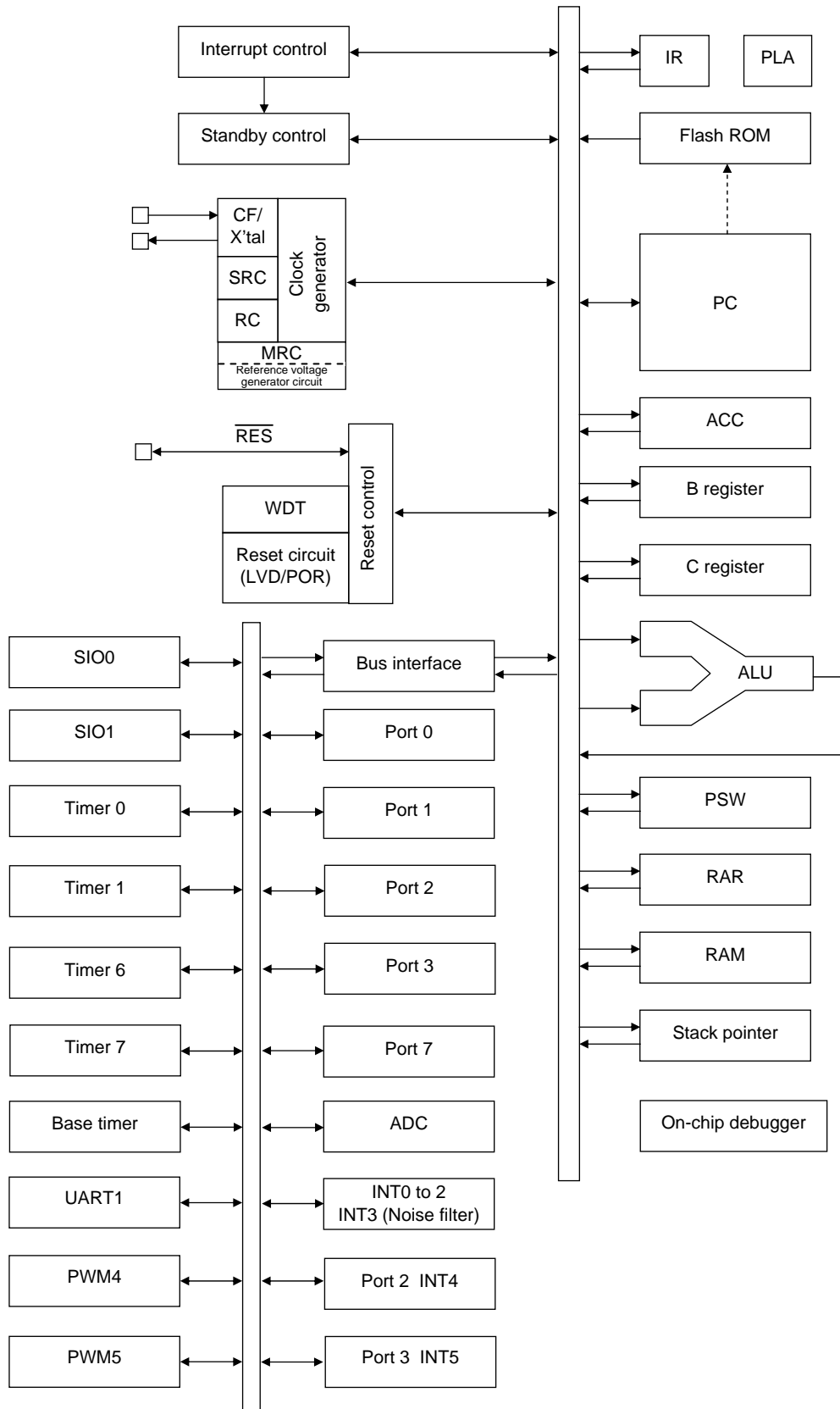
| VQLP32 | NAME |
|--------|------------------------|
| 1 | RES |
| 2 | N.C. |
| 3 | VSS1 |
| 4 | CF1/XT1 |
| 5 | CF2/XT2 |
| 6 | VDD1 |
| 7 | P10/SO0 |
| 8 | P11/SI0/SB0 |
| 9 | P12/SCK0 |
| 10 | P13/SO1/DBGP12 |
| 11 | P14/SI1/SB1/DBGP11 |
| 12 | P15/SCK1/DBGP10 |
| 13 | P16/T1PWML |
| 14 | P17/T1PWMH/BUZ |
| 15 | N.C. |
| 16 | P20/UTX/INT4/T1IN/PWM4 |

| VQLP32 | NAME |
|--------|------------------------|
| 17 | P21/URX/INT4/T1IN/PWM5 |
| 18 | P30/PWM4/INT5/T1IN |
| 19 | P31/PWM5/INT5/T1IN |
| 20 | VSS2 |
| 21 | P00/AN0 |
| 22 | P01/AN1 |
| 23 | P02/AN2 |
| 24 | P03/AN3 |
| 25 | P04/AN4 |
| 26 | P05/AN5/CKO/DBGP00 |
| 27 | P06/AN6/T6O/DBGP01 |
| 28 | P07/T7O/DBGP02 |
| 29 | P70/INT0/T0LCP/AN8 |
| 30 | P71/INT1/T0HCP/AN9 |
| 31 | P72/INT2/T0IN/AN10 |
| 32 | P73/INT3/T0IN |

Note: N.C. pins must be held open (disconnected).

LC87FBH08A

System Block Diagram



LC87FBH08A

Pin Function Chart

| Pin Name | I/O | Description | Option | | | | | | | | | | | | |
|-------------------------------------|--------|--|------------------|---------|---------|------------------|---------|---------|------|--------|--------|--------|---------|---------|-----|
| V _{SS1} , V _{SS2} | - | - Power supply pin | No | | | | | | | | | | | | |
| V _{DD1} | - | + Power supply pin | No | | | | | | | | | | | | |
| Port 0 P00 to P07 | I/O | <ul style="list-style-type: none"> • 8-bit I/O port • I/O specifiable in 4-bit units • Pull-up resistors can be turned on and off in 4-bit units. • HOLD reset input • Port 0 interrupt input • Pin functions <ul style="list-style-type: none"> P05: System clock output P06: Timer 6 toggle output P07: Timer 7 toggle output P00(AN0) to P06(AN6): AD converter input P05(DBGP00) to P07(DBGP02): On-chip debugger 0 port | Yes | | | | | | | | | | | | |
| Port 1 P10 to P17 | I/O | <ul style="list-style-type: none"> • 8-bit I/O port • I/O specifiable in 1-bit units • Pull-up resistors can be turned on and off in 1-bit units. • Pin functions <ul style="list-style-type: none"> P10: SIO0 data output P11: SIO0 data input/bus I/O P12: SIO0 clock I/O P13: SIO1 data output P14: SIO1 data input / bus I/O P15: SIO1 clock I/O P16: Timer 1PWML output P17: Timer 1PWMLH output / beeper output P15(DBGP10) to P13(DBGP12): On-chip-debugger 1 port | Yes | | | | | | | | | | | | |
| Port 2 P20 to P21 | I/O | <ul style="list-style-type: none"> • 2-bit I/O port • I/O specifiable in 1-bit units • Pull-up resistors can be turned on and off in 1-bit units. • Pin functions <ul style="list-style-type: none"> P20: UART transmit / PWM4 output P21: UART receive / PWM5 output P20 to P21: INT4 input / HOLD reset input / timer 1 event input / timer 0L capture input / timer 0H capture input <p>Interrupt acknowledge types</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-left: 20px;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 15%;">Rising</th> <th style="width: 15%;">Falling</th> <th style="width: 15%;">Rising & Falling</th> <th style="width: 15%;">H level</th> <th style="width: 15%;">L level</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">INT4</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">disable</td> <td style="text-align: center;">disable</td> </tr> </tbody> </table> | | Rising | Falling | Rising & Falling | H level | L level | INT4 | enable | enable | enable | disable | disable | Yes |
| | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | |
| INT4 | enable | enable | enable | disable | disable | | | | | | | | | | |
| Port 3 P30 to P31 | I/O | <ul style="list-style-type: none"> • 2-bit I/O port • I/O specifiable in 1 bit units • Pull-up resistors can be turned on and off in 1 bit units. • Pin functions <ul style="list-style-type: none"> P30: PWM4 output P31: PWM5 output P30 to P31: INT5 input/HOLD reset input / timer 1 event input / timer 0L capture input / timer 0H capture input <p>Interrupt acknowledge types</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-left: 20px;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 15%;">Rising</th> <th style="width: 15%;">Falling</th> <th style="width: 15%;">Rising & Falling</th> <th style="width: 15%;">H level</th> <th style="width: 15%;">L level</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">INT5</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">enable</td> <td style="text-align: center;">disable</td> <td style="text-align: center;">disable</td> </tr> </tbody> </table> | | Rising | Falling | Rising & Falling | H level | L level | INT5 | enable | enable | enable | disable | disable | Yes |
| | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | |
| INT5 | enable | enable | enable | disable | disable | | | | | | | | | | |

Continued on next page.

LC87FBH08A

Continued from preceding page.

| Pin Name | I/O | Description | Option | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------------|--------|--|---------|---------|------------------|------------------|---------|---------|------|--------|--------|---------|--------|--------|------|--------|--------|---------|--------|--------|------|--------|--------|--------|---------|---------|------|--------|--------|--------|---------|---------|----|
| Port 7 | I/O | <ul style="list-style-type: none"> • 4-bit I/O port • I/O specifiable in 1 bit units • Pull-up resistors can be turned on and off in 1 bit units. • Pin functions <ul style="list-style-type: none"> P70: INT0 input / HOLD reset input / timer 0L capture input P71: INT1 input / HOLD reset input / timer 0H capture input P72: INT2 input / HOLD reset input / timer 0 event input / timer 0L capture input P73: INT3 input (with noise filter) / timer 0 event input / timer 0H capture input P70(AN8) to P72(AN10): AD converter input Interrupt acknowledge types <table border="1" style="margin-left: 20px; width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Rising</th> <th>Falling</th> <th>Rising & Falling</th> <th>H level</th> <th>L level</th> </tr> </thead> <tbody> <tr> <td>INT0</td> <td>enable</td> <td>enable</td> <td>disable</td> <td>enable</td> <td>enable</td> </tr> <tr> <td>INT1</td> <td>enable</td> <td>enable</td> <td>disable</td> <td>enable</td> <td>enable</td> </tr> <tr> <td>INT2</td> <td>enable</td> <td>enable</td> <td>enable</td> <td>disable</td> <td>disable</td> </tr> <tr> <td>INT3</td> <td>enable</td> <td>enable</td> <td>enable</td> <td>disable</td> <td>disable</td> </tr> </tbody> </table> | | Rising | Falling | Rising & Falling | H level | L level | INT0 | enable | enable | disable | enable | enable | INT1 | enable | enable | disable | enable | enable | INT2 | enable | enable | enable | disable | disable | INT3 | enable | enable | enable | disable | disable | No |
| | | | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | | | | | | | | | | | | | | | | | |
| INT0 | enable | enable | disable | enable | enable | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| INT1 | enable | enable | disable | enable | enable | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| INT2 | enable | enable | enable | disable | disable | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| INT3 | enable | enable | enable | disable | disable | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| P70 to P73 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| $\overline{\text{RES}}$ | I/O | External reset input / internal reset output | No | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CF1/XT1 | I | <ul style="list-style-type: none"> • Ceramic resonator or 32.768kHz crystal oscillator input pin • Pin function <ul style="list-style-type: none"> General-purpose input port | No | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CF2/XT2 | I/O | <ul style="list-style-type: none"> • Ceramic resonator or 32.768kHz crystal oscillator output pin • Pin function <ul style="list-style-type: none"> General-purpose I/O port | No | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Port Output Types

The table below lists the types of port outputs and the presence/absence of a pull-up resistor.

Data can be read into any input port even if it is in the output mode.

| Port Name | Option selected in units of | Option type | Output type | Pull-up resistor |
|------------|-----------------------------|-------------|--|-----------------------|
| P00 to P07 | 1 bit | 1 | CMOS | Programmable (Note 1) |
| | | 2 | Nch-open drain | No |
| P10 to P17 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| P20 to P21 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| P30 to P31 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| P70 | - | No | Nch-open drain | Programmable |
| P71 to P73 | - | No | CMOS | Programmable |
| CF2/XT2 | - | No | Ceramic resonator/32.768kHz crystal resonator output Nch-open drain (N-channel open drain when set to general-purpose output port) | No |

Note 1: The control of the presence or absence of the programmable pull-up resistors for port 0 and the switching between low-and high-impedance pull-up connection is exercised in nibble (4-bit) units (P00 to 03 or P04 to 07).

User Option Table

| Option Name | Option to be Applied on | Mask version *1 | Flash-ROM Version | Option Selected in Units of | Option Selection |
|--------------------------------------|-------------------------|-----------------|-------------------|-----------------------------|------------------|
| Port output type | P00 to P07 | ○ | ○ | 1 bit | CMOS |
| | | | | | Nch-open drain |
| | P10 to P17 | ○ | ○ | 1 bit | CMOS |
| | | | | | Nch-open drain |
| | P20 to P21 | ○ | ○ | 1 bit | CMOS |
| | | | | | Nch-open drain |
| | P30 to P31 | ○ | ○ | 1 bit | CMOS |
| | | | | | Nch-open drain |
| Program start address | - | × *2 | ○ | - | 00000h |
| | | | | | 01E00h |
| Low-voltage detection reset function | Detect function | ○ | ○ | - | Enable:Use |
| | | | | | Disable:Not Used |
| Power-on reset function | Power-On reset level | ○ | ○ | - | 7-level |
| | | | | | 8-level |

*1: Mask option selection - No change possible after mask is completed.

*2: Program start address of the mask version is 00000h.

Recommended Unused Pin Connections

| Port Name | Recommended Unused Pin Connections | |
|------------|--|----------------------------|
| | Board | Software |
| P00 to P07 | Open | Output low |
| P10 to P17 | Open | Output low |
| P20 to P21 | Open | Output low |
| P30 to P31 | Open | Output low |
| P70 to P73 | Open | Output low |
| CF1/XT1 | Pulled low with a 100kΩ resistor or less | General-purpose input port |
| CF2/XT2 | Pulled low with a 100kΩ resistor or less | General-purpose input port |

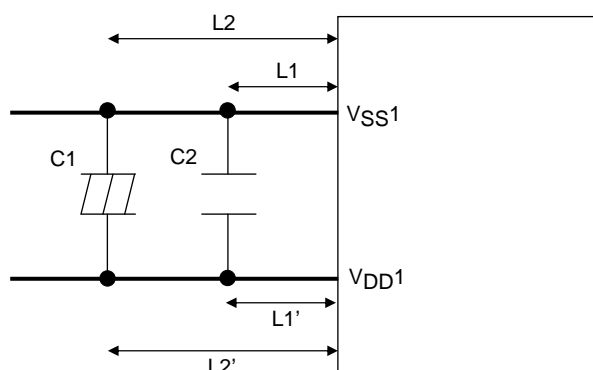
On-chip Debugger Pin Connection Requirements

For the treatment of the on-chip debugger pins, refer to the separately available documents entitled "RD87 on-chip debugger installation manual".

Power Pin Treatment Recommendations (VDD1, VSS1)

Connect bypass capacitors that meet the following conditions between the VDD1 and VSS1 pins:

- Connect among the VDD1 and VSS1 pins and bypass capacitors C1 and C2 with the shortest possible heavy lead wires, making sure that the impedances between the both pins and the bypass capacitors are as possible ($L1=L1'$, $L2=L2'$).
- Connect a large-capacity capacitor C1 and a small-capacity capacitor C2 in parallel. The capacitance of C2 should approximately 0.1μF.



Note: Be sure to electrically short-circuit between the VSS1 and VSS2 pins.

LC87FBH08A

Absolute Maximum Ratings at Ta = 25°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | unit |
|-------------------------------|-----------------------------------|---------------------------------------|---|--|------|------|---------|------|
| | | | | VDD[V] | min | typ | max | |
| Maximum supply voltage | VDD max | VDD1 | | | -0.3 | | +6.5 | V |
| Input voltage | VI | CF1 | | | -0.3 | | VDD+0.3 | |
| Input/output voltage | VI/O | Ports 0, 1, 2, 3, Port 7, CF2, RES | | | -0.3 | | VDD+0.3 | |
| High level output current | Peak output current | IOPH(1) | Ports 0, 1, 2, 3 | CMOS output select Per 1 applicable pin | | -10 | | mA |
| | | IOPH(2) | P71 to P73 | Per 1 applicable pin | | -5 | | |
| | Mean output current (Note 1-1) | IOMH(1) | Ports 0, 1, 2, 3 | CMOS output select Per 1 applicable pin | | -7.5 | | |
| | | IOMH(2) | P71 to P73 | Per 1 applicable pin | | -3 | | |
| Total output current | ΣIOAH(1) | Ports 0, 1, 2, 3, P71 to P73 | Total of all applicable pins | | -25 | | | |
| Low level output current | Peak output current | IOPL(1) | P02 to P07, Ports 1, 2, 3 | Per 1 applicable pin | | | 20 | |
| | | IOPL(2) | P00, P01 | Per 1 applicable pin | | | 30 | |
| | | IOPL(3) | Port 7, CF2 | Per 1 applicable pin | | | 10 | |
| | Mean output current (Note 1-1) | IOML(1) | P02 to P07 Ports 1, 2, 3 | Per 1 applicable pin | | | | 15 |
| | | IOML(2) | P00, P01 | Per 1 applicable pin | | | | 20 |
| | | IOML(3) | Port 7, CF2 | Per 1 applicable pin | | | | 7.5 |
| | Total output current | ΣIOAL(1) | Ports 0, 1, Ports 2, 3, CF2 | Total of all applicable pins | | | | 70 |
| ΣIOAL(2) | | Port 7 | Total of all applicable pins | | | | 15 | |
| Power dissipation | Pd max(1) | QFP36(7×7) | Ta=-40 to +85°C Package only | | | | 120 | mW |
| | Pd max(2) | | Ta=-40 to +85°C Package with thermal resistance board (Note 1-2) | | | | 275 | |
| Operating ambient temperature | Topr | | | | -40 | | +85 | °C |
| Storage ambient temperature | Tstg | | | | -55 | | +125 | |

Note 1-1: The mean output current is a mean value measured over 100ms.

Note 1-2: SEMI standards thermal resistance board (size: 76.1×114.3×1.6mm, glass epoxy) is used.

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

LC87FBH08A

Allowable Operating Conditions at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | unit |
|-------------------------------------|---------------|--|---|---------------|------------|---------|-------------|------|
| | | | | VDD[V] | min | typ | max | |
| Operating supply voltage (Note 2-1) | VDD(1) | VDD1 | 0.245μs ≤ tCYC ≤ 200μs | | 2.7 | | 5.5 | V |
| | VDD(2) | | 0.294μs ≤ tCYC ≤ 200μs | | 2.2 | | 5.5 | |
| | VDD(3) | | 0.735μs ≤ tCYC ≤ 200μs | | 1.8 | | 5.5 | |
| Memory sustaining supply voltage | VHD | VDD1 | RAM and register contents sustained in HOLD mode. | | 1.6 | | | |
| High level input voltage | VIH(1) | Ports 1, 2, 3, 7 | | 1.8 to 5.5 | 0.3VDD+0.7 | | VDD | |
| | VIH(2) | Ports 0 | | 1.8 to 5.5 | 0.3VDD+0.7 | | VDD | |
| | VIH(3) | CF1, CF2, RES | | 1.8 to 5.5 | 0.75VDD | | VDD | |
| Low level input voltage | VIL(1) | Ports 1, 2, 3, 7 | | 4.0 to 5.5 | VSS | | 0.1VDD+0.4 | |
| | | | | 1.8 to 4.0 | VSS | | 0.2VDD | |
| | VIL(2) | Ports 0 | | 4.0 to 5.5 | VSS | | 0.15VDD+0.4 | |
| | | | | 1.8 to 4.0 | VSS | | 0.2VDD | |
| VIL(3) | CF1, CF2, RES | | 1.8 to 5.5 | VSS | | 0.25VDD | | |
| High level output current | IOH(1) | Ports 0, 1, 2, P71 to P73 | Per 1 applicable pin | 4.5 to 5.5 | -1.0 | | | |
| | IOH(2) | | | 2.7 to 4.5 | -0.35 | | | |
| | IOH(3) | | | 1.8 to 2.7 | -0.15 | | | |
| | IOH(4) | Ports 3, P05 (System clock output function used) | Per 1 applicable pin | 4.5 to 5.5 | -6.0 | | | |
| | IOH(5) | | | 2.7 to 4.5 | -1.4 | | | |
| | IOH(6) | | | 1.8 to 2.7 | -0.8 | | | |
| | ΣIOH(1) | Ports 0, 1, 2, 3, 7 | Total of all applicable pins | 4.5 to 5.5 | -25 | | | |
| | ΣIOH(2) | | | 2.7 to 4.5 | -11.2 | | | |
| ΣIOH(3) | 1.8 to 2.7 | | | -5.4 | | | | |
| Low level output current | IO(1) | Ports 0, 1, 2, 3 | Per 1 applicable pin | 4.5 to 5.5 | | | 10 | |
| | IO(2) | | | 2.7 to 4.5 | | | 1.4 | |
| | IO(3) | | | 1.8 to 2.7 | | | 0.8 | |
| | IO(4) | Port 7, CF2 | Per 1 applicable pin | 2.7 to 5.5 | | | 1.4 | |
| | IO(5) | | | 1.8 to 2.7 | | | 0.8 | |
| | IO(6) | P00, P01 | Per 1 applicable pin | 4.5 to 5.5 | | | 25 | |
| | IO(7) | | | 2.7 to 4.5 | | | 4 | |
| | IO(8) | | | 1.8 to 2.7 | | | 2 | |
| | ΣIO(1) | Ports 0, 1, 2, 3, CF2 | Total of all applicable pins | 4.5 to 5.5 | | | 70 | |
| | ΣIO(2) | | | 2.7 to 4.5 | | | 34.6 | |
| | ΣIO(3) | | | 1.8 to 2.7 | | | 19.2 | |
| | ΣIO(4) | Ports 7 | Total of all applicable pins | 2.7 to 5.5 | | | 5.6 | |
| ΣIO(5) | 1.8 to 2.7 | | | | | 3.2 | | |
| Instruction cycle time (Note 2-2) | tCYC | | | 2.7 to 5.5 | 0.245 | | 200 | |
| | | | | 2.2 to 5.5 | 0.294 | | 200 | |
| | | | | 1.8 to 5.5 | 0.735 | | 200 | |
| External system clock frequency | FEXCF | CF1 | <ul style="list-style-type: none"> • CF2 pin open • System clock frequency division ratio=1/1 • External system clock duty=50±5% | 2.7 to 5.5 | 0.1 | | 12 | |
| | | | | 1.8 to 5.5 | 0.1 | | 4 | |
| | | | | 3.0 to 5.5 | 0.2 | | 24.4 | |
| | | | | 2.0 to 5.5 | 0.2 | | 8 | |

Note 2-1: VDD must be held greater than or equal to 2.2V in the flash ROM onboard programming mode.

Note 2-2: Relationship between tCYC and oscillation frequency is 3/FmCF at a division ratio of 1/1 and 6/FmCF at a division ratio of 1/2.

Continued on next page.

LC87FBH08A

Continued from preceding page.

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---|----------|-------------|---|---------------------|------|--------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| Oscillation frequency range (Note 2-3) | FmCF(1) | CF1, CF2 | 12MHz ceramic oscillation. See Fig. 1. | 2.7 to 5.5 | | 12 | | MHz |
| | FmCF(2) | CF1, CF2 | 10MHz ceramic oscillation. See Fig. 1. | 2.2 to 5.5 | | 10 | | |
| | FmCF(3) | CF1, CF2 | 4MHz ceramic oscillation. CF oscillation normal amplifier size selected. (CFLAMP=0) See Fig. 1. | 1.8 to 5.5 | | 4 | | |
| | | | 4MHz ceramic oscillation. CF oscillation low amplifier size selected. (CFLAMP=1) See Fig. 1. | 2.2 to 5.5 | | 4 | | |
| | FmMRC(1) | | Frequency variable RC oscillation. (Note 2-4) | 1.8 to 5.5 | 7.84 | 8.0 | 8.16 | |
| | FmMRC(2) | | Frequency variable RC oscillation. • Ta=-10 to +85°C (Note 2-4) | 1.8 to 5.5 | 7.88 | 8.0 | 8.12 | |
| | FmRC | | Internal medium-speed RC oscillation | 1.8 to 5.5 | 0.5 | 1.0 | 2.0 | |
| | FmSRC | | Internal low-speed RC oscillation | 1.8 to 5.5 | 50 | 100 | 200 | |
| | FsX'tal | XT1, XT2 | 32.768kHz crystal oscillation See Fig. 1. | 1.8 to 5.5 | | 32.768 | | kHz |
| Oscillation stabilization time | tmsMRC | | When Frequency variable RC oscillation state is switched from stopped to enabled. See Fig. 3. | 1.8 to 5.5 | | | 100 | μs |

Note 2-3: See Tables 1 and 2 for the oscillation constants.

Note 2-4: When switching the system clock, allow an oscillation stabilization time of 100μs or longer after the frequency variable RC oscillator circuit transmits from the "oscillation stopped" to "oscillation enabled" state.

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

LC87FBH08A

Electrical Characteristics at Ta = -40°C to +85°C, V_{SS1} = V_{SS2} = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---------------------------|----------------------|--|--|---------------------|----------------------|---------------------|-----|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| High level input current | I _{IH} (1) | Ports 0, 1, 2, 3, Ports 7, $\overline{\text{RES}}$ | Output disabled Pull-up resistor off V _{IN} =V _{DD} (Including output Tr's off leakage current) | 1.8 to 5.5 | | | 1 | μA |
| | I _{IH} (2) | CF1, CF2 | Input port selected V _{IN} =V _{DD} | 1.8 to 5.5 | | | 1 | |
| | I _{IH} (3) | CF1 | Reset state V _{IN} =V _{DD} | 1.8 to 5.5 | | | 15 | |
| Low level input current | I _{IL} (1) | Ports 0, 1, 2, 3, Ports 7, $\overline{\text{RES}}$ | Output disabled Pull-up resistor off V _{IN} =V _{SS} (Including output Tr's off leakage current) | 1.8 to 5.5 | -1 | | | |
| | I _{IL} (2) | CF1, CF2 | Input port selected V _{IN} =V _{SS} | 1.8 to 5.5 | -1 | | | |
| High level output voltage | V _{OH} (1) | Ports 0, 1, 2 P71 to P73 | I _{OH} =-1mA | 4.5 to 5.5 | V _{DD} -1 | | | V |
| | V _{OH} (2) | | I _{OH} =-0.35mA | 2.7 to 5.5 | V _{DD} -0.4 | | | |
| | V _{OH} (3) | | I _{OH} =-0.15mA | 1.8 to 5.5 | V _{DD} -0.4 | | | |
| | V _{OH} (4) | Ports 3 P05 (System clock output function used) | I _{OH} =-6mA | 4.5 to 5.5 | V _{DD} -1 | | | |
| | V _{OH} (5) | | I _{OH} =-1.4mA | 2.7 to 5.5 | V _{DD} -0.4 | | | |
| | V _{OH} (6) | | I _{OH} =-0.8mA | 1.8 to 5.5 | V _{DD} -0.4 | | | |
| Low level output voltage | V _{OL} (1) | Ports 0, 1, 2, 3 | I _{OL} =10mA | 4.5 to 5.5 | | | 1.5 | V |
| | V _{OL} (2) | | I _{OL} =1.4mA | 2.7 to 5.5 | | | 0.4 | |
| | V _{OL} (3) | | I _{OL} =0.8mA | 1.8 to 5.5 | | | 0.4 | |
| | V _{OL} (4) | Port 7, CF2 | I _{OL} =1.4mA | 2.7 to 5.5 | | | 0.4 | |
| | V _{OL} (5) | | I _{OL} =0.8mA | 1.8 to 5.5 | | | 0.4 | |
| | V _{OL} (6) | P00, P01 | I _{OL} =25mA | 4.5 to 5.5 | | | 1.5 | |
| | V _{OL} (7) | | I _{OL} =4mA | 2.7 to 5.5 | | | 0.4 | |
| | V _{OL} (8) | | I _{OL} =2mA | 1.8 to 5.5 | | | 0.4 | |
| Pull-up resistance | R _{pu} (1) | Ports 0, 1, 2, 3, Ports 7 | V _{OH} =0.9V _{DD} When Port 0 selected low-impedance pull-up. | 4.5 to 5.5 | 15 | 35 | 80 | kΩ |
| | R _{pu} (2) | | V _{OH} =0.9V _{DD} When Port 0 selected high-impedance pull-up. | 1.8 to 4.5 | 18 | 50 | 230 | |
| | R _{pu} (3) | Port 0 | V _{OH} =0.9V _{DD} When Port 0 selected high-impedance pull-up. | 1.8 to 5.5 | 100 | 200 | 400 | |
| Hysteresis voltage | V _{HYS} (1) | Ports 1, 2, 3, Ports 7, $\overline{\text{RES}}$ | | 2.7 to 5.5 | | 0.1V _{DD} | | V |
| | V _{HYS} (2) | | | 1.8 to 2.7 | | 0.07V _{DD} | | |
| Pin capacitance | CP | All pins | For pins other than that under test: V _{IN} =V _{SS} f=1MHz Ta=25°C | 1.8 to 5.5 | | 10 | | pF |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

LC87FBH08A

SIO0 Serial I/O Characteristics at Ta = -40°C to +85°C, V_{SS1} = V_{SS2} = 0V (Note 4-1-1)

| Parameter | | Symbol | Pin/ Remarks | Conditions | V _{DD} [V] | Specification | | | unit | |
|---------------|-----------------|------------------------|-----------------------|--|---|--------------------|--------------------|-----------------------------|--------------------|------|
| | | | | | | min | typ | max | | |
| Serial clock | Input clock | Frequency | tSCK(1) | SCK0(P12) | • See Fig. 5. | 1.8 to 5.5 | 2 | | | tCYC |
| | | Low level pulse width | tSCKL(1) | | | | 1 | | | |
| | | High level pulse width | tSCKH(1) | | | | 1 | | | |
| | | | tSCKHA(1) | | | | | | | |
| | | | | | • Continuous data transmission/reception mode • See Fig. 5. (Note 4-1-2) | | 4 | | | |
| | | | | | | | | | | |
| Serial clock | Output clock | Frequency | tSCK(2) | SCK0(P12) | • CMOS output selected • See Fig. 5. | 1.8 to 5.5 | 4/3 | | | tSCK |
| | | Low level pulse width | tSCKL(2) | | | | 1/2 | | | |
| | | High level pulse width | tSCKH(2) | | | | 1/2 | | | |
| | | | tSCKHA(2) | | | | | | | |
| | | | | • Continuous data transmission/reception mode • CMOS output selected • See Fig. 5. | | tSCKH(2) +2tCYC | | tSCKH(2) +(10/3) tCYC | tCYC | |
| | | | | | | | | | | |
| Serial input | Data setup time | tsDI(1) | SB0(P11), SIO(P11) | • Must be specified with respect to rising edge of SIOCLK. • See Fig. 5. | 1.8 to 5.5 | 0.05 | | | | |
| | Data hold time | thDI(1) | | | | 0.05 | | | | |
| Serial output | Input clock | Output delay time | tdD0(1) | SO0(P10), SB0(P11) | • Continuous data transmission/reception mode (Note 4-1-3) • Synchronous 8-bit mode (Note 4-1-3) (Note 4-1-3) | 1.8 to 5.5 | | | (1/3)tCYC +0.08 | μs |
| | | | tdD0(2) | | | | | | 1tCYC +0.08 | |
| | tdD0(3) | | | | | | (1/3)tCYC +0.08 | | | |

Note 4-1-1: These specifications are theoretical values. Add margin depending on its use.

Note 4-1-2: To use serial-clock-input in continuous trans/rec mode, a time from SIO_{RUN} being set when serial clock is "H" to the first negative edge of the serial clock must be longer than tSCKHA.

Note 4-1-3: Must be specified with respect to falling edge of SIOCLK. Must be specified as the time to the beginning of output state change in open drain output mode. See Fig. 5.

LC87FBH08A

SI01 Serial I/O Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V (Note 4-2-1)

| Parameter | | Symbol | Pin/ Remarks | Conditions | VDD[V] | Specification | | | | |
|---------------|-------------------|------------------------|-----------------------|--|---|--------------------|-----|--------------------|------|------|
| | | | | | | min | typ | max | unit | |
| Serial clock | Input clock | Frequency | tSCK(3) | SCK1(P15) | • See Fig. 5. | 1.8 to 5.5 | 2 | | | tCYC |
| | | Low level pulse width | tSCKL(3) | | | | 1 | | | |
| | | High level pulse width | tSCKH(3) | | | | 1 | | | |
| | Output clock | Frequency | tSCK(4) | SCK1(P15) | • CMOS output selected • See Fig. 5. | 1.8 to 5.5 | 2 | | | tSCK |
| | | Low level pulse width | tSCKL(4) | | | | 1/2 | | | |
| | | High level pulse width | tSCKH(4) | | | | 1/2 | | | |
| Serial input | Data setup time | tsDI(2) | SI1(P14), SB1(P14) | • Must be specified with respect to rising edge of SIOCLK. • See Fig. 5. | 1.8 to 5.5 | (1/3)tCYC +0.01 | | | μs | |
| | Data hold time | thDI(2) | | | | 0.01 | | | | |
| Serial output | Output delay time | tdD0(4) | SO1(P13), SB1(P14) | • Must be specified with respect to falling edge of SIOCLK. • Must be specified as the time to the beginning of output state change in open drain output mode. • See Fig. 5. | 1.8 to 5.5 | | | (1/2)tCYC +0.05 | μs | |

Note 4-2-1: These specifications are theoretical values. Add margin depending on its use.

Pulse Input Conditions at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | VDD[V] | Specification | | | |
|----------------------------|--------------------|--|---|-------------------------|---------------|-----|-----|------|
| | | | | | min | typ | max | unit |
| High/low level pulse width | tPIH(1) tPIL(1) | INT0(P70), INT1(P71), INT2(P72), INT4(P20 to P21) INT5(P30 to P31) | • Interrupt source flag can be set. • Event inputs for timer 0 or 1 are enabled. | 1.8 to 5.5 | 1 | | | tCYC |
| | tPIH(2) tPIL(2) | INT3(P73) when noise filter time constant is 1/1 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 1.8 to 5.5 | 2 | | | |
| | tPIH(3) tPIL(3) | INT3(P73) when noise filter time constant is 1/32 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 1.8 to 5.5 | 64 | | | |
| | tPIH(4) tPIL(4) | INT3(P73) when noise filter time constant is 1/128 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 1.8 to 5.5 | 256 | | | |
| | tPIL(5) | RES | | • Resetting is enabled. | 1.8 to 5.5 | 200 | | |

LC87FBH08A

AD Converter Characteristics at $V_{SS1} = V_{SS2} = 0V$

<12bits AD Converter Mode at $T_a = -40^{\circ}C$ to $+85^{\circ}C$ >

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|----------------------------|--------|---|--|---------------|----------|-----|----------|---------|
| | | | | $V_{DD}[V]$ | min | typ | max | unit |
| Resolution | N | AN0(P00) to AN6(P06), AN8(P70) to AN10(P72) | | 1.8 to 5.5 | | 12 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | 2.7 to 5.5 | | | ± 16 | LSB |
| | | | | 1.8 to 5.5 | | | ± 20 | |
| Conversion time | TCAD | | • See Conversion time calculation formulas. (Note 6-2) | 2.7 to 5.5 | 32 | | 115 | μs |
| | | | | 2.2 to 5.5 | 134 | | 215 | |
| | | | | 1.8 to 5.5 | 400 | | 430 | |
| Analog input voltage range | VAIN | | | 1.8 to 5.5 | V_{SS} | | V_{DD} | V |
| Analog port input current | IAINH | $VAIN = V_{DD}$ | 1.8 to 5.5 | | | 1 | μA | |
| | IAINL | $VAIN = V_{SS}$ | 1.8 to 5.5 | -1 | | | | |

<8bits AD Converter Mode at $T_a = -40^{\circ}C$ to $+85^{\circ}C$ >

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|----------------------------|--------|---|--|---------------|----------|-----|-----------|---------|
| | | | | $V_{DD}[V]$ | min | typ | max | unit |
| Resolution | N | AN0(P00) to AN6(P06), AN8(P70) to AN10(P72) | | 1.8 to 5.5 | | 8 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | 1.8 to 5.5 | | | ± 1.5 | LSB |
| | | | | | | | | |
| Conversion time | TCAD | | • See Conversion time calculation formulas. (Note 6-2) | 2.7 to 5.5 | 20 | | 90 | μs |
| | | | | 2.2 to 5.5 | 80 | | 135 | |
| | | | | 1.8 to 5.5 | 245 | | 265 | |
| Analog input voltage range | VAIN | | | 1.8 to 5.5 | V_{SS} | | V_{DD} | V |
| Analog port input current | IAINH | $VAIN = V_{DD}$ | 1.8 to 5.5 | | | 1 | μA | |
| | IAINL | $VAIN = V_{SS}$ | 1.8 to 5.5 | -1 | | | | |

Note 6-1: The quantization error ($\pm 1/2LSB$) must be excluded from the absolute accuracy. The absolute accuracy must be measured in the microcontroller's state in which no I/O operations occur at the pins adjacent to the analog input channel.

Note 6-2: The conversion time refers to the period from the time an instruction for starting a conversion process till the time the conversion results register(s) are loaded with a complete digital conversion value corresponding to the analog input value.

The conversion time is 2 times the normal-time conversion time when:

- The first AD conversion is performed in the 12-bit AD conversion mode after a system reset.
- The first AD conversion is performed after the AD conversion mode is switched from 8-bit to 12-bit conversion mode.

Conversion time calculation formulas:

$$12\text{bits AD Converter Mode: } TCAD(\text{Conversion time}) = ((52/(\text{AD division ratio}))+2) \times (1/3) \times tCYC$$

$$8\text{bits AD Converter Mode: } TCAD(\text{Conversion time}) = ((32/(\text{AD division ratio}))+2) \times (1/3) \times tCYC$$

| External oscillation (FmCF) | Operating supply voltage range (V_{DD}) | System division ratio (SYSDIV) | Cycle time (tCYC) | AD division ratio (ADDIV) | AD conversion time (TCAD) | |
|-----------------------------|---|--------------------------------|-------------------|---------------------------|---------------------------|----------------|
| | | | | | 12bit AD | 8bit AD |
| CF-12MHz | 2.7V to 5.5V | 1/1 | 250ns | 1/8 | 34.8 μs | 21.5 μs |
| CF-8MHz | 2.7V to 5.5V | 1/1 | 375ns | 1/8 | 52.25 μs | 32.25 μs |
| | 2.2V to 5.5V | 1/1 | 375ns | 1/32 | 208.25 μs | 128.25 μs |
| CF-4MHz | 2.7V to 5.5V | 1/1 | 750ns | 1/8 | 104.5 μs | 64.5 μs |
| | 2.2V to 5.5V | 1/1 | 750ns | 1/16 | 208.5 μs | 128.5 μs |
| | 1.8V to 5.5V | 1/1 | 750ns | 1/32 | 416.5 μs | 256.5 μs |

LC87FBH08A

Reference voltage (VREF17) Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|--|---------|-------------|------------|---------------------|------|------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| Output voltage | VOVREF | | | 2.0 to 5.5 | 1.67 | 1.75 | 1.83 | V |
| Reference voltage operation current (Note 7-1) | IDDVREF | | | 2.0 to 5.5 | | 110 | | μA |
| Operation stabilization time (Note 7-2) | tVRW | | | 2.0 to 5.5 | | | 100 | μs |

Note 7-1: IDDVREF denotes the currents that only flow to multivariable RC oscillator circuit's reference voltage circuit.

Note 7-2: tVRW denotes the stabilization time from starting multivariable RC oscillator.

Power-on Reset (POR) Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---------------------------------|--------|-------------|---|-------------------------|------|------|------|------|
| | | | | Option selected voltage | min | typ | max | unit |
| POR release voltage | PORRL | | <ul style="list-style-type: none"> Select from option. (Note 8-1) | 1.67V | 1.55 | 1.66 | 1.77 | V |
| | | | | 1.97V | 1.85 | 1.96 | 2.07 | |
| | | | | 2.07V | 1.93 | 2.05 | 2.17 | |
| | | | | 2.37V | 2.23 | 2.35 | 2.47 | |
| | | | | 2.57V | 2.43 | 2.55 | 2.67 | |
| | | | | 2.87V | 2.71 | 2.85 | 2.99 | |
| | | | | 3.86V | 3.65 | 3.83 | 4.00 | |
| | | | | 4.35V | 4.12 | 4.32 | 4.50 | |
| Detection voltage unknown state | POUKS | | <ul style="list-style-type: none"> See Fig. 7. (Note 8-2) | | | 0.7 | 0.95 | |
| Power supply rise time | PORIS | | <ul style="list-style-type: none"> Power supply rise time from 0V to 1.6V. | | | | 100 | ms |

Note8-1: The POR release level can be selected out of 8 levels only when the LVD reset function is disabled.

Note8-2: POR is in an unknown state before transistors start operation.

Low Voltage Detection Reset (LVD) Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---|--------|-------------|--|-------------------------|------|------|------|------|
| | | | | Option selected voltage | min | typ | max | unit |
| LVD reset voltage (Note 9-2) | LVDET | | <ul style="list-style-type: none"> Select from option. (Note 9-1) (Note 9-3) See Fig. 8. | 1.91V | 1.81 | 1.91 | 2.01 | V |
| | | | | 2.01V | 1.90 | 2.00 | 2.10 | |
| | | | | 2.31V | 2.20 | 2.30 | 2.40 | |
| | | | | 2.51V | 2.40 | 2.50 | 2.60 | |
| | | | | 2.81V | 2.68 | 2.80 | 2.92 | |
| | | | | 3.79V | 3.62 | 3.78 | 3.94 | |
| | | | | 4.28V | 4.09 | 4.27 | 4.45 | |
| LVD hysteresis width | LVHYS | | | 1.91V | | 50 | | mV |
| | | | | 2.01V | | 50 | | |
| | | | | 2.31V | | 50 | | |
| | | | | 2.51V | | 50 | | |
| | | | | 2.81V | | 50 | | |
| | | | | 3.79V | | 50 | | |
| | | | | 4.28V | | 50 | | |
| Detection voltage unknown state | LVUKS | | <ul style="list-style-type: none"> See Fig. 8. (Note 9-4) | | | 0.7 | 0.95 | V |
| Low voltage detection minimum width (Reply sensitivity) | TLVDW | | <ul style="list-style-type: none"> LVDET-0.5V See Fig. 9. | | 0.2 | | | ms |

Note9-1: The LVD reset level can be selected out of 7 levels only when the LVD reset function is enabled.

Note9-2: LVD reset voltage specification values do not include hysteresis voltage.

Note9-3: LVD reset voltage may exceed its specification values when port output state changes and/or when a large current flows through port.

Note9-4: LVD is in an unknown state before transistors start operation.

LC87FBH08A

Consumption Current Characteristics at Ta = -40°C to +85°C, V_{SS1} = V_{SS2} = 0V

| Parameter | Symbol | Pin/ Remarks | Conditions | Specification | | | | unit |
|---|--|------------------|--|---------------------|-----|------|------|------|
| | | | | V _{DD} [V] | min | typ | max | |
| Normal mode consumption current (Note 10-1) (Note 10-2) | IDDOP(1) | V _{DD1} | <ul style="list-style-type: none"> FmCF=12MHz ceramic oscillation mode System clock set to 12MHz side Internal low speed and medium speed RC oscillation stopped. | 2.7 to 5.5 | | 5.1 | 9.3 | mA |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/1 frequency division ratio | 2.7 to 3.6 | | 3.1 | 5.6 | |
| | IDDOP(2) | | <ul style="list-style-type: none"> CF1=24MHz external clock System clock set to CF1 side Internal low speed and medium speed RC oscillation stopped. | 3.0 to 5.5 | | 5.2 | 10 | |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/2 frequency division ratio | 3.0 to 3.6 | | 3.3 | 6.2 | |
| | IDDOP(3) | | <ul style="list-style-type: none"> FmCF=10MHz ceramic oscillation mode System clock set to 10MHz side Internal low speed and medium speed RC oscillation stopped. | 2.2 to 5.5 | | 4.4 | 8.4 | |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/1 frequency division ratio | 2.2 to 3.6 | | 2.8 | 5.5 | |
| | IDDOP(4) | | <ul style="list-style-type: none"> FmCF=4MHz ceramic oscillation mode System clock set to 4MHz side Internal low speed and medium speed RC oscillation stopped. | 1.8 to 5.5 | | 2.3 | 5.3 | |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/1 frequency division ratio | 1.8 to 3.6 | | 1.6 | 3.0 | |
| | IDDOP(5) | | <ul style="list-style-type: none"> CF oscillation low amplifier size selected. (CFLAMP=1) FmCF=4MHz ceramic oscillation mode System clock set to 4MHz side Internal low speed and medium speed RC oscillation stopped. | 2.2 to 5.5 | | 0.97 | 2.4 | |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/4 frequency division ratio | 2.2 to 3.6 | | 0.55 | 1.2 | |
| | IDDOP(6) | | <ul style="list-style-type: none"> FsX'tal=32.768kHz crystal oscillation mode Internal low speed RC oscillation stopped. System clock set to internal medium speed RC oscillation. | 1.8 to 5.5 | | 0.44 | 1.5 | |
| | | | <ul style="list-style-type: none"> Frequency variable RC oscillation stopped. 1/2 frequency division ratio | 1.8 to 3.6 | | 0.28 | 0.80 | |
| | IDDOP(7) | | <ul style="list-style-type: none"> FsX'tal=32.768kHz crystal oscillation mode Internal low speed and medium speed RC oscillation stopped. | 1.8 to 5.5 | | 3.4 | 5.5 | |
| | | | <ul style="list-style-type: none"> System clock set to 8MHz with frequency variable RC oscillation 1/1 frequency division ratio | 1.8 to 3.6 | | 2.4 | 4.6 | |
| | IDDOP(8) | | <ul style="list-style-type: none"> External FsX'tal and FmCF oscillation stopped. System clock set to internal low speed RC oscillation. | 1.8 to 5.5 | | 51 | 163 | |
| | | | <ul style="list-style-type: none"> Internal medium speed RC oscillation stopped. Frequency variable RC oscillation stopped. 1/1 frequency division ratio | 1.8 to 3.6 | | 38 | 103 | |
| IDDOP(9) | <ul style="list-style-type: none"> External FsX'tal and FmCF oscillation stopped. System clock set to internal low speed RC oscillation. | 5.0 | | 51 | 136 | | | |
| | <ul style="list-style-type: none"> Internal medium speed RC oscillation stopped. Frequency variable RC oscillation stopped. | 3.3 | | 38 | 99 | | | |
| | <ul style="list-style-type: none"> 1/1 frequency division ratio | 2.5 | | 36 | 94 | | | |
| | <ul style="list-style-type: none"> Ta=-10 to +50°C | | | | | | | |

Note10-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note10-2: The consumption current values do not include operational current of LVD function if not specified.

Continued on next page.

LC87FBH08A

Continued from preceding page.

| Parameter | Symbol | Pin/ Remarks | Conditions | Specification | | | | |
|---|------------|-------------------|--|---------------------|-----|------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| Normal mode consumption current (Note 10-1) (Note 10-2) | IDDOP(10) | V _{DD} 1 | <ul style="list-style-type: none"> • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal low speed and medium speed RC oscillation stopped. | 1.8 to 5.5 | | 34 | 97 | μA |
| | | | <ul style="list-style-type: none"> • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio | 1.8 to 3.6 | | 14 | 44 | |
| | IDDOP(11) | | <ul style="list-style-type: none"> • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal low speed and medium speed RC oscillation stopped. | 5.0 | | 34 | 88 | |
| | | | <ul style="list-style-type: none"> • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio • Ta=-10 to +50°C | 3.3 | | 14 | 36 | |
| HALT mode consumption current (Note 10-1) (Note 10-2) | IDDHALT(1) | | <ul style="list-style-type: none"> • HALT mode • FmCF=12MHz ceramic oscillation mode • System clock set to 12MHz side | 2.7 to 5.5 | | 2.6 | 4.8 | mA |
| | | | <ul style="list-style-type: none"> • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio | 2.7 to 3.6 | | 1.4 | 2.4 | |
| | IDDHALT(2) | | <ul style="list-style-type: none"> • HALT mode • CF1=24MHz external clock • System clock set to CF1 side | 3.0 to 5.5 | | 2.7 | 5.3 | |
| | | | <ul style="list-style-type: none"> • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio | 3.0 to 3.6 | | 1.6 | 2.9 | |
| | IDDHALT(3) | | <ul style="list-style-type: none"> • HALT mode • FmCF=10MHz ceramic oscillation mode • System clock set to 10MHz side | 2.2 to 5.5 | | 2.2 | 4.3 | |
| | | | <ul style="list-style-type: none"> • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio | 2.2 to 3.6 | | 1.2 | 2.2 | |
| | IDDHALT(4) | | <ul style="list-style-type: none"> • HALT mode • FmCF=4MHz ceramic oscillation mode • System clock set to 4MHz side | 1.8 to 5.5 | | 1.3 | 3.3 | |
| | | | <ul style="list-style-type: none"> • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio | 1.8 to 3.6 | | 0.56 | 1.2 | |
| | IDDHALT(5) | | <ul style="list-style-type: none"> • HALT mode • CF oscillation low amplifier size selected. (CFLAMP=1) • FmCF=4MHz ceramic oscillation mode | 2.2 to 5.5 | | 0.74 | 1.8 | |
| | | | <ul style="list-style-type: none"> • System clock set to 4MHz side • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/4 frequency division ratio | 2.2 to 3.6 | | 0.34 | 0.68 | |
| | IDDHALT(6) | | <ul style="list-style-type: none"> • HALT mode • FsX'tal=32.768kHz crystal oscillation mode • Internal low speed RC oscillation stopped. | 1.8 to 5.5 | | 0.32 | 0.90 | |
| | | | <ul style="list-style-type: none"> • System clock set to internal medium speed RC oscillation • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio | 1.8 to 3.6 | | 0.21 | 0.44 | |

Note10-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note10-2: The consumption current values do not include operational current of LVD function if not specified.

Continued on next page.

LC87FBH08A

Continued from preceding page.

| Parameter | Symbol | Pin/ remarks | Conditions | Specification | | | | |
|---|-------------|--|---|---------------------|-------|------|-----|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| HALT mode consumption current (Note 10-1) (Note 10-2) | IDDHALT(7) | V _{DD} 1 | <ul style="list-style-type: none"> • HALT mode • FsX'tal=32.768kHz crystal oscillation mode • Internal low speed and medium speed RC oscillation stopped. • System clock set to 8MHz with frequency variable RC oscillation • 1/1 frequency division ratio | 1.8 to 5.5 | | 1.3 | 2.3 | mA |
| | | | | 1.8 to 3.6 | | 0.91 | 1.5 | |
| | IDDHALT(8) | | <ul style="list-style-type: none"> • HALT mode • External FsX'tal and FmCF oscillation stopped. • System clock set to internal low speed RC oscillation. • Internal medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio | 1.8 to 5.5 | | 18 | 68 | μA |
| | | | | 1.8 to 3.6 | | 11 | 35 | |
| | IDDHALT(9) | | <ul style="list-style-type: none"> • HALT mode • External FsX'tal and FmCF oscillation stopped. • System clock set to internal low speed RC oscillation. • Internal medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio • Ta=-10 to +50°C | 5.0 | | 18 | 46 | |
| | | | | 3.3 | | 11 | 27 | |
| | | | | 2.5 | | 7.4 | 19 | |
| | IDDHALT(10) | | <ul style="list-style-type: none"> • HALT mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio | 1.8 to 5.5 | | 24 | 98 | |
| | | | | 1.8 to 3.6 | | 8.0 | 35 | |
| | IDDHALT(11) | | <ul style="list-style-type: none"> • HALT mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal low speed and medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio • Ta=-10 to +50°C | 5.0 | | 24 | 63 | |
| | | | | 3.3 | | 8.0 | 23 | |
| | | | | 2.5 | | 3.5 | 11 | |
| HOLD mode consumption current (Note 10-1) (Note 10-2) | IDDHOLD(1) | HOLD mode • CF1=V _{DD} or open (External clock mode) | 1.8 to 5.5 | | 0.019 | 23 | | |
| | | | 1.8 to 3.6 | | 0.011 | 11 | | |
| | IDDHOLD(2) | | 5.0 | | 0.019 | 1.2 | | |
| | | | 3.3 | | 0.011 | 0.59 | | |
| | | | 2.5 | | 0.010 | 0.30 | | |
| | IDDHOLD(3) | | HOLD mode • CF1=V _{DD} or open (External clock mode) • LVD option selected | 1.8 to 5.5 | | 2.6 | 26 | |
| | | | | 1.8 to 3.6 | | 2.0 | 13 | |
| | IDDHOLD(4) | | HOLD mode • CF1=V _{DD} or open (External clock mode) • Ta=-10 to +50°C • LVD option selected | 5.0 | | 2.6 | 3.8 | |
| 3.3 | | | | 2.0 | 2.8 | | | |
| 2.5 | | | | 1.7 | 2.5 | | | |
| Timer HOLD mode consumption current (Note 10-1) (Note 10-2) | IDDHOLD(5) | Timer HOLD mode • FsX'tal=32.768kHz crystal oscillation mode | 1.8 to 5.5 | | 22 | 84 | | |
| | | | 1.8 to 3.6 | | 6.5 | 30 | | |
| | IDDHOLD(6) | | 5.0 | | 22 | 53 | | |
| | | | 3.3 | | 6.5 | 16 | | |
| | | 2.5 | | 2.7 | 7.2 | | | |

Note10-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note10-2: The consumption current values do not include operational current of LVD function if not specified.

LC87FBH08A

F-ROM Programming Characteristics at Ta = +10°C to +55°C, VSS1 = VSS2 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|-----------------------------|----------|-------------|------------------------------------|---------------|-----|-----|-----|------|
| | | | | VDD[V] | min | typ | max | unit |
| Onboard programming current | IDDFW(1) | VDD1 | • Only current of the Flash block. | 2.2 to 5.5 | | 5 | 10 | mA |
| Programming time | tFW(1) | | • Erasing time | 2.2 to 5.5 | | 20 | 30 | ms |
| | tFW(2) | | • Programming time | | | 40 | 60 | μs |

UART (Full Duplex) Operating Conditions at Ta = -40°C to +85°C, VSS1 = VSS2 = 0V

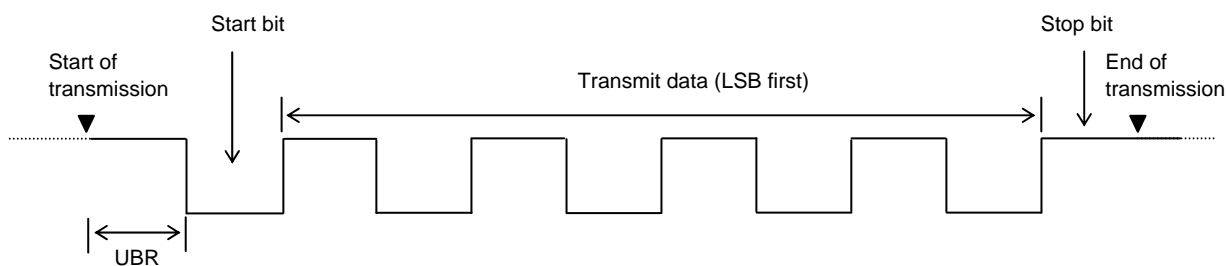
| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---------------|--------|-------------|------------|---------------|------|-----|--------|------|
| | | | | VDD[V] | min | typ | max | unit |
| Transfer rate | UBR | P20, P21 | | 1.8 to 5.5 | 16/3 | | 8192/3 | tCYC |

Data length: 7/8/9 bits (LSB first)

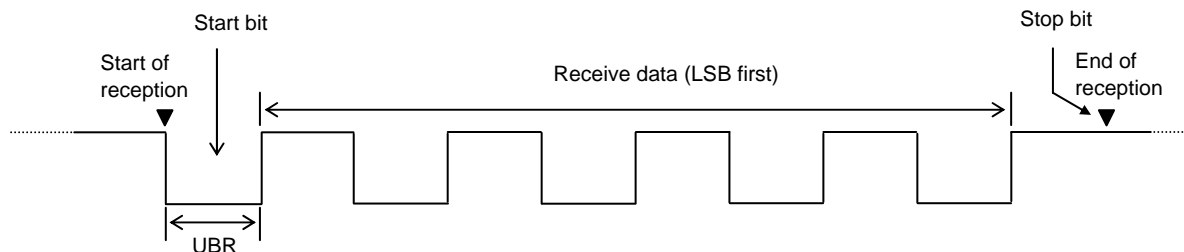
Stop bits: 1 bit (2-bit in continuous data transmission)

Parity bits: None

Example of Continuous 8-bit Data Transmission Mode Processing (First Transmit Data=55H)



Example of Continuous 8-bit Data Reception Mode Processing (First Receive Data=55H)



LC87FBH08A

Characteristics of a Sample Main System Clock Oscillation Circuit

Given below are the characteristics of a sample main system clock oscillation circuit that are measured using a Our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 1 Characteristics of a Sample Main System Clock Oscillator Circuit with a Ceramic Oscillator

- CF oscillation normal amplifier size selected (CFLAMP=0)

■MURATA

| Nominal Frequency | Type | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|-------------------|------|--------------------|------------------|---------|--------|--------|-----------------------------|--------------------------------|----------|-----------------|
| | | | C1 [pF] | C2 [pF] | Rf [Ω] | Rd [Ω] | | typ [ms] | max [ms] | |
| 12MHz | SMD | CSTCE12M0G52-R0 | (10) | (10) | Open | 680 | 2.6 to 5.5 | 0.02 | 0.3 | Internal C1, C2 |
| 10MHz | SMD | CSTCE10M0G52-R0 | (10) | (10) | Open | 680 | 2.1 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS10M0G53-B0 | (15) | (15) | Open | 680 | 2.4 to 5.5 | 0.02 | 0.3 | |
| | | CSTLS10M0G53095-B0 | (15) | (15) | Open | 680 | 2.0 to 5.5 | 0.01 | 0.15 | |
| 8MHz | SMD | CSTCE8M00G52-R0 | (10) | (10) | Open | 1k | 2.1 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS8M00G53-B0 | (15) | (15) | Open | 1k | 2.2 to 5.5 | 0.02 | 0.3 | |
| | | CSTLS8M00G53095-B0 | (15) | (15) | Open | 1k | 1.9 to 5.5 | 0.01 | 0.15 | |
| 6MHz | SMD | CSTCR6M00G53-R0 | (15) | (15) | Open | 1.5k | 2.0 to 5.5 | 0.02 | 0.3 | |
| | | CSTCR6M00G53093-R0 | (15) | (15) | Open | 1.5k | 1.8 to 5.5 | 0.01 | 0.15 | |
| | LEAD | CSTLS6M00G53-B0 | (15) | (15) | Open | 1.5k | 2.0 to 5.5 | 0.02 | 0.3 | |
| | | CSTLS6M00G53095-B0 | (15) | (15) | Open | 1.5k | 1.8 to 5.5 | 0.01 | 0.15 | |
| 4MHz | SMD | CSTCR4M00G53-R0 | (15) | (15) | Open | 1.5k | 1.8 to 5.5 | 0.03 | 0.45 | |
| | LEAD | CSTLS4M00G53-B0 | (15) | (15) | Open | 1.5k | 1.8 to 5.5 | 0.02 | 0.3 | |

- CF oscillation low amplifier size selected (CFLAMP=1)

■MURATA

| Nominal Frequency | Type | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|-------------------|------|--------------------|------------------|---------|--------|--------|-----------------------------|--------------------------------|----------|-----------------|
| | | | C1 [pF] | C2 [pF] | Rf [Ω] | Rd [Ω] | | typ [ms] | max [ms] | |
| 12MHz | SMD | CSTCE12M0G52-R0 | (10) | (10) | Open | 470 | 3.9 to 5.5 | 0.03 | 0.45 | Internal C1, C2 |
| 10MHz | SMD | CSTCE10M0G52-R0 | (10) | (10) | Open | 470 | 2.9 to 5.5 | 0.03 | 0.45 | |
| | LEAD | CSTLS10M0G53-B0 | (15) | (15) | Open | 470 | 3.6 to 5.5 | 0.03 | 0.45 | |
| | | CSTLS10M0G53095-B0 | (15) | (15) | Open | 470 | 2.7 to 5.5 | 0.02 | 0.3 | |
| 8MHz | SMD | CSTCE8M00G52-R0 | (10) | (10) | Open | 680 | 2.7 to 5.5 | 0.03 | 0.45 | |
| | LEAD | CSTLS8M00G53-B0 | (15) | (15) | Open | 680 | 3.0 to 5.5 | 0.03 | 0.45 | |
| | | CSTLS8M00G53095-B0 | (15) | (15) | Open | 680 | 2.5 to 5.5 | 0.01 | 0.15 | |
| 6MHz | SMD | CSTCR6M00G53-R0 | (15) | (15) | Open | 1k | 2.6 to 5.5 | 0.03 | 0.45 | |
| | | CSTCR6M00G53095-R0 | (15) | (15) | Open | 1k | 2.2 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS6M00G53-B0 | (15) | (15) | Open | 1k | 2.7 to 5.5 | 0.03 | 0.45 | |
| | | CSTLS6M00G53095-B0 | (15) | (15) | Open | 1k | 2.2 to 5.5 | 0.01 | 0.15 | |
| 4MHz | SMD | CSTCR4M00G53-R0 | (15) | (15) | Open | 1k | 2.1 to 5.5 | 0.04 | 0.6 | |
| | | CSTCR4M00G53095-R0 | (15) | (15) | Open | 1k | 1.8 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS4M00G53-B0 | (15) | (15) | Open | 1k | 2.1 to 5.5 | 0.02 | 0.3 | |
| | | CSTLS4M00G53095-B0 | (15) | (15) | Open | 1k | 1.8 to 5.5 | 0.01 | 0.15 | |

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized in following cases (see Figure 3).

- The time interval that is required for the oscillation to get stabilized after the instruction for starting the mainclock oscillation circuit is executed.
- The time interval that is required for the oscillation to get stabilized after the HOLD mode is reset and oscillation is started.
- The time interval that is required for the oscillation to get stabilized after the X'tal Hold mode, under the state which the main clock oscillation is enabled, is reset and oscillation is started.

Characteristics of a Sample Subsystem Clock Oscillator Circuit

Given below are the characteristics of a sample subsystem clock oscillation circuit that are measured using a our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 2 Characteristics of a Sample Subsystem Clock Oscillator Circuit with a Crystal Oscillator

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| Nominal Frequency | Type | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|-------------------|------|-----------------|------------------|---------|--------|--------|-----------------------------|--------------------------------|---------|-----------------------------|
| | | | C1 [pF] | C2 [pF] | Rf [Ω] | Rd [Ω] | | typ [s] | max [s] | |
| 32.768kHz | SMD | MC-306 | 9 | 9 | Open | 330k | 1.8 to 5.5 | 1.4 | 4.0 | Applicable CL value = 7.0pF |

■SEIKO INSTRUMENTS

| Nominal Frequency | Type | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|-------------------|------|-----------------|------------------|---------|--------|--------|-----------------------------|--------------------------------|---------|------------------------------|
| | | | C1 [pF] | C2 [pF] | Rf [Ω] | Rd [Ω] | | typ [s] | max [s] | |
| 32.768kHz | SMD | SSP-T7-F | 18 | 22 | Open | 330k | 1.8 to 5.5 | 0.75 | 2.0 | Applicable CL value = 12.5pF |

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after VDD goes above the operating voltage lower limit (see Figure 3).

- The time interval that is required for the oscillation to get stabilized after the instruction for starting the subclock oscillation circuit is executed.
- The time interval that is required for the oscillation to get stabilized after the Hold mode, under the state which the subclock oscillation is enabled, is reset and oscillation is started.

(Notes on the implementation of the oscillator circuit)

- Oscillation is influenced by the circuit pattern layout of printed circuit board. Place the oscillation-related components as close to the CPU chip and to each other as possible with the shortest possible pattern length.
- Keep the signal lines whose state changes suddenly or in which large current flows as far away from the oscillator circuit as possible and make sure that they do not cross one another.
- Be sure to insert a current limiting resistor (Rd) so that the oscillation amplitude never exceeds the input voltage level that is specified as the absolute maximum rating.
- The oscillator circuit constants shown above are sample characteristic values that are measured using the Our designated oscillation evaluation board. Since the accuracy of the oscillation frequency and other characteristics vary according to the board on which the IC is installed, it is recommended that the user consult the resonator vendor for oscillation evaluation of the IC on a user's production board when using the IC for applications that require high oscillation accuracy. For further information, contact your resonator vendor or Our company sales representative serving your locality.
- It must be noted, when replacing the flash ROM version of a microcontroller with a mask ROM version, that their operating voltage ranges may differ even when the oscillation constant of the external oscillator is the same.

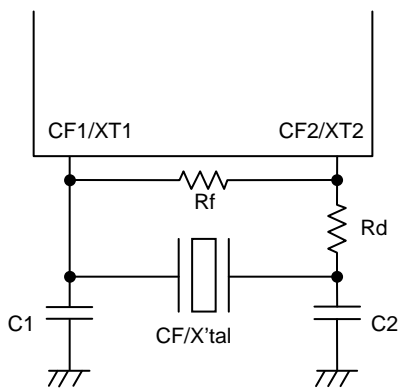


Figure 1 CF and XT Oscillator Circuit

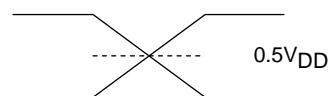
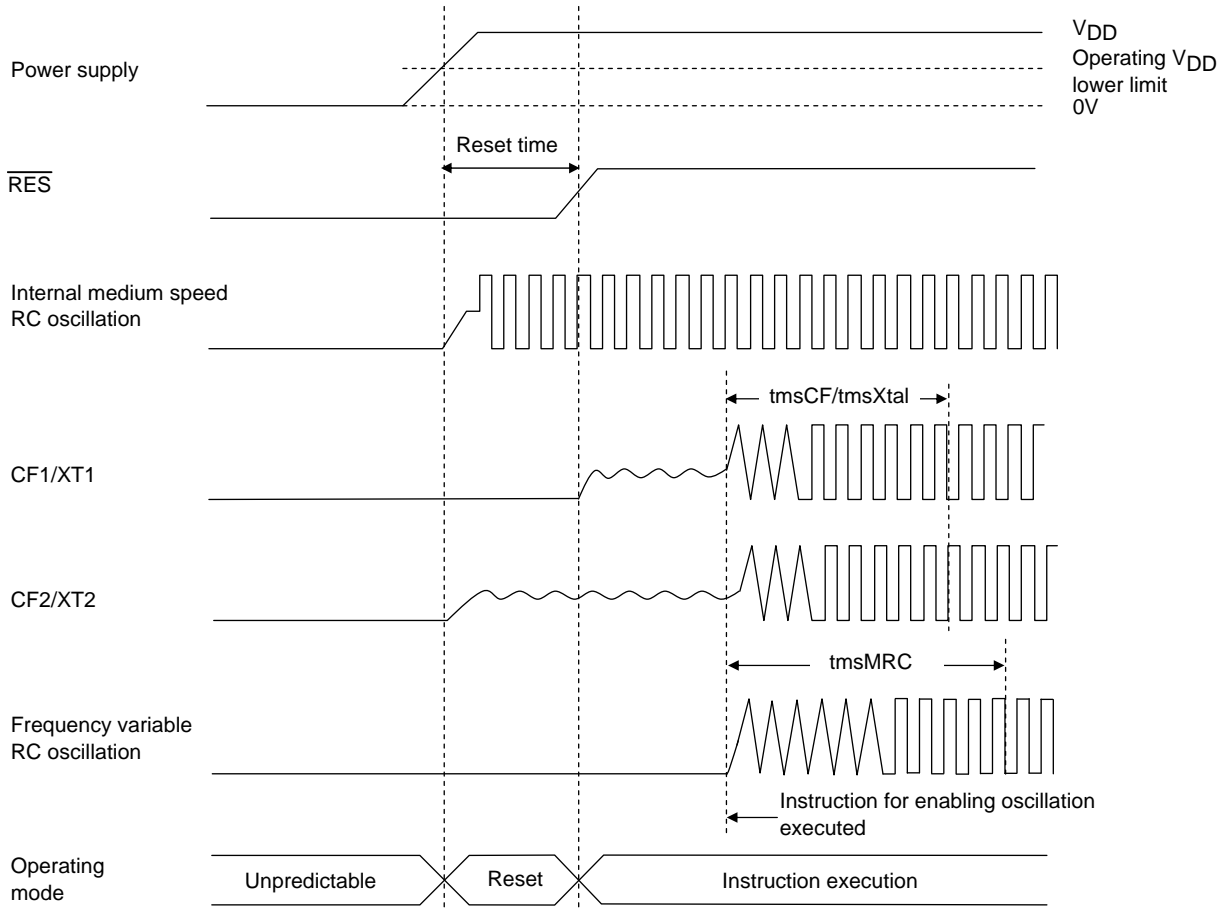
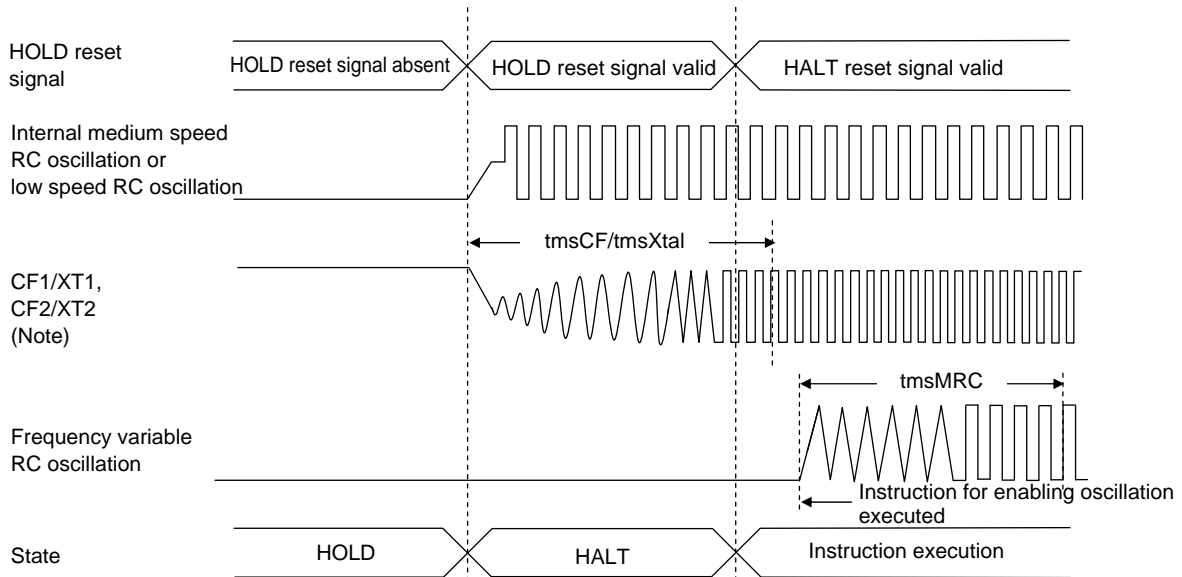


Figure 2 AC Timing Measurement Point

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Reset Time and Oscillation Stabilization Time

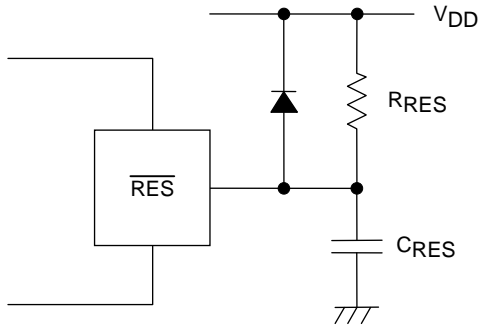


HOLD Reset Signal and Oscillation Stabilization Time

Note: External oscillation circuit is selected.

Figure 3 Oscillation Stabilization Times

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Note:
External circuits for reset may vary depending on the usage of POR and LVD. Please refer to the user's manual for more information.

Figure 4 Reset Circuit

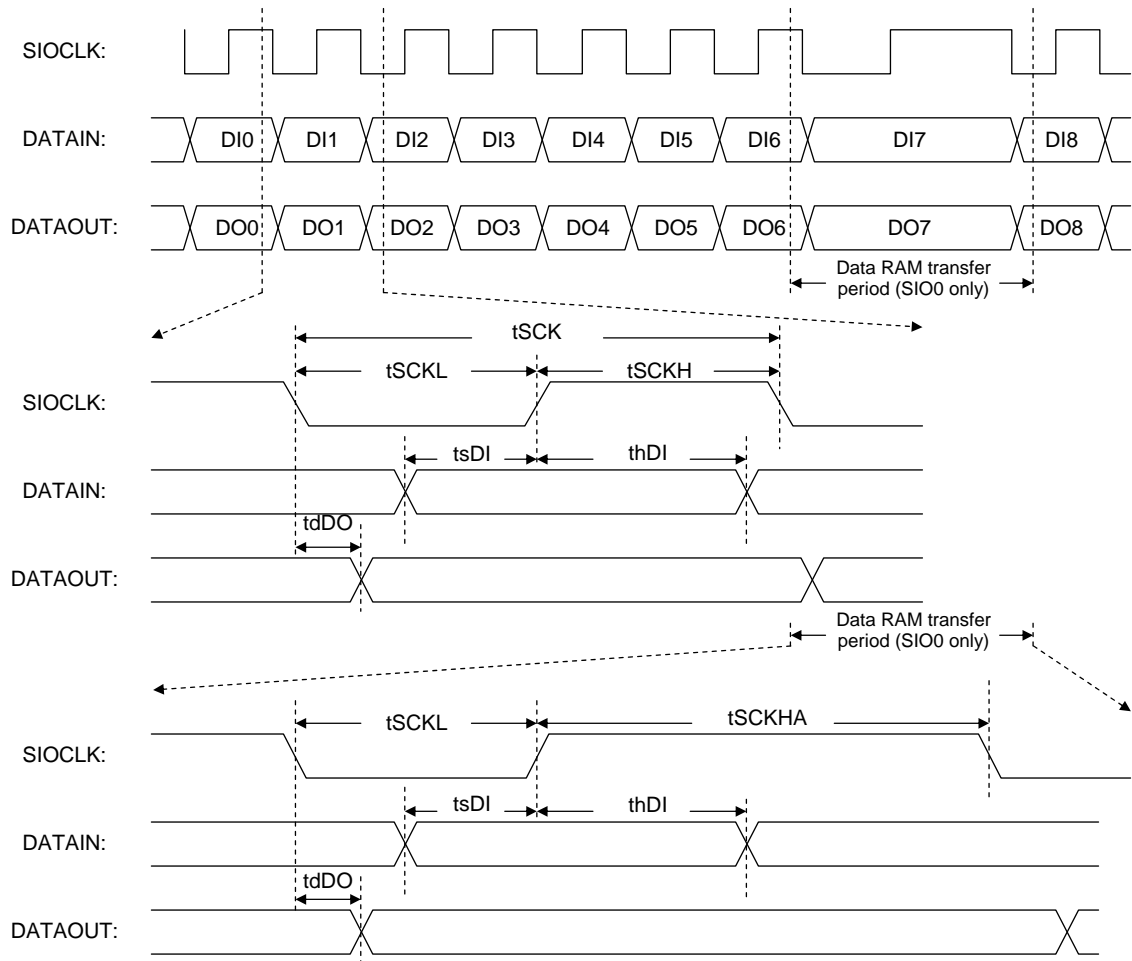


Figure 5 Serial I/O Output Waveforms

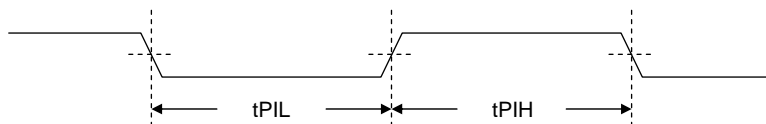


Figure 6 Pulse Input Timing Signal Waveform

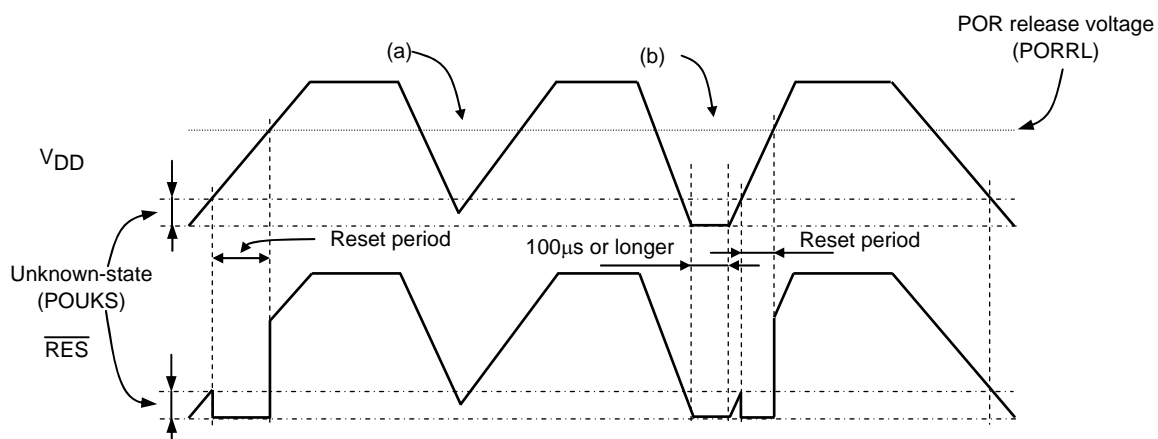


Figure 7 Waveform observed when only POR is used (LVD not used)
(RESET pin: Pull-up resistor RRES only)

- The POR function generates a reset only when power is turned on starting at the VSS level.
- No stable reset will be generated if power is turned on again when the power level does not go down to the VSS level as shown in (a). If such a case is anticipated, use the LVD function together with the POR function or implement an external reset circuit.
- A reset is generated only when the power level goes down to the VSS level as shown in (b) and power is turned on again after this condition continues for 100µs or longer.

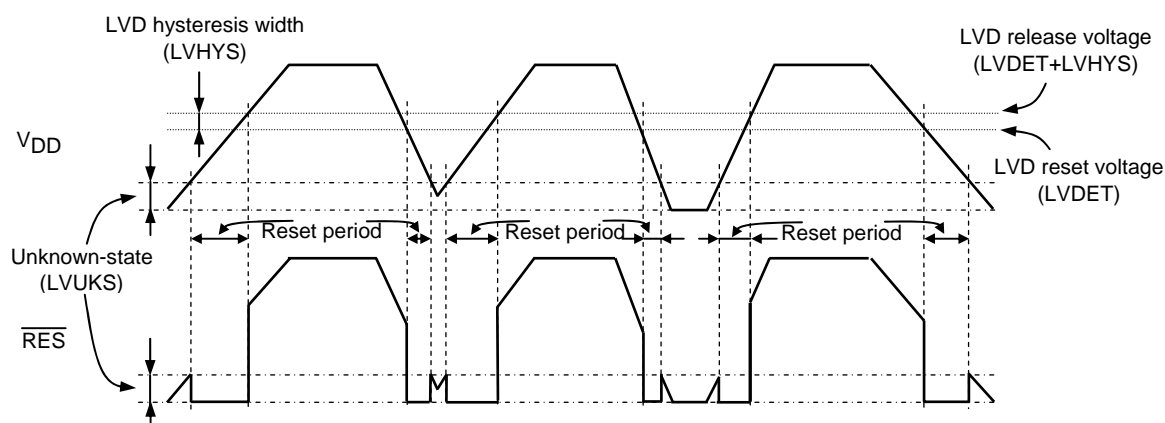


Figure 8 Waveform observed when both POR and LVD functions are used
(RESET pin: Pull-up resistor RRES only)

- Resets are generated both when power is turned on and when the power level lowers.
- A hysteresis width (LVHYS) is provided to prevent the repetitions of reset release and entry cycles near the detection level.

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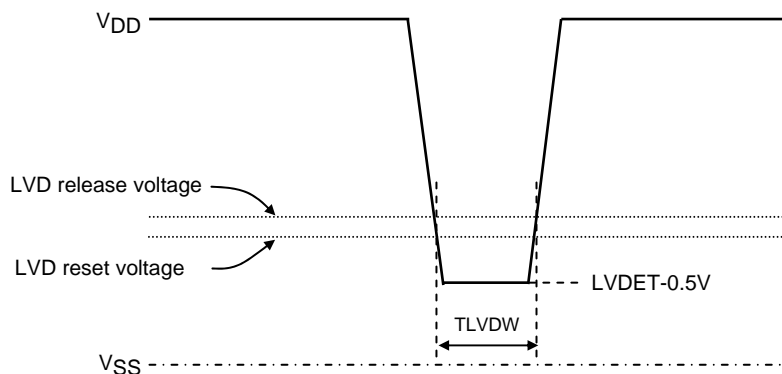


Figure 9 Low voltage detection minimum width
(Example of momentary power loss/Voltage variation waveform)

ORDERING INFORMATION

| Device | Package | Shipping (Qty / Packing) |
|-------------------|--|--------------------------|
| LC87FBH08AU-EB-3H | LQFP36 7x7 / QFP36 (Pb-Free / Halogen Free) | 500 / Tray Foam |
| LC87FBH08AU-EB-NH | LQFP36 7x7 / QFP36 (Pb-Free / Halogen Free) | 1000 / Tape & Reel |

† For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D. http://www.onsemi.com/pub_link/Collateral/BRD8011-D.PDF

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