


SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

LC87BK08A LC87BK06A LC87BK04A

CMOS IC
8K/6K/4K-byte ROM and 256-byte RAM integrated
8-bit 1-chip Microcontroller

Overview

The SANYO LC87BK08A/06A/04A is an 8-bit microcomputer 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/6K/4K-byte ROM, 256-byte RAM, 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, an asynchronous/synchronous SIO interface, a 12-bit/8-bit 8-channel AD converter, a system clock frequency divider, an internal reset and a 15-source 9-vector interrupt feature.

Features

■ROM

- 8192 × 8 bits (LC87BK08A)
- 6144 × 8 bits (LC87BK06A)
- 4096 × 8 bits (LC87BK04A)

■RAM

- 256 × 9 bits

■Minimum Bus Cycle

- 83.3ns (12MHz at $V_{DD}=2.7V$ to 5.5V)

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

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■ Minimum Instruction Cycle Time

- 250ns (12MHz at $V_{DD}=2.7V$ to 5.5V)

■ Ports

- Normal withstand voltage I/O ports
 - Ports I/O direction can be designated in 1-bit units 12 (P1n, P20, P21, P70, 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 2 (V_{SS1} , V_{DD1})

■ 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

■ SIO

- SIO1: 8-bit asynchronous/synchronous serial interface
 - Mode 0: Synchronous 8-bit serial I/O (2- or 3-wire configuration, 2 to 512 tCYC transfer clocks)
 - Mode 1: Asynchronous serial I/O (half-duplex, 8 data bits, 1 stop bit, 8 to 2048 tCYC baudrates)
 - Mode 2: Bus mode 1 (start bit, 8 data bits, 2 to 512 tCYC transfer clocks)
 - Mode 3: Bus mode 2 (start detect, 8 data bits, stop detect)

■ AD Converter: 12 bits/8 bits \times 8 channels

- 12 bits/8 bits AD converter resolution selectable

■ Remote Control Receiver Circuit (sharing pins with P15, SCK1, 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 generating the source clock for the subclock

■ Watchdog Timer

- Capable 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

- 15 sources, 9 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/base timer |
| 5 | 00023H | H or L | T0H |
| 6 | 0002BH | H or L | T1L/T1H |
| 7 | 00033H | H or L | None |
| 8 | 0003BH | H or L | SIO1 |
| 9 | 00043H | H or L | ADC/T6/T7 |
| 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 \times 8 bits (5 tCYC execution time)
- 24 bits \times 16 bits (12 tCYC execution time)
- 16 bits \div 8 bits (8 tCYC execution time)
- 24 bits \div 16 bits (12 tCYC execution time)

■ Oscillation Circuits

- Internal oscillation circuits
 - Low-speed RC oscillation circuit : For system clock (100kHz)
 - Medium-speed RC oscillation circuit : For system clock (1MHz)
 - Frequency variable RC oscillation circuit : For system clock (8MHz)
- External oscillation circuits
 - Hi-speed CF oscillation circuit: For system clock, with internal Rf
 - Low speed crystal oscillation circuit: For low-speed system clock, 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 4 levels (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 (3 levels: 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 three ways of resetting the HALT mode.
 - (1) Setting the reset pin to the low level
 - (2) System resetting by watchdog timer or low-voltage detection
 - (3) Occurrence of an interrupt
- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
 - 1) The CF, RC, and crystal oscillators automatically stop operation.
 - 2) There are four ways of resetting the HOLD mode.
 - (1) Setting the reset pin to the lower level.
 - (2) System resetting by watchdog timer or low-voltage detection
 - (3) Having an interrupt source established at either INT0, INT1, INT2, INT4
 - * INT0 and INT1 HOLD mode reset is available only when level detection is set.
 - (4) Having an interrupt source established at port 0.
- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer.
 - 1) The RC oscillator automatically stop operation.
 - 2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
 - 3) There are five 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) Having an interrupt source established at either INT0, INT1, INT2, INT4
 - * INT0 and INT1 HOLD mode reset is available only when level detection is set.
 - (4) Having an interrupt source established at port 0.
 - (5) Having an interrupt source established in the base timer circuit.

Note: Available only when X'tal oscillation is selected.

■ Package Form

- MFP24S (300mil) : Lead-/Halogen-free type
- SSOP24 (225mil) : Lead-/Halogen-free type
- SSOP24 (275mil) : Lead-/Halogen-free type (build-to-order)
- VCT24 (3×3) : Lead-/Halogen-free type (build-to-order)

■ Development Tools

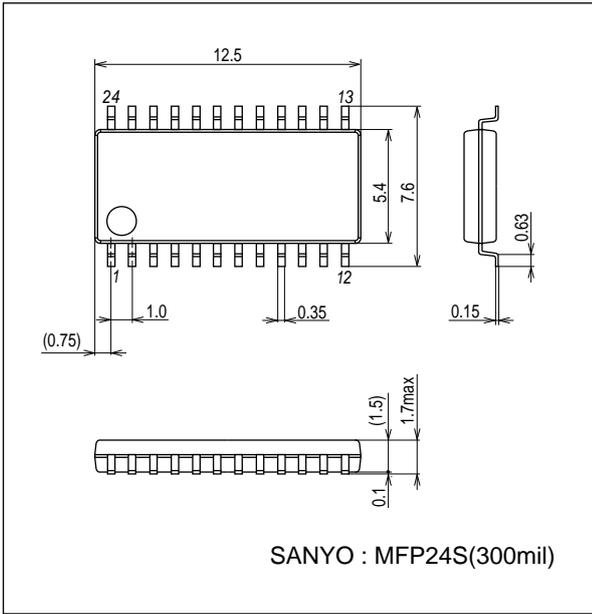
- On-chip-debugger : (1) TCB87 TypeB + LC87FBK08A
(2) TCB87 TypeC (3 wire version) + LC87FBK08A

■ Flash ROM Version

- LC87FBK08A

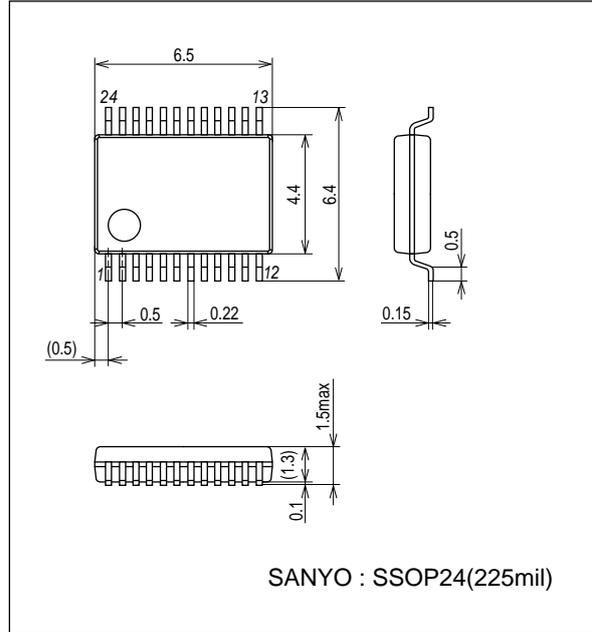
Package Dimensions

unit : mm (typ)
3112B



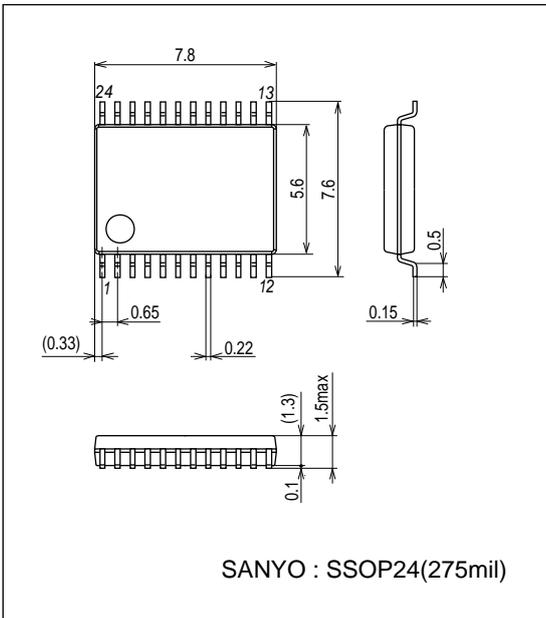
Package Dimensions

unit : mm (typ)
3287



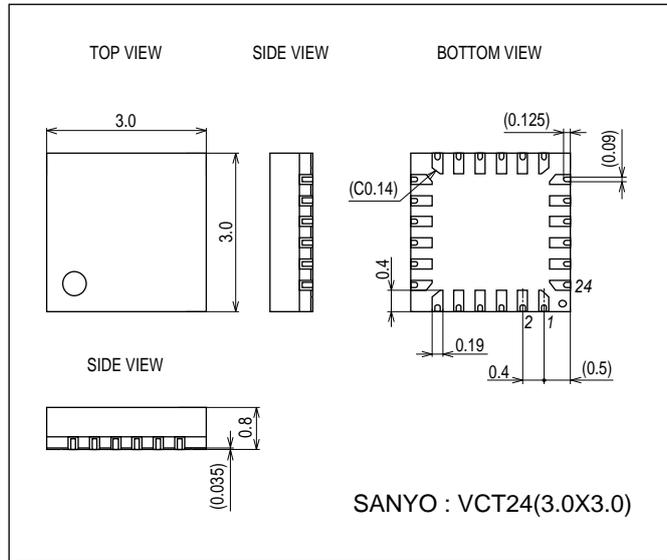
Package Dimensions

unit : mm (typ)
3175C



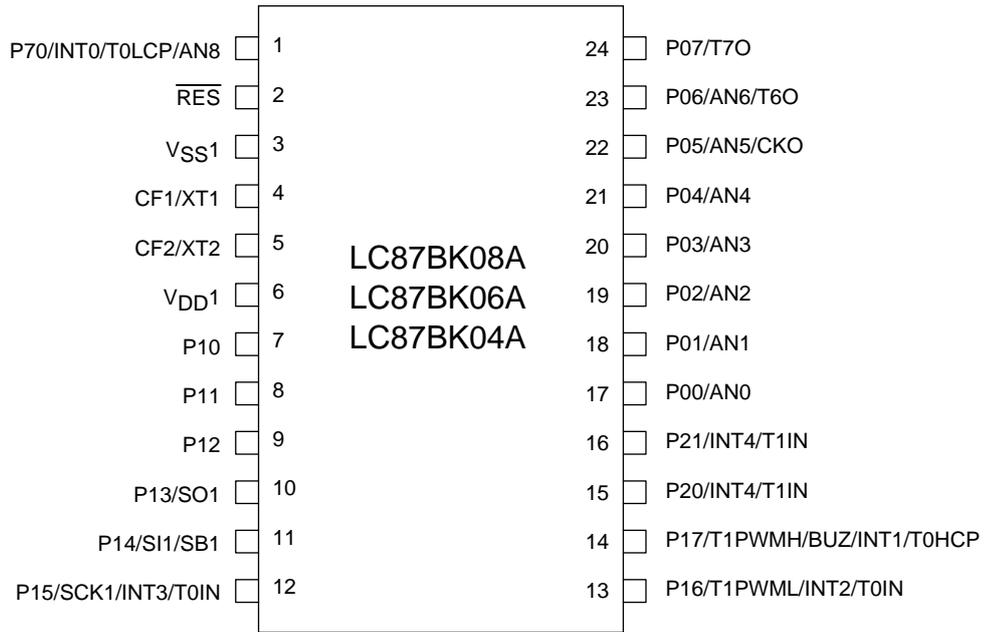
Package Dimensions

unit : mm (typ)
3366



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Pin Assignment



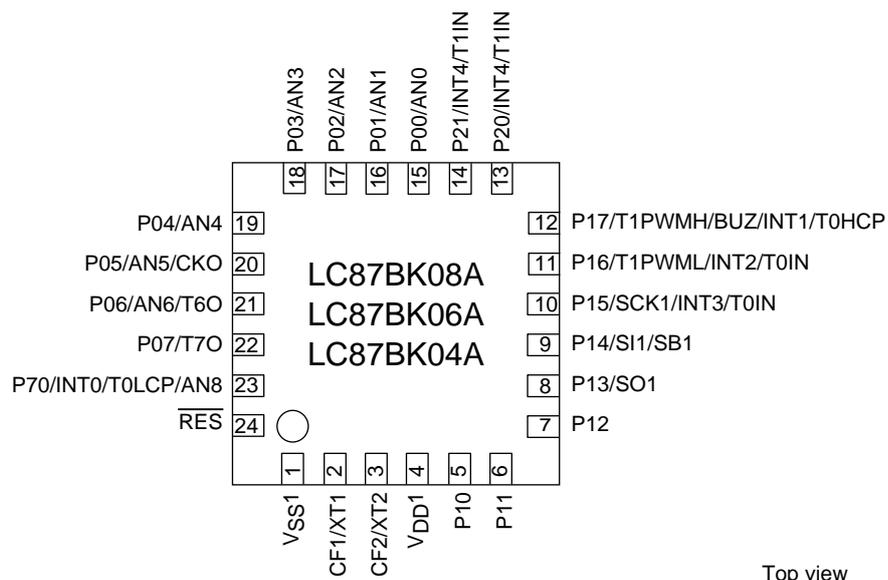
Top view

SANYO: MFP24S(300mil)/SSOP24(225mil) "Lead-/Halogen-free Type"
SSOP24(275mil) "Lead-/Halogen-free Type" (build-to-order)

| MFP24S SSOP24 | NAME |
|------------------|--------------------|
| 1 | P70/INT0/T0LCP/AN8 |
| 2 | RES |
| 3 | V _{SS} 1 |
| 4 | CF1/XT1 |
| 5 | CF2/XT2 |
| 6 | V _{DD} 1 |
| 7 | P10 |
| 8 | P11 |
| 9 | P12 |
| 10 | P13/SO1 |
| 11 | P14/SI1/SB1 |
| 12 | P15/SCK1/INT3/T0IN |

| MFP24S SSOP24 | NAME |
|------------------|---------------------------|
| 13 | P16/T1PWML/INT2/T0IN |
| 14 | P17/T1PWMH/BUZ/INT1/T0HCP |
| 15 | P20/INT4/T1IN |
| 16 | P21/INT4/T1IN |
| 17 | P00/AN0 |
| 18 | P01/AN1 |
| 19 | P02/AN2 |
| 20 | P03/AN3 |
| 21 | P04/AN4 |
| 22 | P05/AN5/CKO |
| 23 | P06/AN6/T6O |
| 24 | P07/T7O |

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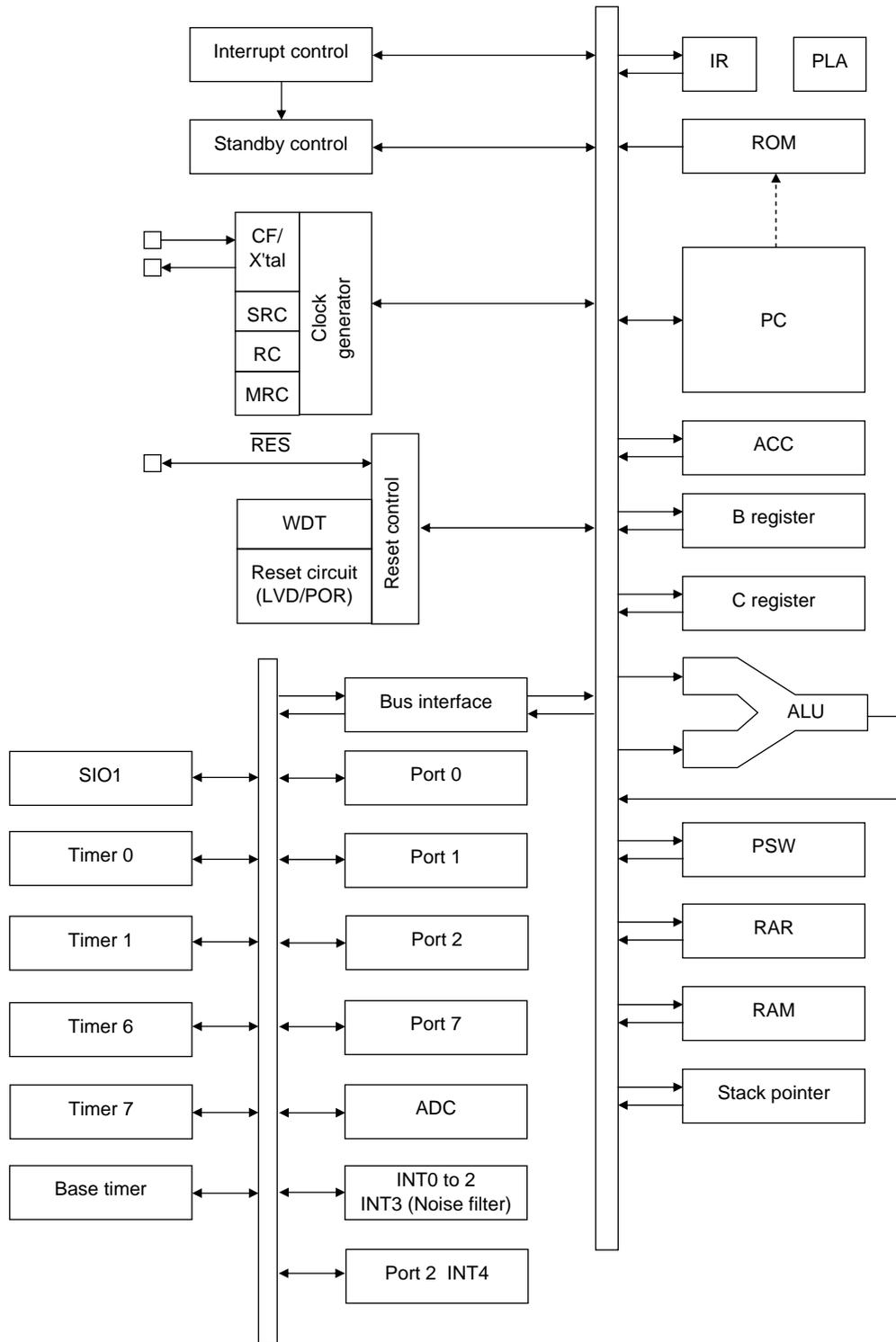


SANYO: VCT24(3×3) “Lead-/Halogen-free Type” (build-to-order)

| VCT24 | NAME |
|-------|---------------------------|
| 1 | V _{SS} 1 |
| 2 | CF1/XT1 |
| 3 | CF2/XT2 |
| 4 | V _{DD} 1 |
| 5 | P10 |
| 6 | P11 |
| 7 | P12 |
| 8 | P13/SO1 |
| 9 | P14/SI1/SB1 |
| 10 | P15/SCK1/INT3/T0IN |
| 11 | P16/T1PWML/INT2/T0IN |
| 12 | P17/T1PWMH/BUZ/INT1/T0HCP |

| VCT24 | NAME |
|-------|--------------------|
| 13 | P20/INT4/T1IN |
| 14 | P21/INT4/T1IN |
| 15 | P00/AN0 |
| 16 | P01/AN1 |
| 17 | P02/AN2 |
| 18 | P03/AN3 |
| 19 | P04/AN4 |
| 20 | P05/AN5/CKO |
| 21 | P06/AN6/T6O |
| 22 | P07/T7O |
| 23 | P70/INT0/T0LCP/AN8 |
| 24 | RES |

System Block Diagram



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Pin Description

| Pin Name | I/O | Description | Option | | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------|--------|---|------------------|---------|---------|------------------|---------|---------|------|--------|--------|---------|---------|---------|------|--------|--------|--------|---------|---------|------|--------|--------|--------|---------|---------|-----|
| V _{SS} 1 | - | - Power supply pin | No | | | | | | | | | | | | | | | | | | | | | | | | |
| V _{DD} 1 | - | + 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 P05: System clock output P06: Timer 6 toggle output P07: Timer 7 toggle output P00(AN0) to P06(AN6): AD converter input | 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 P13: SIO1 data output P14: SIO1 data input / bus I/O P15: SIO1 clock I/O / INT3 input (with noise filter) / timer 0 event input / timer 0H capture input P16: Timer 1PWML output / INT2 input/HOLD reset input/timer 0 event input / timer 0L capture input P17: Timer 1PWMH output / beeper output / INT1 input / HOLD reset input / timer 0H capture input Interrupt acknowledge type <table border="1" style="margin-left: 20px;"> <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>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 | INT1 | enable | enable | disable | enable | enable | INT2 | enable | enable | enable | disable | disable | INT3 | enable | enable | enable | disable | disable | Yes |
| | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | | | | | | | | | | | | | |
| INT1 | enable | enable | disable | enable | enable | | | | | | | | | | | | | | | | | | | | | | |
| INT2 | enable | enable | enable | disable | disable | | | | | | | | | | | | | | | | | | | | | | |
| INT3 | enable | enable | enable | disable | disable | | | | | | | | | | | | | | | | | | | | | | |
| 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 P20 to P21: INT4 input / HOLD reset input / timer 1 event input / timer 0L capture input / timer 0H capture input Interrupt acknowledge types <table border="1" style="margin-left: 20px;"> <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>INT4</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 | INT4 | enable | enable | enable | disable | disable | Yes | | | | | | | | | | | | |
| | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | | | | | | | | | | | | | |
| INT4 | enable | enable | enable | disable | disable | | | | | | | | | | | | | | | | | | | | | | |
| Port 7 P70 | I/O | <ul style="list-style-type: none"> • 1-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 P70: INT0 input / HOLD reset input / timer 0L capture input P70(AN8): AD converter input Interrupt acknowledge types <table border="1" style="margin-left: 20px;"> <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> </tbody> </table> | | Rising | Falling | Rising & Falling | H level | L level | INT0 | enable | enable | disable | enable | enable | No | | | | | | | | | | | | |
| | Rising | Falling | Rising & Falling | H level | L level | | | | | | | | | | | | | | | | | | | | | | |
| INT0 | enable | enable | disable | enable | enable | | | | | | | | | | | | | | | | | | | | | | |

Continued on next page.

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Continued from preceding page.

| Pin Name | I/O | Description | Option |
|----------|-----|--|--------|
| 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 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 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 |
| P70 | - | No | Nch-open drain | 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 | |
| Program start address | - | × | ○ | - | 00000h |
| | | | | | 01E00h |
| Low-voltage detection reset function | Detect function | ○ | ○ | - | Enable:Use |
| | | | | | Disable:Not Used |
| Power-on reset function | Power-On reset level | ○ | ○ | - | 3-level |
| | | | | | 4-level |

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

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

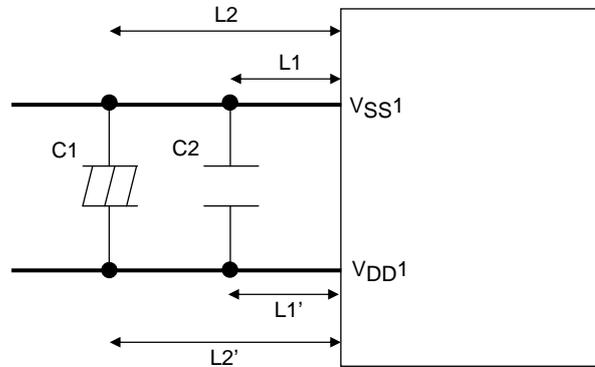
Recommended Unused Pin Connections

| 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 |
| P70 | 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 |

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 be approximately 0.1μF.



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

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | unit |
|-------------------------------|--------------------------------|--|------------------------------|---|------|------|----------------------|------|
| | | | | V _{DD} [V] | min | typ | max | |
| Maximum supply voltage | V _{DD} max | V _{DD} 1 | | | -0.3 | | +6.5 | V |
| Input voltage | V _I | CF1 | | | -0.3 | | V _{DD} +0.3 | |
| Input/output voltage | V _{IO} | Ports 0, 1, 2, P70, CF2, $\overline{\text{RES}}$ | | | -0.3 | | V _{DD} +0.3 | |
| High level output current | Peak output current | IOPH | Ports 0, 1, 2 | CMOS output select Per 1 applicable pin | | -10 | | mA |
| | Mean output current (Note 1-1) | IOMH | Ports 0, 1, 2 | CMOS output select Per 1 applicable pin | | -7.5 | | |
| | Total output current | Σ IOAH(1) | Ports 0, 1, 2 | Total of all applicable pins | | -25 | | |
| Low level output current | Peak output current | IOPL(1) | P02 to P07 Ports 1, 2 | Per 1 applicable pin | | | 20 | |
| | | IOPL(2) | P00, P01 | Per 1 applicable pin | | | 30 | |
| | | IOPL(3) | P70, CF2 | Per 1 applicable pin | | | 10 | |
| | Mean output current (Note 1-1) | IOML(1) | P02 to P07 Ports 1, 2 | Per 1 applicable pin | | | | |
| | | IOML(2) | P00, P01 | Per 1 applicable pin | | | | 20 |
| | | IOML(3) | P70, CF2 | Per 1 applicable pin | | | | 7.5 |
| Total output current | Σ IOAL(1) | Ports 0, 1, 2, 7, CF2 | Total of all applicable pins | | | | 70 | |
| Power dissipation | Pd max(1) | MFP24S(300mil) | | Ta=-40 to +85°C Package only | | | 129 | mW |
| | Pd max(2) | | | Ta=-40 to +85°C Package with thermal resistance board (Note 1-2) | | | 229 | |
| | Pd max(3) | SSOP24(225mil) | | Ta=-40 to +85°C Package only | | | 111 | |
| | Pd max(4) | | | Ta=-40 to +85°C Package with thermal resistance board (Note 1-2) | | | 334 | |
| Operating ambient temperature | T _{opr} | | | | -40 | | +85 | °C |
| Storage ambient temperature | T _{stg} | | | | -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.

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

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | unit |
|-----------------------------------|----------------------|---|---|---------------------|-------------------------|---------------------|--------------------------|------|
| | | | | V _{DD} [V] | min | typ | max | |
| Operating supply voltage | V _{DD} | V _{DD} 1 | 0.245μs ≤ tCYC ≤ 200μs | | 2.7 | | 5.5 | V |
| Memory sustaining supply voltage | V _{HD} | V _{DD} 1 | RAM and register contents sustained in HOLD mode. | | 1.6 | | | |
| High level input voltage | V _{IH} (1) | Ports 1, 2, 7 | | 2.7 to 5.5 | 0.3V _{DD} +0.7 | | V _{DD} | |
| | V _{IH} (2) | Ports 0 | | 2.7 to 5.5 | 0.3V _{DD} +0.7 | | V _{DD} | |
| | V _{IH} (3) | CF1, CF2, RES | | 2.7 to 5.5 | 0.75V _{DD} | | V _{DD} | |
| Low level input voltage | V _{IL} (1) | Ports 1, 2, 7 | | 4.0 to 5.5 | V _{SS} | | 0.1V _{DD} +0.4 | |
| | | | | 2.7 to 4.0 | V _{SS} | | 0.2V _{DD} | |
| | V _{IL} (2) | Ports 0 | | 4.0 to 5.5 | V _{SS} | | 0.15V _{DD} +0.4 | |
| | | | | 2.7 to 4.0 | V _{SS} | | 0.2V _{DD} | |
| V _{IL} (3) | CF1, CF2, RES | | 2.7 to 5.5 | V _{SS} | | 0.25V _{DD} | | |
| High level output current | I _{OH} (1) | Ports 0, 1, 2 | Per 1 applicable pin | 4.5 to 5.5 | -1.0 | | | |
| | I _{OH} (2) | | | 2.7 to 4.5 | -0.35 | | | |
| | I _{OH} (3) | P05 (System clock output function used) | Per 1 applicable pin | 4.5 to 5.5 | -6.0 | | | |
| | I _{OH} (4) | | | 2.7 to 4.5 | -1.4 | | | |
| | ΣI _{OH} (1) | Ports 0, 1, 2 | Total of all applicable pins | 4.5 to 5.5 | -25 | | | |
| | ΣI _{OH} (2) | | | 2.7 to 4.5 | -8.0 | | | |
| Low level output current | I _{OL} (1) | Ports 0, 1, 2 | Per 1 applicable pin | 4.5 to 5.5 | | | 7 | |
| | I _{OL} (2) | | | 2.7 to 4.5 | | | 1 | |
| | I _{OL} (3) | P70, CF2 | Per 1 applicable pin | 2.7 to 5.5 | | | 1 | |
| | I _{OL} (4) | P00, P01 | Per 1 applicable pin | 4.5 to 5.5 | | | 15 | |
| | | | | 2.7 to 4.5 | | | 2 | |
| | ΣI _{OL} (1) | Ports 0 | Total of all applicable pins | 4.5 to 5.5 | | | 40 | |
| | ΣI _{OL} (2) | | | 2.7 to 4.5 | | | 10 | |
| | ΣI _{OL} (3) | Ports 0, 1, 2, CF2 | Total of all applicable pins | 4.5 to 5.5 | | | 70 | |
| | ΣI _{OL} (4) | | | 2.7 to 4.5 | | | 21 | |
| | ΣI _{OL} (5) | Ports 7 | Total of all applicable pins | 2.7 to 5.5 | | | 1 | |
| Instruction cycle time (Note 2-1) | tCYC | | | 2.7 to 5.5 | 0.245 | | 200 | μs |
| 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 | MHz |
| | | | <ul style="list-style-type: none"> • CF2 pin open • System clock frequency division ratio=1/2 • External system clock duty=50±5% | 3.0 to 5.5 | 0.2 | | 24.4 | |

Note 2-1: 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.

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Continued from preceding page.

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|--|----------|-------------|---|---------------------|------|--------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| Oscillation frequency range (Note 2-2) | 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. | 2.7 to 5.5 | | 10 | | |
| | FmCF(3) | CF1, CF2 | 4MHz ceramic oscillation. CF oscillation normal amplifier size selected. (CFLAMP=0) See Fig. 1. | 2.7 to 5.5 | | 4 | | |
| | | | 4MHz ceramic oscillation. CF oscillation low amplifier size selected. (CFLAMP=1) See Fig. 1. | 2.7 to 5.5 | | 4 | | |
| | FmMRC(1) | | Frequency variable RC oscillation. (Note 2-3) | 2.7 to 5.5 | 7.76 | 8.0 | 8.24 | |
| | FmMRC(2) | | Frequency variable RC oscillation. • Ta=-10 to +85°C (Note 2-3) | 2.7 to 5.5 | 7.80 | 8.0 | 8.20 | |
| | FmRC | | Internal medium-speed RC oscillation | 2.7 to 5.5 | 0.5 | 1.0 | 2.0 | |
| | FmSRC | | Internal low-speed RC oscillation | 2.7 to 5.5 | 50 | 100 | 200 | |
| | FsX'tal | XT1, XT2 | 32.768kHz crystal oscillation See Fig. 1. | 2.7 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. | 2.7 to 5.5 | | | 100 | μs |

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

Note 2-3: 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.

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Electrical Characteristics at Ta = -40°C to +85°C, VSS1 = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---------------------------|---------------------|---|--|---------------|----------------------|--------------------|-----|------|
| | | | | VDD[V] | min | typ | max | unit |
| High level input current | I _{IH} (1) | Ports 0, 1, 2, P70, $\overline{\text{RES}}$ | Output disabled Pull-up resistor off V _{IN} =V _{DD} (Including output Tr's off leakage current) | 2.7 to 5.5 | | | 1 | μA |
| | I _{IH} (2) | CF1, CF2 | Input port selected V _{IN} =V _{DD} | 2.7 to 5.5 | | | 1 | |
| | I _{IH} (3) | CF1 | Reset state V _{IN} =V _{DD} | 2.7 to 5.5 | | | 15 | |
| Low level input current | I _{IL} (1) | Ports 0, 1, 2, P70, $\overline{\text{RES}}$ | Output disabled Pull-up resistor off V _{IN} =V _{SS} (Including output Tr's off leakage current) | 2.7 to 5.5 | | -1 | | |
| | I _{IL} (2) | CF1, CF2 | Input port selected V _{IN} =V _{SS} | 2.7 to 5.5 | | -1 | | |
| High level output voltage | V _{OH} (1) | Ports 0, 1, 2 | 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) | P05 (System clock output function used) | I _{OH} =-6mA | 4.5 to 5.5 | V _{DD} -1 | | | |
| | V _{OH} (4) | | I _{OH} =-1.4mA | 2.7 to 5.5 | V _{DD} -0.4 | | | |
| Low level output voltage | V _{OL} (1) | Ports 0, 1, 2 | I _{OL} =7mA | 4.5 to 5.5 | | | 1.5 | V |
| | V _{OL} (2) | | I _{OL} =1mA | 2.7 to 5.5 | | | 0.4 | |
| | V _{OL} (3) | Ports7, CF2 | I _{OL} =1mA | 2.7 to 5.5 | | | 0.4 | |
| | V _{OL} (4) | P00, P01 | I _{OL} =15mA | 4.5 to 5.5 | | | 1.5 | |
| | V _{OL} (5) | | I _{OL} =2mA | 2.7 to 5.5 | | | 0.4 | |
| Pull-up resistance | R _{pu} (1) | Ports 0, 1, 2 P70 | 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) | | 2.7 to 4.5 | 18 | 50 | 150 | | |
| | R _{pu} (3) | Port 0 | V _{OH} =0.9V _{DD} When Port 0 selected high-impedance pull-up. | 2.7 to 5.5 | 100 | 200 | 300 | |
| Hysteresis voltage | VHYS | Ports 1, 2, P70, $\overline{\text{RES}}$ | | 2.7 to 5.5 | | 0.1V _{DD} | | V |
| Pin capacitance | CP | All pins | For pins other than that under test: V _{IN} =V _{SS} f=1MHz Ta=25°C | 2.7 to 5.5 | | | 10 | pF |

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SIO1 Serial I/O Characteristics at Ta = -40°C to +85°C, V_{SS1} = 0V (Note 4)

| Parameter | | Symbol | Pin/ Remarks | Conditions | V _{DD} [V] | Specification | | | | |
|---------------|-------------------|------------------------|-----------------------|--|---|--------------------|-----|--------------------|------|------|
| | | | | | | min | typ | max | unit | |
| Serial clock | Input clock | Frequency | tSCK(3) | SCK1(P15) | • See Fig. 5. | 2.7 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. | 2.7 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) | SB1(P14), S11(P14) | • Must be specified with respect to rising edge of SIOCLK. • See Fig. 5. | 2.7 to 5.5 | (1/3)tCYC +0.01 | | | | |
| | 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. | 2.7 to 5.5 | | | (1/2)tCYC +0.05 | μs | |

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

Pulse Input Conditions at Ta = -40°C to +85°C, V_{SS1} = 0V

| Parameter | Symbol | Pin/Remarks | Conditions | V _{DD} [V] | Specification | | | |
|----------------------------|--------------------|--|---|-------------------------|---------------|-----|-----|------|
| | | | | | min | typ | max | unit |
| High/low level pulse width | tPIH(1) tPIL(1) | INT0(P70), INT1(P17), INT2(P16), INT4(P20 to P21) | • Interrupt source flag can be set. • Event inputs for timer 0 or 1 are enabled. | 2.7 to 5.5 | 1 | | | tCYC |
| | tPIH(2) tPIL(2) | INT3(P15) when noise filter time constant is 1/1 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.7 to 5.5 | 2 | | | |
| | tPIH(3) tPIL(3) | INT3(P15) when noise filter time constant is 1/32 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.7 to 5.5 | 64 | | | |
| | tPIH(4) tPIL(4) | INT3(P15) when noise filter time constant is 1/128 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.7 to 5.5 | 256 | | | |
| | tPIL(5) | RES | | • Resetting is enabled. | 2.7 to 5.5 | 200 | | |

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

<12bits AD Converter Mode/ $T_a = -40^{\circ}C$ 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) | | 2.7 to 5.5 | | 12 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | | 3.0 to 5.5 | | ± 16 | LSB |
| | | | | | 2.7 to 5.5 | | ± 20 | |
| Conversion time | TCAD | | • See Conversion time calculation formulas. (Note 6-2) | | 4.0 to 5.5 | 32 | 115 | μs |
| | | | | | 3.0 to 5.5 | 64 | 115 | |
| | | | | | 2.7 to 5.5 | 134 | 215 | |
| Analog input voltage range | VAIN | | | 2.7 to 5.5 | V_{SS} | V_{DD} | V | |
| Analog port input current | I _{AINH} | | V _{AIN} =V _{DD} | 2.7 to 5.5 | | 1 | μA | |
| | I _{AINL} | | V _{AIN} =V _{SS} | 2.7 to 5.5 | -1 | | | |

<8bits AD Converter Mode/ $T_a = -40^{\circ}C$ 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) | | 2.7 to 5.5 | | 8 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | | 2.7 to 5.5 | | ± 1.5 | LSB |
| | | | | | | | | |
| Conversion time | TCAD | | • See Conversion time calculation formulas. (Note 6-2) | | 4.0 to 5.5 | 20 | 90 | μs |
| | | | | | 3.0 to 5.5 | 40 | 90 | |
| | | | | | 2.7 to 5.5 | 80 | 135 | |
| Analog input voltage range | VAIN | | | 2.7 to 5.5 | V_{SS} | V_{DD} | V | |
| Analog port input current | I _{AINH} | | V _{AIN} =V _{DD} | 2.7 to 5.5 | | 1 | μA | |
| | I _{AINL} | | V _{AIN} =V _{SS} | 2.7 to 5.5 | -1 | | | |

Conversion time calculation formulas:

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

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

| External oscillation (F _{mCF}) | Operating supply voltage range (V_{DD}) | System division ratio (SYSDIV) | Cycle time (t _{CYC}) | AD division ratio (ADDIV) | AD conversion time (TCAD) | |
|--|---|--------------------------------|--------------------------------|---------------------------|---------------------------|----------------|
| | | | | | 12bit AD | 8bit AD |
| CF-12MHz | 4.0V to 5.5V | 1/1 | 250ns | 1/8 | 34.8 μs | 21.5 μs |
| | 3.0V to 5.5V | 1/1 | 250ns | 1/16 | 69.5 μs | 42.8 μs |
| | 2.7V to 5.5V | 1/1 | 250ns | 1/32 | 138.8 μs | 85.5 μs |
| CF-8MHz | 4.0V to 5.5V | 1/1 | 375ns | 1/8 | 52.25 μs | 32.25 μs |
| | 3.0V to 5.5V | 1/1 | 375ns | 1/16 | 104.25 μs | 64.25 μs |
| | 2.7V to 5.5V | 1/1 | 375ns | 1/32 | 208.25 μs | 128.25 μs |
| CF-4MHz | 3.0V to 5.5V | 1/1 | 750ns | 1/8 | 104.5 μs | 64.5 μs |
| | 2.7V to 5.5V | 1/1 | 750ns | 1/16 | 208.5 μs | 128.5 μs |

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.

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

| Parameter | Symbol | Pin/Remarks | Conditions | Option selected voltage | Specification | | | |
|---------------------------------|--------|-------------|---|-------------------------|---------------|------|------|------|
| | | | | | min | typ | max | unit |
| POR release voltage | PORRL | | <ul style="list-style-type: none"> Select from option. (Note 7-1) | 2.57V | 2.45 | 2.57 | 2.69 | V |
| | | | | 2.87V | 2.75 | 2.87 | 2.99 | |
| | | | | 3.86V | 3.73 | 3.86 | 3.99 | |
| | | | | 4.35V | 4.21 | 4.35 | 4.49 | |
| Detection voltage unknown state | POUKS | | <ul style="list-style-type: none"> See Fig. 7. (Note 7-2) | | | 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 |

Note7-1: The POR release level can be selected out of 4 levels only when the LVD reset function is disabled.

Note7-2: POR is in an unknown state before transistors start operation.

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

| Parameter | Symbol | Pin/Remarks | Conditions | Option selected voltage | Specification | | | |
|---|--------|-------------|---|-------------------------|---------------|------|------|------|
| | | | | | min | typ | max | unit |
| LVD reset voltage (Note 8-2) | LVDET | | <ul style="list-style-type: none"> Select from option. (Note 8-1) (Note 8-3) | 2.81V | 2.71 | 2.81 | 2.91 | V |
| | | | | 3.79V | 3.67 | 3.79 | 3.91 | |
| | | | | 4.28V | 4.15 | 4.28 | 4.41 | |
| LVD hysteresys width | LVHYS | | <ul style="list-style-type: none"> See Fig. 8. | 2.81V | | 60 | | mV |
| | | | | 3.79V | | 65 | | |
| | | | | 4.28V | | 65 | | |
| Detection voltage unknown state | LVUKS | | <ul style="list-style-type: none"> See Fig. 8. (Note 8-4) | | | 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 |

Note8-1: The LVD reset level can be selected out of 3 levels only when the LVD reset function is enabled.

Note8-2: LVD reset voltage specification values do not include hysteresis voltage.

Note8-3: LVD reset voltage may exceed its specification values when port output state changes and/or when a large current flows through port.

Note8-4: LVD is in an unknown state before transistors start operation.

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Consumption Current Characteristics at Ta = -40°C to +85°C, VSS1 = 0V

| Parameter | Symbol | Pin/ Remarks | Conditions | Specification | | | | |
|---|--|-----------------|--|---------------|-----|------|------|------|
| | | | | VDD[V] | min | typ | max | unit |
| Normal mode consumption current (Note 9-1) (Note 9-2) | IDDOP(1) | VDD1 | <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 | | 4.8 | 8.7 | mA |
| | | | | 2.7 to 3.6 | | 2.4 | 4.7 | |
| | 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 | | 5.0 | 9.6 | |
| | | | | 3.0 to 3.6 | | 2.9 | 5.5 | |
| | 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. | 2.7 to 5.5 | | 4.1 | 7.8 | |
| | | | | 2.7 to 3.6 | | 2.3 | 4.2 | |
| | 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. | 2.7 to 5.5 | | 2.0 | 4.4 | |
| | | | | 2.7 to 3.6 | | 1.1 | 2.2 | |
| | 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 | 2.7 to 5.5 | | 0.84 | 2.2 | |
| | | | | 2.7 to 3.6 | | 0.38 | 0.91 | |
| | IDDOP(6) | | <ul style="list-style-type: none"> FsX'tal=32.768kHz crystal oscillation mode Internal low speed RC oscillation stopped. | 2.7 to 5.5 | | 0.40 | 1.3 | |
| | | | | 2.7 to 3.6 | | 0.21 | 0.60 | |
| | IDDOP(7) | | <ul style="list-style-type: none"> FsX'tal=32.768kHz crystal oscillation mode Internal low speed and medium speed RC oscillation stopped. | 2.7 to 5.5 | | 2.8 | 5.1 | |
| | | | | 2.7 to 3.6 | | 1.8 | 3.2 | |
| | IDDOP(8) | | <ul style="list-style-type: none"> External FsX'tal and FmCF oscillation stopped. System clock set to internal low speed RC oscillation. | 2.7 to 5.5 | | 48 | 149 | |
| | | | | 2.7 to 3.6 | | 29 | 82 | |
| 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 | | 48 | 124 | | | |
| | | 3.3 | | 29 | 74 | | | |
| | | | <ul style="list-style-type: none"> Internal medium speed RC oscillation stopped. Frequency variable RC oscillation stopped. 1/1 frequency division ratio Ta=-10 to +50°C | | | | | μA |

Note9-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified.

Continued on next page.

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Continued from preceding page.

| Parameter | Symbol | Pin/ Remarks | Conditions | Specification | | | | |
|---|------------|-------------------|---|---------------------|-----|------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| Normal mode consumption current (Note 9-1) (Note 9-2) | 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. | 2.7 to 5.5 | | 24 | 82 | μA |
| | | | | 2.7 to 3.6 | | 8.2 | 35 | |
| | 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. Frequency variable RC oscillation stopped. 1/2 frequency division ratio | 5.0 | | 24 | 64 | |
| | | | | 3.3 | | 8.2 | 23 | |
| HALT mode consumption current (Note 9-1) (Note 9-2) | IDDHALT(1) | V _{DD} 1 | <ul style="list-style-type: none"> HALT mode 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 | | 2.0 | 3.7 | mA |
| | | | | 2.7 to 3.6 | | 0.99 | 1.7 | |
| | IDDHALT(2) | | <ul style="list-style-type: none"> HALT mode CF1=24MHz external clock System clock set to CF1 side Internal low speed and medium speed RC oscillation stopped. Frequency variable RC oscillation stopped. 1/2 frequency division ratio | 3.0 to 5.5 | | 2.0 | 4.7 | |
| | | | | 3.0 to 3.6 | | 1.2 | 2.2 | |
| | IDDHALT(3) | | <ul style="list-style-type: none"> HALT mode FmCF=10MHz ceramic oscillation mode System clock set to 10MHz side Internal low speed and medium speed RC oscillation stopped. | 2.7 to 5.5 | | 1.6 | 3.4 | |
| | | | | 2.7 to 3.6 | | 0.89 | 1.6 | |
| | IDDHALT(4) | | <ul style="list-style-type: none"> HALT mode FmCF=4MHz ceramic oscillation mode System clock set to 4MHz side Internal low speed and medium speed RC oscillation stopped. Frequency variable RC oscillation stopped. 1/1 frequency division ratio | 2.7 to 5.5 | | 1.0 | 2.5 | |
| | | | | 2.7 to 3.6 | | 0.4 | 0.91 | |
| | IDDHALT(5) | | <ul style="list-style-type: none"> HALT mode 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. Frequency variable RC oscillation stopped. 1/4 frequency division ratio | 2.7 to 5.5 | | 0.6 | 1.4 | |
| | | | | 2.7 to 3.6 | | 0.27 | 0.57 | |
| | IDDHALT(6) | | <ul style="list-style-type: none"> HALT mode FsX^{tal}=32.768kHz crystal oscillation mode Internal low speed RC oscillation stopped. System clock set to internal medium speed RC oscillation | 2.7 to 5.5 | | 0.29 | 0.87 | |
| | | | | 2.7 to 3.6 | | 0.19 | 0.40 | |

Note9-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified.

Continued on next page.

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Continued from preceding page.

| Parameter | Symbol | Pin/ remarks | Conditions | Specification | | | | |
|--|--|------------------|---|---------------------|-----|-------|------|------|
| | | | | V _{DD} [V] | min | typ | max | unit |
| HALT mode consumption current (Note 9-1) (Note 9-2) | IDDHALT(7) | V _{DD1} | <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 | 2.7 to 5.5 | | 0.92 | 1.6 | mA |
| | | | | 2.7 to 3.6 | | 0.66 | 1.1 | |
| | 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 | 2.7 to 5.5 | | 15 | 68 | μA |
| | | | | 2.7 to 3.6 | | 9.0 | 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 | | 15 | 39 | |
| | | | | 3.3 | | 9.0 | 23 | |
| | 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 | 2.7 to 5.5 | | 20 | 85 | |
| | | | | 2.7 to 3.6 | | 5.6 | 30 | |
| | 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 | | 20 | 51 | |
| | | | | 3.3 | | 5.6 | 17 | |
| HOLD mode consumption current (Note 9-1) (Note 9-2) | IDDHOLD(1) | HOLD mode | <ul style="list-style-type: none"> • CF1=V_{DD} or open (External clock mode) | 2.7 to 5.5 | | 0.012 | 20 | |
| | | | | 2.7 to 3.6 | | 0.008 | 8.0 | |
| | IDDHOLD(2) | | <ul style="list-style-type: none"> • CF1=V_{DD} or open (External clock mode) • Ta=-10 to +50°C | 5.0 | | 0.012 | 1.2 | |
| | | | | 3.3 | | 0.008 | 0.59 | |
| | IDDHOLD(3) | | <ul style="list-style-type: none"> • LVD option selected | 2.7 to 5.5 | | 2.0 | 23 | |
| | | | | 2.7 to 3.6 | | 1.6 | 10 | |
| IDDHOLD(4) | <ul style="list-style-type: none"> • CF1=V_{DD} or open (External clock mode) • Ta=-10 to +50°C • LVD option selected | 5.0 | | 2.0 | 3.8 | | | |
| | | 3.3 | | 1.6 | 2.8 | | | |
| Timer HOLD mode consumption current (Note 9-1) (Note 9-2) | IDDHOLD(5) | Timer HOLD mode | <ul style="list-style-type: none"> • FsX'tal=32.768 kHz crystal oscillation mode | 2.7 to 5.5 | | 16 | 70 | |
| | | | | 2.7 to 3.6 | | 4.2 | 25 | |
| | IDDHOLD(6) | | <ul style="list-style-type: none"> • Ta=-10 to +50°C | 5.0 | | 16 | 42 | |
| | | | | 3.3 | | 4.2 | 11 | |

Note9-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified.

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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 SANYO-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 | 2.7 to 5.5 | 0.02 | 0.3 | Internal C1, C2 |
| 10MHz | SMD | CSTCE10M0G52-R0 | (10) | (10) | Open | 680 | 2.7 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS10M0G53-B0 | (15) | (15) | Open | 680 | 2.7 to 5.5 | 0.02 | 0.3 | |
| 8MHz | SMD | CSTCE8M00G52-R0 | (10) | (10) | Open | 1.0k | 2.7 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS8M00G53-B0 | (15) | (15) | Open | 1.0k | 2.7 to 5.5 | 0.02 | 0.3 | |
| 6MHz | SMD | CSTCR6M00G53-R0 | (15) | (15) | Open | 1.5k | 2.7 to 5.5 | 0.02 | 0.3 | |
| | LEAD | CSTLS6M00G53-B0 | (15) | (15) | Open | 1.5k | 2.7 to 5.5 | 0.02 | 0.3 | |
| 4MHz | SMD | CSTCR4M00G53-R0 | (15) | (15) | Open | 1.5k | 2.7 to 5.5 | 0.03 | 0.45 | |
| | LEAD | CSTLS4M00G53-B0 | (15) | (15) | Open | 1.5k | 2.7 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 | 0.04 | 0.6 | 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 | |
| | | CSTLS8M00G53093-B0 | (15) | (15) | Open | 680 | 2.7 to 5.5 | 0.02 | 0.3 | |
| 6MHz | SMD | CSTCR6M00G53-R0 | (15) | (15) | Open | 1.0k | 2.7 to 5.5 | 0.03 | 0.45 | |
| | LEAD | CSTLS6M00G53-B0 | (15) | (15) | Open | 1.0k | 2.8 to 5.5 | 0.03 | 0.45 | |
| | | CSTLS6M00G53093-B0 | (15) | (15) | Open | 1.0k | 2.7 to 5.5 | 0.02 | 0.3 | |
| 4MHz | SMD | CSTCR4M00G53-R0 | (15) | (15) | Open | 1.0k | 2.7 to 5.5 | 0.04 | 0.6 | |
| | LEAD | CSTLS4M00G53-B0 | (15) | (15) | Open | 1.0k | 2.7 to 5.5 | 0.02 | 0.3 | |

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 SANYO-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

■EPSON TOYOCOM

| 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 | 2.7 to 5.5 | 1.4 | 4.0 | Applicable CL value = 7.0pF |

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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 | SSP-T7-F | 18 | 18 | Open | 0 | 2.7 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 SANYO-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 SANYO Semiconductor 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.

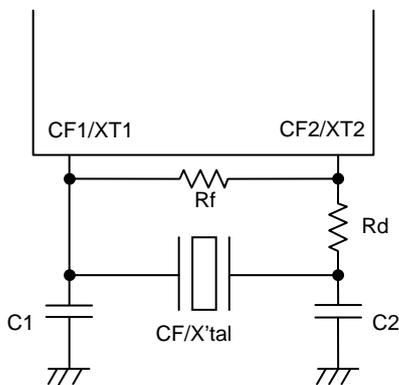


Figure 1 CF and XT Oscillator Circuit

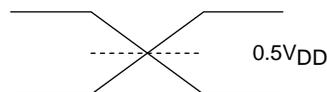
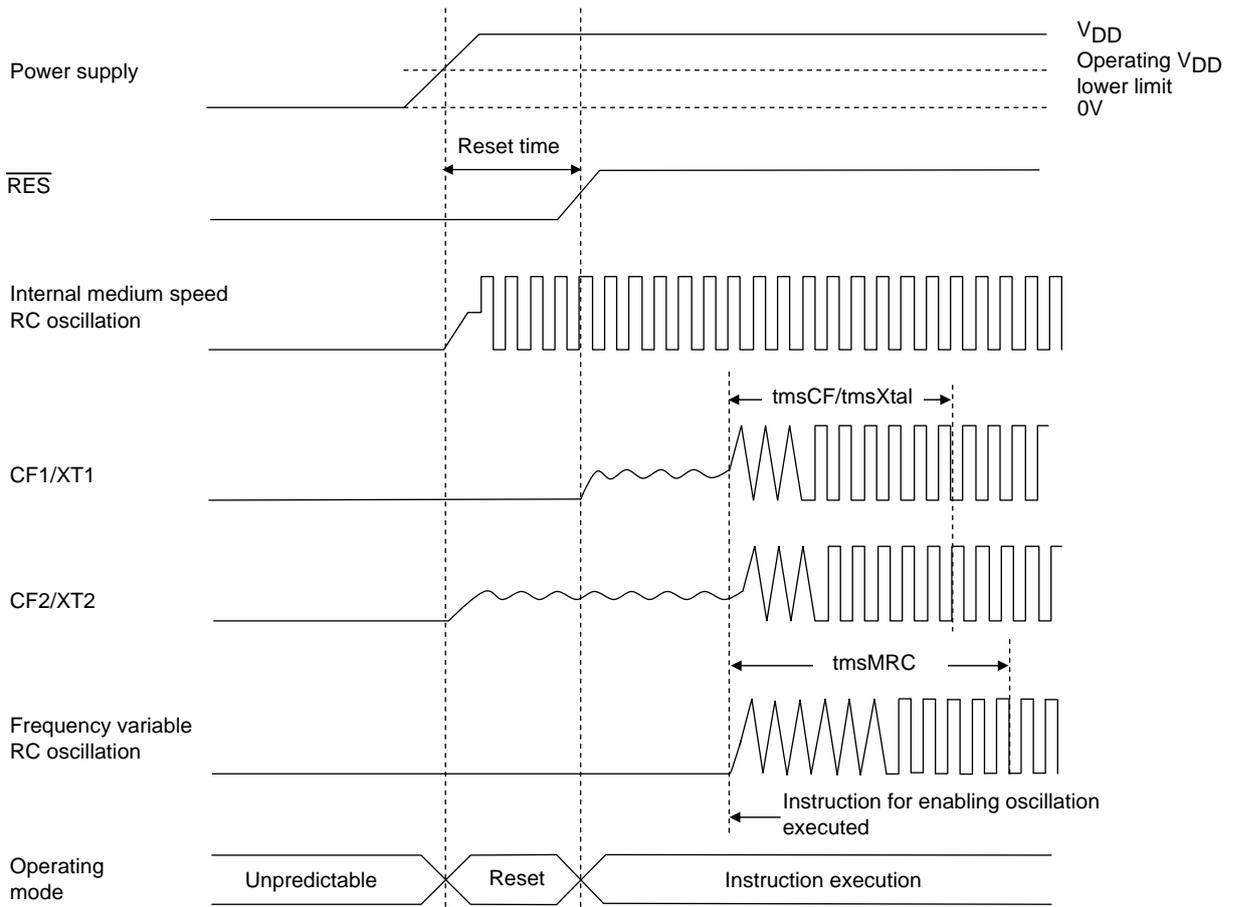
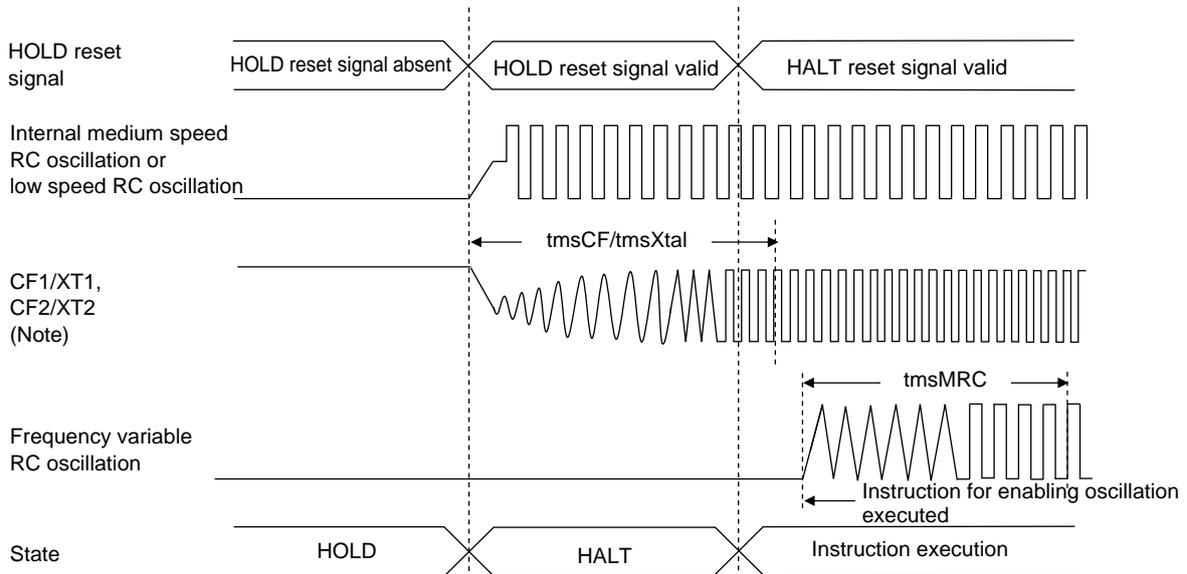


Figure 2 AC Timing Measurement Point



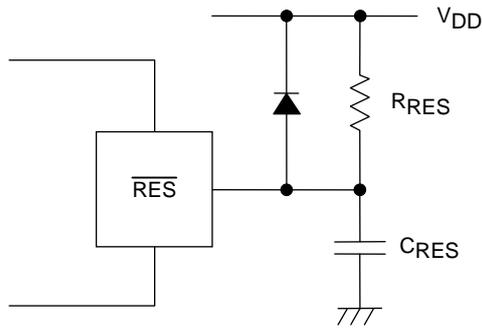
Reset Time and Oscillation Stabilization Time



HOLD Reset Signal and Oscillation Stabilization Time

Note: External oscillation circuit is selected.

Figure 3 Oscillation Stabilization Times



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

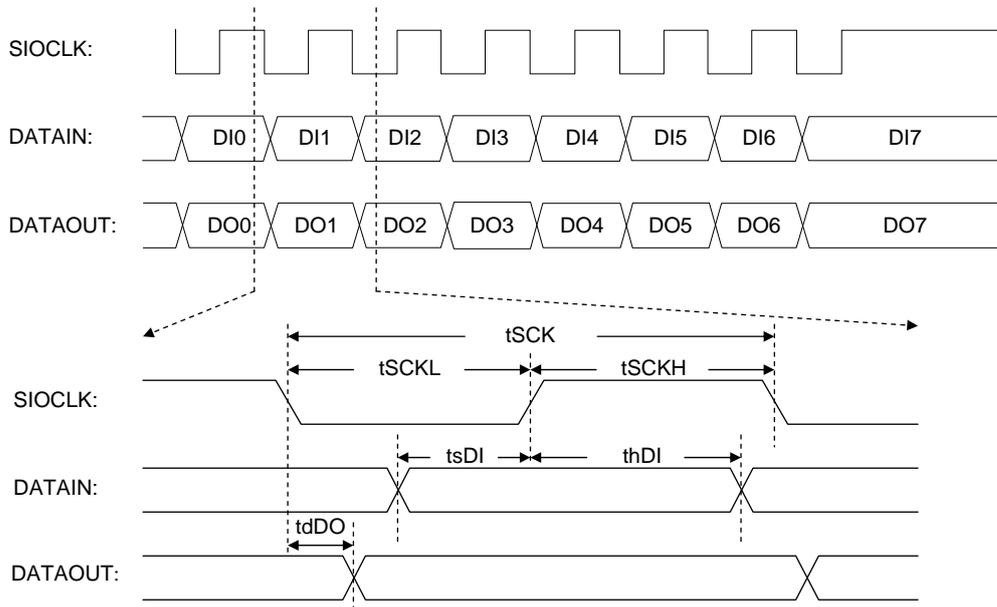


Figure 5 Serial I/O Output Waveforms

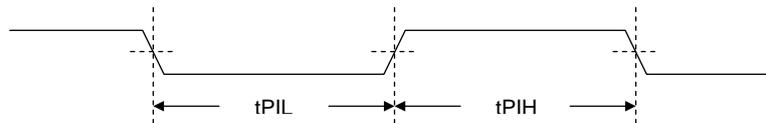


Figure 6 Pulse Input Timing Signal Waveform

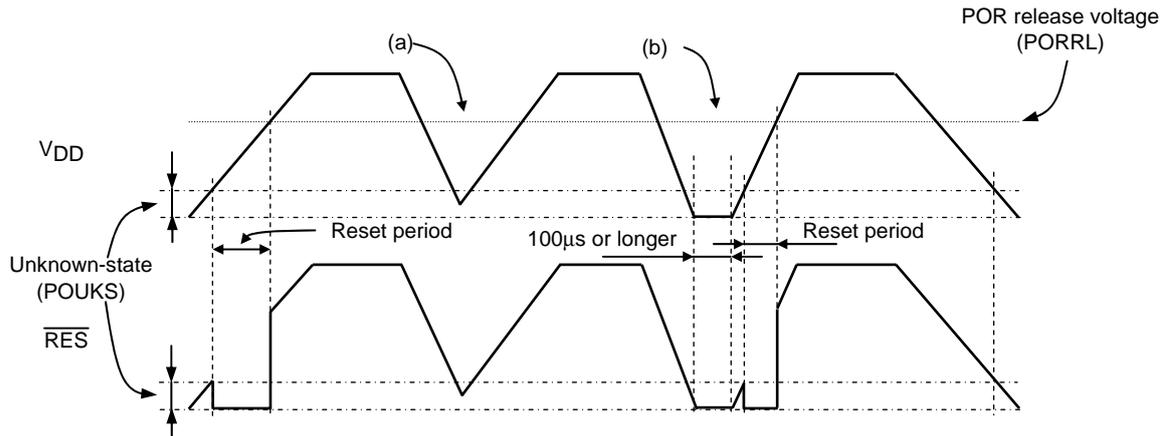


Figure 7 Waveform observed when only POR is used (LVD not used)
(RESET pin: Pull-up resistor R_{RES} only)

- The POR function generates a reset only when power is turned on starting at the V_{SS} level.
- No stable reset will be generated if power is turned on again when the power level does not go down to the V_{SS} 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 V_{SS} level as shown in (b) and power is turned on again after this condition continues for $100\mu s$ or longer.

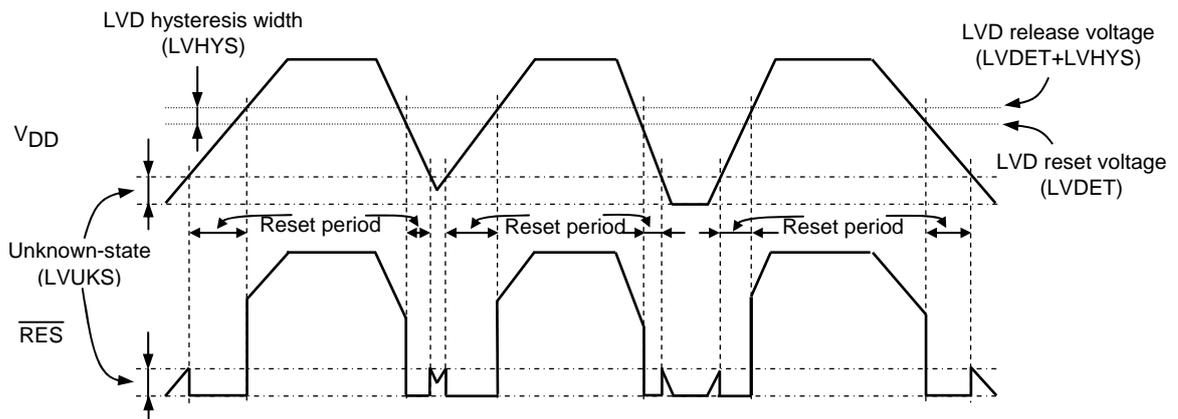


Figure 8 Waveform observed when both POR and LVD functions are used
(RESET pin: Pull-up resistor R_{RES} only)

- 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.

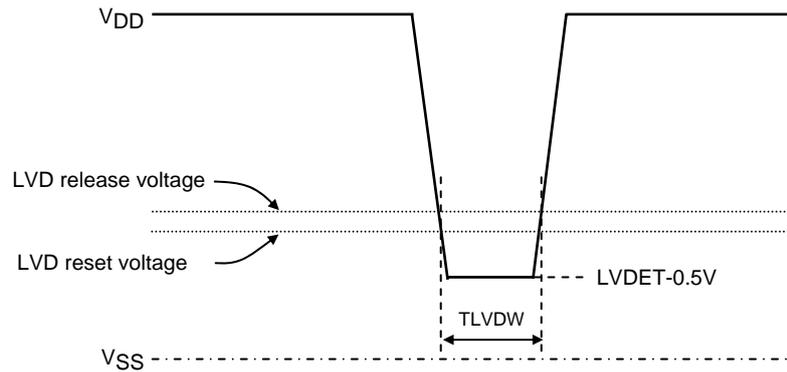


Figure 9 Low voltage detection minimum width
(Example of momentary power loss/Voltage variation waveform)

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