

CMOS 8-Bit Microcontroller

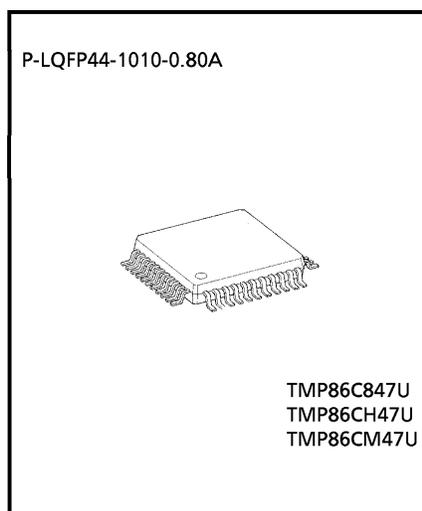
**TMP86C847, TMP86CH47, TMP86CM47**

The TMP86C847/H47/M47 are the high-speed, high-performance and low-power consumption 8-bit microcomputer, including ROM, RAM, multi-function timer/counter, serial interface a 10-bit AD converter on chip.

| Product No. | ROM           | RAM          | Package             | OTP MCU    |
|-------------|---------------|--------------|---------------------|------------|
| TMP86C847U  | 8 K × 8 bits  | 512 × 8 bits | P-LQFP44-1010-0.80A | TMP86PM47U |
| TMP86CH47U  | 16 K × 8 bits |              |                     |            |
| TMP86CM47U  | 32 K × 8 bits |              |                     |            |

**Features**

- ◆ 8-bit single chip microcomputer TLCS-870/C series
- ◆ Instruction execution time: 0.25 μs (at 16 MHz)  
122 μs (at 32.768 kHz)
- ◆ 132 types and 731 basic instructions
- ◆ 18 interrupt sources (External: 6, Internal: 12)
- ◆ Input/Output ports (35 pins)
- ◆ 8-bit timer counter: 2 ch
  - Timer, PWM, PPG, PDO, Event counter modes
- ◆ Time Base Timer
- ◆ Watchdog Timer
  - Interrupt source/reset output (programmable)
- ◆ Serial interface
  - 8-bit SIO: 1 ch
  - 8-bit UART: 1 ch



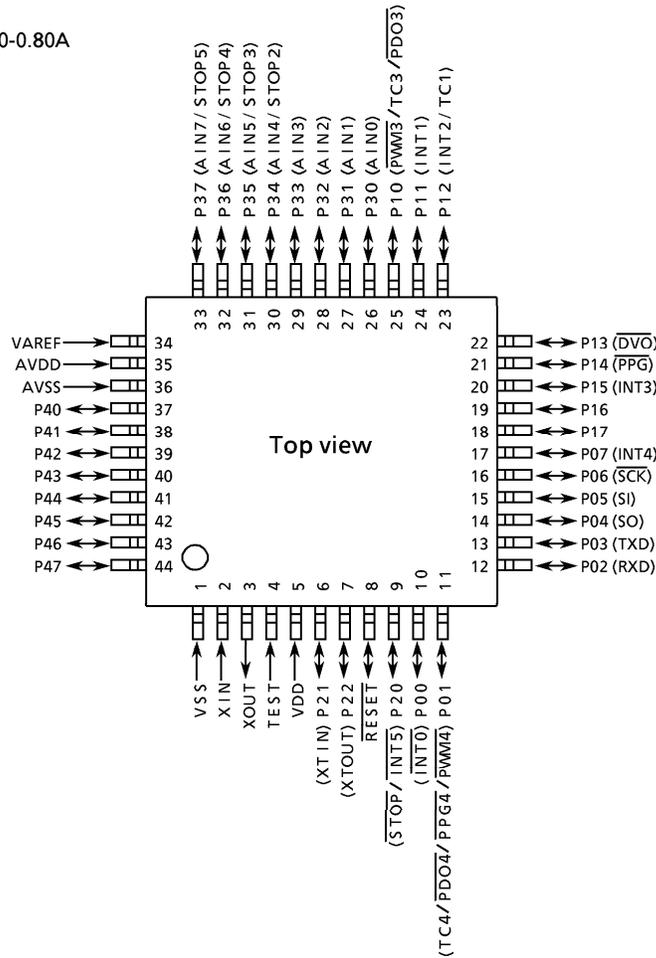
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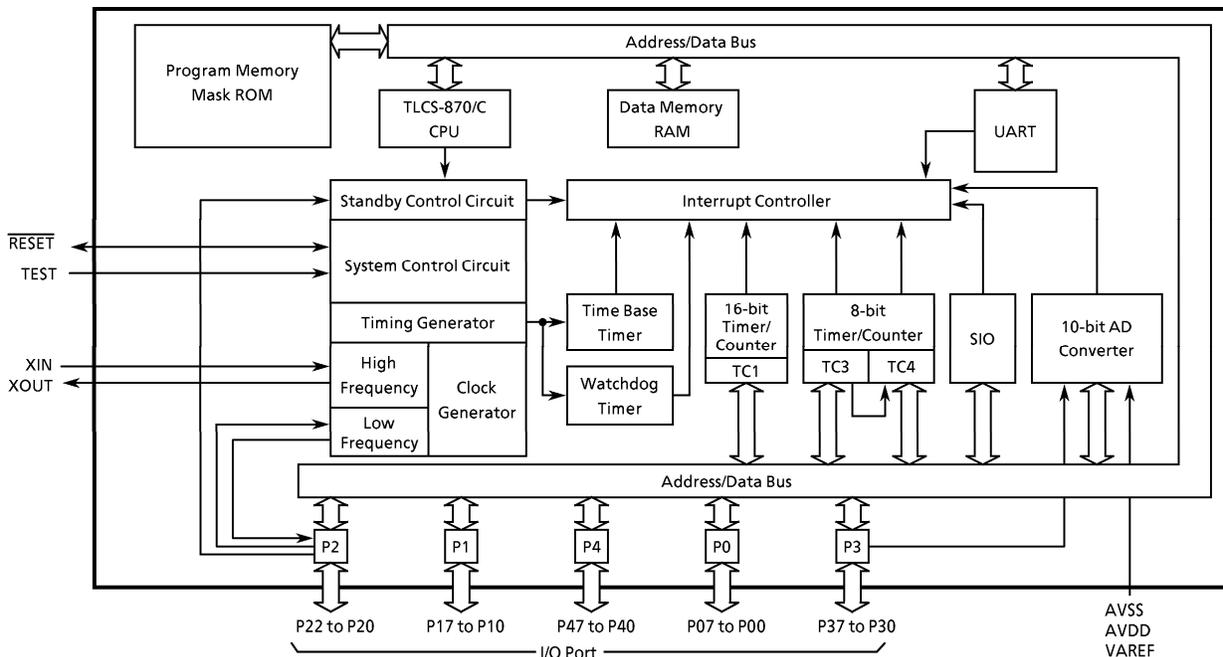
- ◆ 10-bit successive approximation type AD converter
  - Analog input: 8 ch
- ◆ 16-bit timer counter: 1 ch
  - Timer, Event counter, Pulse width measurement, Programmable Pulse Generator (PPG), External-triggered Window modes
- ◆ Key On Wake Up: 4 ch
- ◆ Dual clock operation
  - Single/Dual-clock mode
- ◆ Nine power saving operating modes
  - STOP mode: Oscillation stops. Battery/Capacitor back-up. Port output hold/High-impedance.
  - SLOW 1, 2 mode: Low power consumption operation using low-frequency clock. (32.768 kHz)
  - IDLE 0 mode: CPU stops, and peripherals operate using high-frequency clock of Time-Base-Timer. Release by INTTBT interrupt.
  - IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by interrupts.
  - IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
  - SLEEP 0 mode: CPU stops, and peripherals operate using low-frequency clock of Time-Base-Timer. Release by INTTBT interrupt.
  - SLEEP 1 mode: CPU stops, and peripherals operate using low-frequency clock. Release by interrupts.
  - SLEEP 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
- ◆ Wide operating voltage: 4.5 to 5.5 V at 16 MHz/32.768 kHz  
2.7 to 5.5 V at 8 MHz/32.768 kHz  
1.8 to 5.5 V at 4.2 MHz/32.768 kHz

Pin Assignments (Top View)

P-LQFP44-1010-0.80A



Block Diagram



## Pin Functions

| Pin Name   | I/O                | Functions  |  |                            |
|--|--------------------|--|--|----------------------------|
| P07 (INT4)   | I/O (Input)        | 8-bit I/O port.<br>When used as input port, external interrupt input, serial clock input/output, serial data input/output and timer/counter 4 input/output, the latch must be set to "1".                      | External interrupt input   |                            |
| P06 ( $\overline{\text{SCK}}$ )  | I/O (Input/Output) |  | SIO input/output   |                            |
| P05 (SI)   | I/O (Input)        |  |  |                            |
| P04 (SO)   | I/O (Output)       |  | UART Data output   |                            |
| P03 (TXD)  | I/O (Output)       |  | UART Data input  |                            |
| P02 (RXD)  | I/O (Input)        |  | Timer/Counter input<br>PPG output, PWM output, PDO output  |                            |
| P01 ( $\overline{\text{PWM4/TC4/}}$<br>$\overline{\text{PDO4/PPG4}}$ ) | I/O (Input/Output) |  | External interrupt input   |                            |
| P00 ( $\overline{\text{INT0}}$ )                                       | I/O (Input)        |  | —  |                            |
| P17  | I/O                | 8-bit I/O port with latch.<br>Each bit of these ports can be individually configured as an input or an output under software control.<br>An output latch is set to "1" when using it as a functional terminal. | External interrupt input   |                            |
| P16  | I/O                |  | PPG output   |                            |
| P15 (INT3)   | I/O (Input)        |  | Divider output   |                            |
| P14 ( $\overline{\text{PPG}}$ )  | I/O (Output)       |  | External interrupt input. Timer/Counter input  |                            |
| P13 ( $\overline{\text{DVO}}$ )  | I/O (Output)       |  | External interrupt input.  |                            |
| P12 (INT2/TC1)   | I/O (Input)        |  | Timer/Counter input<br>PWM output, PDO output  |                            |
| P11 (INT1)   | I/O (Input)        |  | External interrupt input<br>STOP mode release signal input   |                            |
| P10 ( $\overline{\text{PWM3/TC3/}}$<br>$\overline{\text{PDO3}}$ )      | I/O (Input/Output) |  | Resonator connecting pins for low-frequency clock. For inputting external clock, XTIN is used and XTOUT is opened.   |                            |
| P20 (INT5/STOP1)   | I/O (Input)        |  | 8-bit I/O port.<br>Each bit of these ports can be individually configured as an input or output under software control.<br>When used as analog input, then must be set to "1". | AD converter analog inputs |
| P21 (XTIN)   | I/O (Input)        |  |  | —                          |
| P22 (XTOUT)  | I/O (Output)       |  |  |                            |
| P37 (AIN7/STOP5)   | I/O (Input)        | —  |  |                            |
| P36 (AIN6/STOP4)   |                    |  |  |                            |
| P35 (AIN5/STOP3)   |                    |  |  |                            |
| P34 (AIN4/STOP2)   |                    |  |  |                            |
| P33 (AIN3)   |                    |  |  |                            |
| P32 (AIN2)   |                    |  |  |                            |
| P31 (AIN1)   |                    |  |  |                            |
| P30 (AIN0)   |                    |  |  |                            |
| P47  | I/O                | 8-bit I/O port with latch.<br>Each bit of these ports can be individually configured as an input or an output under software control.  | —  |                            |
| P46  |                    |  |  |                            |
| P45  |                    |  |  |                            |
| P44  |                    |  |  |                            |
| P43  |                    |  |  |                            |
| P42  |                    |  |  |                            |
| P41  |                    |  |  |                            |
| P40  |                    |  |  |                            |
| TEST   | Input              | Test pin for out-going test. Be fixed to Low.  |  |                            |
| RESET  | I/O                | Reset signal input or watchdog timer output/address-trap-reset output  |  |                            |
| XIN  | Input              | Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.  |  |                            |
| XOUT   | Output             |  |  |                            |
| VSS  | Power Supply       | 0.0 [V] (GND)  |  |                            |
| VDD  |                    | + 5 V  |  |                            |
| AVSS   |                    | 0.0 [V] (GND)  |  |                            |
| AVDD   |                    | AD circuit power supply  |  |                            |
| VAREF  |                    | Analog reference voltage inputs (High, Low)  |  |                            |

## Operational Description

### 1. CPU Core Functions

The CPU core consists of a CPU, a system clock controller, and an interrupt controller.

This section provides a description of the CPU core, the program memory, the data memory, the external memory interface, and the reset circuit.

#### 1.1 Memory Address Map

The TMP86C847/H47/M47 memory consist of 4 blocks: ROM, RAM, DBR (Data Buffer Register) and SFR (Special Function Register). They are all mapped in 64-Kbyte address space. Figure 1-1 shows the TMP86C847/H47/M47 memory address map. The general-purpose registers are not assigned to the RAM address space.

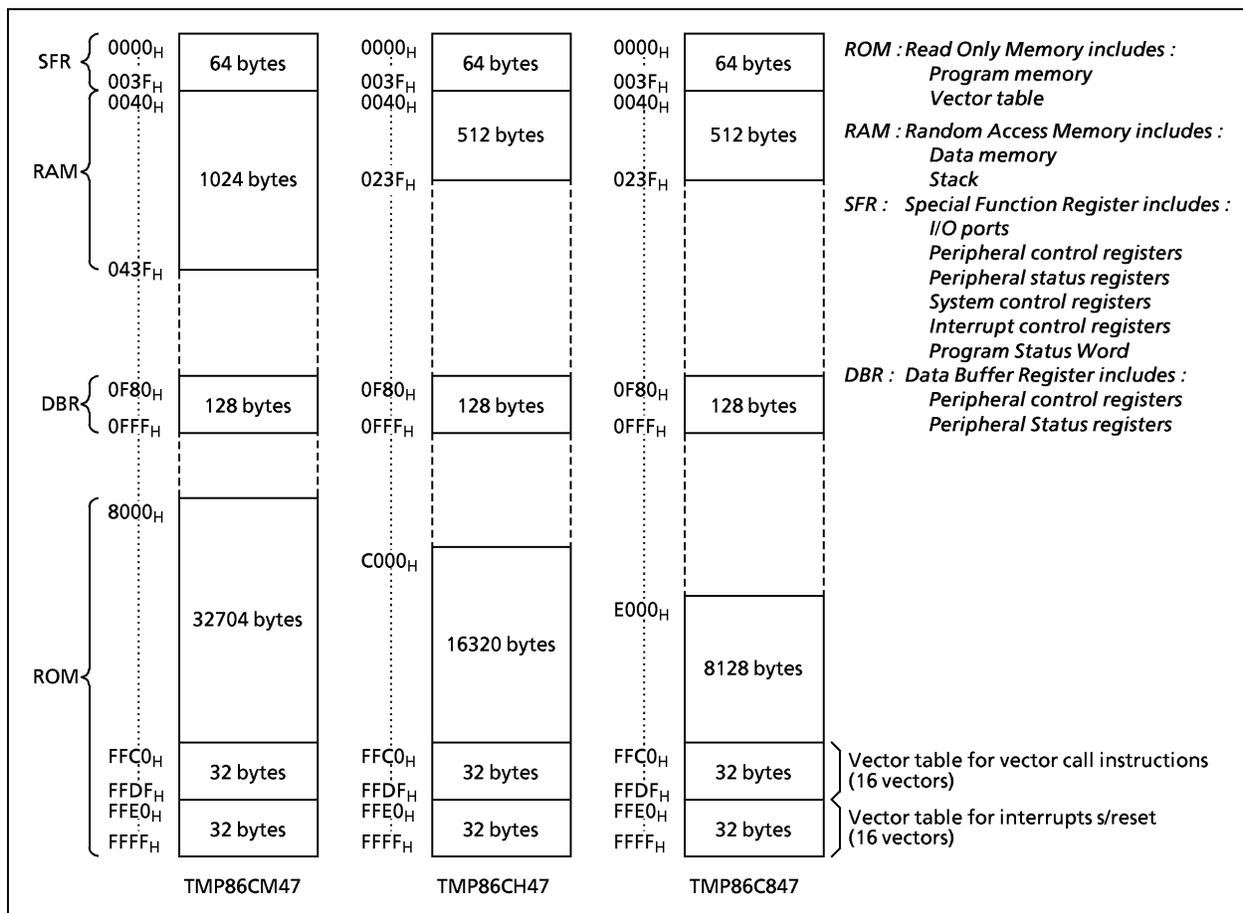


Figure 1-1. Memory Address Maps

#### 1.2 Program Memory (ROM)

The TMP86C847 has a 8 K×8 bits (Address E000H to FFFFH), TMP86CH47 has a 16 K×8 bits (Address C000H to FFFFH), and the TMP86CM47 has a 32 K×8 bits (address 8000H to FFFFH) of program memory (mask programmed ROM). However, placing program memory on the internal RAM is deregulated if a certain procedure is executed (See 2.4.5 Address trap).

## 4. Electrical Characteristics

Absolute Maximum Ratings ( $V_{SS} = 0\text{ V}$ )

| Parameter  | Symbol            | Pins            | Rating                  | Unit             |
|--|-------------------|-----------------|-------------------------|------------------|
| Supply Voltage                                     | $V_{DD}$          |                 | - 0.3 to 5.5            | V                |
| Input Voltage                                      | $V_{IN}$          |                 | - 0.3 to $V_{DD} + 0.3$ |                  |
| Output Voltage                                     | $V_{OUT}$         |                 | - 0.3 to $V_{DD} + 0.3$ |                  |
| Output Current (Per 1 pin)                         | $I_{OUT1\ IOH}$   | P1, P3, P4 port | - 1.8                   | mA               |
|  | $I_{OUT2\ IOL}$   | P1, P3 port     | 3.2                     |                  |
|  | $I_{OUT3\ IOL}$   | P0, P2, P4 port | 30                      |                  |
| Output Current (Total)                             | $\Sigma I_{OUT1}$ | P1, P3 port     | 60                      |                  |
|  | $\Sigma I_{OUT2}$ | P0, P2, P4 port | 80                      |                  |
| Power Dissipation [ $T_{opr} = 85^\circ\text{C}$ ] | PD                |                 | 250                     |                  |
| Soldering Temperature (Time)                       | $T_{sld}$         |                 | 260 (10 sec)            | $^\circ\text{C}$ |
| Storage Temperature                                | $T_{stg}$         |                 | - 55 to 125             |                  |
| Operating Temperature                              | $T_{opr}$         |                 | - 40 to 85              |                  |

Note: The absolute maximum ratings are rated values, which must not be exceeded during operation, even for an instant. Any one of the ratings must not be exceeded. If any absolute maximum rating is exceeded, a device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user. Thus, when designing products which include this device, ensure that no absolute maximum rating value will ever be exceeded.

Recommended Operating Condition ( $V_{SS} = 0\text{ V}$ ,  $T_{opr} = -40\text{ to }85^\circ\text{C}$ )

| Parameter                 | Symbol     | Pins                    | Condition                             | Min                     | Max                     | Unit |
|---------------------------|------------|-------------------------|---------------------------------------|-------------------------|-------------------------|------|
| Supply Voltage            | $V_{DD}$   |                         | $f_c = 16\text{ MHz}$                 | NORMAL1, 2 mode         | 4.5                     | 5.5  |
|                           |            |                         |                                       | IDLE1, 2 mode           |                         |      |
|                           |            |                         | $f_c = 8\text{ MHz}$                  | NORMAL1, 2 mode         | 2.7                     |      |
|                           |            |                         |                                       | IDLE1, 2 mode           |                         |      |
|                           |            |                         | $f_c = 4.2\text{ MHz}$                | NORMAL1, 2 mode         | 1.8                     |      |
|                           |            |                         |                                       | IDLE1, 2 mode           |                         |      |
| $f_s = 32.768\text{ kHz}$ | SLOW mode  | 1.8                     |                                       |                         |                         |      |
|                           | SLEEP mode |                         |                                       |                         |                         |      |
|                           |            | STOP mode               |                                       |                         |                         |      |
| Input high Level          | $V_{IH1}$  | Except Hysteresis input | $V_{DD} \geq 4.5\text{ V}$            | $V_{DD} \times 0.70$    | $V_{DD}$                | V    |
|                           | $V_{IH2}$  | Hysteresis input        |                                       | $V_{DD} \times 0.75$    |                         |      |
|                           | $V_{IH3}$  |                         |                                       | $V_{DD} < 4.5\text{ V}$ |                         |      |
| Input low Level           | $V_{IL1}$  | Except Hysteresis input | $V_{DD} \geq 4.5\text{ V}$            | 0                       | $V_{DD} \times 0.30$    | V    |
|                           | $V_{IL2}$  | Hysteresis input        |                                       |                         | $V_{DD} \times 0.25$    |      |
|                           | $V_{IL3}$  |                         |                                       |                         | $V_{DD} < 4.5\text{ V}$ |      |
| Clock Frequency           | $f_c$      | XIN, XOUT               | $V_{DD} = 4.5\text{ to }5.5\text{ V}$ | 1.0                     | 16.0                    | MHz  |
|                           |            |                         | $V_{DD} = 2.7\text{ to }5.5\text{ V}$ |                         | 8.0                     |      |
|                           |            |                         | $V_{DD} = 1.8\text{ to }5.5\text{ V}$ |                         | 4.2                     |      |
|                           | $f_s$      | XTIN, XTOUT             |                                       | 30.0                    | 34.0                    | kHz  |

Note: The recommended operating conditions for a device are operating conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating conditions other than the recommended operating conditions (supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating conditions for the device are always adhered to.

## DC Characteristics

 $(V_{SS} = 0\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                          | Symbol    | Pins                                | Condition  | Min  | Typ. | Max     | Unit             |
|------------------------------------|-----------|-------------------------------------|--|--|------|---------|------------------|
| Hysteresis Voltage                 | $V_{HS}$  | Hysteresis input                    |  | –  | 0.9  | –       | V                |
| Input Current                      | $I_{IN1}$ | TEST                                | $V_{DD} = 5.5\text{ V}, V_{IN} = 5.5\text{ V}/0\text{ V}$  | –  | –    | $\pm 2$ | $\mu\text{A}$    |
|                                    | $I_{IN2}$ | Sink Open Drain, Tri-state          |  |  |      |         |                  |
|                                    | $I_{IN3}$ | RESET, STOP                         |  |  |      |         |                  |
| Input Resistance                   | $R_{IN1}$ | TEST Pull-Down                      |  | –  | 70   | –       | $\text{k}\Omega$ |
|                                    | $R_{IN2}$ | RESET Pull-Up                       |  | 100  | 200  | 450     |                  |
| Output Leakage Current             | $I_{LO1}$ | Sink Open Drain                     | $V_{DD} = 5.5\text{ V}, V_{OUT} = 5.5\text{ V}$  | –  | –    | 2       | $\mu\text{A}$    |
|                                    | $I_{LO2}$ | Tri-state                           | $V_{DD} = 5.5\text{ V}, V_{OUT} = 5.5\text{ V}/0\text{ V}$   | –  | –    | $\pm 2$ |                  |
| Output High Voltage                | $V_{OH}$  | Tri-state Port                      | $V_{DD} = 4.5\text{ V}, V_{OH} = -0.7\text{ mA}$   | 4.1  | –    | –       | V                |
| Output Low Current                 | $V_{OL}$  | Except $X_{OUT}, P0, P4, P2$ Port   | $V_{DD} = 4.5\text{ V}, V_{OL} = 1.6\text{ mA}$  | –  | –    | 0.4     | $\text{mA}$      |
|                                    | $I_{OL}$  | High Current Port (P0, P2, P4 Port) | $V_{DD} = 4.5\text{ V}, V_{OL} = 1.0\text{ V}$   | –  | 20   | –       |                  |
| Supply Current in NORMAL1, 2 mode  | $I_{DD}$  |                                     | $V_{DD} = 5.5\text{ V}$<br>$V_{IN} = 5.3/0.2\text{ V}$<br>$f_c = 16\text{ MHz}$<br>$f_s = 32.768\text{ kHz}$ | –  | 7.5  | 9       | $\text{mA}$      |
| Supply Current in IDLE0, 1, 2 mode |           |                                     |  | –  | 5.5  | 6.5     |                  |
| Supply Current in SLOW1 mode       |           |                                     | $V_{DD} = 3.0\text{ V}$<br>$V_{IN} = 2.8/0.2\text{ V}$<br>$f_s = 32.768\text{ kHz}$                          | –  | 8    | 20      | $\mu\text{A}$    |
| Supply Current in SLEEP1 mode      |           |                                     |  | –  | 5    | 15      |                  |
| Supply Current in SLEEP0 mode      |           |                                     |  | –  | 4    | 13      |                  |
| Supply Current in STOP mode        |           |                                     |  | $V_{DD} = 5.5\text{ V}$<br>$V_{IN} = 5.3/0.2\text{ V}$ | –    | 0.5     |                  |

Note 1: Typical values show those at  $T_{opr} = 25^{\circ}\text{C}$ ,  $V_{DD} = 5\text{ V}$

Note 2: Input current ( $I_{IN1}$ ,  $I_{IN3}$ ); The current through pull-up or pull-down resistor is not included.

Note 3:  $I_{DD}$  does not include  $I_{REF}$  current.

## AD Conversion Characteristics

(V<sub>SS</sub> = 0.0 V, 4.5 V to 5.5 V, Topr = -40 to 85°C)

| Parameter  | Symbol             | Condition  | Min                    | Typ. | Max               | Unit |
|--|--------------------|--|------------------------|------|-------------------|------|
| Analog Reference Voltage                         | V <sub>AREF</sub>  |  | A <sub>VDD</sub> - 1.0 | -    | A <sub>VDD</sub>  | V    |
| Power Supply Voltage of Analog Control Circuit   | A <sub>VDD</sub>   |  | V <sub>DD</sub>        |      |                   |      |
| Analog Reference Voltage Range                   | ΔV <sub>AREF</sub> |  | 3.5                    | -    | -                 |      |
| Analog Input Voltage                             | V <sub>AIN</sub>   |  | V <sub>SS</sub>        | -    | V <sub>AREF</sub> |      |
| Power Supply Current of Analog Reference Voltage | I <sub>REF</sub>   | V <sub>DD</sub> = A <sub>VDD</sub> = V <sub>AREF</sub> = 5.5 V<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V           | -                      | 0.6  | 1.0               | mA   |
| Non linearity Error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 5.0 V,<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 5.0 V | -                      | -    | ±2                | LSB  |
| Zero Point Error                                 |                    |  | -                      | -    | ±2                |      |
| Full Scale Error                                 |                    |  | -                      | -    | ±2                |      |
| Total Error                                      |                    |  | -                      | -    | ±2                |      |

(V<sub>SS</sub> = 0.0 V, 2.7 V to 4.5 V, Topr = -40 to 85°C)

| Parameter  | Symbol             | Condition  | Min                    | Typ. | Max               | Unit |
|--|--------------------|--|------------------------|------|-------------------|------|
| Analog Reference Voltage                         | V <sub>AREF</sub>  |  | A <sub>VDD</sub> - 1.0 | -    | A <sub>VDD</sub>  | V    |
| Power Supply Voltage of Analog Control Circuit   | A <sub>VDD</sub>   |  | V <sub>DD</sub>        |      |                   |      |
| Analog Reference Voltage Range                   | ΔV <sub>AREF</sub> |  | 2.5                    | -    | -                 |      |
| Analog Input Voltage                             | V <sub>AIN</sub>   |  | V <sub>SS</sub>        | -    | V <sub>AREF</sub> |      |
| Power Supply Current of Analog Reference Voltage | I <sub>REF</sub>   | V <sub>DD</sub> = A <sub>VDD</sub> = V <sub>AREF</sub> = 4.5 V<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V           | -                      | 0.5  | 0.8               | mA   |
| Non linearity Error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 2.7 V,<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 2.7 V | -                      | -    | ±2                | LSB  |
| Zero Point Error                                 |                    |  | -                      | -    | ±2                |      |
| Full Scale Error                                 |                    |  | -                      | -    | ±2                |      |
| Total Error                                      |                    |  | -                      | -    | ±2                |      |

(V<sub>SS</sub> = 0.0 V, 2.0 V to 2.7 V, Topr = -40 to 85°C)  
(V<sub>SS</sub> = 0.0 V, 1.8 V to 2.0 V, Topr = -10 to 85°C)

| Parameter  | Symbol             | Condition  | Min                    | Typ. | Max               | Unit |
|--|--------------------|--|------------------------|------|-------------------|------|
| Analog Reference Voltage                         | V <sub>AREF</sub>  |  | A <sub>VDD</sub> - 0.9 | -    | A <sub>VDD</sub>  | V    |
| Power Supply Voltage of Analog Control Circuit   | A <sub>VDD</sub>   |  | V <sub>DD</sub>        |      |                   |      |
| Analog Reference Voltage Range                   | ΔV <sub>AREF</sub> | 1.8 V ≤ V <sub>DD</sub> < 2.0 V  | 1.8                    | -    | -                 |      |
|  |                    | 2.0 V ≤ V <sub>DD</sub> < 2.7 V  | 2.0                    | -    | -                 |      |
| Analog Input Voltage                             | V <sub>AIN</sub>   |  | V <sub>SS</sub>        | -    | V <sub>AREF</sub> |      |
| Power Supply Current of Analog Reference Voltage | I <sub>REF</sub>   | V <sub>DD</sub> = A <sub>VDD</sub> = V <sub>AREF</sub> = 2.7 V<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V           | -                      | 0.3  | 0.5               | mA   |
| Non linearity Error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 1.8 V,<br>V <sub>SS</sub> = AV <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 1.8 V | -                      | -    | ±4                | LSB  |
| Zero Point Error                                 |                    |  | -                      | -    | ±4                |      |
| Full Scale Error                                 |                    |  | -                      | -    | ±4                |      |
| Total Error                                      |                    |  | -                      | -    | ±4                |      |

Note 1: The total error includes all errors except a quantization error, and is defined as a maximum deviation from the ideal conversion line.

Note 2: Conversion time is different in recommended value by power supply voltage.  
About conversion time, please refer to "2.8.2 Register Framing".

Note 3: Please use input voltage to AIN input Pin in limit of V<sub>AREF</sub> - V<sub>SS</sub>.  
When voltage of range outside is input, conversion value becomes unsettled and gives affect to other channel conversion value.

Note 4: Analog Reference Voltage Range: ΔV<sub>AREF</sub> = V<sub>AREF</sub> - V<sub>SS</sub>

Note 5: When AD is used with V<sub>DD</sub> < 2.7 V, the guaranteed temperature range varies with the operating voltage.

## AC Characteristics

 $(V_{SS} = 0\text{ V}, V_{DD} = 4.5\text{ to }5.5\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                    | Symbol | Condition                                 | Min   | Typ.  | Max   | Unit          |
|------------------------------|--------|---|-------|-------|-------|---------------|
| Machine Cycle Time           | tcy    | NORMAL1, 2 mode                           | 0.25  | -     | 4     | $\mu\text{s}$ |
|                              |        | IDLE0, 1, 2 mode                          |       |       |       |               |
|                              |        | SLOW1, 2 mode                             | 117.6 | -     | 133.3 |               |
|                              |        | SLEEP0, 1, 2 mode                         |       |       |       |               |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  | -     | 31.25 | -     | ns            |
| Low Level Clock Pulse Width  | twcL   | fc = 16 MHz                               | -     | 31.25 | -     | ns            |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) | -     | 15.26 | -     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | -     | 15.26 | -     | $\mu\text{s}$ |

 $(V_{SS} = 0\text{ V}, V_{DD} = 2.7\text{ to }4.5\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                    | Symbol | Condition                                 | Min   | Typ.  | Max   | Unit          |
|------------------------------|--------|---|-------|-------|-------|---------------|
| Machine Cycle Time           | tcy    | NORMAL1, 2 mode                           | 0.5   | -     | 4     | $\mu\text{s}$ |
|                              |        | IDLE0, 1, 2 mode                          |       |       |       |               |
|                              |        | SLOW1, 2 mode                             | 117.6 | -     | 133.3 |               |
|                              |        | SLEEP0, 1, 2 mode                         |       |       |       |               |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  | -     | 62.5  | -     | ns            |
| Low Level Clock Pulse Width  | twcL   | fc = 8 MHz                                | -     | 62.5  | -     | ns            |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) | -     | 15.26 | -     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | -     | 15.26 | -     | $\mu\text{s}$ |

 $(V_{SS} = 0\text{ V}, V_{DD} = 1.8\text{ to }2.7\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                    | Symbol | Condition                                 | Min   | Typ.   | Max   | Unit          |
|------------------------------|--------|---|-------|--------|-------|---------------|
| Machine Cycle Time           | tcy    | NORMAL1, 2 mode                           | 0.95  | -      | 4     | $\mu\text{s}$ |
|                              |        | IDLE0, 1, 2 mode                          |       |        |       |               |
|                              |        | SLOW1, 2 mode                             | 117.6 | -      | 133.3 |               |
|                              |        | SLEEP0, 1, 2 mode                         |       |        |       |               |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  | -     | 119.05 | -     | ns            |
| Low Level Clock Pulse Width  | twcL   | fc = 4.2 MHz                              | -     | 119.05 | -     | ns            |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) | -     | 15.26  | -     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | -     | 15.26  | -     | $\mu\text{s}$ |

## Recommended Oscillating Conditions - 1

 $(V_{SS} = 0\text{ V}, V_{DD} = 4.5\text{ to }5.5\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                  | Oscillator                     | Oscillation Frequency     | Recommended Oscillator    | Recommended Constant |                  |
|----------------------------|--------------------------------|---------------------------|---------------------------|----------------------|------------------|
|                            |                                |                           |                           | C <sub>1</sub>       | C <sub>2</sub>   |
| High-frequency Oscillation | Ceramic Resonator              | 16 MHz                    | MURATA CSA16.00MXZ040     | 10 pF                | 10 pF            |
|                            |                                | 8 MHz                     | MURATA CSA8.00MTZ         | 30 pF                | 30 pF            |
|                            |                                |                           | MURATA CST8.00MTW         | 30 pF (built-in)     | 30 pF (built-in) |
| 4.19 MHz                   | MURATA CSA4.19MG<br>CST4.19MGW | 30 pF<br>30 pF (built-in) | 30 pF<br>30 pF (built-in) |                      |                  |
| Low-frequency Oscillation  | Crystal Oscillator             | 32.768 kHz                | SII VT-200                | 6 pF                 | 6 pF             |

## Recommended Oscillating Conditions - 2

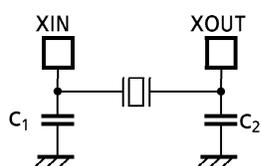
 $(V_{SS} = 0\text{ V}, V_{DD} = 2.7\text{ to }5.5\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                  | Oscillator        | Oscillation Frequency | Recommended Oscillator          | Recommended Constant      |                           |
|----------------------------|-------------------|-----------------------|---------------------------------|---------------------------|---------------------------|
|                            |                   |                       |                                 | C <sub>1</sub>            | C <sub>2</sub>            |
| High-frequency Oscillation | Ceramic Resonator | 8 MHz                 | MURATA CSA8.00MTZ<br>CST8.00MTW | 30 pF<br>30 pF (built-in) | 30 pF<br>30 pF (built-in) |
|                            |                   | 4.19 MHz              | MURATA CSA4.19MG<br>CST4.19MGW  | 30 pF<br>30 pF (built-in) | 30 pF<br>30 pF (built-in) |

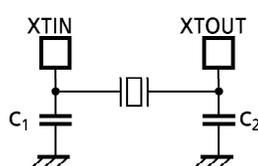
## Recommended Oscillating Conditions - 3

 $(V_{SS} = 0\text{ V}, V_{DD} = 1.8\text{ to }5.5\text{ V}, T_{opr} = -40\text{ to }85^{\circ}\text{C})$ 

| Parameter                  | Oscillator        | Oscillation Frequency | Recommended Oscillator         | Recommended Constant      |                           |
|----------------------------|-------------------|-----------------------|--------------------------------|---------------------------|---------------------------|
|                            |                   |                       |                                | C <sub>1</sub>            | C <sub>2</sub>            |
| High-frequency Oscillation | Ceramic Resonator | 4.19 MHz              | MURATA CSA4.19MG<br>CST4.19MGW | 30 pF<br>30 pF (built-in) | 30 pF<br>30 pF (built-in) |



(1) High-frequency Oscillation



(2) Low-frequency Oscillation

**Note 1:** An electrical shield by metal shield plate on the surface of IC package is recommended in order to protect the device from the high electric field stress applied from CRT (Cathodic Ray Tube) for continuous reliable operation.

**Note 2:** The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL;  
<http://www.murata.co.jp/search/index.html>

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