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.

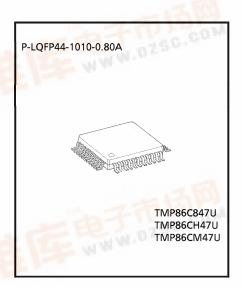
| Product No. | ROM           | RAM          | Package             | OTP MCU    |
|-------------|---------------|--------------|---------------------|------------|
| TMP86C847U  | 8 K × 8 bits  | 540 O.L.     |                     |            |
| TMP86CH47U  | 16 K × 8 bits | 512 × 8 bits | P-LQFP44-1010-0.80A | TMP86PM47U |
| TMP86CM47U  | 32 K × 8 bits | 1 K × 8 bits |                     |            |

#### **Features**

- ◆ 8-bit single chip microcomputer TLCS-870/C series
- Instruction execution time: 0.25 μs (at 16 MHz)  $122 \mu s (at 32.768 \text{ kHz})$
- ◆ 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

df.dzsc.com

- 8-bit SIO: 1 ch
- 8-bit UART: 1 ch



• For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance / Handling Precautions.

Quality and Reliability Assurance / Handling Precautions.

TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.

In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..

The TOSHIBA products listed in this document are intended for usage in general electronics applications. (computer of the products are intended for usage in general electronics applications.)

The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.

The products described in this document are subject to the foreign exchange and foreign trade laws.

The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.

the information contained herein is subject to change without notice.

- ♦ 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 interruput.

• IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by

interruputs.

• IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release

by interruputs.

• SLEEP 0 mode: CPU stops, and peripherals operate using low-frequency clock of Time-Base-

Timer. Release by INTTBT interruput.

• SLEEP 1 mode: CPU stops, and peripherals operate using low-frequency clock. Release by

interruputs.

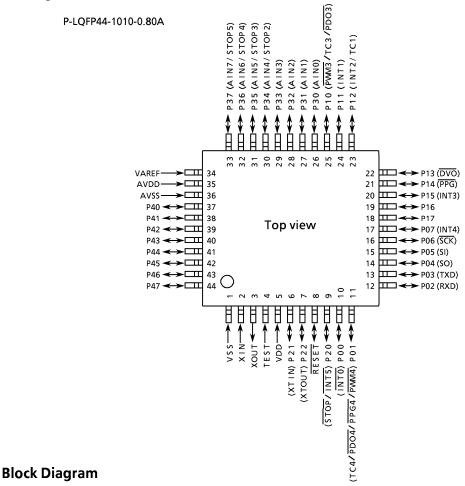
• SLEEP 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release

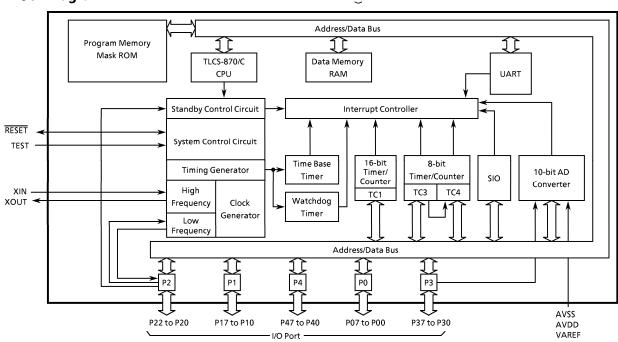
by interruputs.

♦ 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)





## **Pin Functions**

| Pin Name                     | I/O                   | Functi  | ons  |  |  |  |  |
|------------------------------|-----------------------|---|--|--|--|--|--|
| P07 (INT4)                   | I/O (Input)           |   | External interrupt input   |  |  |  |  |
| P06 (SCK)                    | I/O<br>(Input/Output) |   |  |  |  |  |  |
| P05 (SI)                     | I/O (Input)           | 8-bit I/O port.   | SIO input/output   |  |  |  |  |
| P04 (SO)                     | I/O (Output)          | When used as input port, external interrupt input, serial clock input/output, serial data |  |  |  |  |  |
| P03 (TXD)                    | I/O (Output)          | input/output and timer/counter 4  | UART Data output   |  |  |  |  |
| P02 (RXD)                    | I/O (Input)           | input/output, the latch must be set to "1".   | UART Data input  |  |  |  |  |
| P01 (PWM4/TC4/<br>PDO4/PPG4) | I/O<br>(Input/Output) |   | Timer/Counter input<br>PPG output, PWM output, PDO output                        |  |  |  |  |
| P00 (INTO)                   | I/O (Input)           |   | External interrupt input   |  |  |  |  |
| P17                          | I/O                   |   | _  |  |  |  |  |
| P16                          | I/O                   |   |  |  |  |  |  |
| P15 (INT3)                   | I/O (Input)           | 8-bit I/O port with latch.  | External interrupt input   |  |  |  |  |
| P14 (PPG)                    | I/O (Output)          | Each bit of these ports can be individually   | PPG output   |  |  |  |  |
| P13 (DVO)                    | I/O (Output)          | configured as an input or an output under software control.                               | Divider output   |  |  |  |  |
| P12 (INT2/TC1)               | I/O (Input)           | An output latch is set to "1" when using it as a functional terminal.                     | External interrupt input. Timer/Counter input                                    |  |  |  |  |
| P11 (INT1)                   | I/O (Input)           | as a functional terminal.   | External interrupt input.  |  |  |  |  |
| P10<br>(PWM3/TC3/PDO3)       | I/O<br>(Input/Output) |   | Timer/Counter input PWM output, PDO output                                       |  |  |  |  |
| P20 (INT5/STOP1)             | I/O (Input)           | 3-bit I/O port with latch.  | External interrupt input STOP mode release signal input                          |  |  |  |  |
| P21 (XTIN)                   | I/O (Input)           | When used as input port, external interrupt input, and STOP mode release signal input,    | Resonator connecting pins for lo   |  |  |  |  |
| P21 (XTIN)                   | I/O (Output)          | the latch must be set to "1".   | frequency clock. For inputting external clock, XTIN is used and XTOUT is opened. |  |  |  |  |
| P37 (AIN7/STOP5)             | i/O (Output)          |   | Clock, A Thy is used and A TOO I is opened.                                      |  |  |  |  |
| P36 (AIN6/STOP4)             |                       |   | S T O P  |  |  |  |  |
| P35 (AIN5/STOP3)             |                       |   | mode<br> release   |  |  |  |  |
| P34 (AIN4/STOP2)             |                       | 8-bit I/O port.   Each bit of these ports can be individually                             | signal<br>  input  |  |  |  |  |
| P33 (AIN3)                   | I/O (Input)           | configured as an input or output under software control.                                  | AD converter analog inputs   |  |  |  |  |
| P32 (AIN2)                   |                       | When used as analog input, then must be   |  |  |  |  |  |
| P31 (AIN1)                   |                       | set to "1".   | -  |  |  |  |  |
| P30 (AIN0)                   |                       |   |  |  |  |  |  |
| P47                          |                       |   |  |  |  |  |  |
| P46                          |                       |   |  |  |  |  |  |
| P45                          |                       |   |  |  |  |  |  |
| P44                          |                       | 8-bit I/O port with latch. Each bit of these ports can be individually                    |  |  |  |  |  |
| P43                          | 1/0                   | configured as an input or an output under   | _  |  |  |  |  |
| P42                          |                       | software control.   |  |  |  |  |  |
| P41                          |                       |   |  |  |  |  |  |
| P40                          |                       |   |  |  |  |  |  |
| TEST                         | Input                 | Test pin for out-going test. Be fixed to Low.   |  |  |  |  |  |
| RESET                        | I/O                   | Reset signal input or watchdog timer output/a   | address-trap-reset output  |  |  |  |  |
| XIN                          | Input                 | Resonator connecting pins for high-frequency  | ·  |  |  |  |  |
| хоит                         | Output                | is used and XOUT is opened.   | , clock. For imputting external clock, All                                       |  |  |  |  |
| VSS                          | •                     | 0.0 [V] (GND)   |  |  |  |  |  |
| VDD                          |                       | +5 V  |  |  |  |  |  |
| AVSS                         | Power Supply          | 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.

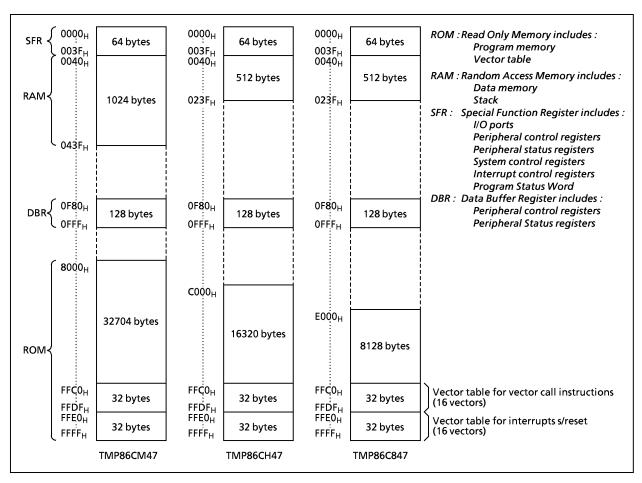


Figure 1-1. Memory Address Maps

#### 1.2 Program Memory (ROM)

The TMP86C847 has a 8 K×8 bits (Address  $E000_H$  to  $FFFF_H$ ), TMP86CH47 has a 16 K×8 bits (Address  $C000_H$  to  $FFFF_H$ ), and the TMP86CM47 has a 32 K×8 bits (address  $8000_H$  to  $FFFF_H$ ) 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  $(V_{SS} = 0 V)$ 

| Parameter                                  | Symbol                            | Pins            | Rating                         | Unit |
|--|-----------------------------------|-----------------|--------------------------------|------|
| Supply Voltage                             | V <sub>DD</sub>                   |                 | – 0.3 to 5.5                   |      |
| Input Voltage                              | V <sub>IN</sub>                   |                 | - 0.3 to V <sub>DD</sub> + 0.3 | ] ,  |
| Output Voltage                             | V <sub>OUT</sub>                  |                 | - 0.3 to V <sub>DD</sub> + 0.3 | ]    |
|  | I <sub>OUT1</sub> I <sub>OH</sub> | P1, P3, P4 port | - 1.8                          | ]    |
| Output Current (Per 1 pin)                 | I <sub>OUT2</sub> I <sub>OL</sub> | P1, P3 port     | 3.2                            |      |
|  | I <sub>OUT3</sub> I <sub>OL</sub> | P0, P2, P4 port | 30                             | ]    |
| Output Current (Total)                     | Σl <sub>OUT1</sub>                | P1, P3 port     | 60                             | mA   |
| Output Current (Total)                     | ΣI <sub>OUT2</sub>                | P0, P2, P4 port | 80                             |      |
| Power Dissipation [T <sub>opr</sub> = 85℃] | PD                                |                 | 250                            | ]    |
| Soldering Temperature (Time)               | Tsld                              |                 | 260 (10 sec)                   |      |
| Storage Temperature                        | Tstg                              |                 | – 55 to 125                    | ີ ℃  |
| Operating Temperature                      | Topr                              |                 | – 40 to 85                     | 1    |

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

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

| Parameter        | Symbol           | Pins                    | С  | ondition              | Min                  | Max                  | Unit |  |
|------------------|------------------|-------------------------|--|-----------------------|----------------------|----------------------|------|--|
|                  |                  |                         |  | NORMAL1, 2 mode       | 4.5                  |                      |      |  |
|                  |                  |                         | fc = 16 MHz                              | IDLE1, 2 mode         | 4.5                  |                      |      |  |
|                  |                  |                         | C. OBALL                                 | NORMAL1, 2 mode       | 2.7                  |                      |      |  |
|                  |                  |                         | fc = 8 MHz                               | IDLE1, 2 mode         | 2.7                  |                      |      |  |
| Supply Voltage   | V <sub>DD</sub>  |                         |  | NORMAL1, 2 mode       |                      | 5.5                  |      |  |
|                  |                  |                         | fc = 4.2 MHz                             | IDLE1, 2 mode         |                      |                      |      |  |
|                  |                  |                         | 1,3-                                     | SLOW mode             | 1.8                  |                      |      |  |
|                  |                  |                         |  | SLEEP mode            |                      |                      | V    |  |
|                  |                  |                         |  | STOP mode             |                      |                      |      |  |
|                  | V <sub>IH1</sub> | Except Hysteresis input |  | <sub>DD</sub> ≧ 4.5 V | $V_{DD} \times 0.70$ |                      |      |  |
| Input high Level | V <sub>IH2</sub> | Hysteresis input        | V D                                      | D = 4.3 V             | $V_{DD} \times 0.75$ | $V_{DD}$             |      |  |
|                  | V <sub>IH3</sub> |                         | V <sub>C</sub>                           | <sub>DD</sub> < 4.5 V | $V_{DD} \times 0.90$ |                      |      |  |
|                  | V <sub>IL1</sub> | Except Hysteresis input |  | <sub>oD</sub> ≧ 4.5 V |                      | $V_{DD} \times 0.30$ |      |  |
| Input low Level  | $V_{IL2}$        | Hysteresis input        | V  | oD = 4.3 V            | 0                    | $V_{DD} \times 0.25$ |      |  |
|                  | V <sub>IL3</sub> |                         | V <sub>D</sub>                           | <sub>DD</sub> < 4.5 V |                      | $V_{DD} \times 0.10$ |      |  |
|                  |                  |                         | V <sub>DD</sub> =                        | = 4.5 to 5.5 V        |                      | 16.0                 |      |  |
| Clock Frequency  | fc               | XIN, XOUT               | $V_{DD} = 2.7 \text{ to } 5.5 \text{ V}$ |                       | 1.0                  | 8.0                  | MHz  |  |
| Clock Frequency  |                  |                         | $V_{DD} = 1.8 \text{ to } 5.5 \text{ V}$ |                       |                      | 4.2                  |      |  |
|                  | fs               | 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** 

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

| Parameter           | Symbol           | Pins                                      | Condition  | Min | Тур. | Max | Unit |
|---------------------|------------------|---|--|-----|------|-----|------|
| Hysteresis Voltage  | V <sub>HS</sub>  | Hysteresis input                          |  | -   | 0.9  | _   | ٧    |
|                     | I <sub>IN1</sub> | TEST                                      |  |     |      |     |      |
| Input Current       | I <sub>IN2</sub> | Sink Open Drain, Tri-state                | $V_{DD} = 5.5 \text{ V}, V_{IN} = 5.5 \text{ V}/0 \text{ V}$ | _   | _    | ± 2 | μΑ   |
|                     | I <sub>IN3</sub> | RESET, STOP                               |  |     |      |     |      |
| In cost Desistance  | R <sub>IN1</sub> | TEST Pull-Down                            |  | _   | 70   | _   | LO   |
| Input Resistance    | R <sub>IN2</sub> | RESET Pull-Up                             |  | 100 | 200  | 450 | kΩ   |
| Output Leakage      | I <sub>LO1</sub> | Sink Open Drain                           | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V            | _   | _    | 2   |      |
| Current             | I <sub>LO2</sub> | Tri-state                                 | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V/0 V        | -   | _    | ± 2 | μΑ   |
| Output High Voltage | V <sub>OH</sub>  | Tri-state Port                            | $V_{DD} = 4.5  V, V_{OH} = -0.7  \text{mA}$                  | 4.1 | _    | _   | V    |
|                     | V <sub>OL</sub>  | Except X <sub>OUT</sub> , P0, P4, P2 Port | $V_{DD} = 4.5  V, V_{OL} = 1.6  \text{mA}$                   | _   | _    | 0.4 |      |
| Output Low Current  | l <sub>OL</sub>  | High Current Port (P0, P2, P4 Port)       | V <sub>DD</sub> = 4.5 V, V <sub>OL</sub> = 1.0 V             | _   | 20   | _   |      |
| Supply Current in   |                  |   | V <sub>DD</sub> = 5.5 V                                      | _   | 7.5  | 9   | mA   |
| NORMAL1, 2 mode     | ]                |   | V <sub>IN</sub> = 5.3/0.2 V                                  | _   | 7.5  | ,   |      |
| Supply Current in   |                  |   | fc = 16 MHz  | _   | 5.5  | 6.5 |      |
| IDLE0, 1, 2 mode    | ]                |   | fs = 32.768 kHz  |     | 3.5  | 0.5 |      |
| Supply Current in   |                  |   |  | _   | 8    | 20  |      |
| SLOW1 mode          | I <sub>DD</sub>  |   | $V_{DD} = 3.0 \text{ V}$                                     |     |      | 20  |      |
| Supply Current in   | טטי              |   | $V_{IN} = 2.8/0.2 \text{ V}$                                 | _   | 5    | 15  |      |
| SLEEP1 mode         |                  |   | fs = 32.768 kHz  |     |      | 13  | μA   |
| Supply Current in   |                  |   |  | _   | 4    | 13  |      |
| SLEEP0 mode         | ]                |   |  | _   |      | 13  |      |
| Supply Current in   |                  |   | $V_{DD} = 5.5 V$   | _   | 0.5  | 10  |      |
| STOP mode           |                  |   | $V_{IN} = 5.3/0.2 V$   |     | 0.0  |     |      |

Note 1: Typical values show those at Topr =  $25^{\circ}$ 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: IDD does not include IREF current.

### **AD Conversion Characteristics**

### $(V_{SS} = 0.0 \text{ V}, 4.5 \text{ V to } 5.5 \text{ V}, \text{Topr} = -40 \text{ to } 85^{\circ}\text{C})$

| Parameter   | Symbol               | Condition  | Min                    | Тур.            | Max               | Unit    |
|---|----------------------|--|------------------------|-----------------|-------------------|---------|
| Analog Reference Voltage                            | V <sub>AREF</sub>    |  | A <sub>VDD</sub> - 1.0 | -               | A <sub>VDD</sub>  |         |
| Power Supply Voltage of<br>Analog Control Circuit   | A <sub>VDD</sub>     |  |                        | V <sub>DD</sub> |                   | v       |
| Analog Reference Voltage Range                      | $\triangle V_{AREF}$ |  | 3.5                    | -               | _                 | 1       |
| Analog Input Voltage                                | V <sub>AIN</sub>     |  | V <sub>SS</sub>        | -               | V <sub>AREF</sub> | 1       |
| Power Supply Current of<br>Analog Reference Voltage | I <sub>REF</sub>     | $V_{DD} = A_{VDD} = V_{AREF} = 5.5 V$<br>$V_{SS} = AVSS = 0.0 V$ | -                      | 0.6             | 1.0               | mA      |
| Non linearity Error                                 |                      |  | _                      | _               | ± 2               |         |
| Zero Point Error                                    |                      | $V_{DD} = A_{VDD} = 5.0 \text{ V},$                              | -                      | _               | ± 2               | ] , , , |
| Full Scale Error                                    |                      | $V_{SS} = AVSS = 0.0 V$ $V_{\Delta REF} = 5.0 V$                 | -                      | -               | ± 2               | LSB     |
| Total Error   |                      | - AILL   | -                      | -               | ± 2               |         |

### $(V_{SS} = 0.0 \text{ V}, 2.7 \text{ V to } 4.5 \text{ V}, \text{Topr} = -40 \text{ to } 85^{\circ}\text{C})$

| Parameter   | Symbol               | Condition  | Min                    | Тур.            | Max               | Unit |
|---|----------------------|--|------------------------|-----------------|-------------------|------|
| Analog Reference Voltage                            | V <sub>AREF</sub>    |  | A <sub>VDD</sub> – 1.0 | -               | A <sub>VDD</sub>  |      |
| Power Supply Voltage of<br>Analog Control Circuit   | A <sub>VDD</sub>     |  |                        | V <sub>DD</sub> |                   | v    |
| Analog Reference Voltage Range                      | $\triangle V_{AREF}$ |  | 2.5                    | -               | _                 |      |
| Analog Input Voltage                                | V <sub>AIN</sub>     |  | V <sub>SS</sub>        | -               | V <sub>AREF</sub> |      |
| Power Supply Current of<br>Analog Reference Voltage | I <sub>REF</sub>     | $V_{DD} = A_{VDD} = V_{AREF} = 4.5 V$<br>$V_{SS} = AVSS = 0.0 V$ | -                      | 0.5             | 0.8               | mA   |
| Non linearity Error                                 |                      |  | -                      | -               | ± 2               |      |
| Zero Point Error                                    |                      | $V_{DD} = A_{VDD} = 2.7 \text{ V},$                              | -                      | -               | ± 2               | LCD  |
| Full Scale Error                                    |                      | $V_{SS} = AVSS = 0.0 V$<br>$V_{AREF} = 2.7 V$                    | -                      | -               | ± 2               | LSB  |
| Total Error   |                      | - AILL   | -                      | -               | ± 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                    | Тур. | Max               | Unit |
|---|----------------------|--|------------------------|------|-------------------|------|
| Analog Reference Voltage                            | $V_{AREF}$           |  | A <sub>VDD</sub> - 0.9 | _    | A <sub>VDD</sub>  |      |
| Power Supply Voltage of<br>Analog Control Circuit   | A <sub>VDD</sub>     |  | V <sub>DD</sub>        |      |                   | ]    |
| Analas Bafaransa Valtasa Bansa                      | Δ.,,                 | $1.8 \text{ V} \le \text{V}_{DD} < 2.0 \text{ V}$                                | 1.8                    | -    | _                 | V    |
| Analog Reference Voltage Range                      | $\triangle V_{AREF}$ | $2.0 \text{ V} \le \text{V}_{DD} < 2.7 \text{ V}$                                | 2.0                    | -    | -                 | 1    |
| Analog Input Voltage                                | V <sub>AIN</sub>     |  | V <sub>SS</sub>        | _    | V <sub>AREF</sub> | 1    |
| Power Supply Current of<br>Analog Reference Voltage | I <sub>REF</sub>     | $V_{DD} = A_{VDD} = V_{AREF} = 2.7 \text{ V}$<br>$V_{SS} = AVSS = 0.0 \text{ V}$ | -                      | 0.3  | 0.5               | mA   |
| Non linearity Error                                 |                      |  | _                      | -    | ± 4               |      |
| Zero Point Error                                    |                      | $V_{DD} = A_{VDD} = 1.8 V,$  | _                      | _    | ± 4               | 1    |
| Full Scale Error                                    |                      | $V_{SS} = AVSS = 0.0 V$<br>$V_{AREF} = 1.8 V$                                    | _                      | _    | ± 4               | LSB  |
| Total Error   |                      | ANLI   | -                      | -    | ±4                | 1    |

- 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:  $\triangle V_{AREF} = V_{AREF} V_{SS}$ Note 5: When AD is used with VDD < 2.7 V, the guaranteed temperature range varies with the operating voltage.

### **AC Characteristics**

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

| Parameter                    | Symbol | Condition                                 | Min    | Тур.  | Max   | Unit |
|------------------------------|--------|---|--------|-------|-------|------|
|                              |        | NORMAL1, 2 mode                           |        |       |       |      |
| Machina Cycla Tima           | +0.4   | IDLE0, 1, 2 mode                          | 0.25 – |       | 4     |      |
| Machine Cycle Time           | tcy    | SLOW1, 2 mode                             | 447.6  |       | 133.3 | μS   |
|                              |        | SLEEP0, 1, 2 mode                         | 117.6  | _     |       |      |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  |        |       |       | ns   |
| Low Level Clock Pulse Width  | twcL   | fc = 16 MHz                               | _      | 31.25 | _     | 113  |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) |        | 45.26 |       | ,,c  |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | _      | 15.26 | _     | μ\$  |

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

| Parameter                    | Symbol | Condition                                 | Min   | Тур.  | Max   | Unit |
|------------------------------|--------|---|-------|-------|-------|------|
|                              |        | NORMAL1, 2 mode                           |       |       |       |      |
| Machine Cycle Time           | +0.4   | IDLE0, 1, 2 mode                          | 0.5   | _     | 4     | ا م  |
| Machine Cycle Time           | tcy    | SLOW1, 2 mode                             | 447.6 |       | 422.2 | μS   |
|                              |        | SLEEP0, 1, 2 mode                         | 117.6 | _     | 133.3 |      |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  |       | 62.5  | _     | ns   |
| Low Level Clock Pulse Width  | twcL   | fc = 8 MHz                                | _     |       |       | 113  |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) |       | 15.26 | -     |      |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | ı     |       |       | μS   |

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

| Parameter                    | Symbol | Condition                                 | Min   | Тур.    | Max     | Unit |
|------------------------------|--------|---|-------|---------|---------|------|
|                              |        | NORMAL1, 2 mode                           |       |         |         |      |
| Machine Cycle Time           | +0.4   | IDLE0, 1, 2 mode                          | 0.95  | _       | 4       |      |
| Wachine Cycle Time           | tcy    | SLOW1, 2 mode                             | 447.6 |         | - 133.3 | μS   |
|                              |        | SLEEP0, 1, 2 mode                         | 117.6 | 117.6 – |         |      |
| High Level Clock Pulse Width | twcH   | For external clock operation (XIN input)  |       |         | _       | ns   |
| Low Level Clock Pulse Width  | twcL   | fc = 4.2 MHz                              | _     | 119.05  |         | 113  |
| High Level Clock Pulse Width | twsH   | For external clock operation (XTIN input) |       | 15.26   |         | ,,c  |
| Low Level Clock Pulse Width  | twsL   | fs = 32.768 kHz                           | _     | 15.26   | -       | μS   |

Recommended Oscillating Conditions - 1

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

| Danamatan      | 0 ''' 1                        | Oscillation | _      |                   | Recommended Constant |                  |  |
|----------------|--------------------------------|-------------|--------|-------------------|----------------------|------------------|--|
| Parameter      | Oscillator                     | Frequency   | Recom  | mended Oscillator | C <sub>1</sub>       | C <sub>2</sub>   |  |
|                |                                | 16 MHz      | MURATA | CSA16.00MXZ040    | 10 pF                | 10 pF            |  |
| I link formula | gh-frequency Ceramic Resonator | 0.0411-     | MURATA | CSA8.00MTZ        | 30 pF                | 30 pF            |  |
| Oscillation    |                                | 8 MHz       |        | CST8.00MTW        | 30 pF (built-in)     | 30 pF (built-in) |  |
| Oscillation    |                                | 4.19 MHz    | MURATA | CSA4.19MG         | 30 pF                | 30 pF            |  |
|                |                                | 4. 19 IVIDZ |        | CST4.19MGW        | 30 pF (built-in)     | 30 pF (built-in) |  |
| Low-frequency  | Crustal Oscillator             | 32.768 kHz  | SII    | VT-200            | 6 pF                 | 6 pF             |  |
| Oscillation    | cillation Crystal Oscillator   |             | 311    | V 1-200           | o pr                 | o pr             |  |

Recommended Oscillating Conditions - 2

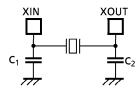
$$(V_{SS} = 0 \text{ V}, V_{DD} = 2.7 \text{ to } 5.5 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$$

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

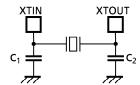
Recommended Oscillating Conditions - 3

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

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