

Comparison table of TMP86C829B/H29B/M29B/PM29A/PM29B/C929AXB and TMP86FM29   Difference

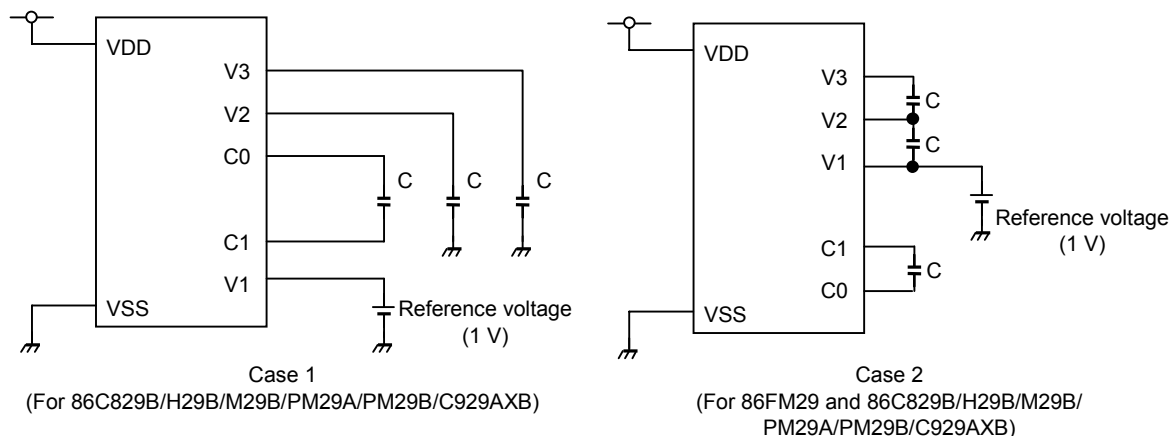
|                                   | TMP86C829B<br>TMP86CH29B<br>TMP86CM29B                                     | TMP86PM29A<br>TMP86PM29B | TMP86C929AXB<br>(Emulation chip)<br>(Note 3)                                  | TMP86FM29F                                                                                              |
|-----------------------------------|----------------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| ROM                               | 8 K (Mask ROM)<br>16 K (Mask ROM)<br>32 K (Mask ROM)                       | 32 K (OTP)               | –                                                                             | 32 K (Flash)                                                                                            |
| RAM                               | 512<br>1.5 K<br>1.5 K                                                      | 1.5 K                    | –                                                                             | 2 K                                                                                                     |
| I/O                               | 42 pin                                                                     |                          | 42 pin (MCU part)                                                             | 42 pin                                                                                                  |
| External Interrupt                | 5 pin                                                                      |                          |                                                                               | 5 pin                                                                                                   |
| AD Converter                      | 10-bit AD converter × 8 ch                                                 |                          |                                                                               | 10-bit AD converter × 8 ch                                                                              |
| Timer Counter                     | 18-bit timer × 1 ch<br>8-bit timer × 4 ch                                  |                          |                                                                               | 18-bit timer × 1 ch<br>8-bit timer × 4 ch                                                               |
| Serial Interface                  | 8-bit UART / SIO × 1 ch                                                    |                          |                                                                               | 8-bit UART / SIO × 1 ch                                                                                 |
| LCD                               | 32 seg × 4 com                                                             |                          |                                                                               | 32 seg × 4 com (Note 2)                                                                                 |
| Key-on Wakeup                     | 4 ch                                                                       |                          |                                                                               | 4 ch                                                                                                    |
| Operating Voltage in MCU Mode     | 1.8 to 5.5 V at 4.2 MHz<br>2.7 to 5.5 V at 8 MHz<br>4.5 to 5.5 V at 16 MHz |                          | 1.8 to 5.25 V at 4.2 MHz<br>2.7 to 5.25 V at 8 MHz<br>4.5 to 5.25 V at 16 MHz | 1.8 to 3.6 V at 4.2 MHz (External clock)<br>1.8 to 3.6 V at 8 MHz (Resonator)<br>2.7 to 3.6 V at 16 MHz |
| Operating Temperature in MCU Mode | –40 to 85°C                                                                |                          | 0 to 60°C                                                                     | –40 to 85°C                                                                                             |
| Writing to Flash Memory           | –                                                                          |                          |                                                                               | 2.7 to 3.6V at 16 MHz<br>25°C ± 5°C                                                                     |
| CPU Wait (Note 1)                 | N/A                                                                        |                          |                                                                               | Available                                                                                               |

Note 1: The CPU wait is a CPU halt function for stabilizing of power supply of Flash memory. The CPU wait period is as follows. In the CPU wait period except RESET, CPU is halted but peripheral functions are not halted. Therefore, if the interrupt occurs during the CPU wait period, the interrupt latch is set. In this case, if the IMF has been set to “1”, the interrupt service routine is executed after CPU wait period. For details refer to 2.14 “Flash Memory” in TMP86FM29 data sheet.

Thus, even if the same software is executed in 86FM29 and 86C829B/H29B/M29B/PM29A/PM29B /C929AXB, the operation process is not the same. Therefore, when the final operating confirmation on target application is executed for software development of Mask ROM Product (86C829B/H29B/M29B), not the Flash product (86FM29) but the OTP product (86PM29A/PM29B) should be used.

| Condition                                                               | Wait Time       | Halt/Operate |             |
|-------------------------------------------------------------------------|-----------------|--------------|-------------|
|                                                                         |                 | CPU          | Peripherals |
| After reset release                                                     | $2^{10}/f_c[s]$ | Halt         | Halt        |
| Changing from STOP mode to NORMAL mode (at $EEPCR<MNPWDW> = “1”$ )      | $2^{10}/f_c[s]$ | Halt         | Operate     |
| Changing from STOP mode to SLOW mode (at $EEPCR<MNPWDW> = “1”$ )        | $2^3/f_s[s]$    | Halt         | Operate     |
| Changing from IDLE0/1/2 mode to NORMAL mode (at $EEPCR<ATPWDW> = “0”$ ) | $2^{10}/f_c[s]$ | Halt         | Operate     |
| Changing from SLEEP0/1/2 mode to SLOW mode (at $EEPCR<ATPWDW> = “0”$ )  | $2^3/f_s[s]$    | Halt         | Operate     |

Note 2: The 86FM29 can not drive the 5V LCD panel because the electrical characteristics in 86FM29 is altered from 86C829B/H29B/M29B/PM29A/PM29B/C929AXB. The recommended operating condition of V3 pin in TMP86FM29 is 3.6V(max). For details, refer to "Electrical Characteristics". When the LCD booster circuit is used in 86FM29, connect the reference voltage and capacitor as shown in "case2". Though the method of "case1" has been recommended in 86C829B/H29B/M29B/PM29A/PM29B datasheets, the 86FM29 should not use method of "case1". Even if the method of "case1" is used in the 86C829B/H29B/M29B/PM29A/PM29B/C929AXB, the function and operation are not issue at all. However, if the "case2" is used, the booster ability becomes higher than "case1". Therefore, when the application board is designed newly in future, the method of "case2" is also recommended in 86C829B/H29B/M29B/PM29A/PM29B/C929AXB.



Note 3: Flash function, CPU wait period and serial PROM mode cannot be emulated in the 86C929AXB. If the software including the flash function is executed in 86C929AXB, the operation process differs from 86FM29.

## CMOS 8-Bit Microcontroller

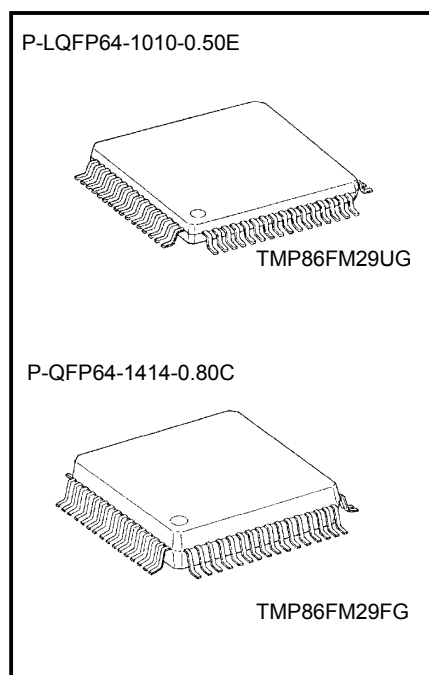
## TMP86FM29UG/FG

The TMP86FM29 is the high-speed, high-performance and low power consumption 8-bit microcomputer, including FLASH, RAM, LCD driver, multi-function timer/counter, serial interface (UART/SIO), a 10-bit AD converter and two clock generators on chip.

| Product No. | FLASH          | RAM           | Package             | Emulation Chip |
|-------------|----------------|---------------|---------------------|----------------|
| TMP86FM29UG | 32768 × 8 bits | 1536 × 8 bits | P-LQFP64-1010-0.50E | TMP86C929AXB   |
| TMP86FM29FG |                |               | P-QFP64-1414-0.80C  |                |

## Features

- ◆ 8-bit single chip microcomputer TLCS-870/C series
- ◆ Instruction execution time: 0.25  $\mu$ s (at 16 MHz)  
122  $\mu$ s (at 32.768 kHz)
- ◆ 132 types and 731 basic instructions
- ◆ 19 interrupt sources (External: 5, Internal: 14)
- ◆ Input/Output ports (39 pins)  
(Out of which 24 pins are also used as SEG pins)
- ◆ 18-bit timer counter: 1 ch
  - Timer, Event counter,  
Pulse width measurement,  
Frequency measurement modes
- ◆ 8-bit timer counter: 4 ch
  - Timer, Event counter,  
PWM output, Programmable divider output,  
PPG output modes
- ◆ Time Base Timer
- ◆ Divider output function



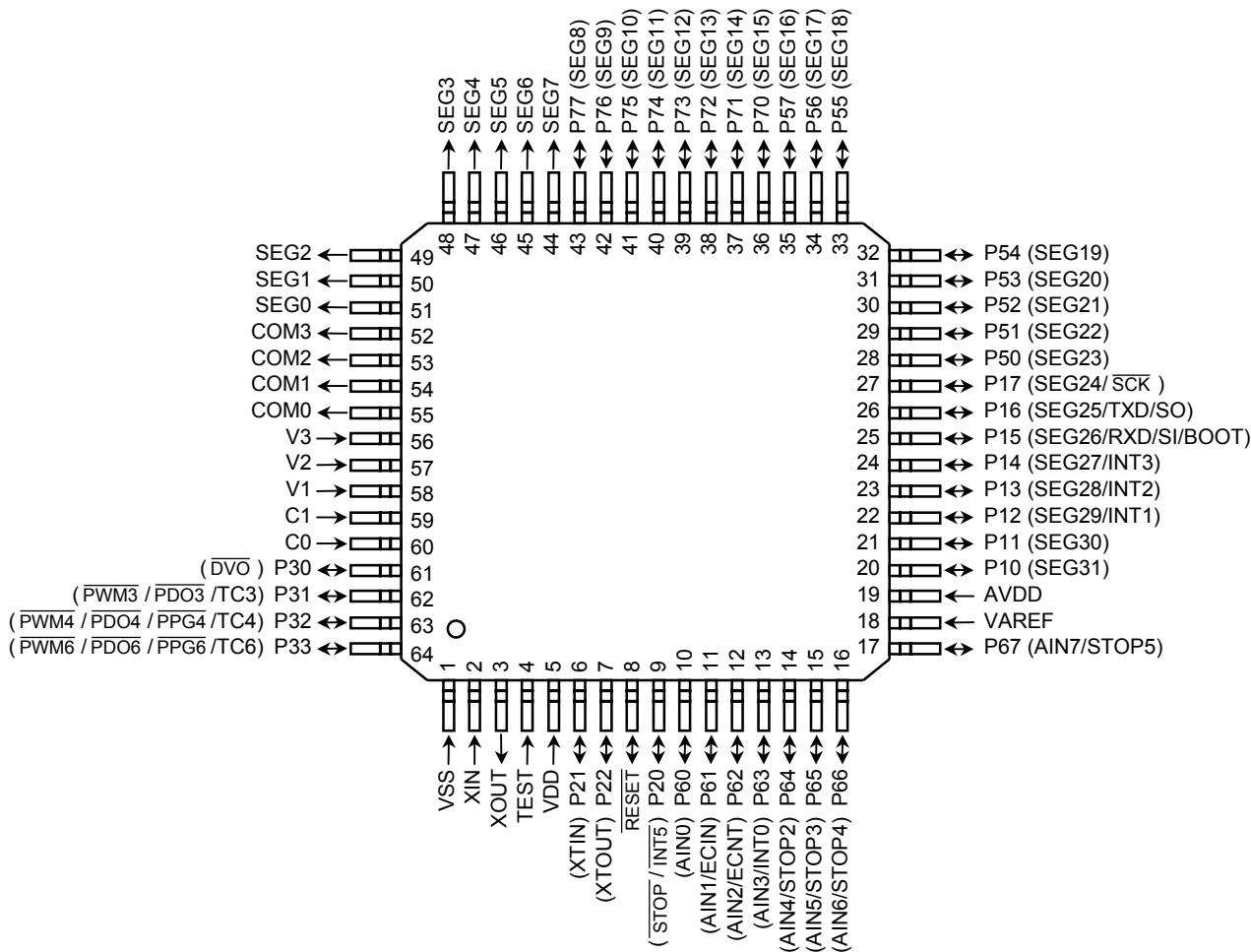
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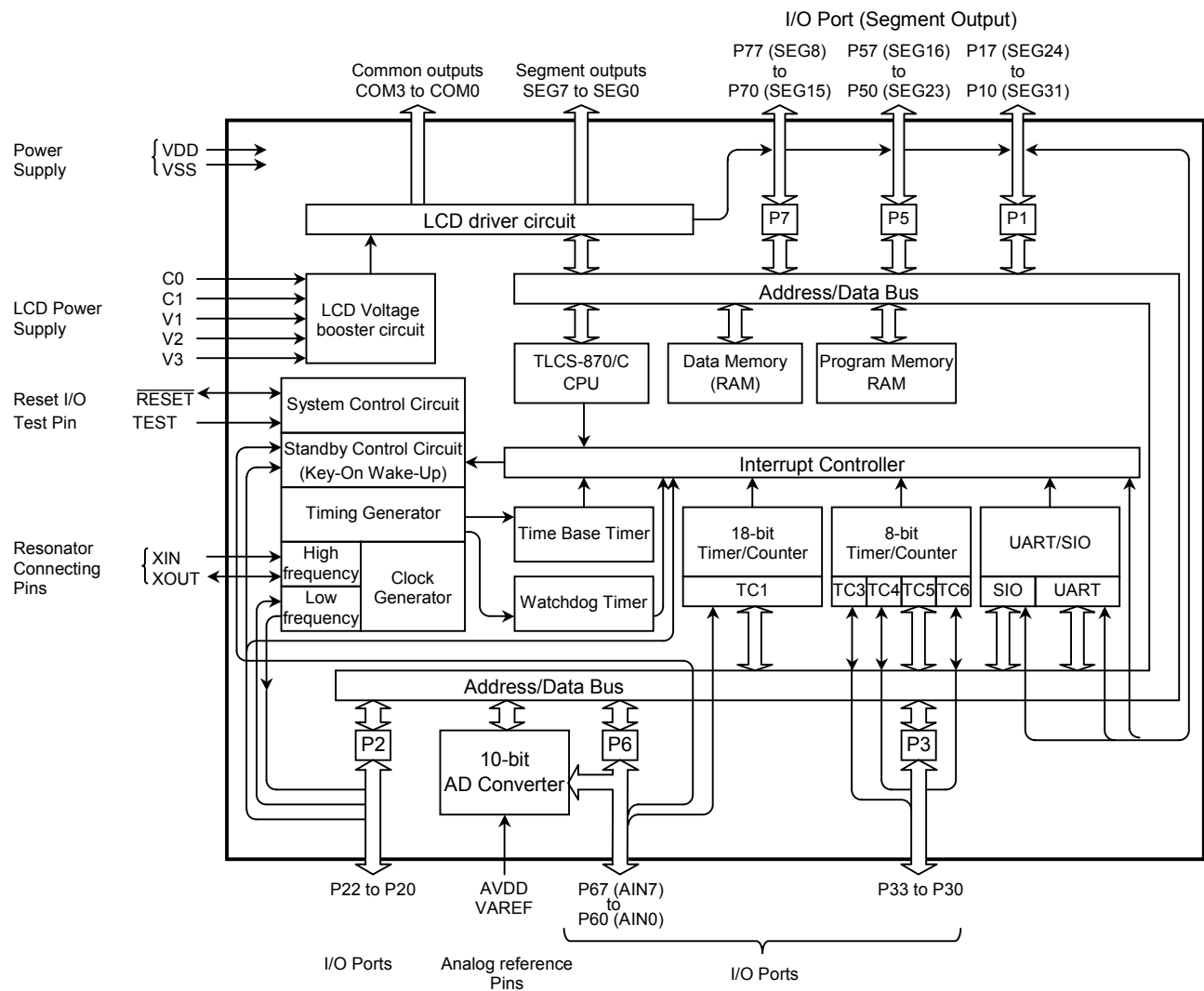
- ◆ Watchdog Timer
  - Interrupt source/reset output (programmable)
- ◆ Serial interface
  - 8-bit UART/SIO: 1ch
- ◆ 10-bit successive approximation type AD converter
  - Analog input: 8 ch
- ◆ Four Key-On Wake-Up pins
- ◆ LCD driver/controller
  - Built-in voltage booster for LCD driver
  - With displaymemory
  - LCD direct drive capability (max 32 seg × 4 com)
  - 1/4, 1/3, 1/2duties or static drive are programmably selectable
- ◆ 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 falling edge of TBTCCR <TBTCK> setting.
  - 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 falling edge of TBTCCR <TBTCK> setting.
  - 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: 1.8 to 3.6 V at 8 MHz/32.768 kHz  
2.7 to 3.6 V at 16 MHz/32.768 kHz

Pin Assignments (Top View)

P-LQFP64-1010-0.50E  
P-QFP64-1414-0.80C



## Block Diagram



## Pin Functions

| Pin Name                         | Input/Output            | Functions                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                          |                            |
|----------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------|
| P17 (SEG24, SCK )                | I/O (I/O)               | 8-bit input/output port with latch.<br>When used as input port, an external interrupt input, serial interface input/output and UART data input/output, the P1LCR must be set to "0" after setting output latch to "1".<br>When used as a LCD segment output, the P1LCR must be set to "1".                                                                                                                                   | Serial clock input/output                                                                                | LCD segment outputs.       |
| P16 (SEG25, TxD, SO)             | I/O (Output)            |                                                                                                                                                                                                                                                                                                                                                                                                                              | UART data output<br>Serial data output                                                                   |                            |
| P15 (SEG26, RxD, SI BOOT)        | I/O (I/O)               |                                                                                                                                                                                                                                                                                                                                                                                                                              | UART data input<br>Serial data input<br>Serial PROM mode control input                                   |                            |
| P14 (SEG27, INT3)                | I/O (I/O)               |                                                                                                                                                                                                                                                                                                                                                                                                                              | External interrupt 3 input                                                                               |                            |
| P13 (SEG28, INT2)                | I/O (I/O)               |                                                                                                                                                                                                                                                                                                                                                                                                                              | External interrupt 2 input                                                                               |                            |
| P12 (SEG29, INT1)                | I/O (I/O)               |                                                                                                                                                                                                                                                                                                                                                                                                                              | External interrupt 1 input                                                                               |                            |
| P11 (SEG30)                      | I/O (Output)            |                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| P10 (SEG31)                      | I/O (Output)            |                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| P22 (XTOUT)                      | I/O (Output)            | 3-bit input/output port with latch. When used as an input port, the output latch must be set to "1".                                                                                                                                                                                                                                                                                                                         | Resonator connecting pins (32.768 kHz)<br>For inputting external clock, XTIN is used and XOUT is opened. |                            |
| P21 (XTIN)                       | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | External interrupt input 5 or STOP mode release signal input                                             |                            |
| P20 (INT5 , STOP )               | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| P33 ( PWM6 , PDO6<br>PPG6 , TC6) | I/O (I/O)               | 4-bit programmable input/output port (Nch high current output).                                                                                                                                                                                                                                                                                                                                                              | Timer counter 6 input/output                                                                             |                            |
| P32 ( PWM4 , PDO4<br>PPG4 , TC4) | I/O (I/O)               | When used as a timer/counter output or divider output, the output latch must be set to "1". When used as an input port or timer/counter input, the P3OUTCR must be set to "0" after P3DR is set to "1".                                                                                                                                                                                                                      | Timer counter 4 input/output                                                                             |                            |
| P31 ( PWM3 , PDO3 ,<br>TC3)      | I/O (I/O)               |                                                                                                                                                                                                                                                                                                                                                                                                                              | Timer counter 3 input/output                                                                             |                            |
| P30 ( DVO )                      | I/O (Output)            |                                                                                                                                                                                                                                                                                                                                                                                                                              | Divider output                                                                                           |                            |
| P57 (SEG16) to<br>P50 (SEG23)    | I/O (Output)            | 8-bit input/output port with latch.<br>When used as a LCD segment output, the P5LCR must be set to "1".                                                                                                                                                                                                                                                                                                                      | LCD segment outputs                                                                                      |                            |
| P67 (AIN7, STOP5)                | I/O (Input)             | 8-bit programmable input/output port (tri-state). Each bit of this port can be individually configured as an input or an output under software control. When used as an analog input, the P6CR must be set to "0" after setting output latch to "0". When used as an input port, a key on wake up input, an external interrupt input and timer/counter input, the P6CR must be set to "0" after setting output latch to "1". | STOP 5 input                                                                                             | AD converter analog inputs |
| P66 (AIN6, STOP4)                | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | STOP 4 input                                                                                             |                            |
| P65 (AIN5, STOP3)                | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | STOP 3 input                                                                                             |                            |
| P64 (AIN4, STOP2)                | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | STOP 2 input                                                                                             |                            |
| P63 (AIN3, INT0 )                | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | External interrupt 0 input                                                                               |                            |
| P62 (AIN2, ECNT)                 | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              | Timer/Counter 1 input                                                                                    |                            |
| P61 (AIN1, ECIN)                 | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| P60 (AIN0)                       | I/O (Input)             |                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| P77 (SEG8) to<br>P70 (SEG15)     | I/O (Output)            | 8-bit input/output port with latch.<br>When used as a LCD segment output, the P7LCR must be set to "1".                                                                                                                                                                                                                                                                                                                      | LCD segment outputs                                                                                      |                            |
| SEG7 to SEG0                     | Output                  | LCD segment outputs                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                          |                            |
| COM3 to COM0                     |                         | LCD common outputs                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                          |                            |
| V3 to V1                         | LCD voltage booster pin | LCD voltage booster pin.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                          |                            |
| C1 to C0                         |                         | Capacitors are required between C0 and C1 pin and V1/V2/V3 pin and GND.                                                                                                                                                                                                                                                                                                                                                      |                                                                                                          |                            |
| XIN, XOUT                        | Input Output            | Resonator connecting pins for high-frequency clock.<br>For inputting external clock, XIN is used and XOUT is opened.                                                                                                                                                                                                                                                                                                         |                                                                                                          |                            |
| RESET                            | I/O                     | Reset signal input or watchdog timer output/address-trap-reset output/system clock reset output                                                                                                                                                                                                                                                                                                                              |                                                                                                          |                            |
| TEST                             | Input                   | Test pin for out-going test, and the serial PROM mode control pin. Usually be fixed to low level. When the serial PROM mode starts, be fixed to "1".                                                                                                                                                                                                                                                                         |                                                                                                          |                            |
| VDD, VSS                         | Power Supply            | +5 V, 0 (GND)                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                          |                            |
| VAREF                            |                         | Analog reference voltage inputs (High)                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                          |                            |
| AVDD                             |                         | AD circuit power supply                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                          |                            |

## 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 TMP86FM29 memory consists of 5 blocks: FLASH memory, BOOT ROM, RAM, DBR (Data buffer register) and SFR (Special function register). They are all mapped in 64-Kbyte address space. Figure 1.1.1 shows the TMP86FM29 memory address map. The general-purpose registers are not assigned to the RAM address space.

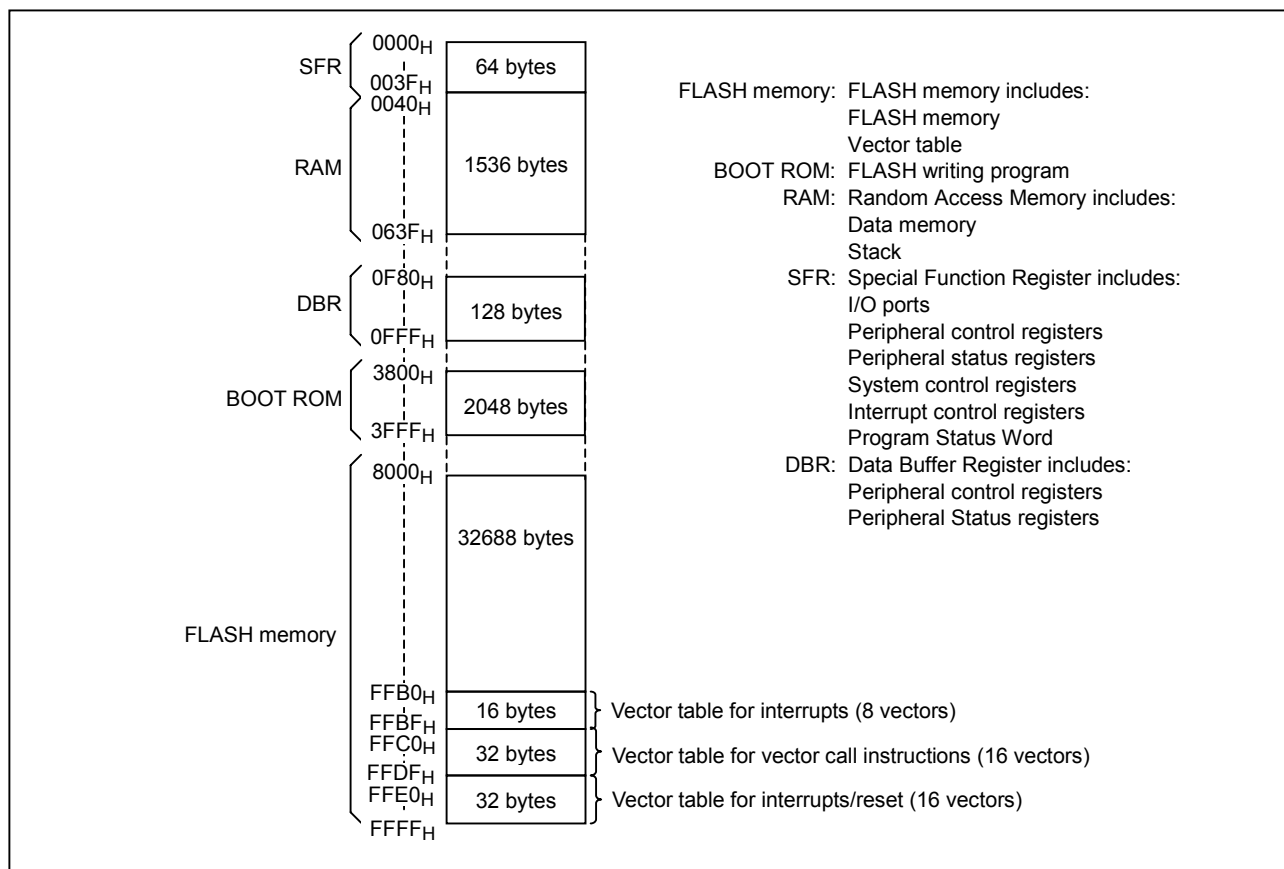


Figure 1.1.1 Memory Address Maps

#### 1.2 Program Memory (FLASH)

The TMP86FM29 has a 32 K × 8 bits (Address 8000H to FFFFH) of Flash memory.

## Electrical Characteristics

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

| Parameter                                            | Symbol            | Pins                     | Rating                 | Unit               |
|------------------------------------------------------|-------------------|--------------------------|------------------------|--------------------|
| Supply voltage                                       | $V_{DD}$          |                          | -0.3 to 4.0            | V                  |
|                                                      | $V_{LCD}$         | V3 pin                   | -0.3 to 4.0            |                    |
| Input voltage                                        | $V_{IN}$          |                          | -0.3 to $V_{DD} + 0.3$ |                    |
| Output voltage                                       | $V_{OUT1}$        |                          | -0.3 to $V_{DD} + 0.3$ |                    |
| Output current (Per 1 pin)                           | $I_{OUT1}$        | P3, P6 ports             | -1.8                   | mA                 |
|                                                      | $I_{OUT2}$        | P1, P2, P5, P6, P7 ports | 3.2                    |                    |
|                                                      | $I_{OUT3}$        | P3 ports                 | 30                     |                    |
| Output current (Total)                               | $\Sigma I_{OUT2}$ | P1, P2, P5, P6, P7 ports | 60                     |                    |
|                                                      | $\Sigma I_{OUT3}$ | P3 ports                 | 80                     |                    |
| Power dissipation [ $T_{opr} = 85^{\circ}\text{C}$ ] | PD                |                          | 350                    | mW                 |
| Soldering temperature (Time)                         | $T_{sld}$         |                          | 260 (10 s)             | $^{\circ}\text{C}$ |
| 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-1 (MCU mode) ( $V_{SS} = 0\text{ V}$ ,  $T_{opr} = -40\text{ to }85^{\circ}\text{C}$ )

| Parameter                                                | Symbol            | Pins                    | Condition                                                |                        | Min                    | Max | Unit |
|----------------------------------------------------------|-------------------|-------------------------|----------------------------------------------------------|------------------------|------------------------|-----|------|
| Supply voltage                                           | V <sub>DD</sub>   |                         | fc = 16 MHz                                              | NORMAL1, 2 mode        | 2.7                    | 3.6 | V    |
|                                                          |                   |                         |                                                          | IDLE0, 1, 2 mode       |                        |     |      |
|                                                          |                   |                         | fc = 8 MHz<br>(In case of connecting the resonator)      | NORMAL1, 2 mode        | 1.8                    |     |      |
|                                                          |                   |                         |                                                          | IDLE0, 1, 2 mode       |                        |     |      |
|                                                          |                   |                         | fc = 4.2 MHz<br>(In case of external clock input)        | NORMAL1, 2 mode        | 1.8                    |     |      |
|                                                          |                   |                         |                                                          | IDLE0, 1, 2 mode       |                        |     |      |
|                                                          |                   |                         | fs =<br>32.768 kHz                                       | SLOW1, 2 mode          |                        |     |      |
|                                                          | SLEEP0, 1, 2 mode |                         |                                                          |                        |                        |     |      |
|                                                          | STOP mode         |                         |                                                          |                        |                        |     |      |
| Input high level                                         | V <sub>IH1</sub>  | Except Hysteresis input | V <sub>DD</sub> ≥ 2.7 V                                  | V <sub>DD</sub> × 0.70 | V <sub>DD</sub>        |     |      |
|                                                          | V <sub>IH2</sub>  | Hysteresis input        |                                                          | V <sub>DD</sub> × 0.75 |                        |     |      |
|                                                          | V <sub>IH3</sub>  |                         | V <sub>DD</sub> < 2.7 V                                  | V <sub>DD</sub> × 0.90 |                        |     |      |
| Input low level                                          | V <sub>IL1</sub>  | Except Hysteresis input | V <sub>DD</sub> ≥ 2.7 V                                  | 0                      | V <sub>DD</sub> × 0.30 |     |      |
|                                                          | V <sub>IL2</sub>  | Hysteresis input        |                                                          |                        | V <sub>DD</sub> × 0.25 |     |      |
|                                                          | V <sub>IL3</sub>  |                         | V <sub>DD</sub> < 2.7 V                                  |                        | V <sub>DD</sub> × 0.10 |     |      |
| Clock frequency<br>(In case of connecting the resonator) | fc                | XIN, XOUT               | V <sub>DD</sub> = 1.8 to 3.6 V                           | 1.0                    | 8.0                    | MHz |      |
|                                                          |                   |                         | V <sub>DD</sub> = 2.7 to 3.6 V                           |                        | 16.0                   |     |      |
|                                                          | fs                | XTIN, XTOUT             | V <sub>DD</sub> = 1.8 to 3.6 V                           | 30.0                   | 34.0                   | kHz |      |
| Clock frequency<br>(In case of external clock input)     | fc                | XIN, XOUT               | V <sub>DD</sub> = 1.8 to 3.6 V                           | 1.0                    | 4.2                    | MHz |      |
|                                                          |                   |                         | V <sub>DD</sub> = 2.7 to 3.6 V                           |                        | 16.0                   |     |      |
|                                                          | fs                | XTIN, XTOUT             | V <sub>DD</sub> = 1.8 to 3.6 V                           | 30.0                   | 34.0                   | kHz |      |
| LCD reference voltage                                    | V1                |                         | Booster circuit is enable<br>(V3 ≥ V <sub>DD</sub> )     | 0.8                    | 1.2                    | V   |      |
| Capacity for LCD booster circuit                         | C <sub>LCD</sub>  |                         | LCD booster circuit is enable<br>(V3 ≥ V <sub>DD</sub> ) | 0.1                    | 0.47                   | μF  |      |

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.

Recommended Operating Condition-2 (Serial PROM mode) ( $V_{SS} = 0\text{ V}$ ,  $T_{opr} = 25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ )

| Parameter       | Symbol   | Pins      | Condition                                  | Min | Max  | Unit |
|-----------------|----------|-----------|--------------------------------------------|-----|------|------|
| Supply voltage  | $V_{DD}$ |           | $2\text{ MHz} \leq f_c \leq 16\text{ MHz}$ | 2.7 | 3.6  | V    |
| Clock frequency | $f_c$    | XIN, XOUT | $V_{DD} = 2.7\text{ to }3.6\text{ V}$      | 2.0 | 16.0 | MHz  |

Note: The operating temperature area of serial PROM mode is  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  and the operating area of high frequency of serial PROM mode is different from MCU mode.

DC Characteristics (V<sub>SS</sub> = 0 V, T<sub>opr</sub> = -40 to 85°C)

| Parameter                                     | Symbol              | Pins                       |                                  | Condition                                                                   | Min                                                      | Typ.            | Max           | Unit |    |     |     |    |
|-----------------------------------------------|---------------------|----------------------------|----------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------|-----------------|---------------|------|----|-----|-----|----|
| Hysteresis voltage                            | V <sub>HS</sub>     | Hysteresis input           |                                  | V <sub>DD</sub> = 3.3 V                                                     | –                                                        | 0.4             | –             | V    |    |     |     |    |
| Input current                                 | I <sub>IN1</sub>    | TEST                       |                                  | V <sub>DD</sub> = 3.6 V, V <sub>IN</sub> = 0 V                              | –                                                        | –               | –5            | μA   |    |     |     |    |
|                                               | I <sub>IN2</sub>    | Sink open drain, Tri-state |                                  | V <sub>DD</sub> = 3.6 V, V <sub>IN</sub> = 3.6 V/0 V                        | –                                                        | –               | ±5            |      |    |     |     |    |
|                                               | I <sub>IN3</sub>    | RESET                      |                                  | V <sub>DD</sub> = 3.6 V, V <sub>IN</sub> = 3.6 V                            | –                                                        | –               | +5            |      |    |     |     |    |
| Input resistance                              | R <sub>IN1</sub>    | TEST pull down             |                                  | V <sub>DD</sub> = 3.6 V, V <sub>IN</sub> = 3.6 V                            | –                                                        | 70              | –             | kΩ   |    |     |     |    |
|                                               | R <sub>IN2</sub>    | RESET pull up              |                                  | V <sub>DD</sub> = 3.6 V, V <sub>IN</sub> = 0 V                              | 100                                                      | 220             | 450           |      |    |     |     |    |
| High frequency feedback resistor              | R <sub>FB</sub>     | XOUT                       |                                  | V <sub>DD</sub> = 3.6 V                                                     | –                                                        | 3               | –             | MΩ   |    |     |     |    |
| Low frequency feedback resistor               | R <sub>FBT</sub>    | XTOUT                      |                                  | V <sub>DD</sub> = 3.6 V                                                     | –                                                        | 20              | –             |      |    |     |     |    |
| Output leakage current                        | I <sub>LO</sub>     | Sink open drain, Tri-state |                                  | V <sub>DD</sub> = 3.6 V<br>V <sub>OUT</sub> = 3.4V/0.2 V                    | –                                                        | –               | ±10           | μA   |    |     |     |    |
| Output high voltage                           | V <sub>OH</sub>     | CMOS, Tri-state            |                                  | V <sub>DD</sub> = 3.6 V, I <sub>OH</sub> = –0.6 mA                          | 3.2                                                      | –               | –             | V    |    |     |     |    |
| Output low voltage                            | V <sub>OL</sub>     | Except XOUT, P3 port       |                                  | V <sub>DD</sub> = 3.6 V, I <sub>OL</sub> = 0.9 mA                           | –                                                        | –               | 0.4           |      |    |     |     |    |
| Output low current                            | I <sub>OL</sub>     | P3 port                    |                                  | V <sub>DD</sub> = 3.6 V, V <sub>OL</sub> = 1.0 V                            | –                                                        | 6               | –             | mA   |    |     |     |    |
| LCD output voltage<br>(LCD booster is enable) | V <sub>2-3OUT</sub> | V2 pin                     |                                  | V3 ≥ V <sub>DD</sub>                                                        | –                                                        | V1 x 2          | –             | V    |    |     |     |    |
|                                               |                     | V3 pin                     |                                  | Reference supply pin: V1<br>SEG/COM pin: No load                            | –                                                        | V1 x 3          | –             |      |    |     |     |    |
| Supply current in<br>NORMAL 1, 2 mode         |                     | Fetch area                 | Flash area                       | V <sub>DD</sub> = 3.6 V                                                     | MNP = “1”                                                | –               | 5.3           | 7.3  | mA |     |     |    |
| Supply current in<br>IDLE 0, 1, 2 mode        |                     |                            | RAM area                         | V <sub>IN</sub> = 3.4 V/0.2 V                                               | MNP = “0”                                                | –               | 3.4           | 5.2  |    |     |     |    |
|                                               |                     |                            | Supply current in<br>SLOW 1 mode | Fetch area                                                                  | Flash area                                               | fc = 16 MHz     | MNP•ATP = “1” | –    |    | 3.1 | 5.2 | μA |
|                                               |                     |                            |                                  |                                                                             |                                                          | fs = 32.768 kHz | MNP•ATP = “0” | –    |    | 2.2 | 4.2 |    |
| Supply current in<br>SLEEP 1 mode             |                     | Fetch area                 | Flash area                       | V <sub>DD</sub> = 3.0 V<br>V <sub>IN</sub> = 2.8 V/0.2 V<br>fs = 32.768 kHz | MNP = “1”                                                | –               | 850           | 1200 |    |     |     |    |
| MNP = “0”                                     |                     |                            |                                  |                                                                             | –                                                        | 7               | 19            |      |    |     |     |    |
| Supply current in<br>SLEEP 0 mode             |                     |                            |                                  |                                                                             | MNP•ATP = “1”                                            | –               | 850           | 1200 |    |     |     |    |
| Supply current in<br>STOP mode                |                     |                            |                                  |                                                                             | MNP•ATP = “0”                                            | –               | 5.5           | 17   |    |     |     |    |
|                                               |                     |                            |                                  |                                                                             | MNP•ATP = “1”                                            | –               | 850           | 1200 |    |     |     |    |
|                                               |                     | MNP•ATP = “0”              | –                                | 4.5                                                                         | 15                                                       |                 |               |      |    |     |     |    |
|                                               |                     |                            |                                  |                                                                             | V <sub>DD</sub> = 3.6 V<br>V <sub>IN</sub> = 3.4 V/0.2 V |                 | –             | 0.5  | 10 |     |     |    |

Note 1: Typical values show those at T<sub>opr</sub> = 25°C.

Note 2: Input current (I<sub>IN1</sub>, I<sub>IN2</sub>): The current through pull-up or pull-down resistor is not included.

Note 3: I<sub>DD</sub> does not include I<sub>REF</sub> current.

Note 4: The supply currents of SLOW2 and SLEEP2 modes are equivalent to IDLE0, IDLE1, IDLE2.

Note 5: MNP (MNPWDW) shows bit0 in EEPICR register and ATP (ATPWDW) shows bit1 in EEPICR register.

Note 6: "Fetch" means reading operation of FLASH data as an instruction by CPU.

## AD Conversion Characteristics

(V<sub>SS</sub> = 0.0 V, 2.7 V ≤ V<sub>DD</sub> ≤ 3.6 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 (Note 4)          | 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> = 3.6 V<br>V <sub>SS</sub> = 0.0 V          | –                      | 0.35 | 0.61              | mA   |
| Non linearity error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 2.7 V<br>V <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 ≤ V<sub>DD</sub> < 2.7 V, Topr = −40 to 85°C)

| Parameter                                        | Symbol             | Condition                                                                                          | Min                    | Typ. | Max               | Unit |
|--------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|------------------------|------|-------------------|------|
| Analog reference voltage                         | V <sub>AREF</sub>  |                                                                                                    | A <sub>VDD</sub> − 0.6 | –    | A <sub>VDD</sub>  | V    |
| Power supply voltage of analog control circuit   | A <sub>VDD</sub>   |                                                                                                    | V <sub>DD</sub>        |      |                   |      |
| Analog reference voltage range<br>(Note 4)       | ΔV <sub>AREF</sub> |                                                                                                    | 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> = 2.0V<br>V <sub>SS</sub> = 0.0 V           | –                      | 0.20 | 0.34              | mA   |
| Non linearity error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 2.0 V<br>V <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 2.0 V | –                      | –    | ±4                | LSB  |
| Zero point error                                 |                    |                                                                                                    | –                      | –    | ±4                |      |
| Full scale error                                 |                    |                                                                                                    | –                      | –    | ±4                |      |
| Total error                                      |                    |                                                                                                    | –                      | –    | ±4                |      |

(V<sub>SS</sub> = 0.0 V, 1.8 V ≤ V<sub>DD</sub> < 2.0 V, Topr = −10 to 85°C) (Note 5)

| Parameter                                        | Symbol             | Condition                                                                                          | Min                    | Typ. | Max               | Unit |
|--------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|------------------------|------|-------------------|------|
| Analog reference voltage                         | V <sub>AREF</sub>  |                                                                                                    | A <sub>VDD</sub> − 0.1 | –    | A <sub>VDD</sub>  | V    |
| Power supply voltage of analog control circuit   | A <sub>VDD</sub>   |                                                                                                    | V <sub>DD</sub>        |      |                   |      |
| Analog reference voltage range (Note 4)          | ΔV <sub>AREF</sub> |                                                                                                    | 1.8                    | –    | –                 |      |
| 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> = 1.8 V<br>V <sub>SS</sub> = 0.0 V          | –                      | 0.18 | 0.31              | mA   |
| Non linearity error                              |                    | V <sub>DD</sub> = A <sub>VDD</sub> = 1.8 V<br>V <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 “2.15.2 Register configuration”.

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> < 2.0 V, the guaranteed temperature range varies with the operating voltage.

Note 6: When AD converter is not used, fix the A<sub>VDD</sub> pin and V<sub>AREF</sub> pin on the V<sub>DD</sub> level.

## AC Characteristics

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 2.7 to 3.6 V, Topr = -40 to 85°C)

| Parameter                    | Symbol | Condition                                                  | Min   | Typ.  | Max   | Unit |
|------------------------------|--------|------------------------------------------------------------|-------|-------|-------|------|
| Machine cycle time           | tcy    | NORMAL1, 2 mode                                            | 0.25  | –     | 4     | μs   |
|                              |        | IDLE1, 2 mode                                              |       |       |       |      |
|                              |        | SLOW1, 2 mode                                              | 117.6 | –     | 133.3 |      |
|                              |        | SLEEP1, 2 mode                                             |       |       |       |      |
| High Level clock pulse width | twcH   | For external clock operation (XIN input), fc = 16 MHz      | –     | 31.25 | –     | ns   |
| Low level clock pulse width  | twcL   |                                                            |       |       |       |      |
| High level clock pulse width | twcH   | For external clock operation (XTIN input), fs = 32.768 kHz | –     | 15.26 | –     | μs   |
| Low level clock pulse width  | twcL   |                                                            |       |       |       |      |

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 1.8 to 3.6 V, Topr = -40 to 85°C)

| Parameter                    | Symbol | Condition                                                  | Min   | Typ.   | Max   | Unit |
|------------------------------|--------|------------------------------------------------------------|-------|--------|-------|------|
| Machine cycle time           | tcy    | NORMAL1, 2 mode                                            | 0.5   | –      | 4     | μs   |
|                              |        | IDLE1, 2 mode                                              |       |        |       |      |
|                              |        | SLOW1, 2 mode                                              | 117.6 | –      | 133.3 |      |
|                              |        | SLEEP1, 2 mode                                             |       |        |       |      |
| High level clock pulse width | twcH   | For external clock operation (XIN input), fc = 4.2 MHz     | –     | 119.04 | –     | ns   |
| Low level clock pulse width  | twcL   |                                                            |       |        |       |      |
| High level clock pulse width | twcH   | For external clock operation (XTIN input), fs = 32.768 kHz | –     | 15.26  | –     | μs   |
| Low level clock pulse width  | twcL   |                                                            |       |        |       |      |

## Timer Counter 1 input (ECIN) Characteristics

(V<sub>SS</sub> = 0 V, Topr = -40 to 85°C)

| Parameter              | Symbol           | Condition                                                 |                   | Min | Typ. | Max | Unit |
|------------------------|------------------|-----------------------------------------------------------|-------------------|-----|------|-----|------|
| TC1 input (ECIN input) | t <sub>TC1</sub> | Frequency measurement mode V <sub>DD</sub> = 2.7 to 3.6 V | Single edge count | —   | —    | 16  | MHz  |
|                        |                  |                                                           | Both edge count   |     |      |     |      |
|                        |                  | Frequency measurement mode V <sub>DD</sub> = 1.8 to 2.7 V | Single edge count | —   | —    | 8   |      |
|                        |                  |                                                           | Both edge count   |     |      |     |      |

## Flash Characteristics

(V<sub>SS</sub> = 0 V)

| Parameter                                                                      | Condition                                                                  | Min | Typ. | Max             | Unit  |
|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----|------|-----------------|-------|
| Number of guaranteed writes (page writing) to Flash memory in serial PROM mode | V <sub>DD</sub> = 2.7 to 3.6 V, 2 MHz ≤ fc ≤ 16 MHz<br>(Topr = 25°C ± 5°C) | —   | —    | 10 <sup>5</sup> | Times |

## Recommended Oscillating Conditions

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  
<http://www.murata.co.jp/search/index.html>