

CMOS 8-Bit Microcontroller

TMP86CH87U, TMP86CM87U

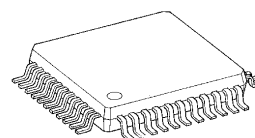
The TMP86CH87/M87 are high speed and high performance 8-bit single chip microcomputers with small package. The MCU contain CPU core, ROM, RAM, CAN controller 2.0B, multirole timer counter, SEI and UART, 10-bit AD converter, and two clock generators on a chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP86CH87U	16 K × 8 bits	1 K × 8 bits	P-LQFP44-1010-0.80B	TMP86PM87U
TMP86CM87U	32 K × 8 bits			

Features

- ◆ 8-bit single chip microcomputer TLCS-870/C series
- ◆ Instruction execution time: 0.25 μ s ($f_c = 16$ MHz)
122 μ s ($f_s = 32.768$ kHz)
- ◆ 132 Types and 731 basic instructions
- ◆ Interrupt sources: 23 factors (External: 6, Internal: 17)
- ◆ Input/Output ports: 35 pins
- ◆ 16-bit Timer/Counter: 1 ch
 - Timer, PPG output, Pulse width measurement, Pulse duty measurement, Event counter
- ◆ 8-bit Timer/Counter: 2 ch
 - Timer, PDO output, Event counter, PWM output, PPG modes
- ◆ Time Base Timer
- ◆ Divider output function
- ◆ Watchdog Timer
 - Interrupt source/Internal Reset (programmable)

P-LQFP44-1010-0.80B



TMP86CH87U
TMP86CM87U

000707EBP1

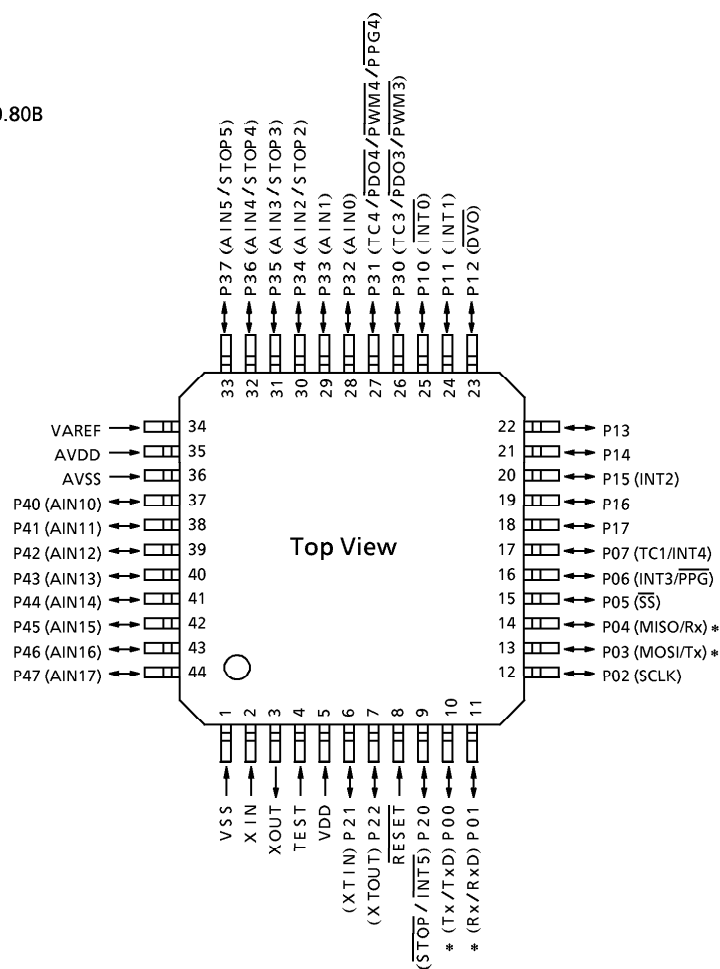
- For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance/Handling Precautions.
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor 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, 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.

- ◆ CAN controller 2.0B: 1 ch (Max 800 Kbps at 16 MHz)
- ◆ Serial interface
 - SEI (MSB/LSB Max: 4 Mbps at 16 MHz)
 - 8-bit UART: 1ch
- ◆ 10-bit successive approximate type AD converter
 - Analog input: 14 ch
- ◆ Key-on wake up: 4 ch
- ◆ Power saving operating modes (9 modes)
 - STOP mode: Oscillation stops. Battery/Capacitor back-up. Port output hold/High-impedance.
 - SLOW 1 mode: Low power consumption operation using low-frequency clock (High-frequency stop)
 - SLOW 2 mode: Low power consumption operation using low-frequency clock (High-frequency run)
 - IDLE 0 mode: CPU stops, and peripherals operate using high-frequency clock of Time-Base-Timer. Release by INTTBT interrupt.
 - IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by interrupts.
 - IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
 - SLEEP 0 mode: CPU stops, and peripherals operate using low-frequency clock of Time-Base-Timer. Release by INTTBT interrupt.
 - SLEEP 1 mode: CPU stops, and peripherals operate using low-frequency clock. Release by interrupts.
 - SLEEP 2 mode: CPU stops, and peripherals operate using high and low-frequency clock. Release by interrupts.

* When using the CAN Controller, the low-frequency oscillator cannot be used.
- ◆ Dual clock operation
- ◆ Wide operating voltage: 4.5 to 5.5 V at 16 MHz/32.768 kHz

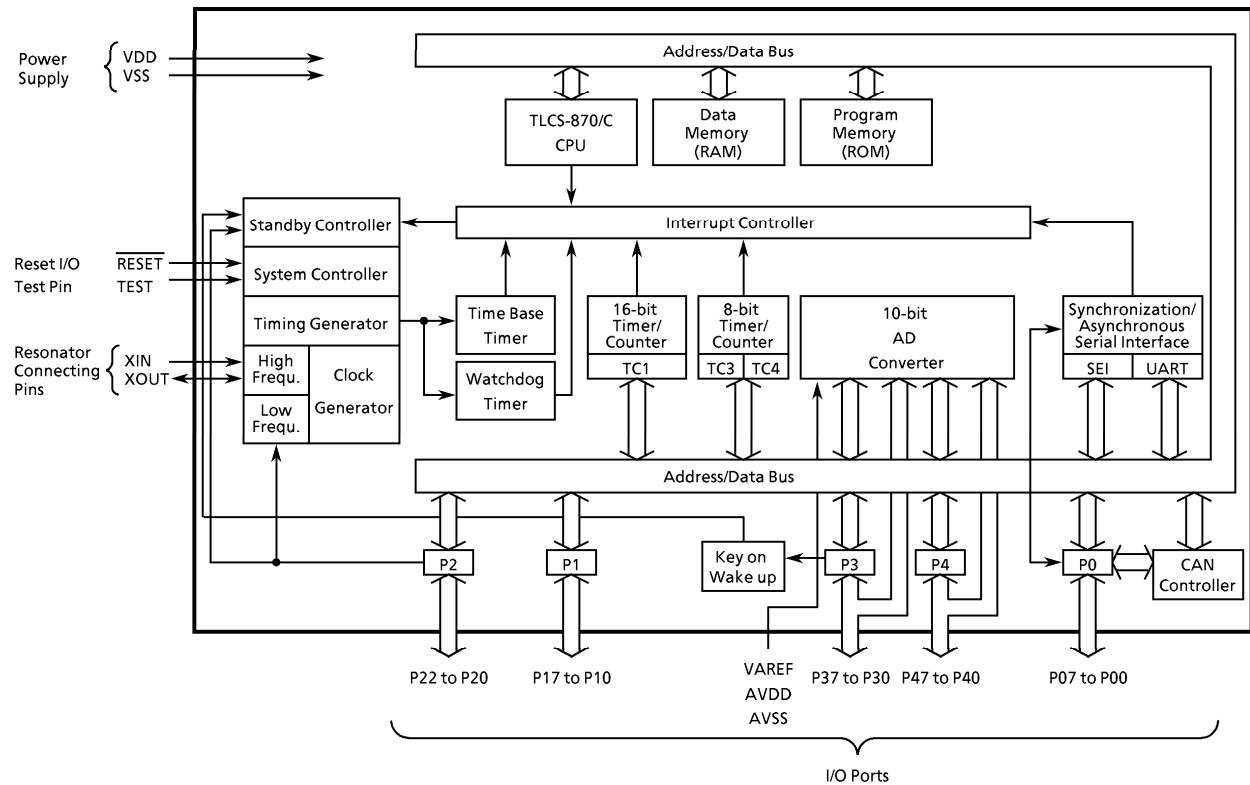
Pin Assignments (Top View)

P-LQFP44-1010-0.80B



* The CAN transmit/receive pins have their connected ports changed depending on how the Multifunction Register (MULSEL) is set. For details, see Section 2.2.1, "P0 Port."

Block Diagram



Pin Functions (1/2)

Pin Name	Input/Output	Function	
P07 (TC1, INT4)	I/O (I/O)	8-bit programmable input/output ports. Each bit of these ports can be individually configured as an input or output under software control. When used as function, the latch must be set to "1". Nch O.D output function.	Timer/Counter 1 input/External interrupt input 4
P06 (INT3, $\overline{\text{PPG}}$)	I/O (Output)		External interrupt input 3/ $\overline{\text{PPG}}$ output
P05 ($\overline{\text{SS}}$)	I/O (Input)		SEI master slave change input
P04 (MISO/Rx)	I/O (I/O)		SEI master input, slave output/ CAN receiving data input
P03 (MOSI/Tx)	I/O (I/O)		SEI master output, slave input/ CAN transmitting data output
P02 (SCLK)	I/O (I/O)		SEI serial clock input/output pin
P01 (Rx/D/Rx)	I/O (Input)		UART data input/CAN receiving data input
P00 (Tx/D/Tx)	I/O (Output)		UART data output/CAN transmitting data output
P17	I/O (I/O)	8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or output under software control. When used as function, the latch must be set to "1".	External interrupt input 2
P16	I/O (I/O)		
P15 (INT2)	I/O (Input)		
P14	I/O (I/O)		
P13	I/O (I/O)		Divider output
P12 ($\overline{\text{DVO}}$)	I/O (Output)		
P11 (INT1)	I/O (Input)		
P10 ($\overline{\text{INT0}}$)	I/O (Input)		
P22 (Tx, XTOUT)	I/O (Output)	3-bit programmable input/output ports. When used as input port and function, the latch must be set to "1".	Resonator connecting pins (32.768 kHz) For inputting external clock, XTIN is used and XTOUT is opened.
P21 (Rx, XTIN)	I/O (Input)		External interrupt input 5 or STOP mode release signal input
P20 (INT5, $\overline{\text{STOP}}$)	I/O (Input)		
P37 (AIN5, $\overline{\text{STOP5}}$)	I/O (Input)	8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or output under software control. When used as function and analog inputted, the latch must be set to "1".	STOP mode release signal input 5
P36 (AIN4, $\overline{\text{STOP4}}$)	I/O (Input)		STOP mode release signal input 4
P35 (AIN3, $\overline{\text{STOP3}}$)	I/O (Input)		STOP mode release signal input 3
P34 (AIN2, $\overline{\text{STOP2}}$)	I/O (Input)		STOP mode release signal input 2
P33 (AIN1)	I/O (Input)		AD converter analog input
P32 (AIN0)	I/O (Input)		
P31 (TC4, $\overline{\text{PDO4}}$, $\overline{\text{PWM4}}$, $\overline{\text{PPG4}}$)	I/O (I/O)		
P30 (TC3, $\overline{\text{PDO3}}$, $\overline{\text{PWM3}}$)	I/O (I/O)		
P47 (AIN17)	I/O (I/O)	8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or output under software control. When used as analog inputted, the latch must be set to "1".	AD converter analog input
P46 (AIN16)	I/O (I/O)		
P45 (AIN15)	I/O (I/O)		
P44 (AIN14)	I/O (I/O)		
P43 (AIN13)	I/O (I/O)		
P42 (AIN12)	I/O (I/O)		
P41 (AIN11)	I/O (I/O)		
P40 (AIN10)	I/O (I/O)		

Pin Functions (2/2)

Pin Name	Input/Output	Function
XIN, XOUT	Input, Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.
RESET	Input	RESET signal input
TEST	Input	TEST pin for out-going test. Be fixed to low.
VDD, VSS	Power Supply	+ 5 V, 0 (GND)
VAREF	Analog Power Supply	Analog reference voltage input (High)
AVDD		AD circuit power supply
AVSS		GND pin for AD converter

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 TMP86CH87/M87 memory consist of 4 blocks: ROM, RAM, SFR (Special Function Register) and DBR (Data Buffer Register). They are all mapped in 64 Kbyte address space. Figure 1-1 shows the TMP86CH87/M87 memory address map. The general-purpose register banks are not assigned to the RAM address space.

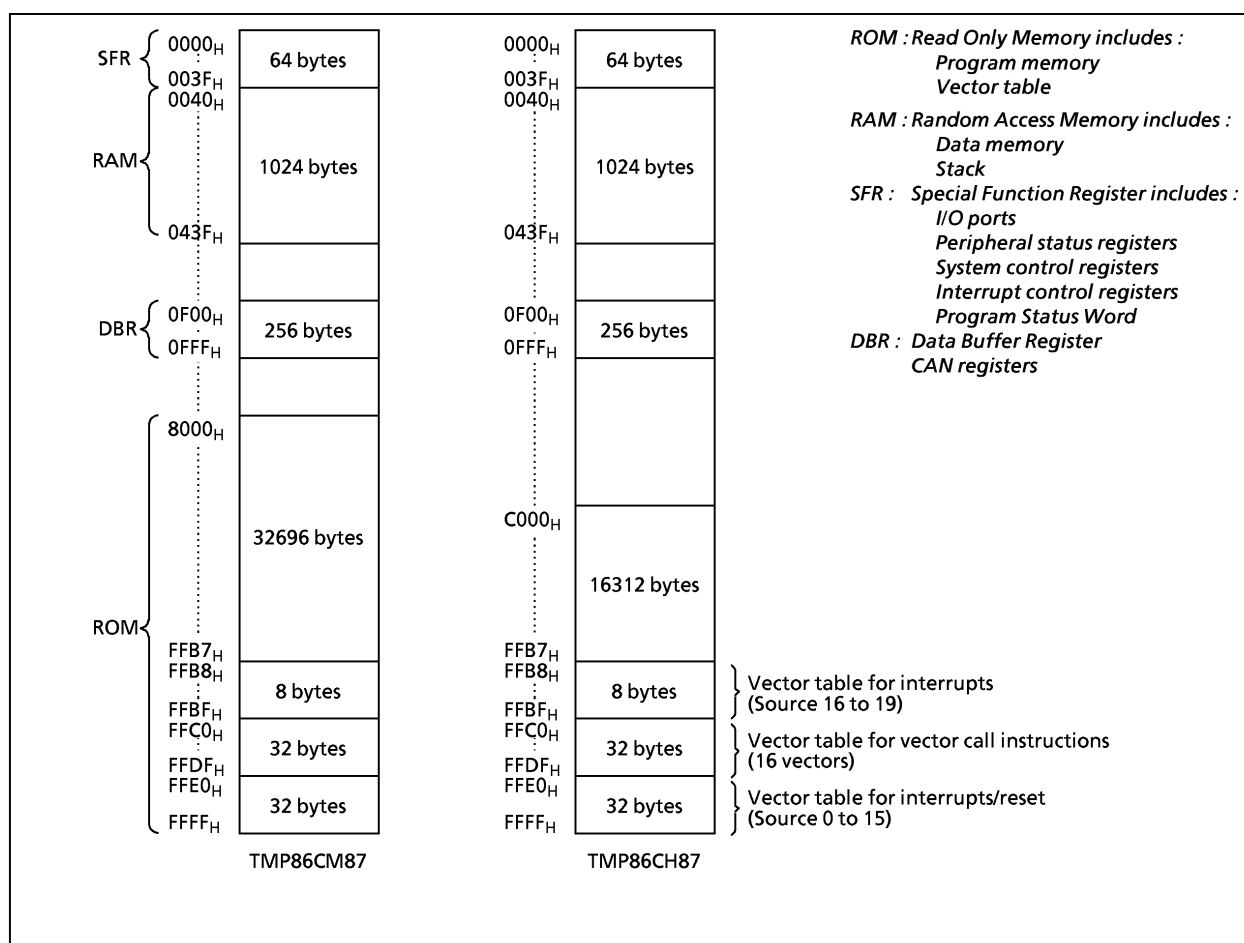


Figure 1-1. Memory Address Maps

1.2 Program Memory (ROM)

The TMP86CH87 has a 16 K×8-bit (address C000_H to FFFF_H), TMP86CM87 has a 32 K×8-bit (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).

Electrical Characteristics

Absolute Maximum Ratings

(V_{SS} = 0 V)

Parameter	Symbol	Pins	Rating	Unit
Supply Voltage	V _{DD}		– 0.3 to 6.5	V
Input Voltage	V _{IN}		– 0.3 to V _{DD} + 0.3	
Output Voltage	V _{OUT1} V _{OUT2}	P21, P22, RESET, Tri-state Port P20, Sink Open Drain Port	– 0.3 to V _{DD} + 0.3 – 0.3 to 5.5	
Output Current (Per 1 pin)	I _{OUT1} I _{OH}	P0, P1, P3, P4 Port	– 1.8	mA
	I _{OUT2} I _{OL}	P1, P2, P3, P4 Port	3.2	
	I _{OUT3} I _{OL}	P0 Port	30	
Output Current (Total)	Σ I _{OUT1}	P0, P1, P3, P4 Port	– 30	
	Σ I _{OUT2}	P1, P2, P3, P4 Port	60	
	Σ I _{OUT3}	P0 Port	80	
Power Dissipation [T _{opr} = 85°C]	PD		350	mW
Soldering Temperature (time)	T _{sld}		260 (10 s)	°C
Storage Temperature	T _{stg}		– 55 to 150	
Operating Temperature	T _{opr}		– 40 to 85	

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

Recommended Operating Condition

(V_{SS} = 0 V, T_{opr} = – 40 to 85°C)

Parameter	Symbol	Pins	Condition	Min	Max	Unit
Supply Voltage	V _{DD}		fc = 16 MHz	4.5	5.5	V
			NORMAL1, 2 mode			
			IDLE0, 1, 2 mode			
			fc = 8 MHz			
			NORMAL1, 2 mode			
Input high Level	V _{IH1}	Except Hysteresis input	V _{DD} ≥ 4.5 V	V _{DD} × 0.70	V _{DD}	
	V _{IH2}	Hysteresis input				
	V _{IH3}		V _{DD} < 4.5 V			
Input low Level	V _{IL1}	Except Hysteresis input	V _{DD} ≥ 4.5 V	0	V _{DD} × 0.30	
	V _{IL2}	Hysteresis input			V _{DD} × 0.25	
	V _{IL3}		V _{DD} < 4.5 V		V _{DD} × 0.10	
Clock Frequency	fc	XIN, XOUT	V _{DD} = 4.5 to 5.5 V	1.0	16.0	MHz
	fs	XTIN, XTOUT	V _{DD} = 4.5 to 5.5 V	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 Standard (tentatively Standard)

DC Characteristics		(V _{SS} = 0 V, Topr = – 40 to 85°C)					
Parameter	Symbol	Pins	Condition	Min	Typ.	Max	Unit
Hysteresis Voltage	V _{HS}	Hysteresis input		–	0.9	–	V
Input Current	I _{IN1}	TEST	V _{DD} = 5.5 V, V _{IN} = 5.5 V/0 V	–	–	± 2	μA
	I _{IN2}	Sink Open Drain, Tri-state Port					
	I _{IN3}	RESET, STOP					
Input Resistance	R _{IN1}	TEST Pull-Down		–	70	–	kΩ
	R _{IN2}	RESET Pull-Up		100	220	450	
Output Leakage Current	I _{LO}	Sink Open Drain, Tri-state Port	V _{DD} = 5.5 V, V _{OUT} = 5.5 V/0 V	–	–	± 2	μA
Output High Voltage	V _{OH}	P0, P1, P3, P4 Port	V _{DD} = 4.5 V, I _{OH} = – 0.7 mA	4.1	–	–	V
Output Low Voltage	V _{OL}	P1, P2, P3, P4 Port	V _{DD} = 4.5 V, I _{OL} = 1.6 mA	–	–	0.4	
Output Low Current	I _{OL}	High Current Port (P0 Port)	V _{DD} = 4.5 V, V _{OL} = 1.0 V	–	20	–	mA
Supply Current in NORMAL 1, 2 mode	I _{DD}		V _{DD} = 5.5 V V _{IN} = 5.3/0.2 V f _c = 16.0 MHz f _s = 32.768 kHz When using CAN controller	–	10	15	
Supply Current in IDLE 1, 2 mode				–	8	12	
Supply Current in NORMAL 1, 2 mode			V _{DD} = 5.5 V V _{IN} = 5.3/0.2 V f _c = 16.0 MHz f _s = 32.768 kHz When not using CAN controller	–	7.5	9	
Supply Current in IDLE 0, 1, 2 mode				–	5.5	6.5	
Supply Current in SLOW 1 mode			V _{DD} = 5.5 V V _{IN} = 5.3 V/0.2 V f _s = 32.768 kHz	–	15	35	μA
Supply Current in SLEEP 1 mode				–	7	25	
Supply Current in SLEEP 0 mode				–	6	25	
Supply Current in STOP mode			V _{DD} = 5.5 V V _{IN} = 5.3 V/0.2 V	–	0.5	15	

Note 1: Typical values show those at Topr = 25°C, V_{DD} = 5 V

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

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

Note 4: The power supply current in STOP2 and SLEEP2 modes each are the same as in IDLE0, 1, and 2 modes.

Note 5: The supply current in NORMAL 1, 2 and IDLE 1, 2 modes varies with use/non-use of the CAN controller.

AD Conversion Characteristics

(V_{SS} = 0.0 V, 4.5 V ≤ V_{DD} ≤ 5.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V _{AREF}		A _{VDD} – 1.0	–	A _{VDD}	V
Power Supply Voltage of Analog Control Circuit	A _{VDD}		V _{DD}			
	A _{VSS}		V _{SS}			
Analog Reference Voltage Range (Note 4)	ΔV _{AREF}	V _{AREF} – A _{VSS}	3.5	–	–	
Analog Input Voltage	V _{AIN}		A _{VSS}	–	V _{AREF}	
Power Supply Current of Analog Reference Voltage	I _{REF}	V _{DD} = A _{VDD} = V _{AREF} = 5.5 V V _{SS} = A _{VSS} = 0.0 V	–	0.6	1.0	mA
Non linearity		V _{DD} = A _{VDD} = 5.0 V, V _{AREF} = 5.0 V, A _{VSS} = 0.0 V	–	–	± 2	LSB
Zero Point Error			–	–	± 2	
Full Scale Error			–	–	± 2	
Total Error			–	–	± 2	

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 "2.11.2 Register Configuration".

Note 3: Please use input voltage to AIN input Pin in limit of V_{AREF} – A_{VSS}.

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_{AREF} = V_{AREF} – A_{VSS}

SEI Operating Conditions (Slave mode) (V_{SS} = 0.0 V, 4.5 V ≤ V_{DD} ≤ 5.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Transfer Rate			15.625 k	–	f _c /4	bps

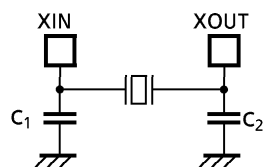
AC Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 40 to 85°C)

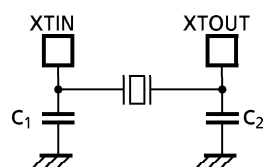
Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	t _{cy}	NORMAL 1, 2 mode	0.25	–	4	μs
		IDLE 0, 1, 2 mode				
		SLOW 1, 2 mode	117.6	–	133.3	
		SLEEP 0, 1, 2 mode				
High Level Clock Pulse Width	t _w CH	For external clock operation (XIN input)	–	31.25	–	ns
Low Level Clock Pulse Width	t _w CL	f _c = 16 MHz				
High Level Clock Pulse Width	t _w CH	For external clock operation (XTIN input)	–	15.26	–	μs
Low Level Clock Pulse Width	t _w CL	f _s = 32.768 kHz				

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

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



(1) High-frequency Oscillation



(2) Low-frequency Oscillation

Note 1: When using the device (oscillator) in places exposed to high electric fields such as cathode-ray tubes, we recommend electrically shielding the package in order to maintain normal operating condition.

Note 2: To ensure stable oscillation, the resonator position, load capacitance, etc. must be appropriate. Because these factors are greatly affected by board patterns, please be sure to evaluate operation on the board on which the device will actually be mounted.

Note 3: 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>

