CMOS 8-Bit Microcontroller

TMP86CS44U

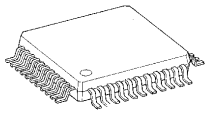
The TMP86CS44 are the high-speed, high-performance and low-power consumption 8-bit microcomputer, including ROM, RAM, multi-function timer/counter, serial interface a 10-bit AD converter on chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP86CS44U	60 K × 8 bits	1 K × 8 bits	P-LQFP44-1010-0.80A	TMP86PS44U

Features

- 8-bit single chip microcomputer TLCS-870/C series
- Instruction execution time: 0.25 μs (at 16 MHz)
  122 μs (at 32.768 kHz)
- 132 types and 731 basic instructions
- 19 interrupt sources (External: 6, Internal: 13)
- Input/Output ports (35 pins)
- 16-bit timer counter: 2 ch
  - Timer, Event counter, Pulse width measurement, Programmable Pulse Generator (PPG), External-trigger Window modes
- 8-bit timer counter: 2 ch
  - Timer, PWM, PPG, PDO, Event counter modes
- Time Base Timer
- Divider output
- Watchdog Timer
  - Interrupt source/reset output (programmable)

P-LQFP44-1010-0.80A



TMP86CS44U
TMP86PS44U

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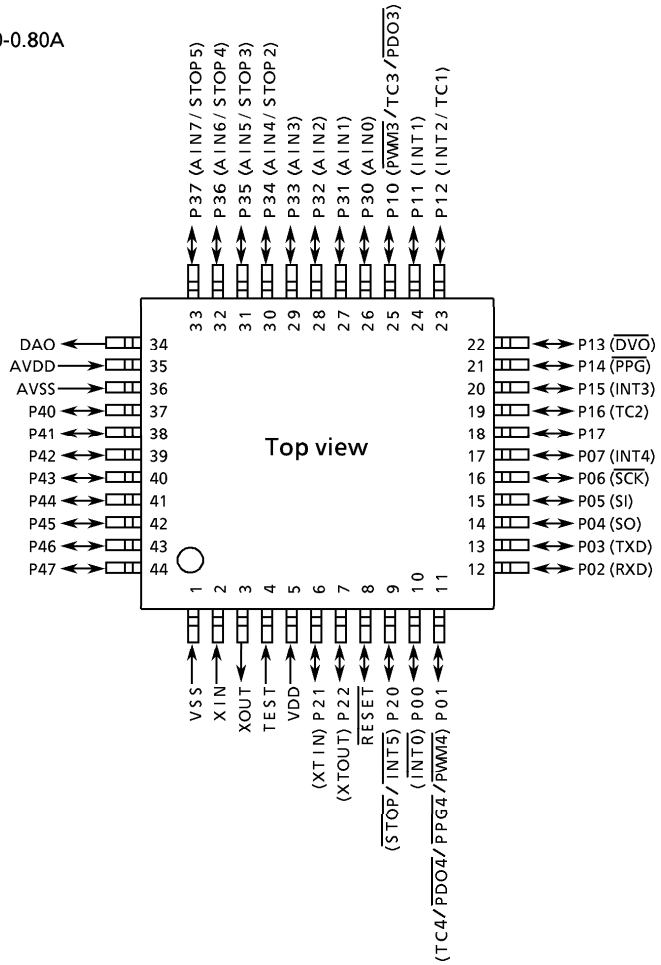
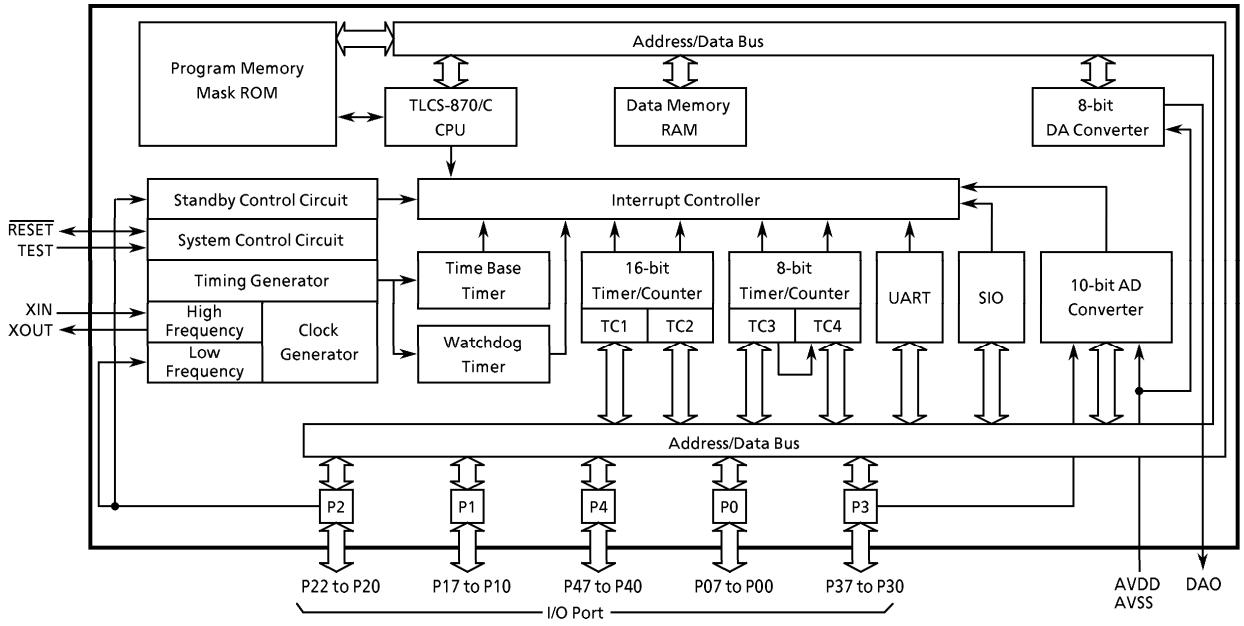
- Serial interface
  - 8-bit SIO: 1 ch
  - 8-bit UART: 1 ch
- 10-bit successive approximation type AD converter
  - Analog input: 8 ch
- 8-bit DA converter
  - Analog output: 1 ch
- Key On Wake Up: 4 ch
- Dual clock operation
  - Single/Dual-clock mode
- Nine power saving operating modes
  - STOP mode: Oscillation stops. Battery/Capacitor back-up. Port output hold/High-impedance.
  - SLOW1 mode: Low power consumption operation using low-frequency clock.
  - SLOW2 mode: Low power consumption operation using high and low frequency clock.
  - IDLE 0 mode: CPU stops, and peripherals operate using high-frequency clock of Time-Base-Timer. Release by falling edge of the clock which is set by TBTCR (TBTCK).
  - 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 falling edge of the clock which is set by TBTCR (TBTCK).
  - 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

Pin Assignments (Top View)

P-LQFP44-1010-0.80A



Block Diagram



Pin Functions

Pin Name	I/O	Functions		
P07 (INT4)	I/O (Input)	8-bit I/O port. When used as input port, external interrupt input, serial clock input/output, serial data input/output and timer/counter 4 input/output, the latch must be set to "1".	External interrupt input	
P06 ($\overline{SCK}$)	I/O (Input/Output)		SIO input/output	
P05 (SI)	I/O (Input)			
P04 (SO)	I/O (Output)			
P03 (TXD)	I/O (Output)		UART Data output	
P02 (RXD)	I/O (Input)		UART Data input	
P01 ($\overline{PWM4}$/TC4/$\overline{PDO4}$/$\overline{PPG4}$)	I/O (Input/Output)		Timer/Counter input PPG output, PWM output, PDO output	
P00 ($\overline{INT0}$)	I/O (Input)		External interrupt input	
P17	I/O	8-bit I/O port with latch. Each bit of these ports can be individually configured as an input or an output under software control. An output latch is set to "1" when using it as a functional terminal.	—	
P16(TC2)	I/O(Input)		Timer/Counter input	
P15 (INT3)	I/O (Input)		External interrupt input	
P14 ($\overline{PPG}$)	I/O (Output)		PPG output	
P13 ($\overline{DVO}$)	I/O (Output)		Divider output	
P12 (INT2/TC1)	I/O (Input)		External interrupt input, Timer/Counter	
P11 (INT1)	I/O (Input)		External interrupt input	
P10 ($\overline{PWM3}$/TC3/$\overline{PDO3}$)	I/O (Input/Output)		Timer/Counter input PWM output, PDO output	
P20 ($\overline{INT5}$/$\overline{STOP1}$)	I/O (Input)	3-bit I/O port with latch. When used as input port, external interrupt input, and STOP mode release signal input, the latch must be set to"1".	External interrupt input STOP mode release signal input	
P21 (XTIN)	I/O (Input)		Resonator connecting pins for low-frequency clock. For inputting external clock, XTIN is used and XTOUT is opened.	
P22 (XTOUT)	I/O (Output)			
P37 (AIN7/STOP5)	I/O (Input)	8-bit I/O port. Each bit of these ports can be individually configured as an input or output under software control. When used as analog input, then must be set to "1".	AD converter analog inputs	STOP mode release signal input
P36 (AIN6/STOP4)				
P35 (AIN5/STOP3)				
P34 (AIN4/STOP2)				
P33 (AIN3)				—
P32 (AIN2)				
P31 (AIN1)				
P30 (AIN0)				
P47	I/O	8-bit I/O port with latch. Each bit of these ports can be individually configured as an input or an output under software control.	—	
P46				
P45				
P44				
P43				
P42				
P41				
P40				
TEST	Input	Test pin for out-going test. Be fixed to Low.		
$\overline{RESET}$	I/O	Reset signal input or watchdog timer output/address-trap-reset output		
XIN	Input	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.		
XOUT	Output			
VSS	Power Supply	0.0 [V] (GND)		
VDD		+ 5 V		
AVSS		0.0 [V] AD, DA circuit GND		
AVDD		+ 5 V AD, DA circuit power supply		
DAO	Output	DA converter analog output		

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 TMP86CS44 memory consist of 4 blocks: ROM, RAM and SFR (Special Function Register). They are all mapped in 64-Kbyte address space. Figure 1-1 shows the TMP86CS44 memory address map. The general-purpose registers are not assigned to the RAM address space.

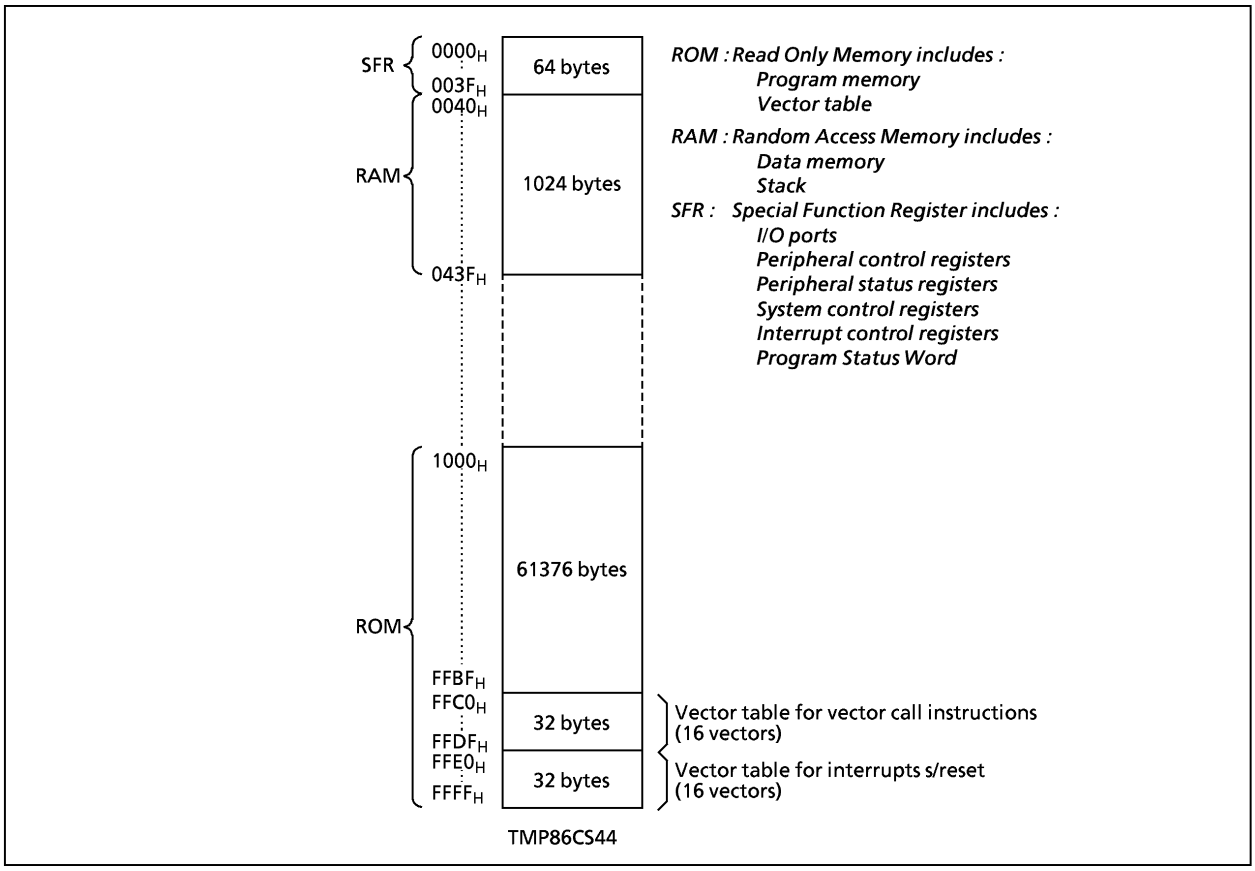


Figure 1-1. Memory Address Maps

1.2 Program Memory (ROM)

The TMP86CS44 has a 60 K×8 bits (Address 1000_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_{DD}		– 0.3 to 6.5	V
Input Voltage	V_{IN}		– 0.3 to V_{DD} + 0.3	
Output Voltage	V_{OUT}		– 0.3 to V_{DD} + 0.3	
Output Current (Per 1 pin)	I_{OUT1} I_{OH}	P1, P3, P4 port	– 1.8	
	I_{OUT2} I_{OL}	P1, P3 port	3.2	mA
	I_{OUT3} I_{OL}	P0, P2, P4 port	30	
Output Current (Total)	ΣI_{OUT1}	P1, P3 port	60	
	ΣI_{OUT2}	P0, P2, P4 port	80	
Power Dissipation [T_{opr} = 85°C]	PD		250	
Soldering Temperature (Time)	Tsld		260 (10 sec)	°C
Storage Temperature	Tstg		– 55 to 125	
Operating Temperature	Topr		– 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, Topr = – 40 to 85°C)

Parameter	Symbol	Pins	Condition		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 16 MHz	NORMAL1, 2 mode	4.5	5.5	V
				IDLE0,1, 2 mode			
			fc = 8 MHz	NORMAL1, 2 mode	2.7		
				IDLE0,1, 2 mode			
			fc = 4.2 MHz	NORMAL1, 2 mode			
				IDLE0,1, 2 mode			
			fs = 32.768 kHz	SLOW1,2 mode			
				SLEEP0,1,2 mode			
				STOP mode	2.0		
Input high Level	V_{IH1}	Except Hysteresis input	$V_{DD} \geqq 4.5$ V		$V_{DD} \times 0.70$	V_{DD}	
	V_{IH2}	Hysteresis input			$V_{DD} \times 0.75$		
	V_{IH3}		$V_{DD} < 4.5$ V		$V_{DD} \times 0.90$		
Input low Level	V_{IL1}	Except Hysteresis input	$V_{DD} \geqq 4.5$ V		0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
	V_{IL3}		$V_{DD} < 4.5$ V			$V_{DD} \times 0.10$	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V		1.0	16.0	MHz
			V_{DD} = 2.7 to 5.5 V			8.0	
	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 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					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistance	R_{IN1}	TEST Pull-Down		–	70	–	kΩ
	R_{IN2}	$\overline{RESET}$ Pull-Up		100	200	450	
Output Leakage Current	I_{LO1}	Sink Open Drain	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	–	–	2	μA
	I_{LO2}	Tri-state	V_{DD} = 5.5 V, V_{OUT} = 5.5 V/0 V	–	–	± 2	
Output High Voltage	V_{OH}	Tri-state Port	V_{DD} = 4.5 V, V_{OH} = – 0.7 mA	4.1	–	–	V
Output Low Voltage	V_{OL}	Except XOUT, P0, P2, P4 Port	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	–	–	0.4	
Output Low Current	I_{OL}	High Current Port (P0, P2, P4 Port)	V_{DD} = 4.5 V, V_{OL} = 1.0 V	–	20	–	mA
Supply Current in NORMAL1, 2 mode	I_{DD}		V_{DD} = 5.5 V V_{IN} = 5.3/0.2 V fc = 16 MHz fs = 32.768 kHz	–	10.5	12	
Supply Current in IDLE0,1, 2 mode				–	5.5	6.5	
Supply Current in SLOW1 mode			V_{DD} = 3.0 V V_{IN} = 2.8/0.2 V fs = 32.768 kHz	–	8	20	μA
Supply Current in SLEEP1 mode				–	5	15	
Supply Current in SLEEP0 mode				–	4	13	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3/0.2 V	–	0.5	10	

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 supply currents of SLOW2 and SLEEP2 modes are equivalent to IDLE 0,1,2.

AD Conversion Characteristics

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

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}	$V_{AREF} = A_{VDD} - A_{VSS}$	A_{VDD}	–	A_{VDD}	V
Power Supply Voltage of Analog Control Circuit	A_{VDD}	$A_{VSS} = V_{SS}$	V_{DD}			
Analog Input Voltage	V_{AIN}	$A_{VSS} = V_{SS}$, $A_{VDD} = V_{DD}$	V_{SS}	–	V_{DD}	
Power Supply Current of Analog Reference Voltage	I_{REF}	$V_{DD} = A_{VDD} = 5.5$ V $V_{SS} = A_{VSS} = 0.0$ V	–	0.6	1.0	mA
Non linearity Error		$V_{DD} = A_{VDD} = 5.0$ V, $V_{SS} = A_{VSS} = 0.0$ V $V_{AREF} = A_{VDD} - A_{VSS}$	–	–	±2	LSB
Zero Point Error			–	–	±2	
Full Scale Error			–	–	±2	
Total Error			–	–	±2	

(V_{SS} = 0.0 V, V_{DD} = 2.7 V to 4.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}	$V_{AREF} = A_{VDD} - A_{VSS}$	A_{VDD}	–	A_{VDD}	V
Power Supply Voltage of Analog Control Circuit	A_{VDD}	$A_{VSS} = V_{SS}$	V_{DD}			
Analog Input Voltage	V_{AIN}	$A_{VSS} = V_{SS}$, $A_{VDD} = V_{DD}$	V_{SS}	–	V_{DD}	
Power Supply Current of Analog Reference Voltage	I_{REF}	$V_{DD} = A_{VDD} = 4.5$ V $V_{SS} = A_{VSS} = 0.0$ V	–	0.5	0.8	mA
Non linearity Error		$V_{DD} = A_{VDD} = 2.7$ V, $V_{SS} = A_{VSS} = 0.0$ V $V_{AREF} = A_{VDD} - A_{VSS}$	–	–	±2	LSB
Zero Point Error			–	–	±2	
Full Scale Error			–	–	±2	
Total Error			–	–	±2	

(V_{SS} = 0 V, V_{DD} = 2.7 to 4.5 V, Topr = – 40 to 85°C)

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 Figure 2-64.
Note 3: Please use input voltage to AIN input Pin in limit of V_{AREF} - V_{SS}.
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: $\triangle V_{AREF} = A_{VDD} - A_{VSS}$

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

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference voltage	A_{VDD}	$A_{VDD} = V_{DD}$	4.5	–	5.5	V
	A_{VSS}	$A_{VSS} = V_{SS}$	V_{SS}	–	V_{SS}	
Resolution			–	–	8	Bits
Linearity Error (Note 1)		$A_{VDD} = V_{DD}$ = 4.5 to 5.5 V $A_{VSS} = V_{SS}$ = 0 V Load conditions 5 pF, 10 MΩ	–	–	± 5	LSB
Settling Time					4	ms
Reference Current (DA Power Dissipation) (Note 2)	I_{DREF}	No load, V_{DD} = 5.5 V, fc = 16 MHz	–	350	500	μA
DAO Output Current (Note 3)	I_{DAO}	$A_{VDD} = V_{DD}$ = 4.5 V $A_{VSS} = V_{SS}$ = 0 V No load 0.5 V bias when inputting 7FH	14	19	–	

DA Conversion Characteristics (V_{SS} = 0.0 V, V_{DD} = 2.7 to 4.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition		Min	Typ.	Max	Unit
Analog Reference voltage	A_{VDD}	$A_{VDD} = V_{DD}$		2.7	–	4.5	V
	A_{VSS}	$A_{VSS} = V_{SS}$		V_{SS}	–	V_{SS}	
Resolution				–	–	8	Bits
Linearity Error (Note 1)		$A_{VDD} = V_{DD}$ = 2.7 to 4.5 V $A_{VSS} = V_{SS}$ = 0 V Load conditions 5 pF, 10 MΩ	– 10°C≦Ta≦85°C	–	–	+ 5 – 8	LSB
			– 40°C≦Ta< – 10°C	–	–	+ 5 – 26	
Settling Time						6	ms
Reference Current (DA Power Dissipation) (Note 2)	I_{DREF}	No load, V_{DD} = 2.7 V, fc = 8 MHz		–	200	300	μA
DAO Output Current (Note 3)	I_{DAO}	$A_{VDD} = V_{DD}$ = 2.7 V $A_{VSS} = V_{SS}$ = 0 V No load 0.5 V bias when inputting 7FH		0.4	5.3	–	

Note 1: In linearity error measurements, the first code (00_H, 01_H) and the last code (FE_H, FF_H) are excluded.
Note 2: DA converter power dissipation
Note 3: DAO current drive capability

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	tcy	NORMAL1, 2 mode	0.25	–	4	μs
		IDLE0,1, 2 mode				
		SLOW1, 2 mode	117.6	–	133.3	
		SLEEP0, 1, 2 mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input) fc = 16 MHz	–	31.25	–	ns
Low Level Clock Pulse Width	t_{WCL}					
High Level Clock Pulse Width	t_{WSH}	For external clock operation (XTIN input) fs = 32.768 kHz	–	15.26	–	μs
Low Level Clock Pulse Width	t_{WSL}					

(V_{SS} = 0 V, V_{DD} = 2.7 to 4.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	NORMAL1, 2 mode	0.5	–	4	μs
		IDLE0,1, 2 mode				
		SLOW1, 2 mode	117.6	–	133.3	
		SLEEP0, 1, 2 mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input) fc = 8 MHz	–	62.5	–	ns
Low Level Clock Pulse Width	t_{WCL}					
High Level Clock Pulse Width	t_{WSH}	For external clock operation (XTIN input) fs = 32.768 kHz	–	15.26	–	μs
Low Level Clock Pulse Width	t_{WSL}					

Recommended Oscillating Conditions - 1

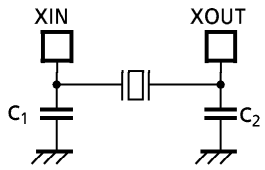
(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 40 to 85°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator		Recommended Constant C_1	Recommended Constant C_2
High-frequency Oscillation	Ceramic Resonator	16 MHz	MURATA	CSA16.00MXZ040	10 pF	10 pF
		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)
Low-frequency Oscillation	Crystal Oscillator	32.768 kHz	SII	VT-200	6 pF	6 pF

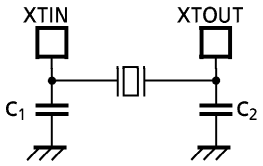
Recommended Oscillating Conditions - 2

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 40 to 85°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator		Recommended Constant C_1	Recommended Constant C_2
High-frequency 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)



(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