

CMOS 8-Bit Microcontroller

TMP87CM23AF, TMP87CP23F

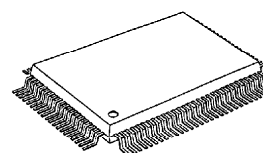
The TMP87CM23A/CP23 are the high speed and high performance 8-bit single chip microcomputers. These MCU contain, large ROM, RAM, input/output ports, LCD driver, a 8-bit AD converter, four multi-function timer/counters, two serial interfaces, and two clock generators on chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP87CM23AF	32 K × 8-bit	1 K × 8-bit	P-QFP100-1420-0.65A	TMP87PP23F
TMP87CP23F	48 K × 8-bit	2 K × 8-bit		

Features

- ◆ 8-bit single chip microcomputer TLCS-870 Series
- ◆ Instruction execution time: 0.5 μ s (at 8 MHz), 122 μ s (at 32.768 kHz)
- ◆ 129 types and 412 basic instructions
 - Multiplication and Division (8 bits × 8 bits, 16 bits ÷ 8 bits): Execution time 3.5 μ s (at 8 MHz)
 - Bit manipulations (Set/Clear/Complement/Load/Store/Test/Exclusive OR)
 - 16-bit data operations
 - 1-byte jump/call (Short relative jump/Vector call)
- ◆ 14 interrupt sources (External: 5, Internal: 9)
 - All sources have independent latches each, and nested interrupt control is available
 - 4 edge-selectable external interrupts with noise reject
 - High-speed task switching by register bank changeover
- ◆ 10 Input/Output ports (Max. 70 pins)
- ◆ Two 16-bit Timer/Counters
 - Timer, Event counter, External trigger timer, Window, PPG output Pulse width measurement modes
- ◆ Two 8-bit Timer/Counters
 - Timer, Event counter, Capture (Pulse width/duty measurement), PWM output, PDO modes
- ◆ Time Base Timer (Interrupt frequency: 1 Hz to 16384 Hz)
- ◆ Divider output function (frequency: 1 kHz to 8 kHz)
- ◆ Watchdog Timer
- ◆ Two 8-bit Serial Interfaces
 - Each 8 bytes transmit/receive data buffer
 - Internal/external serial clock, and 4/8-bit mode

P-QFP100-1420-0.65A

TMP87CM23AF
TMP87CP23F

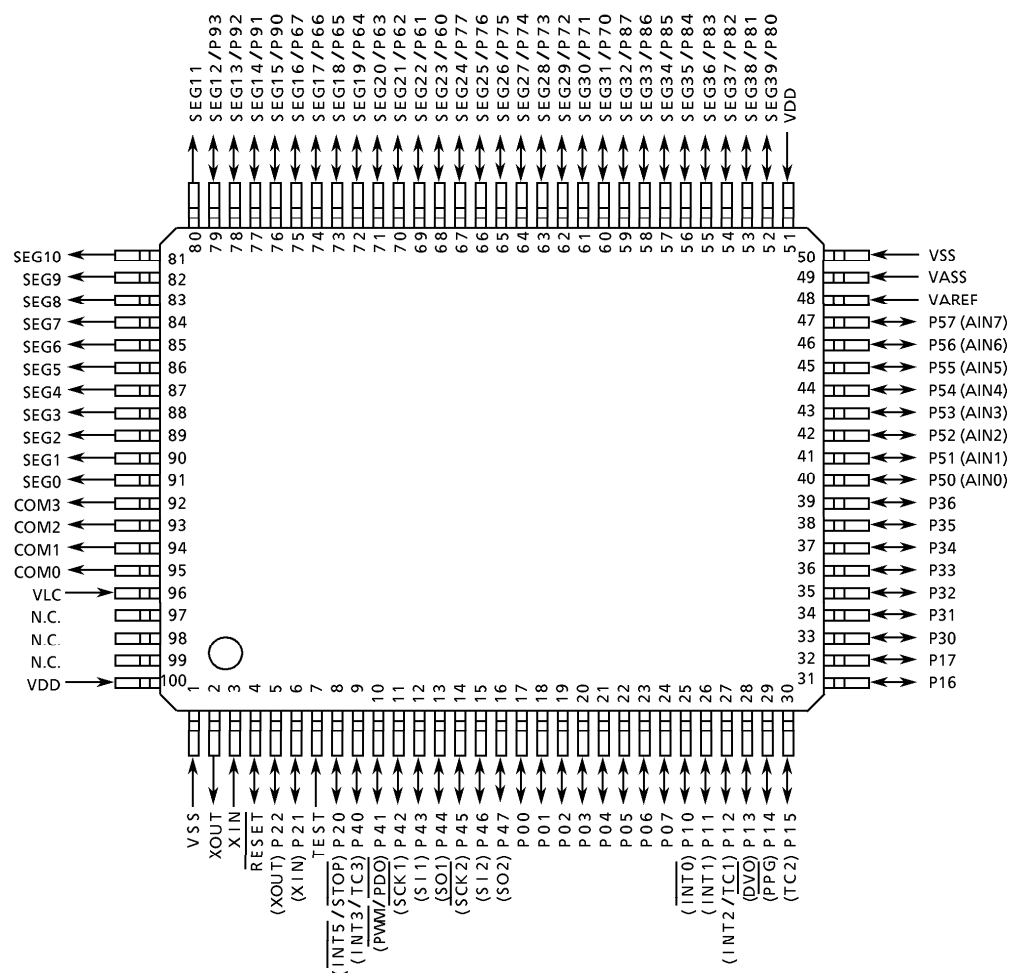
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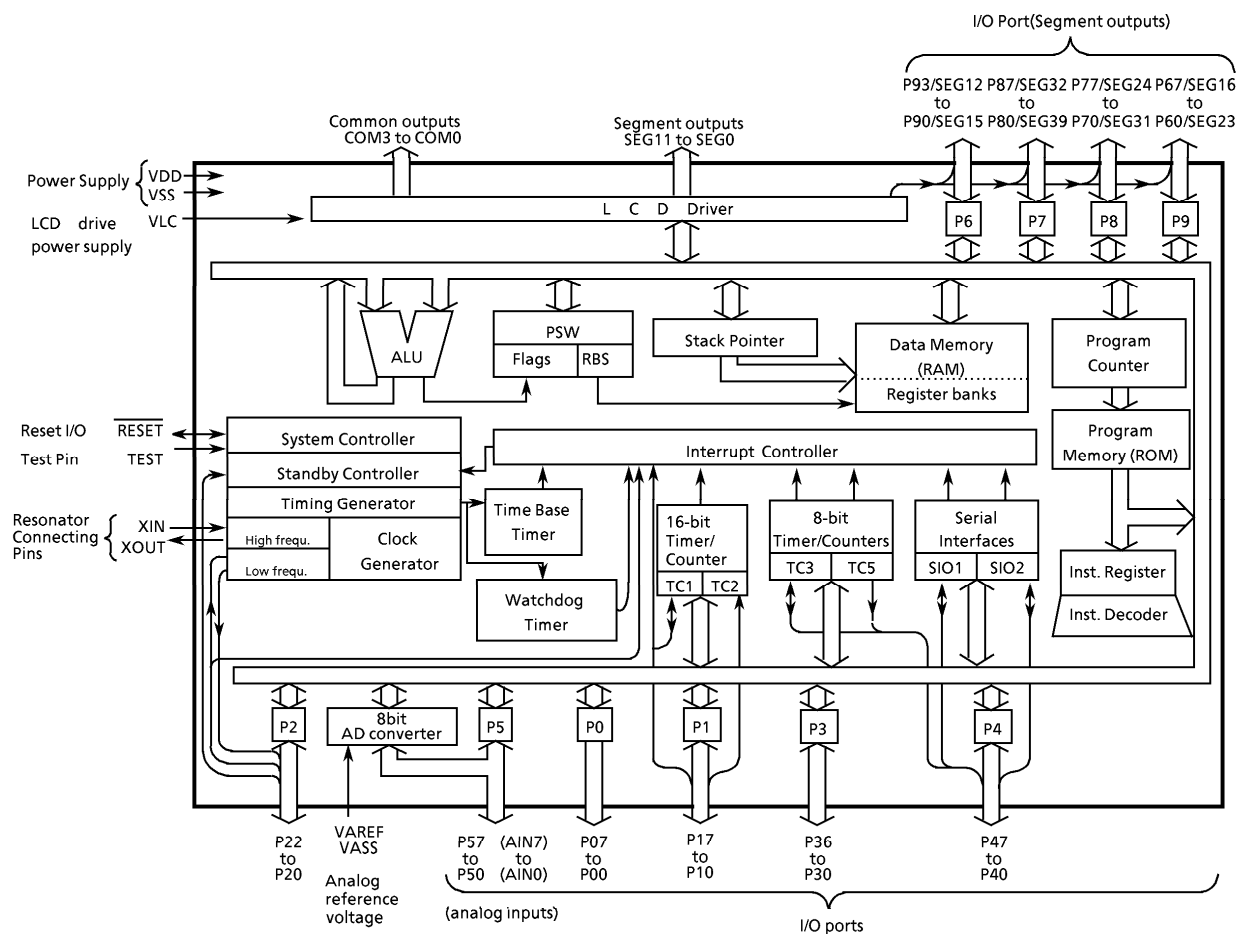
- ◆ LCD driver
 - With display memory (20 bytes)
 - LCD direct drive capability (Max. 40 seg × 4 com)
 - 1/4, 1/3, 1/2 duty or static drive are programmably selectable
- ◆ 8-bit successive approximate type AD converter with sample and hold
 - 8 analog inputs
 - Conversion time: 23 μ s / 92 μ s (at 8 MHz)
- ◆ Dual clock operation (optinal)
- ◆ Five Power saving operating modes
 - STOP mode: Oscillation stops. Battery/Capacitor back-up.
Port output hold/high-impedance.
 - SLOW mode: Low power consumption operation using
low-frequency clock (32.768 kHz).
 - IDLE1 mode: CPU stops, and Peripherals operate using
high-frequency clock.
Release by interrupts.
 - IDLE2 mode: CPU stops, and Peripherals operate using high and low frequency clock.
Release by interrupts.
 - SLEEP mode: CPU stops, and Peripherals operate using low-frequency clock.
Release by interrupts.
- ◆ Operating Voltage: 2.7 to 5.5 V at 4.2 MHz / 32.768 kHz, 4.5 to 5.5 V at 8 MHz / 32.768 kHz
- ◆ Emulation Pod: BM87CP23F0A

Pin Assignments (Top View)

P-QFP100-1420-0.65A



Block Diagram



Pin Function

Pin Name	Input / Output	Function	
P07 to P00 P17, P16	I/O	8-bit programmable input/output ports (tri-state).	
P15 (TC2)	I/O (Input)	Each bit of these ports can be individually configured as an input or an output under software control.	Timer/Counter 2 input
P14 (PPG)	I/O (Output)		Programmable pulse generator output
P13 (DVO)	I/O (Output)		Divider output
P12 (INT2 / TC1)	I/O (Input)	When used as an input port, timer/counter input or external interrupt input, the P0CR/P1CR must be set to "0". When used as timer/counter output or divider output, the P0CR/P1CR must be set to "1" after setting output latch to "1".	External interrupt 2 input or Timer/Counter 1 input
P11 (INT1)	I/O (Input)		External interrupt 1 input
P10 (INT0)	I/O (Input)		External interrupt 0 input
P22 (XTOUT)	I/O (Output)	3-bit input/output port with latch.	Resonator connecting pins (32.768kHz). For inputting external clock, XTIN is used and XTOUT is opened.
P21 (XTIN)	I/O (Input)	When used as an input port, external interrupt input or STOP mode release input, the output latch must be set to "1".	External interrupt 5 input or STOP mode release signal input
P20 (INT5/STOP)	I/O (Input)		
P36 to P30	I/O	7-bit input/output port with latch. When used as input port, the output latch must be set to "1".	
P47 (SO2)	I/O (Output)	8-bit input/output port with latch.	SIO2 serial data output
P46 (SI2)	I/O (Input)		SIO2 serial data input
P45 (SCK2)	I/O (I/O)	When used as serial interface output or timer/counter output, the P4CR1 must be set to "1" after setting output latch to "1".	SIO2 serial clock input/output
P44 (SO1)	I/O (Output)		SIO1 serial data output
P43 (SI1)	I/O (Input)	When used as an input port, serial interface input or external interrupt input, the P4CR1 must be set to "0".	SIO1 serial data input
P42 (SCK1)	I/O (I/O)		SIO1 serial clock input/output
P41 (PWM/PDO)	I/O (Output)		8-bit PWM output, 8-bit programmable divider output
P40 (INT3/TC3)	I/O (Input)		External interrupt 3 input, Timer/Counter 3 input
P57 (AIN07) to P50 (AIN00)	I/O (Input)	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control. When used as analog input, the P5CR must be set to "0".	AD converter analog inputs
SEG39 (P80) to SEG32 (P87)	Output (I/O)	8-bit input/output port with latch. When used as an input port, the segment output control register must be set to "0" after setting output latch to "1".	LCD segment outputs. When used as segment output, the segment output control register must be set to "1".
SEG31 (P70) to SEG24 (P77)	Output (I/O)		
SEG23 (P60) to SEG16 (P67)	Output (I/O)		
SEG15 (P90) to SEG12 (P93)	Output (I/O)	4-bit input/output port with latch. When used as an input port, the segment output control register must be set to "1" after setting output latch to "1".	
SEG11 to SEG0	Output	LCD segment outputs	
COM3 to COM0	Output	LCD common outputs	
XIN, XOUT	Input, Output	Resonator connecting pins for high-frequency clock. 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	
TEST	Input	Test pin for out-going test. Be fixed to low.	
VDD, VSS	Power Supply	+ 5 V, 0 V (GND)	
VAREF, VASS		Analog reference voltage inputs (High, Low)	
VLC		LCD drive power supply.	

OPERATIONAL DESCRIPTION

1. CPU CORE FUNCTIONS

The CPU core consists of a CPU, a system clock controller, an interrupt controller, and a watchdog timer. This section provides a description of the CPU core, the program memory (ROM), the data memory (RAM), and the reset circuit.

1.1 Memory Address Map

The TLCS-870 Series is capable of addressing 64K bytes of memory. Figure 1-1 shows the memory address maps of the TMP87CM23A/P23. In the TLCS-870 Series, the memory is organized 4 address spaces (ROM, RAM, SFR, and DBR). It uses a memory mapped I/O system, and all I/O registers are mapped in the SFR/DBR address spaces. There are 16 banks of general-purpose registers. The register banks are also assigned to the first 128 bytes of the RAM address space.

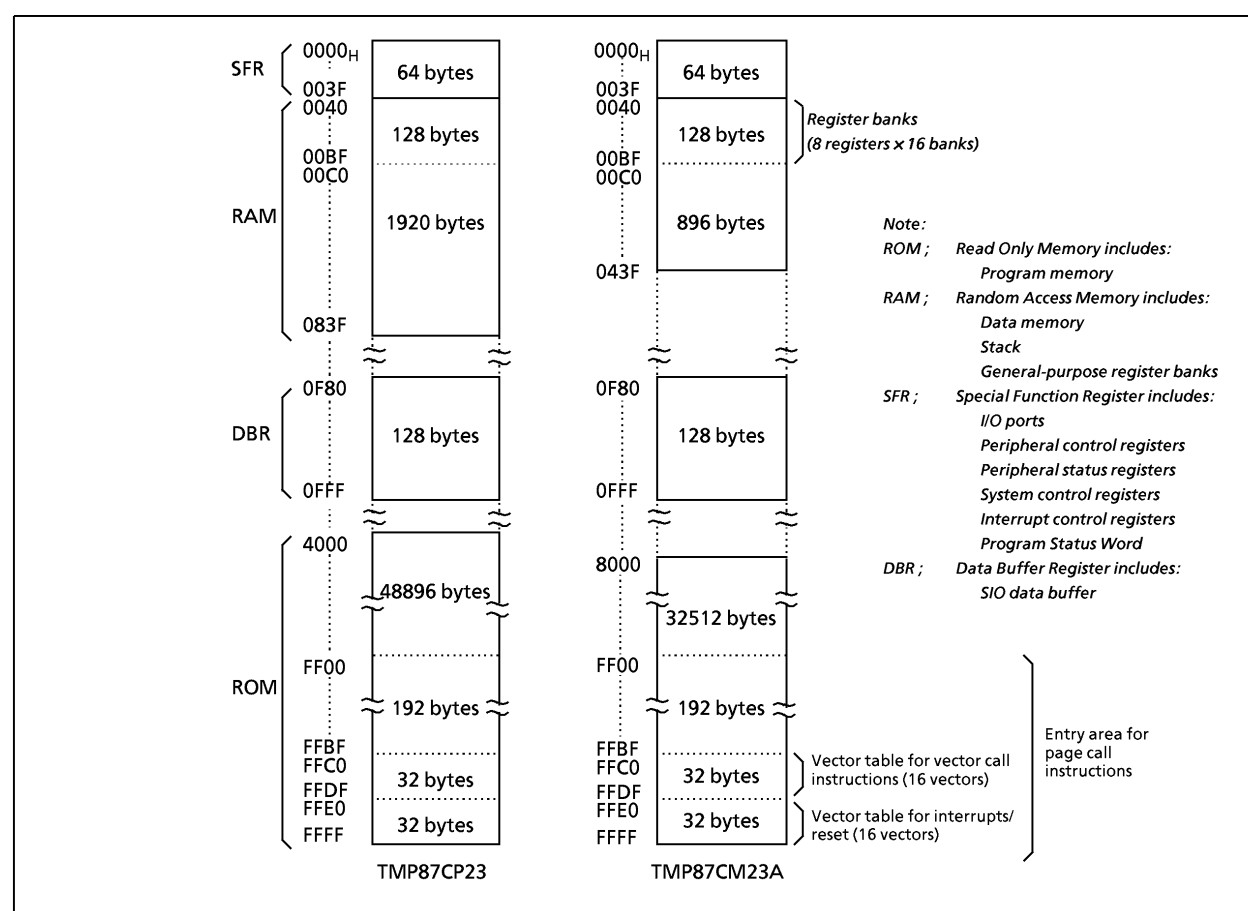


Figure 1-1. Memory Address Maps

Electrical Characteristics

Absolute Maximum Ratings		(V _{SS} = 0 V)		
Parameter	Symbol	Pins	Ratings	Unit
Supply Voltage	V _{DD}		– 0.3 to 6.5	V
Input Voltage	V _{IN}		– 0.3 to V _{DD} + 0.3	V
Output Voltage	V _{OUT}		– 0.3 to V _{DD} + 0.3	V
Output Current (Per 1 pin)	I _{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	3.2	mA
	I _{OUT2}	P41	30	
Output Current (Total)	Σ I _{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	mA
	Σ I _{OUT2}	P41	30	
Power Dissipation [T _{opr} = 70°C]	PD		350	mW
Soldering Temperature (time)	T _{sld}		260 (10 s)	°C
Storage Temperature	T _{stg}		– 55 to 125	°C
Operating Temperature	T _{opr}		– 30 to 70	°C

Note 1: 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.

Note 2: The absolute maximum input/output voltage ratings for the TMP87CM23A/CP23/PP23 are – 0.3 to V_{DD} + 0.3 [V] at all I/O ports including sink open drain output ports. (However, the VPP pin of TMP87PP23 is not contained in these condition.)

Recommended Operating Conditions			(V _{SS} = 0 V, T _{opr} = – 30 to 70°C)				
Parameter	Symbol	Pins	Conditions		Min	Max	Unit
Supply Voltage	V _{DD}		f _c = 8 MHz	NORMAL1, 2 mode	4.5	5.5	V
				IDLE1, 2 mode			
			f _c = 4.2 MHz	NORMAL1, 2 mode	2.7		
				IDLE1, 2 mode			
			f _s = 32.768 kHz	SLOW mode	2.0		
				SLEEP mode			
	STOP mode						
Input High Voltage	V _{IH1}	Except hysteresis input	V _{DD} ≥ 4.5 V		V _{DD} × 0.70	V _{DD}	V
	V _{IH2}	Hysteresis input			V _{DD} × 0.75		
	V _{IH3}		V _{DD} < 4.5 V	V _{DD} × 0.90			
Input Low Voltage	V _{IL1}	Except hysteresis input	V _{DD} ≥ 4.5 V		0	V _{DD} × 0.30	V
	V _{IL2}	Hysteresis input				V _{DD} × 0.25	
	V _{IL3}		V _{DD} < 4.5 V	V _{DD} × 0.10			
Clock Frequency	f _c	XIN, XOUT	V _{DD} = 4.5 to 5.5 V		0.4	8.0	MHz
			V _{DD} = 2.7 to 5.5 V			4.2	
	f _s	XTIN, XTOUT			30.0	34.0	kHz

Note 1: 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.

Note 2: Clock frequency f_c: Supply voltage range is specified in NORMAL1/2 mode and IDLE1/2 mode.

DC Characteristics

(V_{SS} = 0 V, T_{opr} = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V _{HS}	Hysteresis inputs		—	0.9	—	V
Input Current	I _{IN1}	TEST	V _{DD} = 5.5 V, V _{IN} = 5.5 V / 0 V	—	—	± 2	μA
	I _{IN2}	Open drain ports and tri-state ports					
	I _{IN3}	RESET, STOP					
Input Low Current	I _{IL}	Push-pull ports	V _{DD} = 5.5 V, V _{IN} = 0.4 V	—	—	– 2	mA
Input Resistance	R _{IN2}	RESET		100	220	450	kΩ
Output Leakage Current	I _{LO1}	Open drain ports	V _{DD} = 5.5 V, V _{OUT} = 5.5 V	—	—	2	μA
	I _{LO2}	Tri-state ports	V _{OUT} = 5.5 V / 0 V	—	—	± 2	
Segment Output Low Resistance	R _{OS1}	SEG39 to SEG0	V _{DD} = 5 V, V _{DD} – V _{LC} = 3 V	—	20	—	kΩ
Common Output Low Resistance	R _{OC1}	COM3 to COM0					
Segment Output High Resistance	R _{OS2}	SEG39 to SEG0		—	200	—	kΩ
Common Output High Resistance	R _{OC2}	COM3 to COM0					
Segment/Common Output Voltage	V _{O 2/3}	SEG39 to SEG0 and COM3 to COM0		3.8	4.0	4.2	V
	V _{O 1/2}			3.3	3.5	3.7	
	V _{O 1/3}			2.8	3.0	3.2	
Output High Voltage	V _{OH1}	Push-pull ports (P4 port)	V _{DD} = 4.5 V, I _{OH} = – 200 μA	2.4	—	—	V
	V _{OH2}	Tri- state ports (P0, P1, P5 ports)	V _{DD} = 4.5 V, I _{OH} = – 0.7 mA	4.1	—	—	
Output Low Voltage	V _{OL}	Except XOUT and P41	V _{DD} = 4.5 V, I _{OL} = 1.6 mA	—	—	0.4	V
Output Low Current	I _{OL3}	P41	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 f _c = 8 MHz f _s = 32.768 kHz V _{IN} = 5.3 V / 0.2 V	—	10	16	mA
Supply Current in IDLE 1, 2 mode				—	6	10	
Supply Current in SLOW mode			V _{DD} = 3.0 V f _s = 32.768 kHz V _{IN} = 2.8 V / 0.2 V LCD driver is not enable	—	30	60	μA
Supply Current in SLEEP mode				—	15	30	μA
Supply Current in STOP mode				V _{DD} = 5.5 V V _{IN} = 5.3 V / 0.2 V	—	0.5	10

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

Note 2: Input Current; The current through pull-up or pull-down resistor is not included.

Note 3: I_{DD}; Except for I_{REF}

Note 4: Output resistors R_{os}, R_{oc} indicate "on" when switching levels.

Note 5: V_{O2/3} indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.

Note 6: V_{O1/2} indicates an output voltage at the 1/2 level when operating in the 1/2 duty or static mode.

Note 7: V_{O1/3} indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.

Note 8: When using LCD, it is necessary to consider values of R_{os1/2} and R_{bc1/2}.

Note 9: Times for SEG/COM output switching on: R_{os1}, R_{oc1}: 2⁶/f_c, 2/f_c (s)

R_{os2}, R_{oc2}: 1/(n, f_f)

(1/n: duty, f_f: frame frequency)

AD Conversion Characteristics

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V _{AREF}	V _{AREF} – V _{ASS} ≥ 2.5 V	2.7	–	V _{DD}	V
	V _{ASS}		V _{SS}	–	1.5	
Analog Input Voltage	V _{AIN}		V _{ASS}	–	V _{AREF}	V
Analog Supply Current	I _{REF}	V _{AREF} = 5.5 V, V _{ASS} = 0.0 V	–	0.5	1.0	mA
Nonlinearity Error		V _{DD} = 5.0 V, V _{SS} = 0.0 V V _{AREF} = 5.000 V	–	–	± 1	LSB
Zero Point Error		V _{ASS} = 0.000 V or	–	–	± 1	
Full Scale Error		V _{DD} = 2.7 V, V _{SS} = 0.0 V V _{AREF} = 2.700 V	–	–	± 1	
Total Error		V _{ASS} = 0.000 V	–	–	± 2	

Note: Quantizing error is not contained in those errors.

AC Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t _{cy}	In NORMAL 1, 2 mode	0.95	—	10	μs
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	—	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t _{WCH}	For external clock operation (XIN input), f _c = 8 MHz	50	—	—	ns
Low Level Clock Pulse Width	t _{WCL}					
High Level Clock Pulse Width	t _{WSH}	For external clock operation (XTIN input), f _s = 32.768 kHz	14.7	—	—	μs
Low Level Clock Pulse Width	t _{WSL}					

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t _{cy}	In NORMAL 1, 2 mode	0.95	—	10	μs
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	—	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t _{WCH}	For external clock operation (XIN input), f _c = 4.2 MHz	110	—	—	ns
Low Level Clock Pulse Width	t _{WCL}					
High Level Clock Pulse Width	t _{WSH}	For external clock operation (XTIN input), f _s = 32.768 kHz	14.7	—	—	μs
Low Level Clock Pulse Width	t _{WSL}					

Recommended Oscillating Condition-1 (for TMP87CP23)

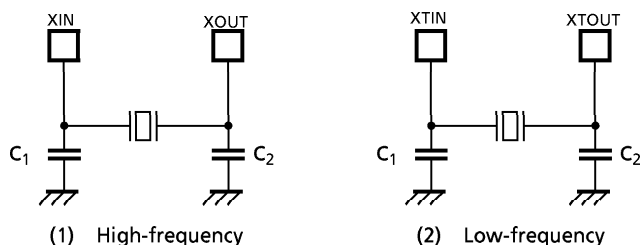
(VSS = 0 V, VDD = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Oscillator	Frequency	Recommender Oscillator	Recommended Condition	
				C ₁	C ₂
High-frequency	Ceramic Resonator	8 MHz	KYOCERA KBR8.0M	30 pF	30 pF
			Standard/Lead Type (MURATA) CSA8.00MTZ CST8.00MTW	Built-in 30 pF	Built-in 30 pF
			Standard/SMP Type (MURATA) CSACS8.00MT	30 pF	30 pF
			Standard/Small Chip Type (MURATA) CSTCS8.00MT	Built-in 30 pF	Built-in 30 pF
	Crystal Oscillator	4 MHz	KYOCERA KBR4.0MS	30 pF	30 pF
		8 MHz	TOYOCOM 210B 8.0000	20 pF	20 pF
Low-frequency	Crystal Oscillator	4 MHz	TOYOCOM 204B 4.0000		
		32.768 kHz	NDK MX-38T	15 pF	15 pF

Recommended Oscillating Condition-2 (for TMP87CP23)

(VSS = 0V, VDD = 2.7 to 5.5V, Topr = – 30 to 70°C)

Parameter	Oscillator	Frequency	Recommender Oscillator	Recommended Condition	
				C ₁	C ₂
High-frequency	Ceramic Resonator	4 MHz	Standard/Lead Type (MURATA) CSA4.00MG CST4.00MGW	30 pF	30 pF
			Standard/SMD Type (MURATA) CSA4.00MGC CSAC4.00MGCM CSTC4.00MG	Built-in 30 pF	Built-in 30 pF
			Standard/Small Chip Type CSTCS4.00MG	30 pF	30 pF
				Built-in 30 pF	Built-in 30 pF
				Built-in 10 pF	Built-in 10 pF



Note 1: When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular 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;
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