CMOS 8-Bit Microcontroller

TMP87C408M, TMP87C408N, TMP87C808M, TMP87C808N TMP87C408LM, TMP87C408LN, TMP87C808LM, TMP87C808LN TMP87C408DM

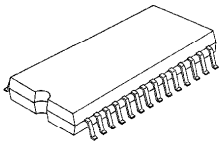
TMP87C408/808/408L/808L is high speed and high performance 8-bit single chip microcomputers to operate on low voltage and low power consumption. This MCU contains ROM, RAM, input/output ports, multi-function timer/counter, a serial interface, and 8-bit A/D converter.

Part No.	ROM	RAM	Package	OTP MCU	Operation Voltage Range
TMP87C408M	4K × 8-bit	256 × 8-bit	P-SOP28-450-1.27	TMP87P808M	2.7 V to 5.5 V at 4.2 MHz 4.5 V to 5.5 V at 8 MHz
TMP87C408N			P-SDIP28-400-1.78	TMP87P808N	
TMP87C408DM			P-SSQP30-56-0.65		
TMP87C808M	8K × 8-bit		P-SOP28-450-1.27	TMP87P808M	
TMP87C808N			P-SDIP28-400-1.78	TMP87P808N	
TMP87C408LM	4K × 8-bit		P-SOP28-450-1.27	TMP87P808LM	1.8 V to 4.0 V at 4.2 MHz
TMP87C408LN			P-SDIP28-400-1.78	TMP87P808LN	
TMP87C808LM	8K × 8-bit		P-SOP28-450-1.27	TMP87P808LM	
TMP87C808LN			P-SDIP28-400-1.78	TMP87P808LN	

Features

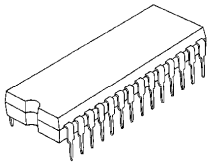
- ◆ 8-bit single chip microcomputer TLCS-870 series
- ◆ Minimum instruction execution time: 0.5 μs (at 8 MHz)
  (TMP87C408/C808/P808)
  0.95 μs (at 4.2 MHz)
  (TMP87C408L/C808L/P808L)
- ◆ 129 types & 412 basic instructions
  - Multiplication (8 bits × 8 bits, 16 bits ÷ 8 bits)
    : Execution time 3.5 μs (at 8 MHz)
    (TMP87C408/C808/P808)
    7.0 μs (at 4 MHz)
    (TMP87C408L/C808L/P808L)
  - Bit manipulations
    (Set / Clear / Complement / Load / Store / Test / Exclusive or)
  - 16-bit data operations
  - 1-byte jump / call (Short relative jump / Vector call)

P-SOP28-450-1.27



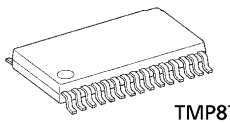
TMP87C408M
TMP87C408LM
TMP87C808M
TMP87C808LM
TMP87P808M
TMP87P808LM

P-SDIP28-400-1.78



TMP87C408N
TMP87C408LN
TMP87C808N
TMP87C808LN
TMP87P808N
TMP87P808LN

P-SSQP30-56-0.65



TMP87C408DM

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◆ 10 interrupt sources (External: 4, Internal: 6)
- All sources have independent latches each, and nested interrupt control is available.
- Edge-selectable external interrupts with noise reject
- High-speed task switching by register bank changeover

◆ Input / Output ports (22 pins)
- Middle current output: 6 pins (Typ.7 mA) (TMP87C408/C808/P808) (Typ. 6 mA) (TMP87C408L/C808L/P808L)

◆ Two 16-bit Timer/Counters
- Timer, Eventcounter, Programmable pulse generator output, Pulse width measurement, External trigger timer, Window modes

◆ Time Base Timer
- Interrupt frequency types: 8 types (1 to 16384 Hz)

◆ Divider output function (frequency: 4 types)

◆ Watchdog Timer

◆ One 8-bit Serial Interface
- With 8 bytes transmit/receive data buffer
- Internal / external serial clock, and 4/8-bit mode

◆ 8-bit Successive approximate type A/D converter with sample and hold
- 6 analog inputs
- Conversion time: 23 μs / 92 μs at 8 MHz programmable selectable (TMP87C408/C808/P808)
  46 μs / 184 μs at 4 MHz programmable selectable (TMP87C408L/C808L/P808L)

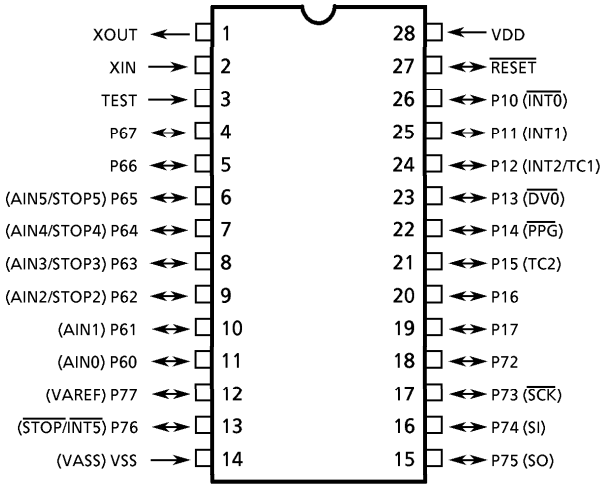
◆ Two Power saving operating modes
- STOP mode: Oscillation stops. Battery/Capacitor back-up
  Port output hold/high-impedance
- IDLE mode : CPU stops, and Peripherals operate using high-frequency clock. Release by interrupts.

◆ Operating voltage : 2.7 to 5.5 V at 4.2 MHz/4.5 to 5.5 V at 8 MHz (TMP87C408/C808/P808)
  1.8 to 4.0 V at 4.2 MHz (TMP87C408L/C808L/P808L)

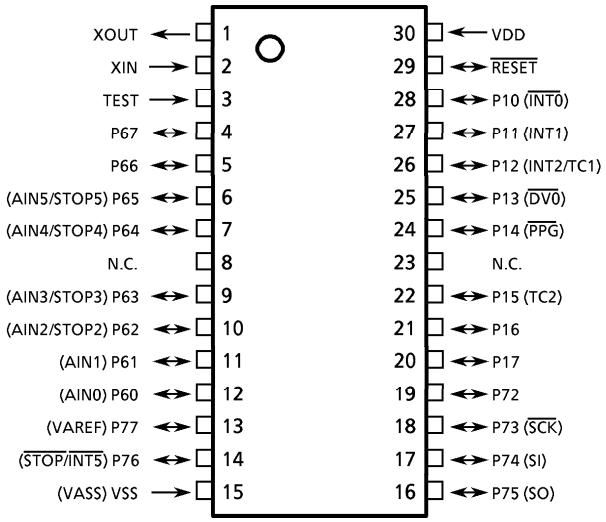
◆ Emulation pod : BM87C408M0A

Pin Assignments (Top View)

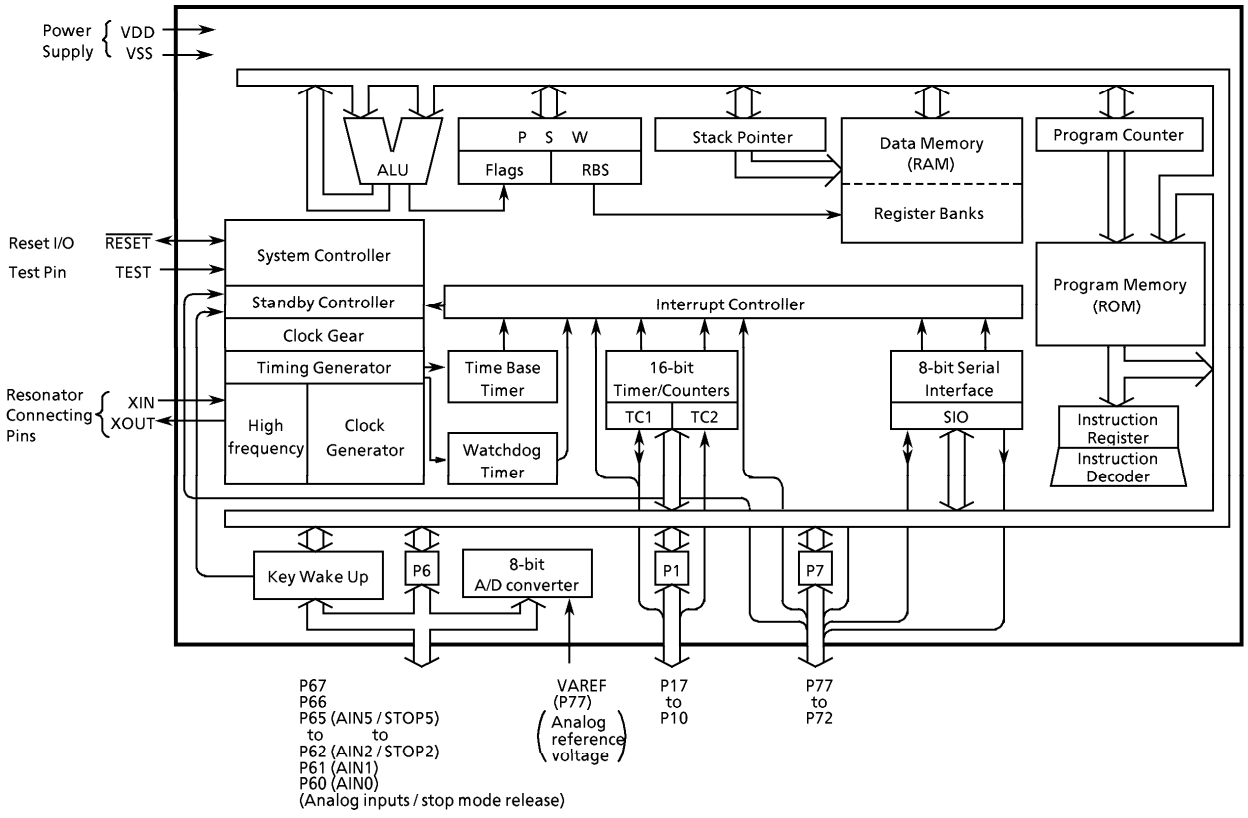
P-SOP28-450-1.27 / P-SDIP28-400-1.78



P-SOP30-56-0.65



Block Diagram



Pin Function

Pin Name	Input / Output	Function	
P17, P16	I/O	8-bit programmable input/output ports (tri-states) Each bit of these ports can be individually configured as an input or an output under software control. When used as an external interrupt input or a timer counter input, the input mode is configured. When used as a divider output or a PPG output, the latch must be set to "1" and the output mode is configured.	
P15 (TC2)	I/O (Input)		Timer/Counter 2 input
P14 ($\overline{\text{PPG}}$)	I/O (Output)		Programmable pulse generator output
P13 ($\overline{\text{DVO}}$)			Divider output
P12 (INT2 / TC1)	I/O (Input)		External interrupt input 2 or Timer/Counter 1 input
P11 (INT1)			External interrupt input 1
P10 ($\overline{\text{INT0}}$)			External interrupt input 0
P67, P66	I/O (Input)	8-bit programmable input/output port (tri-states). Each bit of the port can be individually configured as an input or an output under software control. When used as an analog input or stop mode release input , the input mode is configured.	
P65 (AIN5 / STOP5)			A/D converter analog inputs / Stop mode release inputs
P64 (AIN4 / STOP4)			
P63 (AIN3 / STOP3)			
P62 (AIN2 / STOP2)			
P61 (AIN1)			A/D converter analog inputs
P60 (AIN0)			
P77 (VAREF)	I/O (Output)	6-bit programmable input/output port (tri-states). Each bit of these ports can be individually configured as an input or an output under software control. When used as an external interrupt input or a serial interface input pin, the input mode is configured. When used as a serial interface output pin, the latch must be set to "1" and the output mode is configured.	Analog reference power supply
P76 ($\overline{\text{STOP}}$/$\overline{\text{INT5}}$)			STOP mode release input/External interrupt 5 input
P75 (SO)	I/O (Output)		SIO serial data output
P74 (SI)	I/O (Input)		SIO serial data input
P73 ($\overline{\text{SCK}}$)	I/O (I/O)		SIO serial clock input/output
P72	I/O		
XIN, XOUT	Input, Output	Resonator connecting pins for clock. For inputting external clock, XIN is used and XOUT is opened.	
$\overline{\text{RESET}}$	I/O	Reset signal input or watchdog timer output/address-trap-reset output/system-clock-reset output.	
TEST	Input	Test pin for outgoing test. Be tied to low.	
VDD	Power Supply	2.7 to 5.5 V (TMP87C408/C808/P808), 1.8 to 4.0 V (TMP87C408L/C808L/P808L)	
VSS (VASS)		0 V (GND)	Analog reference GND

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, the data memory, and the reset circuit.

1.1 Memory Address Map

The TLCS-870 Series is capable of addressing 64 Kbytes of memory. Figure 1-1 shows the memory address maps of the 87C408/808/408L/808L. 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 RAM address space.

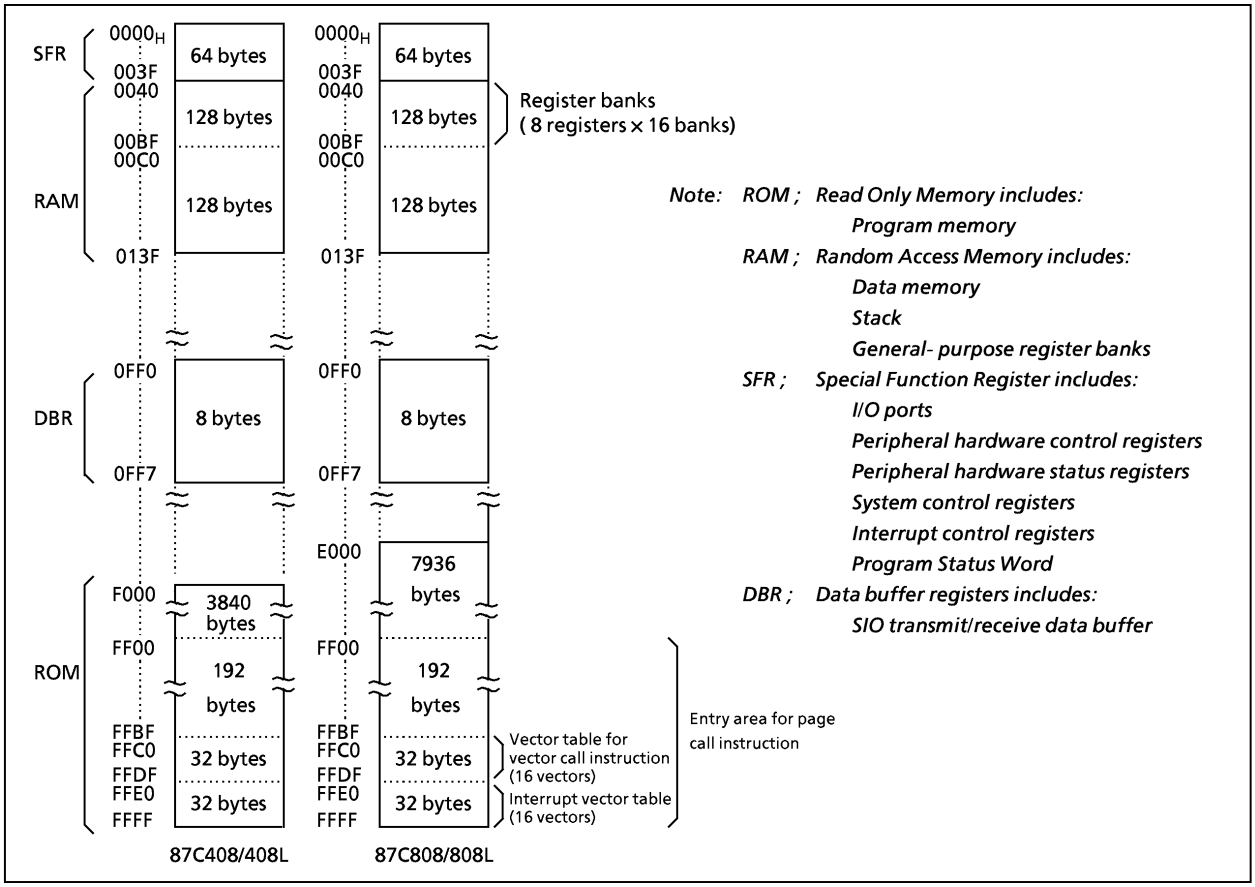


Figure 1-1. Memory Address Map

Electrical Characteristics

(1) 87C408/808

Absolute Maximum Ratings

(V_{SS} = 0 V)

Parameter		Symbol	Conditions		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)	IOL	I_{OUT1}	P1, P6		3.2	mA
		I_{OUT2}	P7 (Middle current port)		15	mA
	IOH	I_{OUT3}	P1, P6, P7		– 1.8	mA
Output Current (Total)	IOL	Σ I_{OUT1}	P1, P6		50	mA
		Σ I_{OUT2}	P7 (Middle current port)		60	mA
	IOH	Σ I_{OUT3}	P1, P6, P7		30	mA
Power Dissipation [Topr = 70°C]		PD		SDIP	300	mW
				SOP	180	
Input Current		I_{IN1}	P1, P6, P7		1.0	mA
		I_{IN2}			– 1.0	
Soldering Temperature (time)		Tsld			260 (10 s)	°C
Storage Temperature		Tstg			– 55 to 125	°C
Operating Temperature		Topr			– 30 to 70	°C

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 Conditions

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 8 MHz	NORMAL mode	4.5	5.5	V
				IDLE mode			
			fc = 4.2 MHz	NORMAL mode	2.7		
				IDLE mode			
			STOP mode		2.0		
Input High Voltage	V_{IH1}	Except hysteresis input	$V_{DD} \geqq 4.5$ V		$V_{DD} \times 0.70$	V_{DD}	V
	V_{IH2}	Hysteresis input			$V_{DD} \times 0.75$		
	V_{IH3}		2.7 V $\leqq V_{DD} <$ 4.5 V		$V_{DD} \times 0.90$		
Input Low Voltage	V_{IL1}	Except hysteresis input	$V_{DD} \geqq 4.5$ V		0	$V_{DD} \times 0.30$	V
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
	V_{IL3}		2.7 V $\leqq V_{DD} <$ 4.5 V			$V_{DD} \times 0.10$	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V		1.0	8.0	MHz
			V_{DD} = 2.7 to 5.5 V			4.2	

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 fc: Supply voltage range is specified in NORMAL mode and IDLE mode.

Note 3: Minimum of clock frequency: 1 MHz $\leqq$ fcgck

D.C. Characteristics

(V_{SS} = 0 V, Topr = – 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	–	2	μA
	I_{IN2}	Tri-state ports							
	I_{IN3}	$\overline{RESET}$, STOPi							
Input Resistance	R_{IN1}	TEST				30	70	150	kΩ
	R_{IN2}	$\overline{RESET}$				100	220	450	
	R_{IN3}	STOPi	i = 2 to 5			30	70	150	
Output Leakl Current	I_{LO}	Tri-state ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V / 0V			–2	–	2	μA
Output High Voltage	V_{OH2}	Tri-state ports	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA			4.1	–	–	V
Output Low Voltage	V_{OL}	Except XOUT and P7	V_{DD} = 4.5V, I_{OL} = 1.6 mA			–	–	0.4	V
Output Low Current	I_{OL3}	P7	V_{DD} = 4.5 V, V_{OL} = 1.0 V			–	7	–	mA
Supply Current in NORMAL mode	I_{DD}		V_{DD} = 5.5 V fc = 8 MHz V_{IN} = 5.3 V / 0.2V	fcgck	fc	–	6.5	10	mA
					fc/2	–	4.0	6.4	
					fc/4	–	2.6	4.7	
					fc/8	–	1.9	3.9	
Supply Current in IDLE mode				fcgck	fc	–	3.3	5.0	
					fc/2	–	2.4	3.9	
					fc/4	–	1.9	3.5	
					fc/8	–	1.6	3.3	
Supply Current in NORMAL mode			V_{DD} = 3.0 V fc = 4.19 MHz V_{IN} = 2.8 V / 0.2V	fcgck	fc	–	1.5	2.5	
					fc/2	–	0.85	1.6	
					fc/4	–	0.6	1.2	
Supply Current in IDLE mode				fcgck	fc	–	0.8	1.4	
					fc/2	–	0.55	1.1	
					fc/4	–	0.45	0.9	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V / 0.2 V			–	0.5	10	μA

Note 1: Typical values show those at Topr = 25°C, VDD = 5 V.
Note 2: Input Current I_{IN1}, I_{IN3}: The current through resistor is not included, when the input resistor (pull-up or pull-down) is contained.
Note 3: I_{DD} ; Except for I_{REF}

A/D 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}		2.7	–	V_{DD}	V
	V_{ASS}		V_{SS}			
Analog Input Voltage Range	V_{AIN}		V_{ASS}	–	V_{AREF}	V
Analog Reference Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} (V_{SS}) = 0.0 V	–	0.8	1.0	mA
Nonlinearity Error		V_{DD} = 5.0 V V_{AREF} = 5.000 V V_{ASS} (V_{SS}) = 0.000 V or V_{DD} = 2.7 V V_{AREF} = 2.700 V V_{ASS} (V_{SS}) = 0.000 V	–	–	± 1	LSB
Zero Point Error			–	–	± 1	
Full Scale Error			–	–	± 1	
Total Error			–	–	± 2	

Note: Quantizing error is not contained in those errors.

TMP87C408DM

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Nonlinearity Error		V_{DD} = 2.7 V V_{AREF} = 2.700 V V_{ASS} (V_{SS}) = 0.000 V	–	–	± 1	LSB
Zero Point Error			–	–	± 3	
Full Scale Error			–	–	± 3	
Total Error			–	–	± 4	

Note: For the TMP87C408, the guaranteed value for A/D conversion accuracy is different when V_{DD} = 2.7 V.

A.C. Characteristics (I)

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

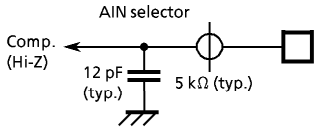
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	In NORMAL mode	0.5	–	4	μs
		In IDLE mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation	50	–	–	ns
Low Level Clock Pulse Width	t_{WCL}	fc = 8 MHz (XIN input)				
A/D Conversion Time	t_{ADC}	ACK = 0	–	46	–	tcy
		ACK = 1		184		
A/D Sampling Time	t_{AIN}		–	4		

A.C. Characteristics (II)

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

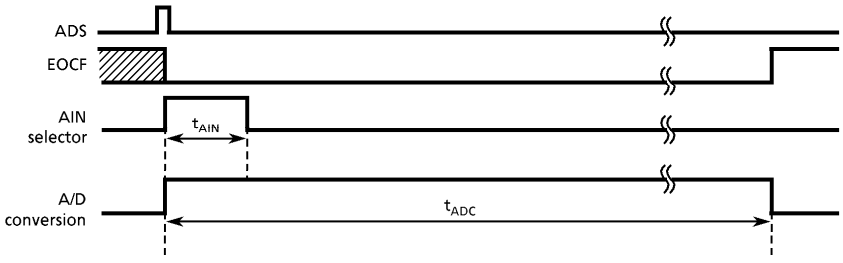
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	In NORMAL mode	0.95	–	4	μs
		In IDLE mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation	110	–	–	ns
Low Level Clock Pulse Width	t_{WCL}	fc = 4.2 MHz				
A/D Conversion Time	t_{ADC}	ACK = 0	–	46	–	tcy
		ACK = 1		184		
A/D Sampling Time	t_{AIN}		–	4		

Note: A/D conversion timing:
Internal circuit for AIN0 to 5



※ To keep the same level of an analog input during t_{AIN} is necessary for charging the electron to the sample hold circuit.

A/D conversion timing



Recommended Oscillating Conditions (Ⅰ)

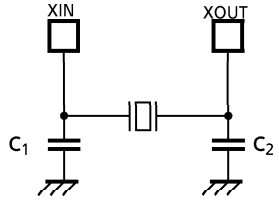
(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator		Recommended Conditions C_1	Recommended Conditions C_2
High-frequency Oscillation	Ceramic Resonator	8 MHz (VDD = 4.5 to 5.5 V)	KYOCERA	KBR8.0M	30 pF	30 pF
			MURATA	CSAC8.00MT	30 pF	30 pF
			MURATA	CSA8.00MTZ CST8.00MTW CSTS8.00MT	—	—
		4.19 MHz (VDD = 2.7 to 5.5 V)	MURATA	CSA4.19MG	30 pF	30 pF
			MURATA	CST4.19MGW	—	—
		4 MHz (VDD = 2.7 to 5.5 V)	KYOCERA	KBR4.0MS	30 pF	30 pF
	Crystal Oscillator	8 MHz (VDD = 4.5 to 5.5 V)	TOYOCOM	210B 8.0000	20 pF	20 pF
		4 MHz (VDD = 2.7 to 5.5 V)	TOYOCOM	204B 4.000		

Recommended Oscillating Conditions (Ⅱ)

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

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator		Recommended Conditions C_1	Recommended Conditions C_2
High-frequency Oscillation	Ceramic Resonator	4.19 MHz (VDD = 2.7 to 5.5 V)	MURATA	CSA4.19MG	30 pF	30 pF
			MURATA	CST4.19MGW	—	—
		4 MHz (VDD = 2.7 to 5.5 V)	MURATA	CSA4.00MG	30 pF	30 pF
				CSA4.00MGC	—	—
			MURATA	CST4.00MGW CSTC4.00MG	—	—
			MURATA	CSTCS4.00MG	—	—



(1) High-frequency Oscillation

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

Electrical Characteristics

(1) 87C408L/808L

Absolute Maximum Ratings

(V_{SS} = 0 V)

Parameter		Symbol	Conditions		Ratings	Unit
Supply Voltage		V_{DD}			– 0.3 to 5.5	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)	IOL	I_{OUT1}	P1, P6		3.2	mA
		I_{OUT2}	P7 (Middle current port)		15	mA
	IOH	I_{OUT3}	P1, P6, P7		– 1.8	mA
Output Current (Total)	IOL	Σ I_{OUT1}	P1, P6		50	mA
		Σ I_{OUT2}	P7 (Middle current port)		60	mA
	IOH	Σ I_{OUT3}	P1, P6, P7		30	mA
Power Dissipation [Topr = 70°C]		PD		SDIP	300	mW
				SOP	180	
Input Current		I_{IN1}	P1, P6, P7		1.0	mA
		I_{IN2}			– 1.0	
Soldering Temperature (time)		Tsld			260 (10 s)	°C
Storage Temperature		Tstg			– 55 to 125	°C
Operating Temperature		Topr			– 30 to 70	°C

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 Conditions

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 4.2 MHz	NORMAL mode	1.8	4.0	V
				IDLE mode			
			STOP mode				
Input High Voltage	V_{IH}				V_{DD} × 0.90	V_{DD}	V
Input Low Voltage	V_{IL}				0	V_{DD} × 0.10	V
Clock Frequency	fc	XIN, XOUT	V_{DD} = 1.8 to 4.0 V		1.0	4.2	MHz

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 fc: Supply voltage range is specified in NORMAL mode and IDLE mode.

Note 3: Minimum of clock frequency: 1 MHz ≦ fcgck

D.C. Characteristics

(V_{SS} = 0 V, Topr = – 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} = 4.0 V V_{IN} = 4.0 V / 0 V			–2	–	2	μA
	I_{IN2}	Tri-state ports							
	I_{IN3}	RESET, STOP							
Input Resistance	R_{IN1}	TEST				30	70	150	kΩ
	R_{IN2}	RESET				100	220	450	
	R_{IN3}	STOPi	i = 2 to 5			30	130	150	
Output Leakl Current	I_{LO}	Tri-state ports	V_{DD} = 4.0 V, V_{OUT} = 4.0 V / 0V			–2	–	2	μA
Output High Voltage	V_{OH2}	Tri-state ports	V_{DD} = 4.0 V, I_{OH} = – 0.5 mA			3.6	–	–	V
Output Low Voltage	V_{OL}	Except XOUT and P7	V_{DD} = 4.0V, I_{OL} = 1.3 mA			–	–	0.4	V
Output Low Current	I_{OL3}	P7	V_{DD} = 4.0 V, V_{OL} = 1.0 V			–	6	–	mA
Supply Current in NORMAL mode	I_{DD}			fcgck	fc	–	2.25	3.6	mA
					fc/2	–	1.35	2.5	
					fc/4	–	0.9	1.9	
Supply Current in IDLE mode				fcgck	fc	–	1.2	1.9	
					fc/2	–	0.9	1.7	
					fc/4	–	0.7	1.5	
Supply Current in NORMAL mode				fcgck	fc	–	1.5	2.5	
					fc/2	–	0.85	1.6	
					fc/4	–	0.6	1.2	
Supply Current in IDLE mode				fcgck	fc	–	0.8	1.4	
					fc/2	–	0.55	1.1	
					fc/4	–	0.45	0.9	
Supply Current in NORMAL mode				fcgck	fc	–	0.9	1.3	
					fc/2	–	0.5	0.8	
					fc/4	–	0.3	0.45	
Supply Current in IDLE mode				fcgck	fc	–	0.35	0.5	
					fc/2	–	0.23	0.35	
					fc/4	–	0.17	0.26	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V / 0.2 V			–	0.5		μA

Note 1: Typical values show those at Topr = 25°C, VDD = 4 V.

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

Note3: I_{DD} ; Except for I_{REF}

A/D Conversion Characteristics (I)

(V_{SS} = 0V, V_{DD} = 1.8 to 4.0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		1.8	–	V_{DD}	V
	V_{ASS}		V_{SS}			
Analog Input Voltage Range	V_{AIN}		V_{ASS}	–	V_{AREF}	V
Nonlinearity Error		1.8 V ≦ V_{AREF} < 2.7 V V_{AREF} ≦ V_{DD} ≦ 4.0 V_{ASS} (V_{SS}) = 0.000 V ACK = 1 (Note2)	–	–	± 2	LSB
Zero Point Error			–	–	± 2	
Full Scale Error			–	–	± 2	
Total Error			–	–	± 4	

Note1: Quantizing error is not contained in those errors.
Note2: ACK ; bit5 of ADCCR (#000E_H) . conversion time = 184 tcy (175.6 μs / at fcgck = 4.19 MHz)

A/D Conversion Characteristics (II)

(V_{SS} = 0V, V_{DD} = 2.7 to 4.0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		2.7	–	V_{DD}	V
	V_{ASS}		V_{SS}			
Analog Input Voltage Range	V_{AIN}		V_{ASS}	–	V_{AREF}	V
Analog Reference Current	I_{REF}	V_{AREF} = 4.0V, V_{ASS} (V_{SS}) = 0.0V	–	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 4.0 V V_{AREF} = 4.000 V V_{ASS} (V_{SS}) = 0.000 V or V_{DD} = 2.7 V V_{AREF} = 2.700 V V_{ASS} (V_{SS}) = 0.000 V	–	–	± 1	LSB
Zero Point Error			–	–	± 1	
Full Scale Error			–	–	± 1	
Total Error			–	–	± 2	

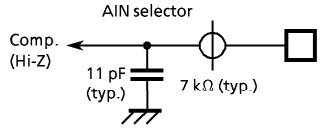
Note: Quantizing error is not contained in those errors.

A.C. Characteristics

(V_{SS} = 0 V, V_{DD} = 1.8 to 4.0 V, Topr = – 30 to 70°C)

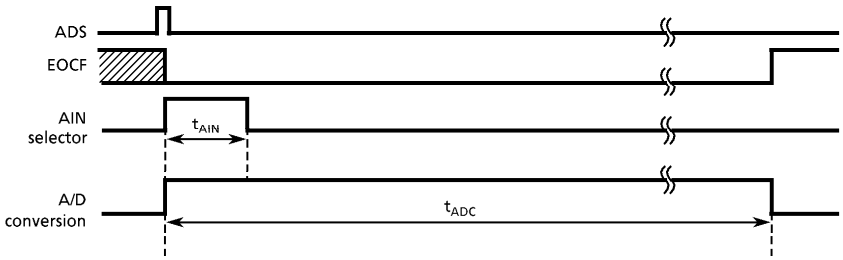
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	In NORMAL mode	0.95	–	4	μs
		In IDLE mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation	110	–	–	ns
Low Level Clock Pulse Width	t_{WCL}	fc = 4.2 MHz				
A/D Conversion Time	t_{ADC}	ACK = 0	–	46	–	tcy
		ACK = 1		184		
A/D Sampling Time	t_{AIN}		–	4		

Note: A/D conversion timing:
Internal circuit for AIN0 to 5



※ To keep the same level of an analog input during t_{AIN} is necessary for charging the electron to the sample hold circuit.

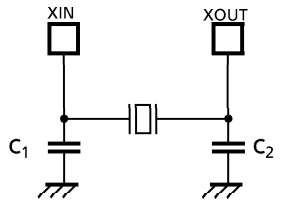
A/D conversion timing



Recommended Oscillating Conditions

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator		Recommended Conditions C_1	Recommended Conditions C_2
High-frequency Oscillation	Ceramic Resonator	4.19 MHz (VDD = 2.7 to 5.5 V)	MURATA	CSA4.19MG	30 pF	30 pF
			MURATA	CST4.19MGW	—	—
		4 MHz (VDD = 2.7 to 5.5 V)	MURATA	CSA4.00MG	30 pF	30 pF
				CSA4.00MGC	—	—
			MURATA	CST4.00MGW CSTC4.00MG	—	—
			MURATA	CSTCS4.00MG	—	—



(1) High-frequency Oscillation

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