CMOS 8-bit Microcontroller

TMP87C409BN, TMP87C409BM, TMP87C809BN, TMP87C809BM

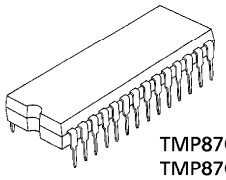
The TMP87C409B/809B are the high speed and high performance 8-bit single chip microcomputers. These MCU contain CPU core, ROM, RAM, input/output ports, three multi-function timer/counters, a 10-bit AD conveter, on a chip. The TMP87C409B/809B provide high current output capability for LED direct drive.

Product No.	ROM	RAM	Package	OTP MCU
TMP87C409BN	4 K × 8 bits	256 × 8 bits	P-SDIP28-400-1.78	TMP87P809N
TMP87C409BM			P-SOP28-450-1.27	TMP87P809M
TMP87C809BN	8 K × 8 bits		P-SDIP28-400-1.78	TMP87P809N
TMP87C809BM			P-SOP28-450-1.27	TMP87P809M

Features

- ◆ 8-bit single chip microcomputer TLCS-870 Series
- ◆ instruction execution time: 0.5 μs (at 8 MHz)
- ◆ 412 basic instruction
  - Multiplication and Division (8 bits × 8 bits, 16 bits ÷ 8 bits)
  - Bit manipulations (Set/Clear/Complement/Load/Store/Test/Exclusive or)
  - 16-bit data operations
  - 1-byte jump/subroutine-call (Short relative jump/Vector call)
- ◆ 11 interrupt sources (External: 4, Internal: 7)
  - All sources have independent latches each, and nested interrupt control is available.
  - 2 edge-selectable external interrupts with noise reject.
  - High-speed task switching by register bank changeover
- ◆ 3 Input/Output ports (22 pins)
  - High current output: 6 pins (Typ. 20 mA)
- ◆ 16-Bit Timer/Counter
  - Timer, Event counter modes

P-SDIP28-400-1.78



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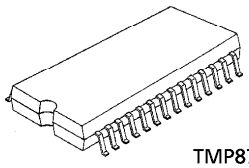

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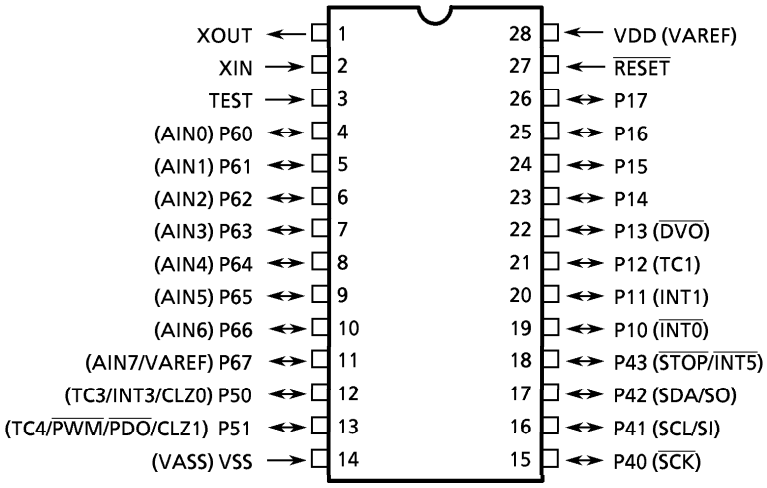
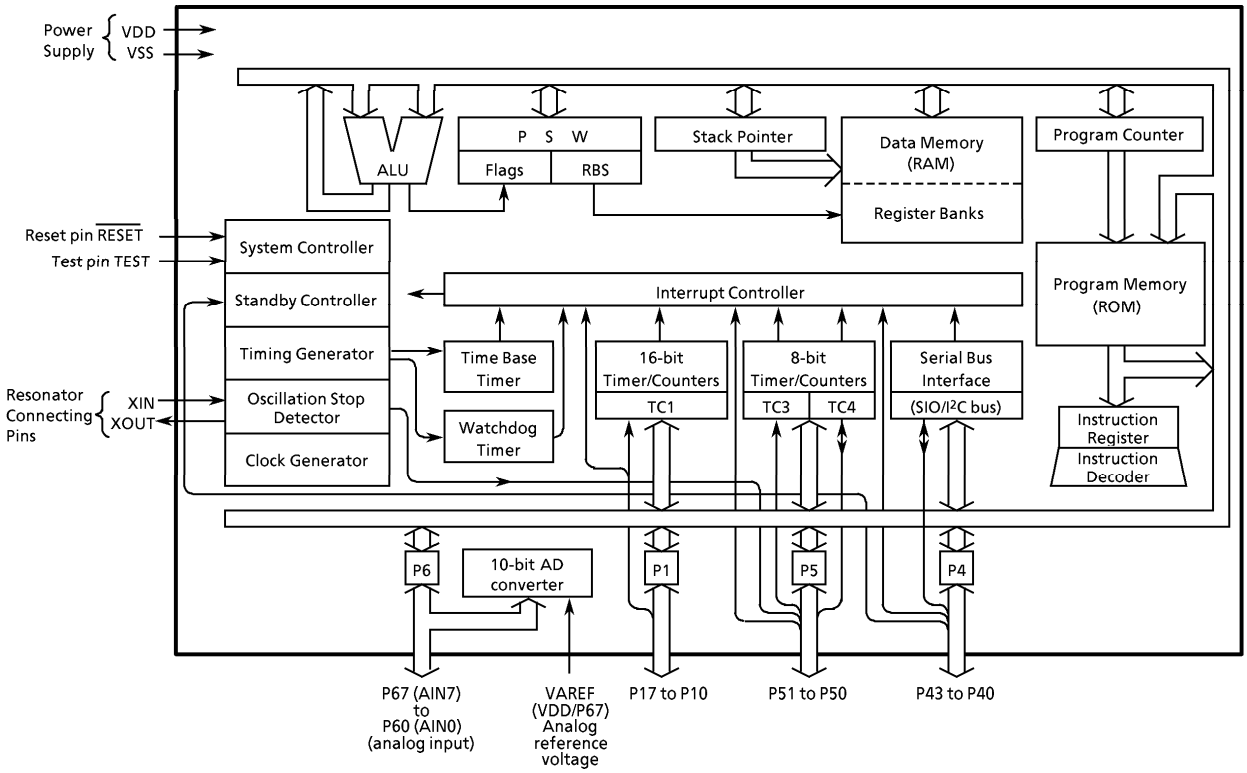
- ◆ Two 8-Bit Timer/Counters
  - Timer, Event counter, Capture (Pulse width/duty measurement), PWM output, Programmable divider output modes.
- ◆ Time Base Timer (Interrupt frequency: 1 Hz to 16 kHz)
- ◆ Divider output function (frequency: 1 kHz to 8 kHz)
- ◆ Watch dog Timer
- ◆ Serial bus Interface (SBI-ver. B)
  - I^2C bus, 8-bit SIO modes.
- ◆ 10-bit successive approximate type AD converter
  - 8 analog inputs
- ◆ Two Oscillation Stop Detector outputs (High-impedance output)
- ◆ 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.
- ◆ Wide operating voltage: 2.2 to 5.5 V at 4.2 MHz/4.5 to 5.5 V at 8 MHz
- ◆ Emulation Pod: BM87C809N0A

Pin Assignments (Top View)

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



Block Diagram



Pin Function

Pin Name	Input / Output	Function	
P17 to P14	I/O	8-bit programmable input/output ports (tri-state). Each bit of the port can be individually configured as an input or an output under software control. When used as an external input or a timer counter input, the input mode is configured. When used as an divider output, the latch must be set to "1".	
P13 ($\overline{DVO}$)	I/O (Output)		Divider output
P12 (TC1)	I/O (Input)		Timer/Counter 1 input
P11 (INT1)			External interrupt input 1
P10 ($\overline{INT0}$)			External interrupt input 0
P43 ($\overline{STOP}$/$\overline{INT5}$)	I/O (Input/Input)	4-bit input/output port with latch (high current output). When used as an input port, an I²C input/output or an external interrupt input the latch must be set to "1".	STOP mode release input/External interrupt 5 input
P42 (SDA/SO)	I/O (I/O/Output)		I²C bus serial data input/output or SIO serial data output
P41 (SCL/SI)	I/O (I/O/Input)		I²C bus serial clock input/output or SIO serial data input
P40 ($\overline{SCK}$)	I/O (I/O)		SIO serial clock input/output
P51 (TC4/$\overline{PWM}$/ $\overline{PDO}$/CLZ1)	I/O (Input/Output /Output/Output))	2-bit programmable input/output ports (tri-state, high current output). Each bit of the port can be individually configured as an input or an output under software control. When used as a timer counter input or an external interrupt input the input mode is configured. When used as a PWM/PDO output, the latch must be set to "1" and the output mode is configured. When used as a oscillation stop detector output, the output mode is configured.	Timer/counter 4 input or 8-bit PWM output or 8-bit PDO output or oscillation stop detector output 1
P50 (TC3/INT3/CLZ0)	I/O (Input/Input /Output)		Timer/counter 3 input or external interrupt input 3 or oscillation stop detector output 0
P67 (AIN7/VAREF)	I/O (Input/Input)	8-bit programmable input/output ports (tri-state). 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 an analog reference power supply, the input mode is configured.	AD converter analog input or analog reference power supply
P66 (AIN6) to P60 (AIN0)	I/O (Input)		AD converter analog inputs
XIN, XOUT	Input, Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opend.	
$\overline{RESET}$	Input	Reset signal input.	
TEST	Input	Test pint for out-going test. Be tied to low.	
VDD (VAREF)	Power Supply	+ 5 V	Analog reference power supply
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 TMP87C409B/809B are capable of addressing 64 Kbytes of memory. Figure 1-1 shows the memory address maps of the TMP87C409B/809B. In the TMP87C409B/809B the memory is organized 3 address spaces (ROM, RAM and SFR). It uses a memory mapped I/O system, and all I/O registers are mapped in the SFR address spaces. There are 16 banks of general-purpose registers. The register banks are also assigned to the RAM address space.

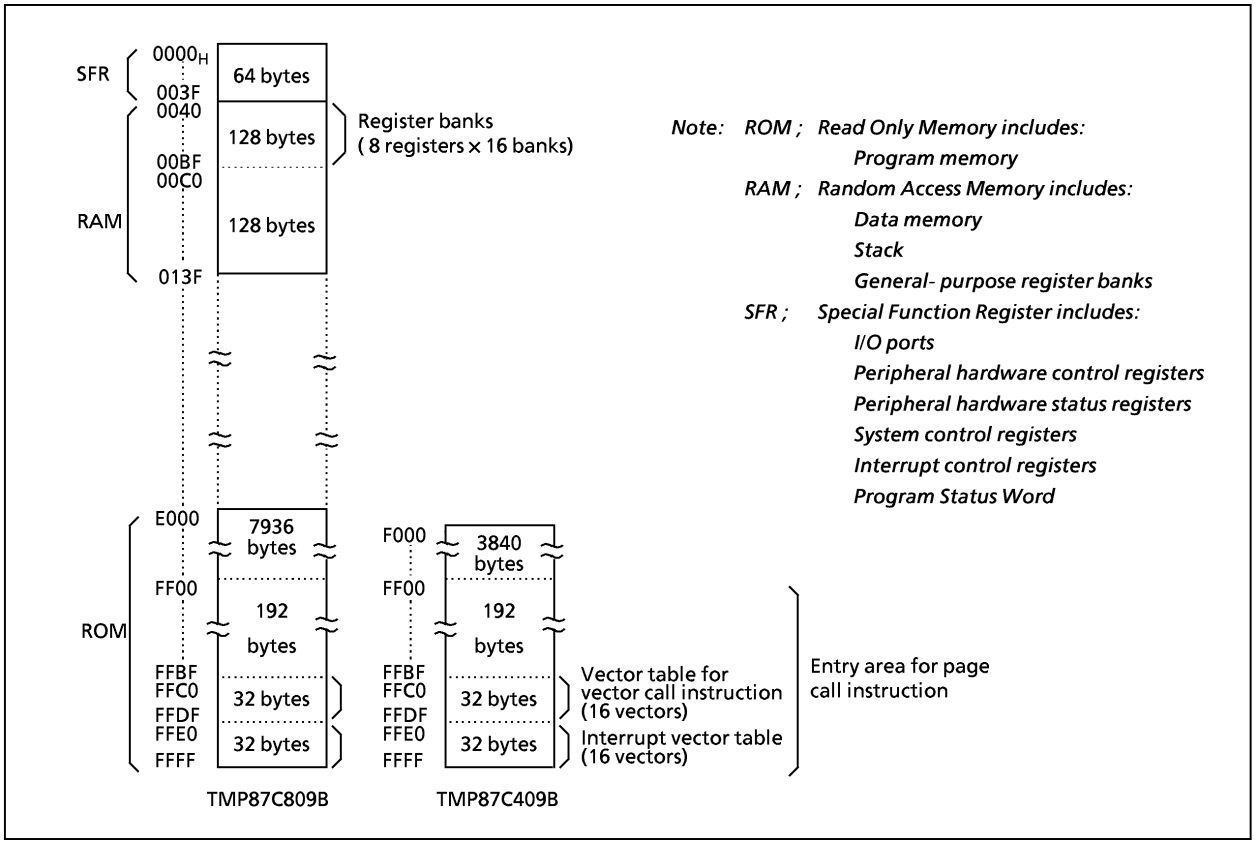


Figure 1-1. Memory address map

Electrical Characteristics

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

Parameter		Symbol	Condition		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_{OUT1}	Ports P1, P5, P6, XOUT		– 0.3 to V_{DD} + 0.3	
		V_{OUT2}	Port P4		– 0.3 to 5.5	V
Output Current (Per 1 pin)	IOL	I_{OUT1}	Ports P1, P6		3.2	mA
		I_{OUT2}	Ports P4, P5		30	
	IOH	I_{OUT3}	Ports P1, P5, P6		– 1.8	
Output Current (Total)	IOL	ΣI_{OUT1}	Ports P1, P6		30	mA
		ΣI_{OUT2}	Ports P4, P5		80	
	IOH	ΣI_{OUT3}	Ports P1, P5, P6		30	
Power Dissipation [Topr = 70°C]		PD		SDIP	300	mW
				SOP	180	
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	2.2		
				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}		$V_{DD} < 4.5$ 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}		$V_{DD} < 4.5$ V			$V_{DD} \times 0.10$	
Clock Frequency	fc	XIN, XOUT	VDD = 4.5 to 5.5 V		1.0	8.0	MHz
			V_{DD} = 2.2 V to 5.5 V			4.2	

Note1: 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.

Note2: Clock frequency fc: Supply voltage range is specified in NORMAL mode and IDLE mode.

DC Characteristics

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions	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}	Tri-state ports					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistance	R_{IN2}	$\overline{RESET}$		100	220	450	kΩ
Output Leakage Current	I_{LO}	Tri-state ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V / 0 V	– 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_{OL1}	Except XOUT, P4 and P5	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	–	–	0.4	
Output Low current	I_{OL3}	P4, P5	V_{DD} = 4.5 V, V_{OL} = 1.0 V	–	20	–	mA
Supply Current in NORMAL mode	I_{DD}		V_{DD} = 5.5 V fc = 8 MHz V_{IN} = 5.3 V / 0.2 V		8	14	mA
Supply Current in IDLE mode					4	6	
Supply Current in NORAML mode			V_{DD} = 3.0 V fc = 4.2 MHz V_{IN} = 2.8V / 0.2 V		2.5	3.5	mA
Supply Current in IDLE mode					1.5	2.0	
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 , V_{DD} = 5 V.

Note 2: Input Current IIN1, IIN3,: The current through resistor is not included, when the input resistor (pull-up or pull-down) is contained.

AD Conversion Characteristics

(V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		2.2	—	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	—	0.5	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} = 2.2 V V_{AREF} = 2.200 V V_{ASS} (V_{SS}) = 0.000 V	—	—	± 2	LSB
Zero Point Error			—	—	± 2	
Full Scale Error			—	—	± 2	
Total Error			—	—	± 4	

Note: Quantizing error is not contained in those errors.

Oscillation Stop Detector Characteristics

(V_{SS} = 0V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Detection time	T_{CLZ}	VDD = 2.2 V to 5.5 V (fc = 2 MHz to 4.2 MHz) VDD = 4.5 V to 5.5 (fc = 8 MHz)	2	20	400	μs

AC Characteristics

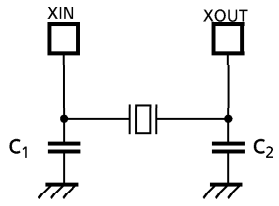
(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	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				

Recommended Oscillating Conditions

(V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator
High-frequency Oscillation	Ceramic Resonator	8 MHz (4.5 V to 5.5 V)	MURATA CSTCC8M00G53-R0
			MURATA CSTLS8M00G53-B0
		4 MHz (2.2 V to 5.5 V)	MURATA CSTCR4M00G53-R0
			MURATA CSTLS4M00G53-B0



(1) High-frequency Oscillation

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;http://www.murata.co.jp/search/index.html