#### CMOS 8-Bit Microcomputer

# TMP88CS43F

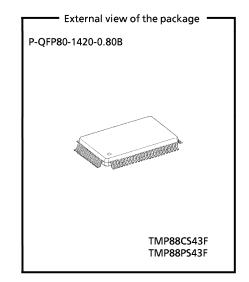
The TMP88CS43F is a high-speed, high-function 8-bit microcomputer built around the TLCS-870/X series CPU core and incorporating sine wave drive PMD (Programmable Motor Driver: PMD), as well as a 10-bit AD converter, multifunction timer/counters, and synchronous/asynchronous serial interfaces.

Product No.	ROM RAM		Package	Built-in OTP	
TMP88CS43F	64 Kbytes	2 K + 128 bytes	P-QFP80-1420-0.80B	TMP88PS43F (Note)	

Note : TMP88PS43F with OTP's RAM capacity is 4 K + 128 bytes. The capacity is not same as TMP88CS43F.

#### Features

- 8-bit single-chip microcomputer TLCS-870/X series
- Minimum instruction execution time: 0.20  $\mu$ s (when operating with 20.0 MHz)
- Fundamental machine instruction: 181 kinds, 842 instructions
- Interrupt sources 35 (6 external, 29 internal)
- Input/Output port: 71 pins
  - Large-current output: 24 pins (typ. 20 mA), capable of LED direct drive
- Programmable motor driver: 2 channels (PMD)
  - Sine wave drive circuit (built-in sine wave data-only RAM)
  - Rotor position detect function
  - Motor control timer and capture function
  - Overload protective function
  - Auto commutation, auto position detection start
- Watchdog Timer (WDT)
- Time Base Timer (TBT)
- Divider output function (DVO)
- 16-bit timer/counter: 2 channels (TC1, CTC)
  - TC1: Timer, external trigger timer, event counter, window mode, pulse width measurement, or PPG1 (Programmable Pulse) output
  - CTC: Timer, event counter, or PPG2 (Programmable Pulse) output

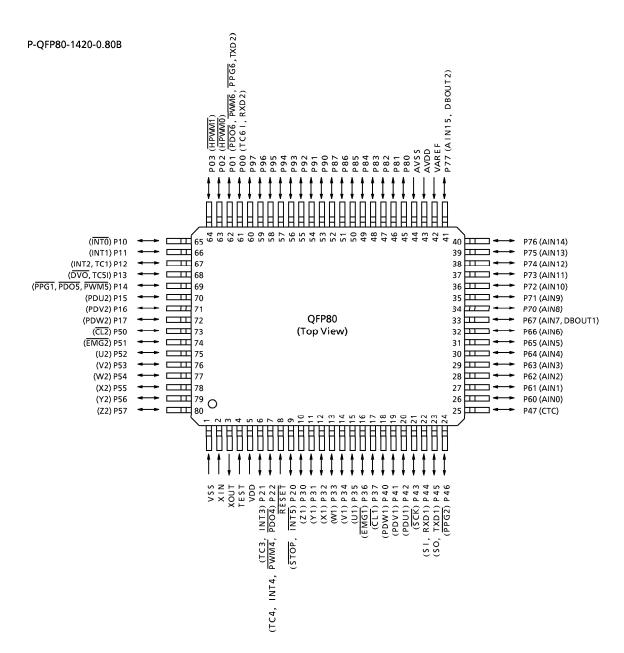


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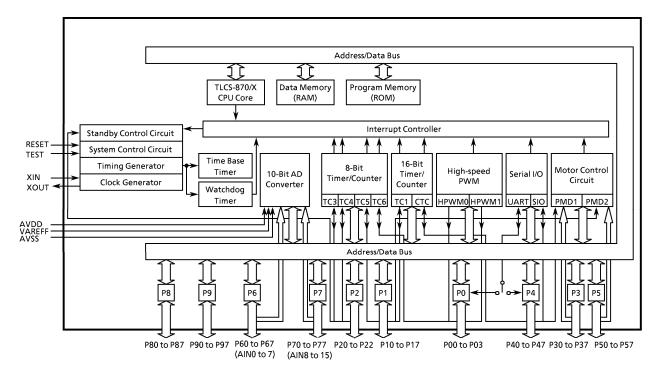
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- ♦ 8-bit timer/counter: 4 channels (TC3, TC4, TC5, TC6)
  - TC3: Timer, event counter, or capture
  - TC4: Timer, event counter, PDO (Programmable Divider Output), PWM (Pulse Width Modulation), or UART baud rate
  - TC5, TC6: Two channels can be cascaded for use as a 16-bit timer
    - Timer, event counter, PWM (Pulse Width Modulation), PPG (Programmable Pulse) output, or PDO (Programmable Divider Output)
- 10-bit successive approximation type AD converter (with sample-and-hold)
   Analog input: 16 channels
- Serial interface: Two channels (SIO, UART)
  - 8-bit SIO (synchronous): 1 channel
  - 8-bit UART (asynchronous): 1 channel (selectable pins to use)
- ◆ 8-bit high-speed PWM: 2 channels
- Low power dissipation mode
  - STOP mode: Operation halted (battery)
  - IDLE mode: CPU halted and only peripheral hardware operating, returned normal by an interrupt
- ◆ Operating voltage: 4.5 to 5.5 V (at 8 to 20 MHz)

## Pin Assignments (Top View)



## **Block Diagram**



# Pin Functions (1/3)

Pin Name	I/O	Function				
P00 (TC6I, RXD2)	l/O (input, input)	<ul> <li>4-bit programmable input/output port. (hysteresis input, tristate output/open-drain output)</li> </ul>	Timer/Counter input 6, UART input 2			
P01 (PDO6, PWM6, PPG6, TXD2)	l/O (output, output)	<ul> <li>Can be set for input or output mode bitwise.</li> <li>Can be set for tristate or open-drain output bitwise.</li> <li>When using as timer/counter or UART input, set these pins for input mode.</li> </ul>	Timer/Counter output 6 or PDO6, PWM6, PPG6, UART output 2			
P02 (HPWM0)	10 (111111)	• When using as timer/counter, UART, or PWM output,	High-speed PWM0 output			
P03 (HPWM1)	I/O (output)	set these pins for output mode.	High-speed PWM1 output			
P10 (INT0)	I/O (innut)	• 8-bit programmable input/output port.	External interrupt input 0			
P11 (INT1)	l/O (input)	<ul> <li>(hysteresis input, tristate output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>	External interrupt 1 input			
P12 (INT2, TC1)	l/O (input, input)	• When using as external interrupt, timer/counter, or position signal input, set these pins for input mode.	External interrupt 2 input or timer/counter 1 input			
P13 (TC5I, DVO)	l/O (input, output)	<ul> <li>When using as DVO output or PPG1 output of TC1, set these pins for output mode after setting the output latch to 1.</li> </ul>	Timer/Counter 5 input or divider output			
P14 (PDO5, PWM5, PPG1)	I/O (output, output, output)		Timer/Counter output or PDO5, PWM5, PPG1			
P15 (PDU2)			Motor control 2 position signal			
P16 (PDV2)	l/O (input)		input			
P17 (PDW2)			(U2, V2, W2 phases)			
P20 (INT5, STOP)	I/O	<ul> <li>3-bit input/output port. (hysteresis input, open-drain output)</li> </ul>	External interrupt 5 input, STOP mode exiting input			
P21 (TC3, INT3)	(input, input)	• When using these pins as timer/counter, external interrupt, or STOP mode exiting input, set the output latch to 1.	Timer/Counter 3 input or external interrupt 3 input			
P22 (TC4, INT4, PWM4, PDO4)	l/O (input, input output, output)		Timer/Counter 4 input or external interrupt 4 input, PWM4 output, PDO4 output			
P30 (Z1)		• 8-bit programmable input/output port.				
P31 (Y1)		<ul> <li>(hysteresis input, tristate output/open-drain output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>				
P32 (X1)	I/O (output)	• Can be set for tristate or open-drain output bitwise.	Motor control 1 output			
P33 (W1)		<ul> <li>Can directly drive LED with large current.</li> <li>When using motor control output, set these pins for</li> </ul>	(Z1, Y1, X1, W1, V1, U1 phases)			
P34 (V1)		output mode. Also, set the output latch to 1. • When using error detection/overload protective input,				
P35 (U1)		set these pins for input mode.				
P36 (EMG1)	l/O (input)		Motor control 1 error detection input			
P37 (CL1)	I/O (input)		Motor control 1 overload protective input			
P40 (PDW1)		• 8-bit programmable input/output port.	Motor control 1 position signal			
P41 (PDV1)	I/O (input)	<ul> <li>(hysteresis input, tristate output/open-drain output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>	input			
P42 (PDU1)		• Can be set for tristate or open-drain output bitwise.	(W1, V1, U1 phases)			
P43 (SCK)		<ul> <li>Can directly drive LED with large current.</li> <li>When using timer/counter, SIO, or position signal</li> </ul>	SIO clock input/output			
P44 (SI, RXD1)	l/O (input)	input, set these pins for input mode. • When using SIO, UART or output, set these pins for	SIO input, UART data input 1			
P45 (SO, TXD1)	I/O (output)	output mode. Also, set the output latch to 1.	SIO output, UART data output 1			
P46 (PPG2)	I/O (output)		Compare timer/counter output			
P47 (CTC)	I/O (input)		Compare timer/counter input			

# Pin Functions (2/3)

Pin Name	I/O	Function			
P50 (CL2)		<ul> <li>8-bit programmable input/output port. (hysteresis input, tristate output/open-drain output)</li> </ul>	Motor control 2 overload protective input		
P51 (EMG2)	l/O (input)	<ul> <li>Can be set for input or output mode bitwise.</li> <li>Can be set for tristate or open-drain output bitwise.</li> <li>Can directly drive LED with large current.</li> </ul>	Motor control 2 error detection input		
P52 (U2)		• When using motor control output, set these pins for			
P53 (V2)	]	<ul> <li>output mode. Also, set the output latch to 1.</li> <li>When using error detection/overload protective input,</li> </ul>			
P54 (W2)		set these pins for input mode.	Motor control 2 output		
P55 (X2)	I/O (output)		(Z2, Y2, X2, W2, V2, U2 phases)		
P56 (Y2)	]				
P57 (Z2)					
P60 (AIN0)		<ul> <li>8-bit programmable input/output port.</li> </ul>			
P61 (AIN1)		<ul> <li>(tristate output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>			
P62 (AIN2)	]	• When using as analog input, set these pins for input			
P63 (AIN3)	l/O (input)	<ul><li>mode. Also, set the output latch to 0.</li><li>When using motor control output, set these pins for</li></ul>	AD converter analog input		
P64 (AIN4)		output mode. Also, set the output latch to 1.			
P65 (AIN5)	]				
P66 (AIN6)					
P67 (AIN7, DBOUT1)	l/O (input, output)		AD converter analog input, Motor control 1 output		
P70 (AIN8)		• 8-bit programmable input/output port.			
P71 (AIN9)	1	(tristate output) Can be set for input or output mode bitwise.			
P72 (AIN10)	1	• When using as analog input, set these pins for input			
P73 (AIN11)	l/O (input)	<ul><li>mode. Also, set the output latch to 0.</li><li>When using motor control output, set these pins for</li></ul>	AD converter analog input		
P74 (AIN12)	]	output mode. Also, set the output latch to 1.			
P75 (AIN13)	]				
P76 (AIN14)					
P77 (AIN15, DBOUT2)	l/O (input, output)		AD converter analog input, Motor control 2 output		
P80		<ul> <li>8-bit programmable input/output port.</li> </ul>			
P81	]	<ul> <li>(tristate output/open-drain output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>			
P82		• Can be set for tristate or open-drain output bitwise.			
P83	] //o		_		
P84					
P85					
P86					
P87					
P90		<ul> <li>8-bit programmable input/output port.</li> </ul>			
P91		<ul> <li>(tristate output/open-drain output)</li> <li>Can be set for input or output mode bitwise.</li> </ul>			
P92		• Can be set for tristate or open-drain output bitwise.			
P93	] //o		_		
P94					
P95					
P96					
P97					

# Pin Functions (3/3)

Pin Name	I/O	Function		
TEST	Input	Used for shipping test. Fix this pin low.		
RESET	Input	Reset signal input		
XIN	Input	High-frequency resonator connecting pins.		
XOUT	Output	When using external clock input, feed it to XIN and leave XOUT open.		
VSS		GND pin		
VDD	1	Power supply		
AVSS	Input	GND for AD conversion circuit		
AVDD	1	Power supply for AD conversion circuit		
VAREF		Analog reference voltage for AD conversion		

#### **Functional Description**

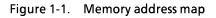
### 1. Functions of the CPU Core

The CPU core consists mainly of the CPU, system clock control circuit, and interrupt control circuit. This chapter describes the CPU core, program memory, data memory, and reset circuit of the TMP88CS43.

### 1.1 Memory Address Map

The memory of the TMP88CS43 consists of four blocks: ROM, RAM, SFR (Special Function Registers), and DBR (Data Buffer Registers), which are mapped into one 1-Mbyte address space. The general-purpose registers consist of 16 banks, which are mapped into the RAM address space. Figure 1-1 shows a memory address map of the TMP88CS43.

		C 00000			
	SFR	{00000 <sub>H</sub> {0003F <sub>H</sub>	64 bytes	Special Function	on Register
	RAM (128 bytes)	00040 <sub>H</sub>	128 bytes	General-purpo (8 registers × 1	ose Register Bank 6 banks)
	RAM (2 Kbytes)	000C0 <sub>H</sub>	2048 bytes	Random-Acce	ss Memory
	DBR	01F80 <sub>H</sub>	128 bytes	Data Buffer Re (peripheral ha status register	rdware control register/
	ROM	04000 <sub>H</sub>	65280 bytes	Program Mem	ory
	(64 Kbytes)	FFF00 <sub>H</sub>	64 bytes	Interrupt Vect	or Table
		FFF40 <sub>H</sub> FFF7F <sub>H</sub>	64 bytes	Vector Table f Vector Call Ins	
		FFF80 <sub>H</sub>	128 bytes	B bytes Interrupt Vector Table	
			TMP88CS43		
Note: ROM: Read-Only Program ( Vector tal RAM: Random Ad Data men Stack	nemory ble ccess Memory	Input Perip Perip Syste	Function Registers /output port heral hardware co heral hardware sta m control register rupt control registe	ntrol register atus register	Data Buffer Registers Input/output port Peripheral hardware control register Peripheral hardware status register
	ourpose register b		am status word	<b>U</b> 1	



## **Electrical Characteristics**

Absolute Maximum Ra	tings	$(V_{SS} = 0V)$			
Parameter	Symbol	Pin	Standard	Unit	Remark
Power Supply Voltage	V <sub>DD</sub>		– 0.3 to 6.5		
Input Voltage	V <sub>IN</sub>		– 0.3 to V <sub>DD</sub> + 0.3	V V	
Output Voltage	V <sub>OUT</sub>		– 0.3 to V <sub>DD</sub> + 0.3		
	I <sub>ОН</sub>	P0, 1, 3, 4, 5, 6, 7, 8, 9	- 1.8		
Output Current	I <sub>OL1</sub>	P0, 1, 2, 6, 7, 8, 9	3.2		
	I <sub>OL2</sub>	P3, P4, P5	30		
	Σ Ι <sub>ΟUT1</sub>	P0, 1, 2, 6, 7, 8, 9	60		Total of all ports except large- current ports
Marco da la completa	Σ Ι <sub>Ουτ2</sub>	P3	60	mA	Total of 8 pins of large-current ports P30 to 7
Mean Output Current	Σ Ι <sub>Ουτ3</sub>	P4	60		Total of 8 pins of large-current ports P40 to 7
	Σ Ι <sub>ΟUT4</sub>	P5	60		Total of 8 pins of large-current ports P50 to 7
Power Dissipation	PD		350	mW	QFP
Operating Temperature	Topr		– 40 to 85		
Soldering Temperature (time)	Tsld		260 (10 s)	°C	
Storage Temperature	Tstg		– 55 to 125		

Note: The Absolute Maximum Ratings stipulate the standards, any parameter of which cannot be exceeded even in an instant. If the device is used under conditions exceeding the Absolute Maximum Ratings, it may break down or degrade, causing injury due to rupture or burning. Therefore, always make sure the Absolute Maximum Ratings will not be exceeded when designing your application equipment.

Recommended Op	erating Con	ditions $(V_{SS} = 0 V, T)$	√opr = − 40 to 8	5° <b>C)</b>			
Parameter	Symbol	Pin		Condition	Min	Max	Unit
Power Supply Voltage	V <sub>DD</sub>		fc = 20 MHz	NORMAL/IDLE/ STOP	4.5	5.5	
High Level Input	V <sub>IH1</sub>	Normal			$V_{DD} \times 0.70$	N	
Voltage	V <sub>IH2</sub>	Hysteresis		V <sub>DD</sub> ≧4.5 V		V <sub>DD</sub>	V
Low Level Input	V <sub>IL1</sub>	Normal		V >4 E.V	0 V <sub>DD</sub> ×0.30		
Voltage	V <sub>IL2</sub>	Hysteresis		V <sub>DD</sub> ≧4.5 V		V <sub>DD</sub> x 0.25	
Clock Frequency	fc	XIN, XOUT	V <sub>DD</sub>	= 4.5 V to 5.5 V	8	20	MHz

Note: The Recommended Operating Conditions show the conditions under which we recommend the device be used in order for it to operate normally while maintaining its quality. If the device is used outside the range of Recommended Operating Conditions (power supply voltage, operating temperature range, or AC/DC rated values), it may operate erratically. Therefore, when designing your application equipment, always make sure its intended working conditions will not exceed the range of Recommended Operating Conditions.

DC Characteristics		(V <sub>SS</sub> = 0 V, Topr = -4	40 to 85°C)				
Parameter	Symbol	Pin	Condition	Min	Тур.	Max	Unit
Input Current	I <sub>IN1</sub> I <sub>IN2</sub> I <sub>IN3</sub>	TEST Sink OD, Tri-state RESET, STOP	V <sub>DD</sub> = 5.5 V V <sub>IN</sub> = 5.5 V / 0 V	-	-	±2	μΑ
Input Resistance	R <sub>IN</sub>	RESET		90	220	510	kΩ
Output Leakage Current	I <sub>LO</sub>	Sink OD, Tri-state	$V_{DD} = 5.5 V, V_{IN} = 5.5 V / 0 V$	-	_	± 2	μΑ
High Level Output Voltage	V <sub>OH</sub>	Tri-state port	$V_{DD}$ = 4.5 V, $I_{OH}$ = -0.7 mA	4.1	-	-	v
Low Lovel Output Current	I <sub>OL1</sub>	P0, 1, 2, 6, 7, 8, 9	$V_{DD}$ = 4.5 V, $V_{OL}$ = 0.4 V	1.6	-	-	
Low Level Output Current	I <sub>OL2</sub>	P3, P5, P4	$V_{DD}$ = 4.5 V, $V_{OL}$ = 1.0 V	-	20	-	
	I <sub>DDO</sub>			-	18	25	mA
Power Supply Current	I <sub>DDL</sub>		$V_{DD} = 5.5 V, V_{IN} = 5.3 V / 0.2 V$	-	16	23	
	I <sub>DDH</sub>		fc = 20 MHz	-	2	100	μΑ

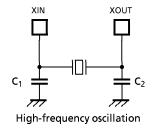
opr = - 40 to 85°C)

Parameter	Sumbol	Pin	Min	Tun	Max		Max		Unit
Parameter	Symbol	PIN	IVIIII	Тур.	8 bits	10 bits	Unit		
Analog Reference Voltage	VA <sub>REF</sub>	$V_{SS} = 0 V, V_{DD} = AV_{DD}$	V <sub>DD</sub> – 1.0	-	V	DD			
Analog Input Voltage			N		V <sub>AREF</sub>		V		
Range	VA <sub>IN</sub>		V <sub>ASS</sub>	-					
Analog Reference Power		$V_{DD} = AV_{DD} = VA_{REF} = 5.0 V$		0.5	1.0		mA		
Supply Current	REF	$V_{SS} = AV_{SS} = 0 V$	_	0.5					
Nonlinearity Error			-	-	± 1	± 2			
Zero Error		$V_{DD} = 5 V, V_{SS} = 0 V$	-	-	± 1	± 2			
Full Scale Error		$AV_{DD} = VA_{REF} = 5 V$	-	-	± 1	± 2	LSB		
Overall Error		$AV_{SS} = 0 V$	_	_	± 2	± 4			

AC Characteristics	(V <sub>SS</sub> =	$(V_{SS} = 0 \text{ V}, V_{DD} = 4.5 \text{ to } 5.5 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$					
Parameter	Symbol	Pin	Min	Тур.	Max	Unit	
Machine Cycle Time	tcy	During NORMAL1 mode During IDLE mode	0.2	_	0.5	μs	
High Level Clock Pulse Width	t <sub>WCH</sub>	When operating with external clock (XIN input)	25				
Low Level Clock Pulse Width	t <sub>WCL</sub>	fc = 20 MHz	25	_	_	ns	

Recommended C	scillation Conditions $(V_{SS} = 0 V, V_{DD} = 4.5 \text{ to } 5.5 V, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$					
Demonster	Descenter	Oscillation	Decomposed and Decompton	Recommended Constant		
Parameter	Resonator	Frequency	Recommended Resonator	C <sub>1</sub>	C <sub>2</sub>	
High-frequency oscillation	Ceramic resonator	16 MHz	I6 MHz CSTLS16MOX51-B0 made by Murata Mfg. Co.		(5 pF)	
		20 MHz	CSTLS20MOX51-B0 made by Murata Mfg. Co.	(5 pF)	(5 pF)	

(C1, C2 built-in type)



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

Note 2: These product numbers and the corresponding specifications are subject to change. For up-todate information, please refer to the following URL; http://www.murata.co.jp/search/index.html