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)

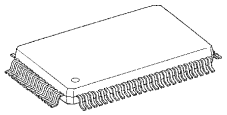
Note : TMP88PS43F with OTP's RAM capacity is 4 K + 128 bytes. The capacity is not same as TMP88CS43F.

Features

- ◆ 8-bit single-chip microcomputer TLCS-870/X series
- ◆ Minimum instruction execution time: 0.20 μs (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

External view of the package

P-QFP80-1420-0.80B



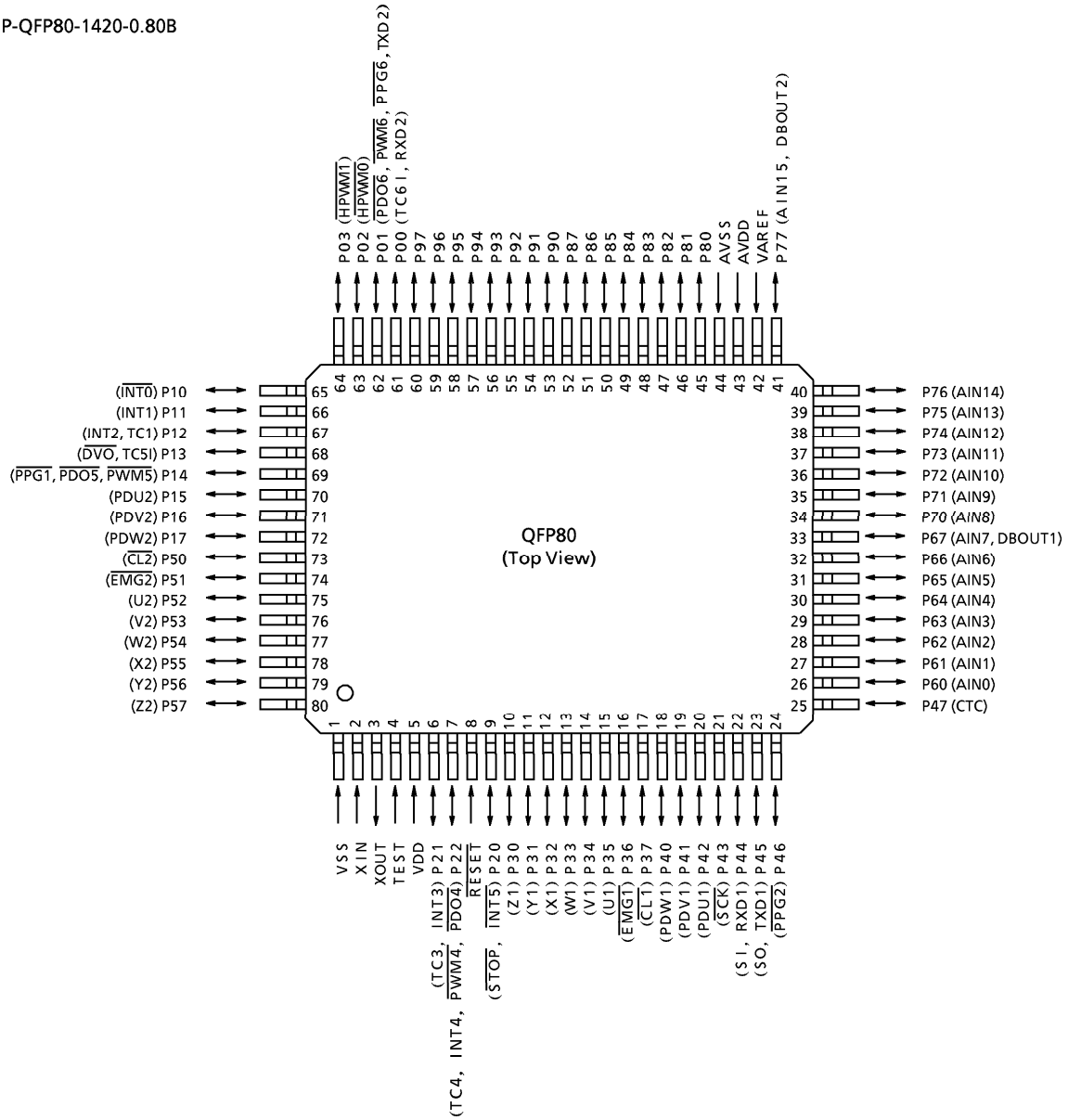
TMP88CS43F
TMP88PS43F

000707EBP1

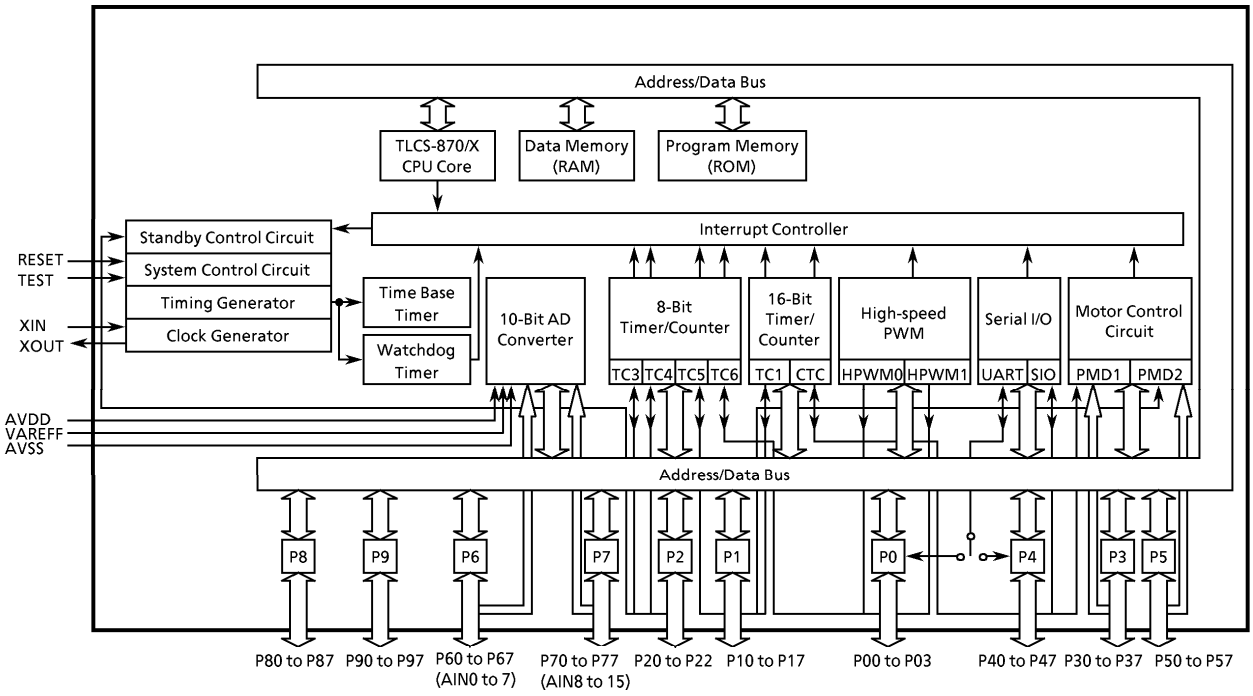
- 8-bit timer/counter: 4 channels (TC3, TC4, TC5, TC6)
  - TC3: Timer, event counter, or capture
  - TC4: Timer, event counter, PDO (Programmable Divider Output), PWM (Pulse Width Modulation), or UART baud rate
  - TC5, TC6: Two channels can be cascaded for use as a 16-bit timer
    Timer, event counter, 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)

P-QFP80-1420-0.80B



Block Diagram



Pin Functions (1/3)

Pin Name	I/O	Function	
P00 (TC6I, RXD2)	I/O (input, input)	● 4-bit programmable input/output port. (hysteresis input, tristate output/open-drain output) ● Can be set for input or output mode bitwise. ● Can be set for tristate or open-drain output bitwise. ● When using as timer/counter or UART input, set these pins for input mode. ● When using as timer/counter, UART, or PWM output, set these pins for output mode.	Timer/Counter input 6, UART input 2
P01 ($\overline{\text{PDO6}}$, $\overline{\text{PWM6}}$, $\overline{\text{PPG6}}$, TXD2)	I/O (output, output)		Timer/Counter output 6 or PDO6, PWM6, PPG6, UART output 2
P02 ($\overline{\text{HPWM0}}$)	I/O (output)		High-speed PWM0 output
P03 ($\overline{\text{HPWM1}}$)			High-speed PWM1 output
P10 ($\overline{\text{INT0}}$)	I/O (input)	● 8-bit programmable input/output port. (hysteresis input, tristate output) ● Can be set for input or output mode bitwise. ● When using as external interrupt, timer/counter, or position signal input, set these pins for input mode. ● When using as DVO output or PPG1 output of TC1, set these pins for output mode after setting the output latch to 1.	External interrupt input 0
P11 (INT1)			External interrupt 1 input
P12 (INT2, TC1)	I/O (input, input)		External interrupt 2 input or timer/counter 1 input
P13 (TC5I, $\overline{\text{DVO}}$)	I/O (input, output)		Timer/Counter 5 input or divider output
P14 ($\overline{\text{PDO5}}$, $\overline{\text{PWM5}}$, $\overline{\text{PPG1}}$)	I/O (output, output, output)		Timer/Counter output or PDO5, PWM5, PPG1
P15 (PDU2)	I/O (input)		Motor control 2 position signal input (U2, V2, W2 phases)
P16 (PDV2)			
P17 (PDW2)			
P20 ($\overline{\text{INT5}}$, $\overline{\text{STOP}}$)	I/O (input, input)	● 3-bit input/output port. (hysteresis input, open-drain output) ● When using these pins as timer/counter, external interrupt, or STOP mode exiting input, set the output latch to 1.	External interrupt 5 input, STOP mode exiting input
P21 (TC3, INT3)			Timer/Counter 3 input or external interrupt 3 input
P22 (TC4, INT4, $\overline{\text{PWM4}}$, $\overline{\text{PDO4}}$)	I/O (input, input output, output)		Timer/Counter 4 input or external interrupt 4 input, PWM4 output, PDO4 output
P30 (Z1)	I/O (output)	● 8-bit programmable input/output port. (hysteresis input, tristate output/open-drain output) ● Can be set for input or output mode bitwise. ● Can be set for tristate or open-drain output bitwise. ● Can directly drive LED with large current. ● When using motor control output, set these pins for output mode. Also, set the output latch to 1. ● When using error detection/overload protective input, set these pins for input mode.	Motor control 1 output (Z1, Y1, X1, W1, V1, U1 phases)
P31 (Y1)			
P32 (X1)			
P33 (W1)			
P34 (V1)			
P35 (U1)			
P36 ($\overline{\text{EMG1}}$)	I/O (input)		Motor control 1 error detection input
P37 ($\overline{\text{CL1}}$)	I/O (input)		Motor control 1 overload protective input
P40 (PDW1)	I/O (input)	● 8-bit programmable input/output port. (hysteresis input, tristate output/open-drain output) ● Can be set for input or output mode bitwise. ● Can be set for tristate or open-drain output bitwise. ● Can directly drive LED with large current. ● When using timer/counter, SIO, or position signal input, set these pins for input mode. ● When using SIO, UART or output, set these pins for output mode. Also, set the output latch to 1.	Motor control 1 position signal input (W1, V1, U1 phases)
P41 (PDV1)			
P42 (PDU1)			
P43 ($\overline{\text{SCK}}$)			SIO clock input/output
P44 (SI, RXD1)	I/O (input)		SIO input, UART data input 1
P45 (SO, TXD1)	I/O (output)		SIO output, UART data output 1
P46 ($\overline{\text{PPG2}}$)	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 ($\overline{CL2}$)	I/O (input)	• 8-bit programmable input/output port. (hysteresis input, tristate output/open-drain output) • Can be set for input or output mode bitwise. • Can be set for tristate or open-drain output bitwise. • Can directly drive LED with large current. • When using motor control output, set these pins for output mode. Also, set the output latch to 1. • When using error detection/overload protective input, set these pins for input mode.	Motor control 2 overload protective input
P51 ($\overline{EMG2}$)			Motor control 2 error detection input
P52 (U2)	I/O (output)		Motor control 2 output (Z2, Y2, X2, W2, V2, U2 phases)
P53 (V2)			
P54 (W2)			
P55 (X2)			
P56 (Y2)			
P57 (Z2)			
P60 (AIN0)	I/O (input)	• 8-bit programmable input/output port. (tristate output) • Can be set for input or output mode bitwise. • When using as analog input, set these pins for input mode. Also, set the output latch to 0. • When using motor control output, set these pins for output mode. Also, set the output latch to 1.	AD converter analog input
P61 (AIN1)			
P62 (AIN2)			
P63 (AIN3)			
P64 (AIN4)			
P65 (AIN5)			
P66 (AIN6)			
P67 (AIN7, DBOUT1)	I/O (input, output)		AD converter analog input, Motor control 1 output
P70 (AIN8)	I/O (input)	• 8-bit programmable input/output port. (tristate output) • Can be set for input or output mode bitwise. • When using as analog input, set these pins for input mode. Also, set the output latch to 0. • When using motor control output, set these pins for output mode. Also, set the output latch to 1.	AD converter analog input
P71 (AIN9)			
P72 (AIN10)			
P73 (AIN11)			
P74 (AIN12)			
P75 (AIN13)			
P76 (AIN14)			
P77 (AIN15, DBOUT2)	I/O (input, output)		AD converter analog input, Motor control 2 output
P80	I/O	• 8-bit programmable input/output port. (tristate output/open-drain output) • Can be set for input or output mode bitwise. • Can be set for tristate or open-drain output bitwise.	—
P81			
P82			
P83			
P84			
P85			
P86			
P87			
P90	I/O	• 8-bit programmable input/output port. (tristate output/open-drain output) • Can be set for input or output mode bitwise. • Can be set for tristate or open-drain output bitwise.	—
P91			
P92			
P93			
P94			
P95			
P96			
P97			

Pin Functions (3/3)

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

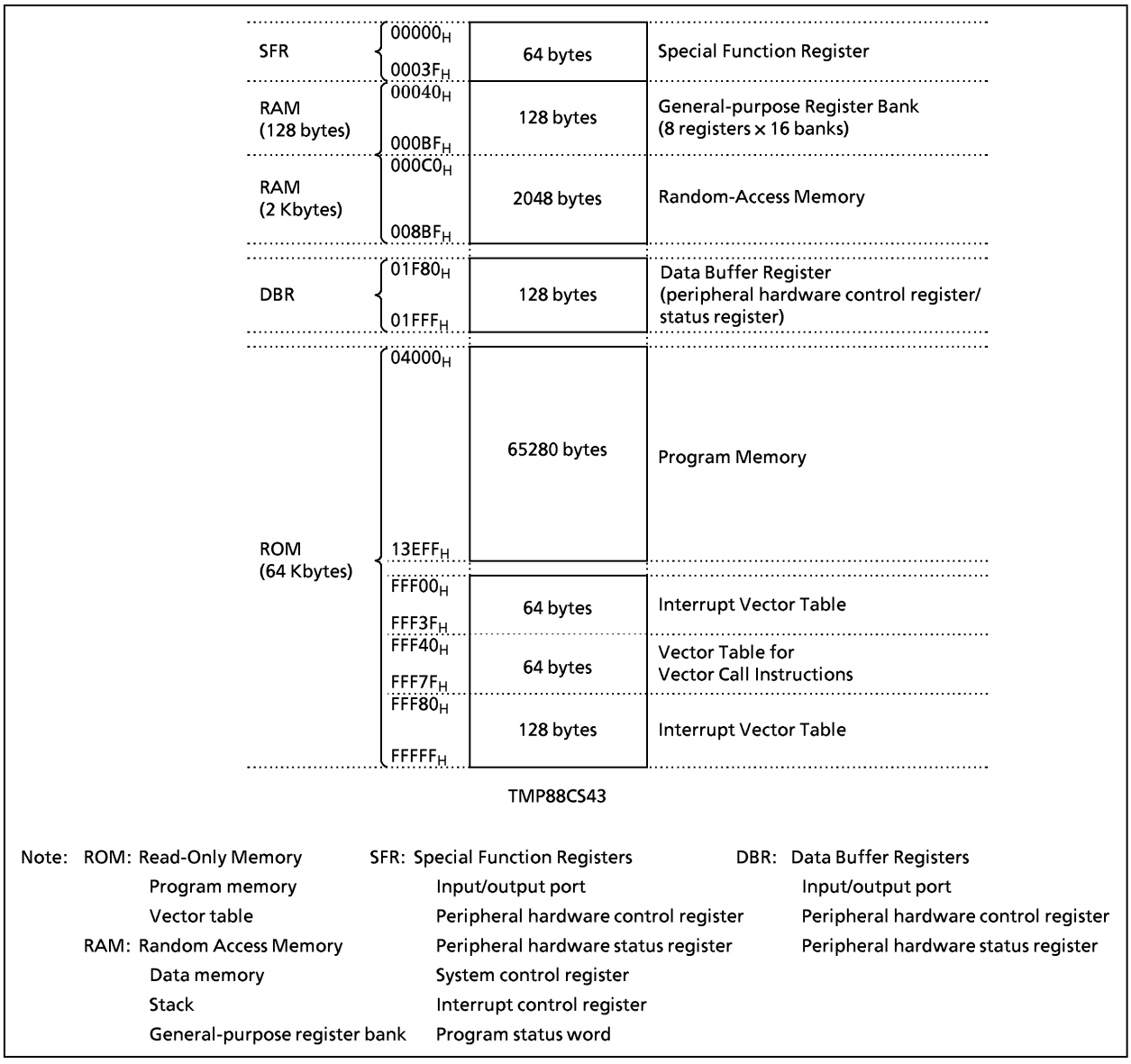
Functional Description

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.



Note: ROM: Read-Only Memory
Program memory
Vector table
RAM: Random Access Memory
Data memory
Stack
General-purpose register bank

SFR: Special Function Registers
Input/output port
Peripheral hardware control register
Peripheral hardware status register
System control register
Interrupt control register
Program status word

DBR: Data Buffer Registers
Input/output port
Peripheral hardware control register
Peripheral hardware status register

Figure 1-1. Memory address map

Electrical Characteristics

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

Parameter	Symbol	Pin	Standard	Unit	Remark
Power 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	I_{OH}	P0, 1, 3, 4, 5, 6, 7, 8, 9	– 1.8	mA	
	I_{OL1}	P0, 1, 2, 6, 7, 8, 9	3.2		
	I_{OL2}	P3, P4, P5	30		
Mean Output Current	ΣI_{OUT1}	P0, 1, 2, 6, 7, 8, 9	60		Total of all ports except large-current ports
	ΣI_{OUT2}	P3	60		Total of 8 pins of large-current ports P30 to 7
	ΣI_{OUT3}	P4	60		Total of 8 pins of large-current ports P40 to 7
	ΣI_{OUT4}	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	°C	
Soldering Temperature (time)	Tsld		260 (10 s)		
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 Operating Conditions (V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pin	Condition		Min	Max	Unit
Power Supply Voltage	V_{DD}		fc = 20 MHz	NORMAL/IDLE/ STOP	4.5	5.5	V
High Level Input Voltage	V_{IH1}	Normal	$V_{DD} \geqq 4.5$ V		$V_{DD} \times 0.70$	V_{DD}	
	V_{IH2}	Hysteresis			$V_{DD} \times 0.75$		
Low Level Input Voltage	V_{IL1}	Normal	$V_{DD} \geqq 4.5$ V		0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis				$V_{DD} \times 0.25$	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 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_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pin	Condition	Min	Typ.	Max	Unit
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V V_{IN} = 5.5 V / 0 V	–	–	± 2	μA
	I_{IN2}	Sink OD, Tri-state					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistance	R_{IN}	$\overline{RESET}$		90	220	510	kΩ
Output Leakage Current	I_{LO}	Sink OD, Tri-state	V_{DD} = 5.5 V, V_{IN} = 5.5 V / 0 V	–	–	± 2	μA
High Level Output Voltage	V_{OH}	Tri-state port	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA	4.1	–	–	V
Low Level Output Current	I_{OL1}	P0, 1, 2, 6, 7, 8, 9	V_{DD} = 4.5 V, V_{OL} = 0.4 V	1.6	–	–	mA
	I_{OL2}	P3, P5, P4	V_{DD} = 4.5 V, V_{OL} = 1.0 V	–	20	–	
Power Supply Current	I_{DDO}		V_{DD} = 5.5 V, V_{IN} = 5.3 V / 0.2 V fc = 20 MHz	–	18	25	
	I_{DDL}			–	16	23	
	I_{DDH}			–	2	100	μA

AD Conversion Characteristics (Topr = – 40 to 85°C)

Parameter	Symbol	Pin	Min	Typ.	Max		Unit
					8 bits	10 bits	
Analog Reference Voltage	VA_{REF}	V_{SS} = 0 V, V_{DD} = AV_{DD}	V_{DD} – 1.0	–	V_{DD}		V
Analog Input Voltage Range	VA_{IN}		V_{ASS}	–	V_{AREF}		
Analog Reference Power Supply Current	I_{REF}	V_{DD} = AV_{DD} = VA_{REF} = 5.0 V V_{SS} = AV_{SS} = 0 V	–	0.5	1.0		mA
Nonlinearity Error		V_{DD} = 5 V, V_{SS} = 0 V AV_{DD} = VA_{REF} = 5 V AV_{SS} = 0 V	–	–	± 1	± 2	LSB
Zero Error			–	–	± 1	± 2	
Full Scale Error			–	–	± 1	± 2	
Overall Error			–	–	± 2	± 4	

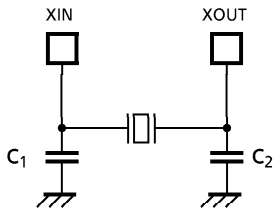
AC Characteristics (V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pin	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	During NORMAL1 mode	0.2	–	0.5	μs
		During IDLE mode				
High Level Clock Pulse Width	t_{WCH}	When operating with external clock (XIN input) fc = 20 MHz	25	–	–	ns
Low Level Clock Pulse Width	t_{WCL}					

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

Parameter	Resonator	Oscillation Frequency	Recommended Resonator	Recommended Constant	
				C_1	C_2
High-frequency oscillation	Ceramic resonator	16 MHz	CSTLS16MOX51-B0 made by Murata Mfg. Co.	(5 pF)	(5 pF)
		20 MHz	CSTLS20MOX51-B0 made by Murata Mfg. Co.	(5 pF)	(5 pF)

(C1, C2 built-in type)



High-frequency oscillation

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-to-date information, please refer to the following URL;
http://www.murata.co.jp/search/index.html