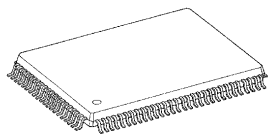
CMOS 8-Bit Microcontroller

TMP86CM25F, TMP86CS25F

The TMP86CM25/S25 are the high-speed, high-performance and low power consumption 8-bit microcomputer, including ROM, RAM, Dot matrix LCD driver, multi-function timer/counter, serial interface (UART/SIO), a 8-bit AD converter and two clock generators on chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP86CM25F	32 K × 8 bits	2 K × 8 bits	P-QFP100-1420-0.65A	TMP86PS25F
TMP86CS25F	60 K × 8 bits			

P-QFP100-1420-0.65A



TMP86CM25F
TMP86CS25F

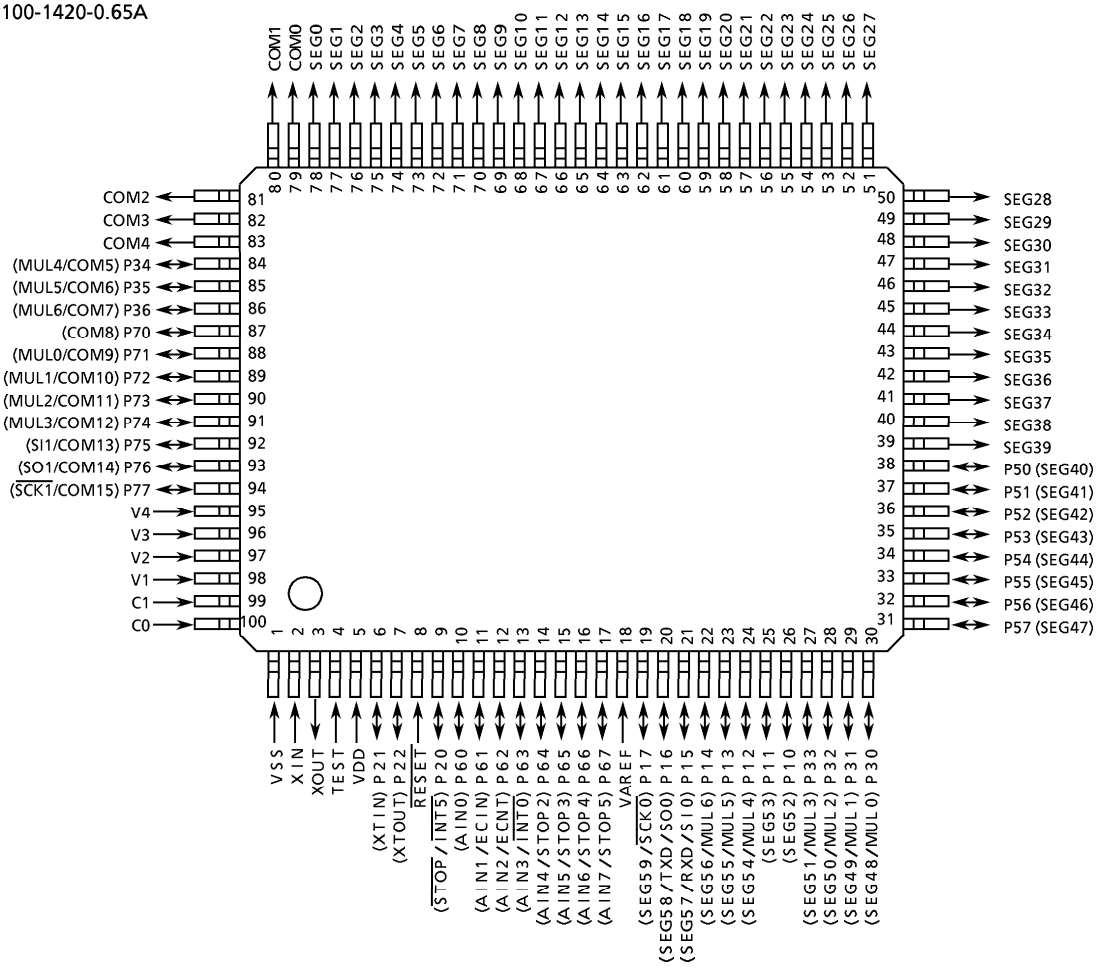
Features

- 8-bit single chip microcomputer TLCS-870/C series
- Instruction execution time: 0.25 μs (at 16 MHz)
  122 μs (at 32.768 kHz)
- 132 types and 731 basic instructions
- 20 interrupt sources (External: 5, Internal: 15)
- Input/Output ports (42 pins)
  (Out of which 20 pins are also used as SEG pins.)
- 18-bit timer counter: 1 ch
  - Timer, Event counter, Pulse width measurement, Frequencymeasurement modes
- 8-bit timer counter: 4 ch
  - Timer, Event counter, PWM output, Programmable Divider Output, PPG modes
- Time Base Timer
- Divider output function
- Watchdog Timer
  - Interrupt source/internal reset generate (programmable)

- Serial interface: 2ch
  - 8-bit UART/SIO: 1ch
  - 8-bit SIO: 1ch
- 8-bit successive approximation type AD converter
  - Analog input: 8 ch
- Four Key On Wake Up pins
- LCD driver/controller
  - Built-in voltage booster for LCD driver
  - With displaymemory
  - LCD direct drive capability (60 seg × 16 com, 60 seg × 8 com, 60 seg × 4 com)
  - 1/16, 1/8, 1/4 duties drive are programmably selectable
- Dual clock operation
  - Single/Dual-clock mode
- Nine power saving operating modes
  - STOP mode: Oscillation stops. Battery/capacitor back-up. Port output hold/high-impedance.
  - SLOW 1, 2 mode: Low power consumption operation using low-frequency clock (32.768 kHz)
  - IDLE0 mode: CPU stops, and peripherals stop except Time-Base-Timer. Release by falling edge of TBTCR<TBTCK> setting.
  - IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by interruputs.
  - IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interruputs.
  - SLEEP 0 mode: CPU stops, and peripherals stop except Time-Base-Timer. Release by falling edge of TBTCR<TBTCK> setting.
  - SLEEP 1 mode: CPU stops, and peripherals operate using low-frequency clock. Release by interrupts.
  - SLEEP 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
- Wide operating voltage: 1.8 to 5.5 V at 4.2 MHz/32.768 kHz,
  2.7 to 5.5 V at 8 MHz/32.768 kHz,
  4.5 to 5.5 V at 16 MHz/32.768 kHz

Pin Assignments (Top View)

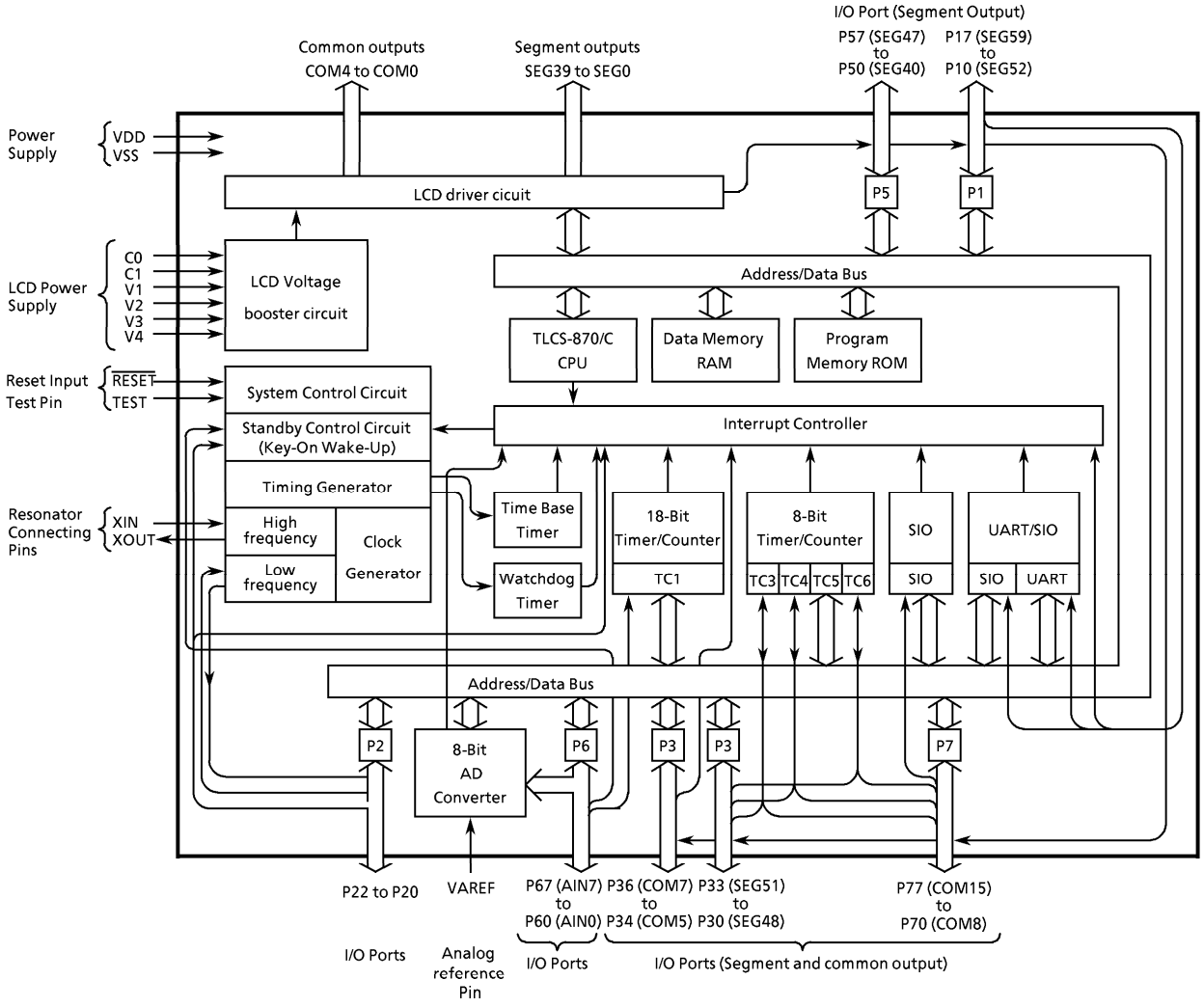
P-QFP100-1420-0.65A



Note: Ports assigned as MUL6 to MUL0 can switch pin assignment by the multifunction register (MULSEL). For functions assigned to each pin, see the table below.

Pin name	Function	Pin assignment
MUL0	$\overline{\text{DVO}}$	P30 or P71
MUL1	$\overline{\text{PWM3}}$, $\overline{\text{PDO3}}$, TC3	P31 or P72
MUL2	$\overline{\text{PPG4}}$, $\overline{\text{PWM4}}$, $\overline{\text{PDO4}}$, TC4	P32 or P73
MUL3	$\overline{\text{PPG6}}$, $\overline{\text{PWM6}}$, $\overline{\text{PDO6}}$, TC6	P33 or P74
MUL4	INT1	P12 or P34
MUL5	INT2	P13 or P35
MUL6	INT3	P14 or P36

Block Diagram



Pin Function

Pin Name	Input/Output	Function		
P17 (SEG59, $\overline{SCK0}$)	I/O (I/O)	8-bit input/output port with latch. When used as input port, an external interruput input, serial clock input/output, serial data input/output or UART data input/output, the latch must be set to "1". When used as a LCD segment output, the P1LCR must be set to "1".	Serial clock input/Output	LCD segment outputs.
P16 (SEG58, TxD, SO0)	I/O (Output)		UART data output Serial data output	
P15 (SEG57, RxD, SI0)	I/O (I/O)		UART data input Serial data input	
P14 (SEG56, MUL6)	I/O (I/O)		External interrupt 3 input	
P13 (SEG55, MUL5)	I/O (I/O)		External interrupt 2 input	
P12 (SEG54, MUL4)	I/O (I/O)		External interrupt 1 input	
P11 (SEG53)	I/O (Output)			
P10 (SEG52)	I/O (Output)			
P22 (XTOUT)	I/O (Output)	3-bit input/output port with latch. When used as an input port, the latch must be set to "1".	Resonator connecting pins (32.768 kHz) For inputting external clock, XTIN is used and XTOUT is opened.	
P21 (XTIN)	I/O (Input)			
P20 ($\overline{INT5}$, $\overline{STOP}$)	I/O (Input)		External interrupt input 5 or STOP mode release signal input	
P36 (COM7, MUL6)	I/O (I/O)	7-bit I/O port with latch. When used as input port, an external interruput input or timer/counter input/output, the latch must be set to "1". When used as a LCD segment output, the P3LCR must be set to "1".	External interrupt 3 input	LCD segment outputs.
P35 (COM6, MUL5)	I/O (I/O)		External interrupt 2 input	
P34 (COM5, MUL4)	I/O (I/O)		External interrupt 1 input	
P33 (SEG51, MUL3)	I/O (I/O)		Timer/counter 6 input/output	
P32 (SEG50, MUL2)	I/O (I/O)		Timer/counter 4 input/output	
P31 (SEG49, MUL1)	I/O (I/O)		Timer/counter 3 input/output	
P30 (SEG48, MUL0)	I/O (Output)		Divider output	
P57 (SEG16) to P50 (SEG23)	I/O (Output)	8-bit input/output port with latch. When used as a LCD segment output, the P5LCR must be set to "1".	LCD segment outputs	
P67 (AIN7, STOP5)	I/O (Input)	8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or an output under software control. When used as a key on wake up input, an external interrupt input and timer/counter input, the P6CR must be set to "1".	STOP5 input	AD converter analog inputs
P66 (AIN6, STOP4)	I/O (Input)		STOP4 input	
P65 (AIN5, STOP3)	I/O (Input)		STOP3 input	
P64 (AIN4, STOP2)	I/O (Input)		STOP2 input	
P63 (AIN3, $\overline{INT0}$)	I/O (Input)		External interrupt 0 input	
P62 (AIN2, ECNT)	I/O (Input)		Timer/counter 1 input	
P61 (AIN1, ECIN)	I/O (Input)			
P60 (AIN0)	I/O (Input)			
P70 (COM8)	I/O (Output)	8-bit I/O port. When used common output, P7 port control register (P7LCR) should be set to 1.		
P71 (COM9, MUL0)	I/O (I/O)		Divider output	
P72 (COM10, MUL1)	I/O (I/O)		Timer/counter 3 input/output	
P73 (COM11, MUL2)	I/O (I/O)		Timer/counter 4 input/output	
P74 (COM12, MUL3)	I/O (I/O)		Timer/counter 6 input/output	
P75 (COM13, SI1)	I/O (I/O)		Serial data input	
P76 (COM14, SO1)	I/O (Output)		Serial data output	
P77 (COM15, $\overline{SCK1}$)	I/O (I/O)		Serial clock input/output	
SEG39 to SEG0	Output	LCD segment outputs		
COM4 to COM0		LCD common outputs		
V 4 to V 1 C1 to C0	LCD voltage booster pin	LCD voltage booster pin. Capacitors are required between C0 and C1 pin and V1/V2/V3/V4 pin and GND.		
XIN, XOUT	Input Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.		
$\overline{RESET}$	Input	Reset signal input		
TEST	Input	Test pin for out-going test. Be fixed to low.		
VDD, VSS	Power Supply	+ 5 V, 0 (GND)		
VAREF		Analog reference voltage input.		

Operational Description

1. CPU Core Functions

The CPU core consists of a CPU, a system clock controller, and an interrupt controller.

This section provides a description of the CPU core, the program memory, the data memory, the external memory interface, and the reset circuit.

1.1 Memory Address Maps

The TMP86CM25/S25 memory consist of 4 blocks: ROM, RAM, DBR (Data Buffer Register) and SFR (Special Function Register). They are all mapped in 64 Kbyte address space. Figure 1-1 shows the TMP86CM25/S25 memory address maps. The general-purpose registers are not assigned to the RAM address space.

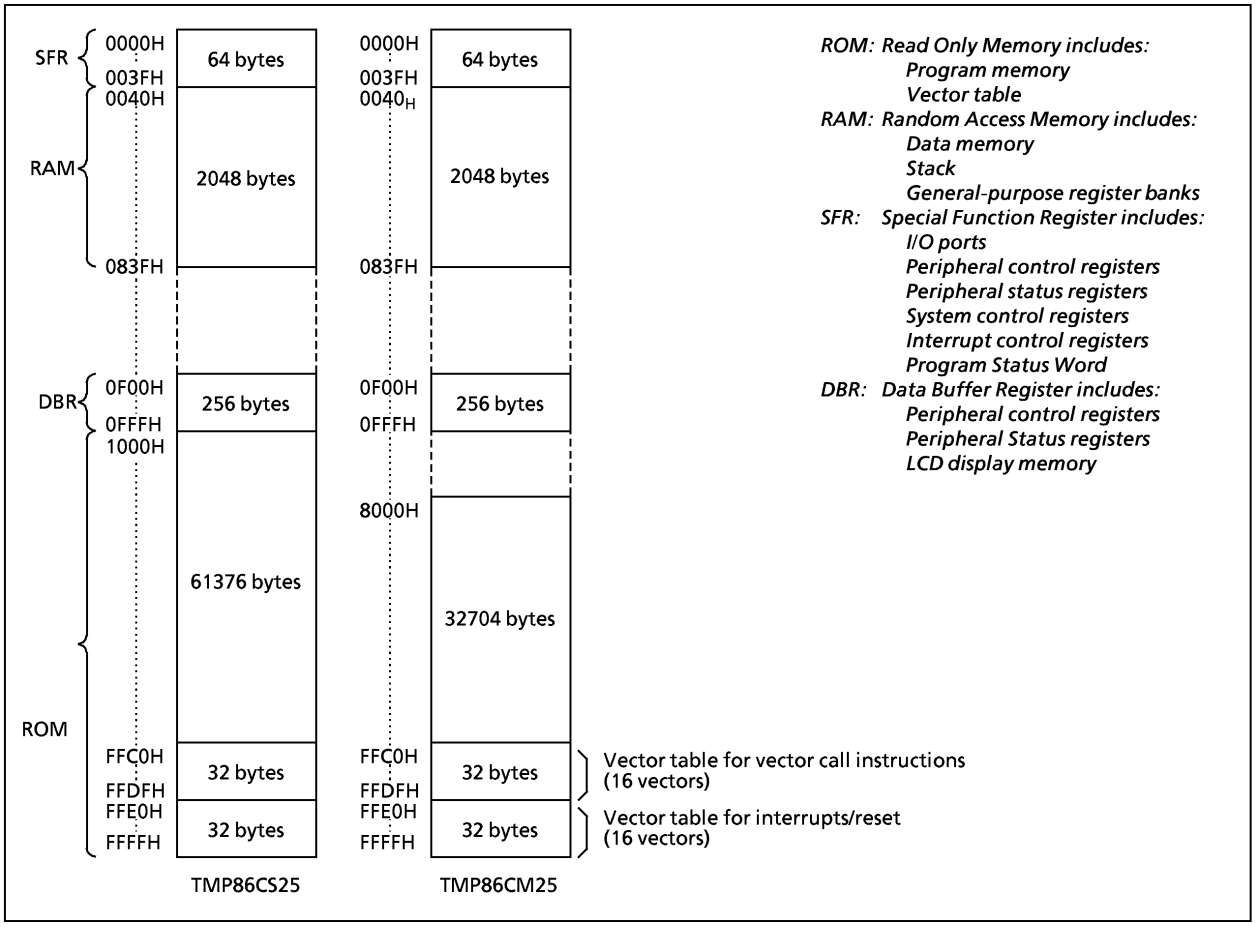


Figure 1-1. Memory Address Maps

1.2 Program Memory (ROM)

The TMP86CM25 has a 32 K×8-bit (address 8000H to FFFFH), and the TMP86CS25 has a 60 K×8-bit (address 1000H to FFFFH) of program memory (mask programmed ROM). However, placing program memory on the internal RAM is deregulated if a certain procedure is executed (See 2.5.5 Address Trap).

Electrical Characteristics

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

Parameter	Symbol	Pins	Rating	Unit
Supply Voltage	V_{DD}		– 0.3 to 6.5	V
Input Voltage	V_{IN}		– 0.3 to V_{DD} + 0.3	
Output Voltage	V_{OUT1}		– 0.3 to V_{DD} + 0.3	
Output Current (Per 1 pin)	I_{OUT1}	P6 Port	– 1.8	mA
	I_{OUT2}	P1, P2, P34 to P36, P5, P6, P7 Port	3.2	
	I_{OUT3}	P30 to P33 Port	30	
Output Current (Total)	ΣI_{OUT2}	P1, P2, P34 to P36, P5, P6, P7 Port	60	
	ΣI_{OUT3}	P30 to P33 Port	80	
Power Dissipation [T_{opr} = 85°C]	PD		350	mW
Soldering Temperature (time)	Tsld		260 (10 s)	°C
Storage Temperature	Tstg		– 55 to 125	
Operating Temperature	Topr		– 40 to 85	

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 Condition (V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pins	Condition		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 16 MHz	NORMAL1, 2 mode	4.5	5.5	V
				IDLE0, 1, 2 mode			
			fc = 8 MHz	NORMAL1, 2 mode	2.7		
				IDLE0, 1, 2 mode			
			fc = 4.2 MHz	NORMAL1, 2 mode	1.8		
				IDLE0, 1, 2 mode			
			fs = 32.768 kHz	SLOW1, 2 mode			
				SLEEP0, 1, 2 mode			
				STOP mode			
Input high Level	V_{IH1}	Except Hysteresis input	$V_{DD} \geqq 4.5$ V		$V_{DD} \times 0.70$	V_{DD}	
	V_{IH2}	Hysteresis input			$V_{DD} \times 0.75$		
	V_{IH3}		$V_{DD} < 4.5$ V		$V_{DD} \times 0.90$		
Input low Level	V_{IL1}	Except Hysteresis input	$V_{DD} \geqq 4.5$ V		0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
	V_{IL3}		$V_{DD} < 4.5$ V			$V_{DD} \times 0.10$	
LCD reference voltage range	$V1_{IN}$	V1	LCDCTL1<REFV> = "1" VDD< V4 (Note 2)		1.0	1.375	
	$V2_{IN}$	V2			2.0	2.750	
	$V3_{IN}$	V3			3.0	4.125	
	$V4_{IN}$	V4			4.0	5.500	
	$V4_{IN}$	V4 (Note 3)	LCDCTL1<REFV> = "0"		–	VDD	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 1.8 to 5.5 V		1.0	4.2	MHz
			V_{DD} = 2.7 to 5.5 V			8.0	
			V_{DD} = 4.5 to 5.5 V			16.0	
	fs	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: When LCDCTL1<REFV> is set to "1", always keep the condition of VDD < V4.

Note 3: When LCDCTL1<REFV> is set to "0", always supply the reference voltage from V4 pin.

DC Characteristics

(V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pins	Condition		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}	Sink Open Drain, Tri-state						
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$						
Input Resistance	R_{IN1}	TEST Pull-Down			–	70	–	kΩ
	R_{IN2}	$\overline{RESET}$ Pull-Up			100	220	450	
Output Leakage Current	I_{LO}	Sink Open Drain, Tri-state	V_{DD} = 5.5 V, V_{OUT} = 5.5 V/0 V		–	–	± 2	μA
Output High Voltage	V_{OH2}	Tri-st Port	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA		4.1	–	–	V
Output Low Voltage	V_{OL}	Except XOUT and P30 to P33 Port	V_{DD} = 4.5 V, I_{OL} = 1.6mA		–	–	0.4	
Output Low Current	I_{OL}	High Current Port (P30 to P33 Port)	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 V_{IN} = 5.3/0.2 V fc = 16 MHz fs = 32.768 kHz	TMP86CM25	–	4.5	7.0	mA
Supply Current in IDLE 0, 1, 2 mode					–	2.7	3.5	
Supply Current in SLOW 1 mode			V_{DD} = 3.0 V V_{IN} = 2.8 V/0.2 V fs = 32.768 kHz LCD driver is not enable.		–	6.0	25	μA
Supply Current in SLEEP 1 mode					–	4.0	15	
Supply Current in SLEEP 0 mode					–	2.5	13	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V		–	0.5	10	
Supply Current in NORMAL 1, 2 mode			V_{DD} = 5.5 V V_{IN} = 5.3/0.2 V fc = 16 MHz fs = 32.768 kHz	TMP86CS25	–	6.0	7.0	mA
Supply Current in IDLE 0, 1, 2 mode					–	4.2	5.0	
Supply Current in SLOW 1 mode			V_{DD} = 3.0 V V_{IN} = 2.8 V/0.2 V fs = 32.768 kHz LCD driver is not enable.		–	8.5	25	μA
Supply Current in SLEEP 1 mode					–	5.0	15	
Supply Current in SLEEP 0 mode					–	3.0	13	
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 Topr = 25°C, V_{DD} = 5 V

Note 2: Input current (I_{IN1}, I_{IN2}): The current through pull-up or pull-down resistor is not included.

Note 3: I_{DD} does not include I_{REF} current.

Note 4: The supply currents of SLOW 2 and SLEEP 2 modes are equivalent to IDLE 0, 1, 2.

AD Conversion Characteristics

(V_{SS} = 0.0 V, 4.5 V ≦ V_{DD} ≦ 5.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		V_{DD} – 1.5	–	V_{DD}	V
Analog Reference Voltage Range (Note 4)	ΔV_{AREF}		3.0	–	–	
Analog Input Voltage	V_{AIN}		V_{SS}	–	V_{AREF}	
Power Supply Current of Analog Reference Voltage	I_{REF}	V_{DD} = V_{AREF} = 5.5 V V_{SS} = 0.0 V	–	0.6	1.0	mA
Non linearity Error		V_{DD} = 5.0 V, V_{SS} = 0.0 V V_{AREF} = 5.0 V	–	–	± 1	LSB
Zero Point Error			–	–	± 1	
Full Scale Error			–	–	± 1	
Total Error			–	–	± 2	

(V_{SS} = 0.0 V, 2.7 V ≦ V_{DD} < 4.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		V_{DD} – 1.5	–	V_{DD}	V
Analog Reference Voltage Range (Note 4)	ΔV_{AREF}		2.5	–	–	
Analog Input Voltage	V_{AIN}		V_{SS}	–	V_{AREF}	
Power Supply Current of Analog Reference Voltage	I_{REF}	V_{DD} = V_{AREF} = 4.5 V V_{SS} = 0.0 V	–	0.5	0.8	mA
Non linearity Error		V_{DD} = 2.7 V, V_{SS} = 0.0 V V_{AREF} = 2.7 V	–	–	± 1	LSB
Zero Point Error			–	–	± 1	
Full Scale Error			–	–	± 1	
Total Error			–	–	± 2	

(V_{SS} = 0.0 V, 2.0 V ≦ V_{DD} <2.7 V, Topr = – 40 to 85°C) Note 5
(V_{SS} = 0.0 V, 1.8 V ≦ V_{DD} <2.0 V, Topr = – 10 to 85°C) Note 5

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}		V_{DD} – 0.9	–	V_{DD}	V
Analog Reference Voltage Range (Note 4)	ΔV_{AREF}	1.8 V ≦ V_{DD} <2.0 V	1.8	–	–	
		2.0 V ≦ V_{DD} <2.7 V	2.0	–	–	
Analog Input Voltage	V_{AIN}		V_{SS}	–	V_{AREF}	
Power Supply Current of Analog Reference Voltage	I_{REF}	V_{DD} = V_{AREF} = 2.7 V V_{SS} = 0.0 V	–	0.3	0.5	mA
Non linearity Error		V_{DD} = 1.8 V, V_{SS} = 0.0 V V_{AREF} = 1.8 V	–	–	± 2	LSB
Zero Point Error			–	–	± 2	
Full Scale Error			–	–	± 2	
Total Error			–	–	± 4	

Note 1: The total error includes all errors except a quantization error, and is defined as maximum deviation from the ideal conversion line.
Note 2: Conversion time is different in recommended value by power supply voltage.
About conversion time, please refer to "2.11.2 Register Configuration".
Note 3: Please use input voltage to AIN input Pin in limit of V_{AREF} - V_{SS}.
When voltage of range outside is input, conversion value becomes unsettled and gives affect to other channel conversion value.
Note 4: Analog Reference Voltage Range: $\Delta V_{AREF} = V_{AREF} - V_{SS}$
Note 5: When AD is used with V_{DD} < 2.7 V, the guaranteed temperature range varies with the operating voltage.

AC Characteristics

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

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	NORMAL 1, 2 mode	0.25	–	4	μs
		IDLE 0, 1, 2 mode				
		SLOW 1, 2 mode	117.6	–	133.3	
		SLEEP 0, 1, 2 mode				
High Level Clock Pulse Width	twcH	For external clock operation (XIN input) fc = 16 MHz	–	31.25	–	ns
Low Level Clock Pulse Width	twcL					
High Level Clock Pulse Width	twcH	For external clock operation (XTIN input) fc = 32.768 kHz	–	15.26	–	μs
Low Level Clock Pulse Width	twcL					

(V_{SS} = 0 V, V_{DD} = 2.7 to 4.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	NORMAL 1, 2 mode	0.5	–	4	μs
		IDLE 0, 1, 2 mode				
		SLOW 1, 2 mode	117.6	–	133.3	
		SLEEP 0, 1, 2 mode				
High Level Clock Pulse Width	twcH	For external clock operation (XIN input) fc = 8 MHz	–	62.5	–	ns
Low Level Clock Pulse Width	twcL					
High Level Clock Pulse Width	twcH	For external clock operation (XTIN input) fc = 32.768 kHz	–	15.26	–	μs
Low Level Clock Pulse Width	twcL					

(V_{SS} = 0 V, V_{DD} = 1.8 to 2.7 V, Topr = – 40 to 85°C)

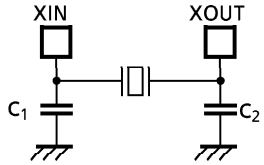
Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	NORMAL 1, 2 mode	0.95	–	4	μs
		IDLE 0, 1, 2 mode				
		SLOW 1, 2 mode	117.6	–	133.3	
		SLEEP 0, 1, 2 mode				
High Level Clock Pulse Width	twcH	For external clock operation (XIN input) fc = 4.2 MHz	–	119.05	–	ns
Low Level Clock Pulse Width	twcL					
High Level Clock Pulse Width	twcH	For external clock operation (XTIN input) fc = 32.768 kHz	–	15.26	–	μs
Low Level Clock Pulse Width	twcL					

Timer Counter 1 input (ECIN) Characteristics

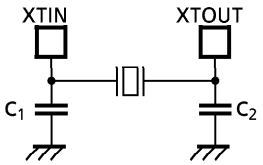
(V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Condition		Min	Typ.	Max	Unit
TC1 input (ECIN input)	t_{TC1}	Frequency measurement mode V_{DD} = 4.5 to 5.5 V	Single edge count	–	–	1.0	MHz
		Frequency measurement mode V_{DD} = 2.7 to 4.5 V	Single edge count	–	–	0.5	
		Frequency measurement mode V_{DD} = 1.8 to 2.7 V	Single edge count	–	–	0.262	

Recommended Oscillating Conditions



(1) High-frequency Oscillation



(2) Low-frequency Oscillation

Note 1: An electrical shield by metal shield plate on the surface of IC package is recommended in order to protect the device from the high electric field stress applied from CRT (Cathodic Ray Tube) for continuous reliable 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