CMOS 8-Bit Microcontroller TMP86FM48UG/FG

The TMP86FM48 is the high-speed, high-performance and low power consumption 8-bit microcomputer, including FLASH, RAM, multi-function timer/counter, serial interface (UART, SIO, I²C), a 10-bit AD converter and two clock generators on chip.

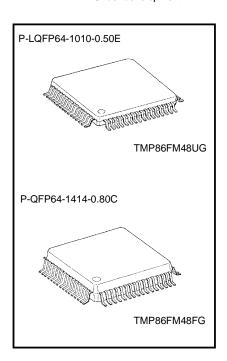
ſ	Product No.	FLASH	FLASH	RAM	Package	Emulation Chip
	FIGULE NO.	(Program area)	(Data area)	INAM	Fackage	
	TMP86FM48UG	32256 × 8 bits	512×8 bits	2.0 K × 8 bits	P-LQFP64-1010-0.50E	*TMP86C948XB
	TMP86FM48FG	32230 × 8 bits			P-QFP64-1414-0.80C	· TIVIF 00C940AB

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 (54 pins)
- 16-bit timer counter: 2 ch
 - Timer, Event counter,

Pulse width measurement, External trigger timer, Window, PPG output modes

- ♦ 8-bit timer counter: 2 ch
 - Timer, Event counter, PWM output, Programmable divider output, Capture modes
- Time base timer
- Divider output function



030619EBP1

The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal
equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are
neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or
failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy
control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control
instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document
shall be made at the customer's own risk.

For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance/Handling Precautions.



Purchase of TOSHIBA I²C components conveys a license under the Philips I²C Patent Rights to use these components in an I²C system, provided that the system conforms to the I²C Standard Specification as defined by Philips.

*: Under development

[•] The information contained herein is subject to change without notice.

The information contained herein is subject to datage without bulket.
 The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of TOSHIBA or others.
 TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general experiments of failed to the table in the transmission of a semiconductor devices in general semiconduc

TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general
can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the
buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and
to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or
damage to property.

In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..

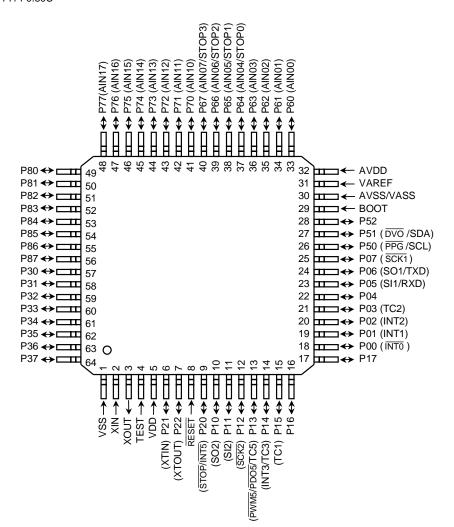
[•] The products described in this document are subject to the foreign exchange and foreign trade laws.

[•] TOSHIBA products should not be embedded to the downstream products which are prohibited to be produced and sold, under any law and regulations.

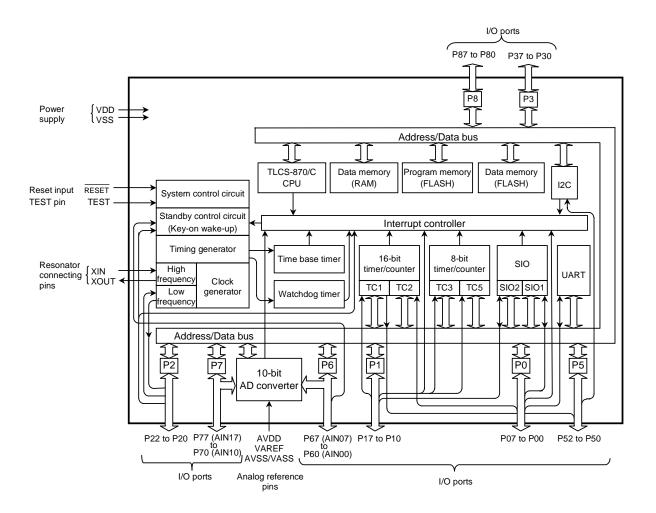
- Watchdog timer
 - Interrupt source/internal reset generate (Programmable)
- Serial interface
 - UART/SIO: 1ch
 - SIO: 1ch
 - I²C bus: 1ch
- 10-bit successive approximation type AD converter
 - Analog input: 16 ch
- Four Key-on wake-up pins
- Dual clock operation
 - Single/dual-clock mode
- Nine power 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)
 - IDLE 0 mode: CPU stops, and peripherals operate using high-frequency clock of 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 operate using low-frequency clock of 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 3.6 V at 8 MHz/32.768 kHz
 2.7 to 3.6 V at 16 MHz/32.768 kHz

Pin Assignments (Top view)

P-LQFP64-1010-0.50E P-QFP64-1414-0.80C



Block Diagram



Pin Functions (1/2)

Pin Name	Input/Output	Fund	ctions		
P07 (SCK1)	I/O (I/O)	8-bit input/output port with latch.	Serial clock input/out	tput 1	
P06 (TXD, SO1)	I/O (Output)	When used as a serial interface output	UART data output, S	Serial data output 1	
P05 (RXD, SI1)	I/O (Input)	or UART output, respective output latch (P0DR) should be set to "1".	UART data input, Se	erial data input 1	
P04	I/O	When used as an input port, an serial			
P03 (TC2)	I/O (Input)	interface input, UART input, timer	Timer counter 2 inpu	ıt	
P02 (INT2)	I/O (Input)	counter input or an external interrupt input, respective output control	External interrupt 2 i	nput	
P01 (INT1)	I/O (Input)	(POOUTCR) should be cleared to "0"	External interrupt 1 i	nput	
P00 (INTO)	I/O (Input)	after setting P0DR to "1".	External interrupt 0 i	nput	
P17	I/O	8-bit input/output port with latch.			
P16	I/O	When used as a timer/counter output or			
P15 (TC1)	I/O (Input)	serial interface output, respective output latch (P1DR) should be set to	Timer counter 1 inpu	ıt	
P14 (TC3,INT3)	I/O (Input)	"1". When used as an input port, a timer counter input, an external interrupt input	Timer counter 3 inpu External interrupt 3 i	-	
P13		or serial interface input, respective	PWM5 output, PDO5	•	
(PWM5 , PDO5 , TC5)	I/O (I/O)	output control (P1OUTCR) should be cleared to "0" after setting P1DR to "1".	Timer/counter 5 inpu	it	
P12 (SCK2)	I/O (I/O)	cleared to o alter setting Fibit to F.	Serial clock input/out	tput 2	
P11 (SI2)	I/O (Input)		Serial data input 2		
P10 (SO2)	I/O (Output)		Serial data output 2		
P22 (XTOUT)	I/O (Output)	3-bit input/output port with latch. When used as an input port or an	Resonator connecting pins (32.768 kF For inputting external clock, XTIN is us		
P21 (XTIN)	I/O (Input)	external interrupt input, respective output control (P2OUTCR) should be	and XTOUT is opened.		
P20 (INT5 , STOP)	I/O (Input)	cleared to "0" after setting output latch (P2DR) to "1".	External interrupt input 5 or STOP mode release signal input		
P37 to P30	I/O	8-bit input/output port with latch (N-ch high-current output). When used as an input port, respective output control (P3OUTCR) should be cleared to "0" after setting output latch (P3DR) to "1".			
P52	I/O	3-bit input/output port with latch (N-ch high-current output). When used as an input port or I ² C bus interface			
P51 (DVO , SDA)	I/O (Output,I/O)	input/output, respective output control (P5OUTCR) should be cleared to "0" after setting output latch (P5DR) to "1".	Divider Output/I ² C bu input/output	us serial data	
P50 (PPG , SCL)	I/O (Output,I/O)	When used as a PPG output or divider output, respective P5DR should be set to "1".	PPG Output/l ² C bus input/output	serial clock	
P67 (AIN07, STOP3)	I/O (Input)	8-bit programmable input/output port (tri-state). Each bit of this port can be	STOP 3 input		
P66 (AIN06, STOP2)	I/O (Input)	individually configured as an input or an output under software control. When	STOP 2 input		
P65 (AIN05, STOP1)	I/O (Input)	used as an input port, respective	STOP 1 input		
P64 (AIN04, STOP0)	I/O (Input)	input/output control (P6CR1) should be cleared to "0" after setting input control	STOP 0 input	AD converter	
P63 (AIN03)	I/O (Input)	(P6CR2) to "1". When used as an analog input or key on wake up input,		analog inputs	
P62 (AIN02)	I/O (Input)	respective P6CR1 should be cleared to "0" after clearing P6CR2 to "0".			
P61 (AIN01)	I/O (Input)	When used as a key on wake up input, STOPCR <stopien> should be set to</stopien>			
P60 (AIN00)	I/O (Input)	STOPCR <stopien> should be set to "1". ($i = 0$ to 3)</stopien>			

Pin Functions (2/2)

Pin Name	Input/Output	Functions	Pin Name		
P77 (AIN17)	I/O (Input)	8-bit programmable input/output port			
P76 (AIN16)	I/O (Input)	(tri-state). Each bit of this port can be individually configured as an input or an			
P75 (AIN15)	I/O (Input)	output under software control. When			
P74 (AIN14)	I/O (Input)	used as an input port, respective input/output control (P7CR1) should be	AD converter analog inputs		
P73 (AIN13)	I/O (Input)	cleared to "0" after setting input control	AD converter analog inputs		
P72 (AIN12)	I/O (Input)	(P7CR2) to "1". When used as an analog input, respective P7CR1 should be			
P71 (AIN11)	I/O (Input)	cleared to "0" after clearing P7CR2 to			
P70 (AIN10)	I/O (Input)	"0".			
P87 to P80	I/O	8-bit input/output port with latch (N-ch high-current output). When used as an input port, respective output control (P8OUTCR) should be cleared to "0" after setting output latch (P8DR) to "1".			
XIN, XOUT	Input Output	Resonator connecting pins for high-freque For inputting external clock, XIN is used a	-		
RESET	Input	Reset signal input			
TEST	Input	Test pin for out-going test. Be fixed to low.			
BOOT	Input	Serial prom mode control input. When wri be fixed to high level.	ting to FLASH memory, BOOT pin should		
VDD, VSS		Power supply for operation			
VAREF	Power Supply	Analog reference voltage for AD conversion	n		
AVDD	Fower Supply	AD circuit power supply			
AVSS/VASS		AD circuit power supply/Analog reference	GND for AD conversion		

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 Map

The TMP86FM48 memory consists of 5 blocks: FLASH memory, BOOT ROM, RAM, DBR (Data buffer register) and SFR (Special function register). They are all mapped in 64-Kbyte address space. Figure 1.1.1 shows the TMP86FM48 memory address map. The general-purpose registers are not assigned to the RAM address space.

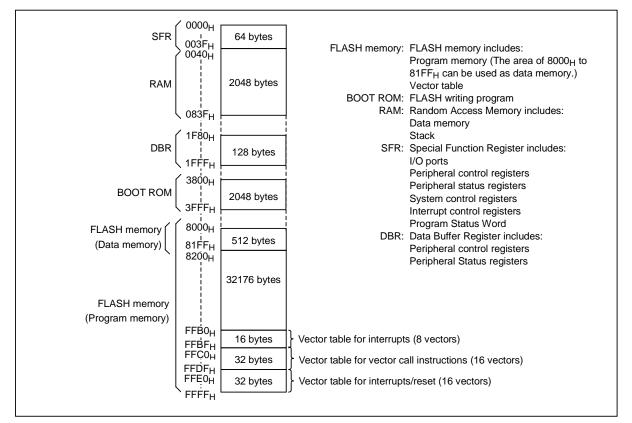


Figure 1.1.1 Memory Address Maps

1.2 Program Memory (FLASH)

The TMP86FM48 has a 32 K \times 8 bits (Address 8000_H to FFFF_H) of program memory (FLASH). The area of 8000H to 81FFH can be used as a 512 \times 8 bits data memory of FLASH.

Electrical Characteristics

Absolute Maximum Rating	$ V_{SS} = 0 V $
-------------------------	------------------

Parameter	Symbol	Pins	Rating	Unit
Supply voltage	V _{DD}		-0.3 to 4.0	
Input voltage	V _{IN}		-0.3 to V _{DD} + 0.3	V
Output voltage	V _{OUT1}		-0.3 to V _{DD} + 0.3	
	I _{OUT1}	P0, P1, P20, P3, P5, P6, P7, P8 ports	-2	
Output current (Per 1 pin)	I _{OUT2}	P0, P1, P2, P4, P6, P7, P8 ports	2	
	I _{OUT3}	P3, P5 ports	$\begin{array}{c c} -0.3 \text{ to } V_{DD} + 0.3 \\ \hline -0.3 \text{ to } V_{DD} + 0.3 \\ \hline -2 \\ 2 \\ 10 \\ \hline -80 \\ 80 \\ \hline 30 \\ 30 \\ \hline 350 \\ 260 (10 \text{ s}) \\ \hline -55 \text{ to } 125 \\ \end{array}$	
	Σlout1	P0, P1, P20, P3, P5, P6, P7, P8 ports	-80	mA
Output current (Total)	ΣΙΟυτ2	P0, P1, P2, P4, P6, P7, P8 ports	80	
	ΣΙΟυτ3	P3, P5 ports	$\begin{array}{c c} -0.3 \text{ to } 4.0 \\ \hline -0.3 \text{ to } V_{\text{DD}} + 0.3 \\ \hline -0.3 \text{ to } V_{\text{DD}} + 0.3 \\ \hline -2 \\ 2 \\ 10 \\ \hline -80 \\ \hline 80 \\ \hline 30 \\ \hline 350 \\ 260 (10 \text{ s}) \\ \end{array}$	
Power dissipation [Topr = 85°C]	PD		350	mW
Soldering temperature (Time)	Tsld		260 (10 s)	
Storage temperature	Tstg		-55 to 125	°C
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.

Parameter	Symbol	Pins	Con	dition	Min	Max	Unit
			fc = 16 MHz NORMAL1, 2 mode		2.7		
			fc = 8 MHz (In case of connecting	NORMAL1, 2 mode			
			the resonator)	IDLE0, 1, 2 mode	1.8		
Supply voltage	V _{DD}		fc = 4.2 MHz (In case of external	NORMAL1, 2 mode		3.6	
			clock input)	IDLE0, 1, 2 mode			
			fs =	SLOW1, 2 mode	1.8		
			32.768 kHz	SLEEP0, 1, 2 mode			V
				STOP mode			
	V _{IH1}	Except Hysteresis input	V _{DD} ≥ 2.7 V		$V_{DD} imes 0.70$	-	
Input high level	V _{IH2}	Hysteresis input	VDD 2 2.7 V		$V_{DD} \times 0.75$	5 V _{DD} 0	
	V _{IH3}		$V_{DD} < 2.7 \ V$		$V_{\text{DD}} \times 0.90$		
	V _{IL1}	Except Hysteresis input				$V_{\text{DD}} \times 0.30$	
Input low level	V _{IL2}	Hysteresis input	$V_{DD} \ge 2.7 V$		0	$V_{\text{DD}} \times 0.25$	
	V _{IL3}		$V_{DD} < 2.7 \ V$			$V_{DD} \\ V_{DD} \times 0.30 \\ V_{DD} \times 0.25 \\ V_{DD} \times 0.10 \\ \hline 8.0 \\ \hline 16.0 \\ \hline 34.0 \\ \hline$	
Clock frequency	fc	XIN, XOUT	$V_{DD} = 1.8$ to 3.6 V	/	1.0	8.0	MU-7
(In case of connecting	ic		$V_{DD} = 2.7 \text{ to } 3.6 \text{ V}$	/	1.0	16.0	MHz
the resonator)	fs	XTIN, XTOUT	$V_{DD} = 1.8$ to 3.6 V	/	30.0	34.0	kHz
Clock frequency	fc	XIN, XOUT	V _{DD} = 1.8 to 3.6 V		1.0	4.2	MHz
(In case of external	10		V _{DD} = 2.7 to 3.6 V		1.0	16.0	IVITZ
clock input)	fs	XTIN, XTOUT	V _{DD} = 1.8 to 3.6 V	/	30.0	34.0	kHz

Recommended Operating Condition-1 (MCU mode) $(V_{SS} = 0 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$

Note: 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.

Recommended Operating Condition-2 (Serial PROM mode)	$(V_{SS} = 0 V, Topr = 25^{\circ}C \pm 5^{\circ}C)$
--	---

Parameter	Symbol	Pins	Condition	Min	Max	Unit
Supply voltage	VDD		$2 \text{ MHz} \le \text{fc} \le 16 \text{ MHz}$	2.7	3.6	V
Clock frequency	fc	XIN, XOUT	VDD = 2.7 to 3.6 V	2.0	16.0	MHz

Note: The operating temperature area of serial PROM mode is $25^{\circ}C \pm 5^{\circ}C$ and the operating area of high frequency of serial PROM mode is different from MCU mode.

Parameter	Symbol		Pir	ns	Cond	lition	Min	Тур.	Max	Unit
Hysteresis voltage	V _{HS}	Hyster	Hysteresis input		$V_{DD} = 3.3 V$	V _{DD} = 3.3 V		0.4	-	V
	I _{IN1}	TEST		$V_{DD}=3.6~V,~V_{IN}$	= 0 V	-	-	-5		
Input current	I _{IN2}	Sink op	pen dra	ain, Tri-state	$V_{DD}=3.6~V,~V_{IN}$	= 3.6 V/0 V	-	-	±5	μA
	I _{IN3}	RESET	F		$V_{DD} = 3.6 V, V_{IN}$	= 3.6 V	-	_	+5	
	R _{IN1}	TEST	pull do	wn	$V_{DD} = 3.6 \text{ V}, \text{ V}_{IN}$	= 3.6 V	-	70	_	
	R _{IN2}	BOOT	pull do	wn	$V_{DD}=3.6~V,~V_{IN}$	= 3.6 V	-	70	_	ko
Input resistance	R _{IN3}	RESET P21, P	¯ pull u 22 por	•	$V_{DD} = 3.6 \text{ V}, \text{ V}_{IN}$		100	220	450	kΩ
High frequency feedback resistor	R _{FB}	хоит			V _{DD} = 3.6 V		-	3	_	Мо
Low frequency feedback resistor	R _{FBT}	ХТОИТ		V _{DD} = 3.6 V		Ι	20	_	MΩ	
Output leakage current	I _{LO}	Sink open drain, Tri-state		V _{DD} = 3.6 V V _{OUT} = 3.4V/0.2 V		_	-	±10	μΑ	
Output high voltage	V _{OH}	CMOS	CMOS, Tri-state		$V_{DD} = 3.6 \text{ V}, I_{OH}$	$V_{DD} = 3.6 \text{ V}, I_{OH} = -0.6 \text{ mA}$		-	-	
Output low voltage	V _{OL}	Except ports	t XOUT	Γ, P3 and P5	$V_{DD} = 3.6 \text{ V}, \text{ I}_{OL} = 0.9 \text{ mA}$		-	-	0.4	V
Output low current	IOL	P3, P5	ports		$V_{DD} = 3.6 \text{ V}, V_{OL} = 1.0 \text{ V}$		-	6	-	mA
Supply current in			Fetch	Flash area	$V_{DD} = 3.6 V$	MNP = "1"	I	5.0	6.0	
NORMAL 1, 2 mode			area	RAM area	$V_{IN} = 3.4 \text{ V/0.2 V}$	MNP = "0"	Ι	3.5	4.8	mA
Supply current in					fc = 16 MHz	MNP•ATP = "1"	-	3.5	4.5	iii v
IDLE 0, 1, 2 mode		-		1	fs = 32.768 kHz	MNP•ATP = "0"	-	2.5	3.7	
Supply current in			Fetch	Flash area	-	MNP = "1"	-	800	1400	
SLOW 1 mode	I _{DD}		area	RAM area	V _{DD} = 3.0 V	MNP = "0"	-	6	20	
Supply current in	יםםי				$V_{\rm IN} = 2.8 \rm V/0.2 \rm V$	MNP•ATP = "1"	-	800	1400	μA
SLEEP 1 mode	-				$f_{\rm IN} = 32.768 \text{ kHz}$	MNP•ATP = "0"	-	5	18	
Supply current in						MNP•ATP = "1"	-	800	1400	P
SLEEP 0 mode	1					$MNP \bullet ATP = "0"$	-	5	18	
Supply current in STOP mode					$V_{DD} = 3.6 V$ $V_{IN} = 3.4 V/0.2 V$		_	0.5	10	

DC Characteristics $(V_{SS} = 0 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$

Note 1: Typical values show those at Topr = 25° C.

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 SLOW2 and SLEEP2 modes are equivalent to IDLE0, IDLE1, IDLE2.

Note 5: MNP (MNPWDW) shows bit0 in EEPCR register and ATP (ATPWDW) shows bit1 in EEPCR register.

Note 6: "Fetch" means reading operation of FLASH data as an instruction by CPU.

AD Conversion Characteristics $(V_{SS} = 0.0 \text{ V}, 2.7 \text{ V} \le V_{DD} \le 3.6 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Analog reference voltage	VAREF		A _{VDD} - 1.0	-	A _{VDD}	
Power supply voltage of analog control circuit	A _{VDD}			V _{DD}		V
Analog reference voltage range (Note 4)	ΔV_{AREF}		2.5	-	-	V
Analog input voltage	V _{AIN}		V _{SS}	-	VAREF	
Power supply current of analog reference voltage	I _{REF}	$V_{DD} = A_{VDD} = V_{AREF} = 3.6 V$ $V_{SS} = 0.0 V$	-	0.35	0.61	mA
Non linearity error		V _{DD} = A _{VDD} = 2.7 V	-	-	<u>+</u> 2	
Zero point error			-	I	±2	LSB
Full scale error		$V_{SS} = 0.0 V$	_	_	±2	LOB
Total error		V _{AREF} = 2.7 V	_	_	±2	

(V_{SS} = 0.0 V, 2.0 V \leq V_{DD} < 2.7 V, Topr = -40 to 85°C)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Analog reference voltage	VAREF		A _{VDD} - 0.6	-	A _{VDD}	
Power supply voltage of analog control circuit	A _{VDD}			V _{DD}		V
Analog reference voltage range (Note 4)	ΔV_{AREF}		2.0	_	_	v
Analog input voltage	V _{AIN}		V _{SS}	-	VAREF	
Power supply current of analog reference voltage	I _{REF}	$V_{DD} = A_{VDD} = V_{AREF} = 2.0V$ $V_{SS} = 0.0 V$	-	0.20	0.34	mA
Non linearity error		V _D = A _{VD} = 2.0 V	-	_	±4	
Zero point error		55 155	-	-	±4	LSB
Full scale error		$V_{SS} = 0.0 V$	-	_	±4	LOB
Total error		$V_{AREF} = 2.0 V$	-	-	±4	

$(V_{SS} = 0.0$ V, 1.8 V $\leq V_{DD} <$ 2.0 V, Topr = -10 to 85°C) (Note 5)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Analog reference voltage	VAREF		$A_{VDD} - 0.1$	_	A _{VDD}	
Power supply voltage of analog control circuit	A _{VDD}			V _{DD}		V
Analog reference voltage range (Note 4)	ΔV_{AREF}		1.8	-	-	v
Analog input voltage	V _{AIN}		V _{SS}	-	VAREF	
Power supply current of analog reference voltage	I _{REF}	$V_{DD} = A_{VDD} = V_{AREF} = 1.8 V$ $V_{SS} = 0.0 V$	-	0.18	0.31	mA
Non linearity error		V _D = A _{VD} = 1.8 V	-	_	±4	
Zero point error		55 155	-	-	±4	LSB
Full scale error		$V_{SS} = 0.0 V$	-	-	±4	LOB
Total error		V _{AREF} = 1.8 V	_	_	±4	

Note 1: The total error includes all errors except a quantization error, and is defined as a 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 "2.15.2 Register configration".

Note 3: Please use input voltage to AIN input Pin in limit of VAREF – VSS. 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: $\triangle VAREF = VAREF VSS$
- Note 5: When AD is used with VDD < 2.0 V, the guaranteed temperature range varies with the operating voltage.

Note 6: When AD converter is not used, fix the AVDD pin and VAREFpin on the V_{DD} level.

AC Characteristics	(V _{SS} = 0 V, V _{DD} = 2.7 to 3.6 V, Topr = -40 to 85°C)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode IDLE1, 2 mode	0.25	-	4	
		SLOW1, 2 mode SLEEP1, 2 mode	117.6	_	133.3	μS
High Level clock pulse width Low level clock pulse width	twcH twcL	For external clock operation (XIN input), fc = 16 MHz	_	31.25	_	ns
High level clock pulse width Low level clock pulse width	twcH twcL	For external clock operation (XTIN input), fs = 32.768 kHz	-	15.26	_	μS

$(V_{SS} = 0 \text{ V}, V_{DD} = 1.8 \text{ to } 3.6 \text{ V}, \text{ Topr} = -40 \text{ to } 85^{\circ}\text{C})$

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.5	-	4	μs
		IDLE1, 2 mode				
		SLOW1, 2 mode	117.6	_	133.3	
		SLEEP1, 2 mode				
High level clock pulse width	twcH	For external clock operation (XIN input), $fc = 4.2 \text{ MHz}$	_	119.04	-	ns
Low level clock pulse width	twcL					
High level clock pulse width	twcH	For external clock operation (XTIN input), fs = 32.768 kHz	_	15.26	_	μS
Low level clock pulse width	twcL					

Flash Characteristics $(V_{SS} = 0 V)$

Parameter	Condition	Min	Тур.	Max	Unit
Number of guaranteed writes (page writing) to Flash memory in serial PROM mode	$V_{DD} = 2.7 \text{ to } 3.6 \text{ V}, 2 \text{ MHz} \le \text{fc} \le 16 \text{ MHz}$ (Topr = 25°C \pm 5°C)	_	_	10 ⁵	Times
Number of guaranteed writes (page writing) to Flash data memory in MCU mode	$V_{DD} = 1.8$ to 3.6 V at fc = 8 MHz $V_{DD} = 2.7$ to 3.6 V at fc = 16 MHz (Topr = -40 to 85°C)	_	_	10 ⁵	Times
Writing time to Flash data memory for one page (64 bytes) in MCU mode		_	4	6	ms

Recommended Oscillating Conditions

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