CMOS 8-Bit Microcontroller

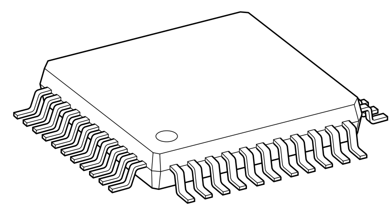
TMP86FH47UG

The TMP86FH47 is a high-speed, high-performance 8-bit microcomputer built around the TLCS-870/C Series core with built-in 16-Kbyte flash memory and it is pin compatible with its mask ROM version, the TMP86C845/847/H47. Writing programs in the built-in flash memory enables this microcomputer to perform the same operations as the TMP86C847/H47. About TMP86C845, please refer to "Difference between TMP86C845 and TMP86Cx47". The built-in flash memory can be rewritten on board (without removing it from the PCB) by a built-in boot program.

Product No.	Flash Memory	RAM	Package
TMP86FH47UG	16384 × 8 bits	512 × 8 bits	P-LQFP44-1010-0.80A

Feautures

P-LQFP44-1010-0.80A



TMP86FH47UG

- 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
- 18 interrupt sources (External: 6, Internal: 12)
- Input/output ports (35 pins)
- 8-bit timer counter: 2 ch
  - Timer, PWM, PPG, PDO, Event counter modes
- Time base timer
- Watchdog timer
  - Interrupt sources/reset output (Programmable)
- Serial interface
  - 8-bit SIO: 1 ch
  - 8-bit UART: 1 ch

- 10-bit successive approximation type AD converter
  - Analog input: 8 ch
- 16-bit timer counter: 1 ch
  - Timer, event counter, pulse width measurment, programmable pulse generator (PPG), external-triggered timer, window modes
- Key-on wakeup: 4 ch
- Dual clock operation
  - Single/dual-clock mode
- Nine power saving operating modes
  - STOP mode: Oscillation stops. Battery/capacitor backup. 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 INTTBT interrupt.
  - IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by interrupts.
  - IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
  - SLEEP 0 mode: CPU stops, and peripherals operate using low-frequency clock of time-base-timer. Release by INTTBT interrupt.
  - 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: 4.5 to 5.5 V at 16 MHz/32.768 kHz
  2.7 to 5.5 V at 8 MHz/32.768 kHz

Note: The operating voltage, the operating temperature and the operating current are different between TMP86FH47 and TMP86C845/847/H47.
About details, please refer to electrical characteristics of each products.

Difference Between TMP86C845 and TMP86Cx47

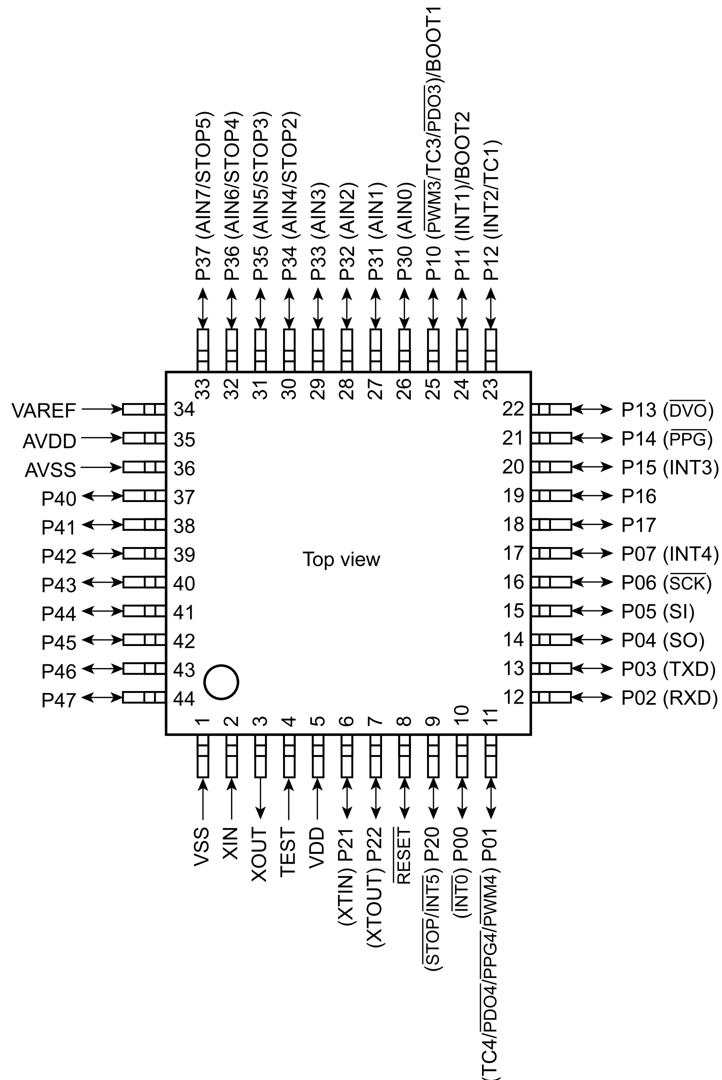
		TMP86Cx47U			TMP86C845U
		TMP86C847U	TMP86CH47U	TMP86CM47U	
ROM (Byte)		8 K	16 K	32 K	8 K
RAM (Byte)		512	512	1 K	256
I/O		35			35
Package (Body size)		QFP44 (10 × 10 mm)			QFP44 (10 × 10 mm)
Min instruction		0.25 μs (at 16 MHz)			0.5 μs (at 8 MHz)
Supply voltage		1.8 to 5.5 V at 4.2 MHz/32.768 kHz 2.7 to 5.5 V at 8.0 MHz/32.768 kHz 4.5 to 5.5 V at 16 MHz/32.768 kHz			2.7 to 5.5 V at 8.0 MHz/ 32.768 kHz
16-bit timer/counter		1 ch			–
8-bit timer/counter		2 ch			2 ch
Time base timer		1 ch			1 ch
Watchdog timer		1 ch			1 ch
AD converter		8 ch			8 ch
Serial I/O		Clocked synchronous: 1 ch, UART: 1 ch			Clocked synchronous: 1 ch
Key on wakeup		4 ch			–
Warm-up counter		6			4
I/O Circuitry	Hysteresis input	P0, P1, P2 port			Port2, P00, P05, P06, P07, P10, P11, P12, P15 pin
	CMOS input	P3, P4 port			Port3, Port4, P01, P02, P03, P04, P13, P14, P16, P17 pin
	$\overline{\text{RESET}}$	Watchdog timer, Adress trap, System clock reset output			Input only
Operation Temp.		–40 to 85°C			–40 to 85°C

(shaded) are difference points between TMP86C845 and TMP86Cx47.

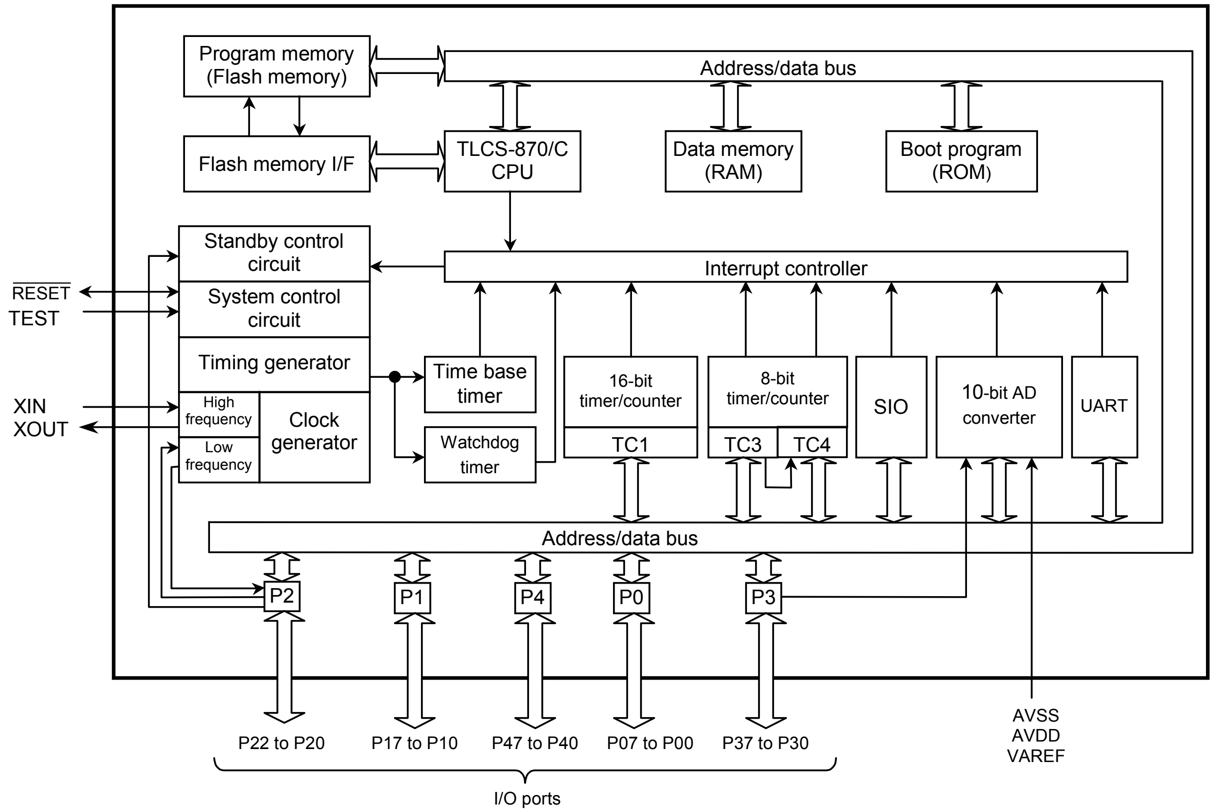
Please refer to "Input/Output Circutry" of TMP86C847/H47/M47 and TMP86C845 for details.

Pin Assignments (Top view)

P-LQFP44-1010-0.80A



Block Diagram



Pin Function

The TMP86FH47 has MCU mode and serial PROM mode.

(1) MCU mode

In the MCU mode, the TMP86FH47 is a pin compatible with the TMP86C845/847/H47 (Make sure to fix the TEST pin to low level).

(2) Serial PROM mode

The serial PROM mode is set by fixing TEST pin, P10 and P11 at "high" respectively when $\overline{\text{RESET}}$ pin is fixed "low".

After release of reset, the built-in BOOT ROM program is activated and the built-in flash memory is rewritten by serial I/F (UART).

Pin Name (Serial PROM mode)	Input/ Output	Functions	Pin Name (MCU mode)
BOOT1/RXD	Input/Input	Fix "High" during reset. This pin is used as RXD pin after releasing reset.	P10
BOOT2/TXD	Input/Output	Fix "High" during reset. This pin is used as TXD pin after releasing reset.	P11
TEST	Input	Fix to "High".	
$\overline{\text{RESET}}$	I/O	Reset signal input or an internal error reset output.	
VDD, AVDD	Power supply	5 V	
VSS, AVSS, VAREF		0 V	
P07 to P00, P17 to P12, P22 to P20, P37 to P30, P47 to P40		Fix to "Low" or "High".	
XIN	Input	Self oscillation with resonator (2 MHz, 4 MHz, 8 MHz, 16 MHz)	
XOUT	Output		

Operation

This section describes the functions and basic operational blocks of TMP86FH47.

The TMP86FH47 has flash memory in place of the mask ROM which is included in the TMP86C845/847/H47. The configuration and function are the same as the TMP86C847/H47. For TMP86C845, however, some functions have been partially changed or deleted. For the functions of TMP86FH47 in details, see the section of TMP86C845/847/H47.

1. Operating Mode

The TMP86FH47 has MCU mode and serial PROM mode.

1.1 MCU Mode

The MCU mode is set by fixing the TEST pin to the low level.

In the MCU mode, the operation is the same as the TMP86C845/847/H47 (TEST pin cannot be used open because it has no built-in pull-down resistor).

1.1.1 Program memory

The TMP86FH47 has a 16-Kbyte built-in flash memory (addresses C000H to FFFFH in the MCU mode).

When using TMP86FH47 for evaluation of TMP86C845/847/H47, the program is written by the serial PROM mode.

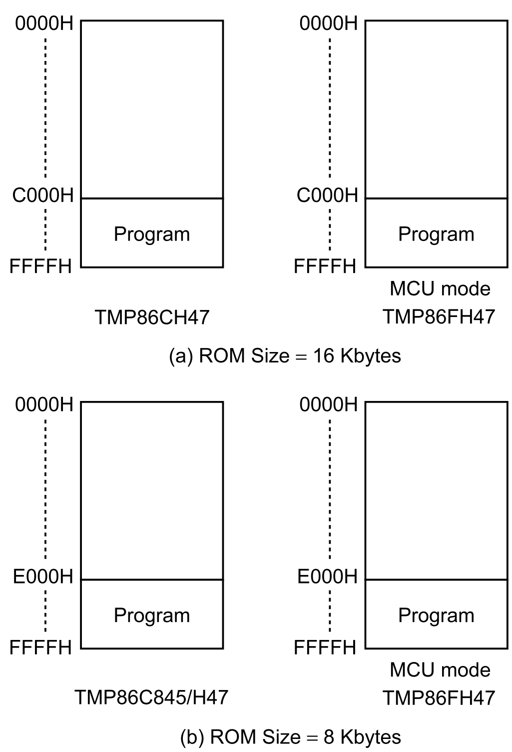


Figure 1.1.1 Program Memory Area

Note: The area that is not in use should be set data to FFH.

2. Serial PROM Mode

2.1 Outline

The TMP86FH47 has a 2-Kbyte BOOT ROM for programming to flash memory. This BOOT ROM is a mask ROM that contains a program to write the flash memory on-board. The BOOT ROM is available in a serial PROM mode and it is controlled by TEST pin and $\overline{\text{RESET}}$ pin and 2 I/O pins, and is communicated with UART. There are four operation modes in a serial PROM mode: flash memory writing mode, RAM loader mode, flash memory SUM output mode and product discrimination code output mode. Operating area of serial PROM mode differs from that of MCU mode. The operating area of serial PROM mode shows in Table 2.1.1.

Table 2.1.1 Operating Area of Serial PROM Mode

Parameter	Symbol	Min	Max	Unit
Operating voltage	V_{DD}	4.5	5.5	V
High frequency	fc	2, 4, 8, 16		MHz
Temperature	Topr	25 ± 5		°C

2.2 Memory Mapping

The BOOT ROM is mapped in address F800H to FFFFH. The BOOT ROM can't be accessed in MCU mode. The Figure 2.2.1 shows a memory mapping.

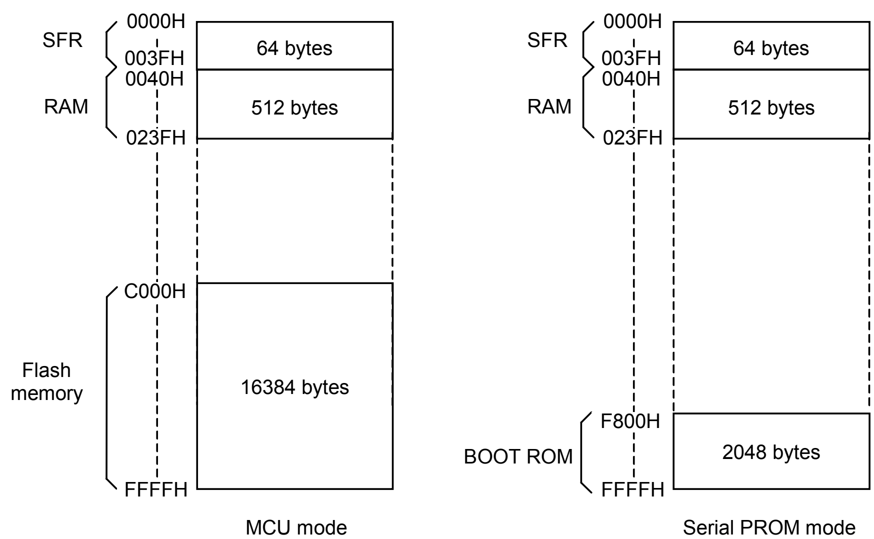


Figure 2.2.1 Memory Address Maps

Electrical Characteristics

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

Parameter	Symbol	Pins	Rating	Unit
Supply voltage	V_{DD}		−0.3 to 5.5	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 (Per 1 pin)	I_{OUT1} I_{OH}	P1, P3, P4 ports	−1.8	mA
	I_{OUT2} I_{OL}	P1, P3 ports	3.2	
	I_{OUT3} I_{OL}	P0, P2, P4 ports	30	
Output current (Total)	ΣI_{OUT1}	P1, P3 ports	60	
	ΣI_{OUT2}	P0, P2, P4 ports	80	
Power dissipation [Topr = 70°C]	PD		250	mW
Soldering temperature (time)	Tsld		260 (10 s)	°C
Storage temperature	Tstg		−55 to 125	
Operating temperature	Topr		−40 to 70 (MCU mode)	
			20 to 30 (Serial PROM mode)	

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

1) MCU mode (V_{SS} = 0 V, Topr = −40 to 70°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			
				STOP mode			
Input high level	V_{IH1}	Except hysteresis input	$V_{DD} \geq 4.5$ 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	$V_{DD} \geq 4.5$ V		0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
	V_{IL3}		$V_{DD} < 4.5$ V			$V_{DD} \times 0.10$	
Clock frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V		1.0	16.0	MHz
			V_{DD} = 2.7 to 5.5 V			8.0	
	fs	XTIN, XTOUT			30.0	34.0	kHz

2) Serial PROM mode (V_{SS} = 0 V, Topr = 20 to 30°C)

Parameter	Symbol	Pins	Condition	Min	Max	Unit
Supply voltage	V_{DD}		fc = 2 MHz, 4 MHz, 8 MHz, 16 MHz	4.5	5.5	V
Input high level	V_{IH1}	Except hysteresis input	V_{DD} = 4.5 to 5.5 V	$V_{DD} \times 0.70$	V_{DD}	
	V_{IH2}	Hysteresis input		$V_{DD} \times 0.75$		
Input low level	V_{IL1}	Except hysteresis input	V_{DD} = 4.5 to 5.5 V	0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis input			$V_{DD} \times 0.25$	
Clock frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V	2.0, 4.0, 8.0, 16		MHz

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.

DC Characteristics (V_{SS} = 0 V, Topr = –40 to 70°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} = 5.5/0 V		–	–	±2	μA
	I_{IN2}	Sink open drain, tri-state						
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$						
Input resistance	R_{IN2}	$\overline{RESET}$ pull up			100	200	450	kΩ
Output leakage current	I_{LO1}	Sink open drain	V_{DD} = 5.5 V, V_{OUT} = 5.5 V		–	–	2	μA
	I_{LO2}	Tri-state	V_{DD} = 5.5 V, V_{OUT} = 5.5/0 V		–	–	±2	
Output high voltage	V_{OH}	Tri-state	V_{DD} = 4.5 V, I_{OH} = –0.7 mA		4.1	–	–	V
Output low voltage	V_{OL}	Except XOUT, P0, P2 and P4 ports	V_{DD} = 4.5 V, I_{OL} = 1.6 mA		–	–	0.4	
Output low current	I_{OL}	High current port (P0, P2, P4 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 V/0.2 V fc = 16 MHz fs = 32.768 kHz		–	8.0	12.5	
Supply current in IDLE1, 2 mode					–	6.0	9.0	
Supply current in IDLE0 mode					–	4.5	9.0	
Supply current in SLOW1 mode			V_{DD} = 3.0 V V_{IN} = 2.8 V/0.2 V fs = 32.768 kHz	When a program operates on flash memory	–	300	600	μA
				When a program operates on RAM	–	8.0	27	
Supply current in SLEEP1 mode					–	7.0	25	
Supply current in SLEEP0 mode					–	6.0	24	
Supply current in STOP mode			V_{DD} = 5.0 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_{IN3}); The current through pull-up resistor is not included.

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

AD Conversion Characteristics (V_{SS} = 0 V, 4.5 V ≤ V_{DD} ≤ 5.5 V, Topr = –40 to 70°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog reference voltage	V_{AREF}		A_{VDD} – 1.0	–	A_{VDD}	V
Power supply voltage of analog control circuit	A_{VDD}		V_{DD}			V
Analog reference voltage range (Note 4)	ΔV_{AREF}		3.5	–	–	V
Analog input voltage	V_{AIN}		V_{SS}	–	V_{AREF}	V
Power supply current of analog reference voltage	I_{REF}	$V_{DD} = A_{VDD} = V_{AREF}$ = 5.5 V $V_{SS} = A_{VSS}$ = 0.0 V	–	0.6	1.0	mA
Non linearity error		$V_{DD} = A_{VDD}$ = 5.0 V $V_{SS} = A_{VSS}$ = 0.0 V V_{AREF} = 5.0 V	–	–	±2	LSB
Zero point error			–	–	±2	
Full scale error			–	–	±2	
Total error			–	–	±2	

(V_{SS} = 0 V, 2.7 V ≤ V_{DD} < 4.5 V, Topr = –40 to 70°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog reference voltage	V_{AREF}		A_{VDD} – 1.0	–	A_{VDD}	V
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}	–	V_{AREF}	V
Power supply current of analog reference voltage	I_{REF}	$V_{DD} = A_{VDD} = V_{AREF}$ = 4.5V $V_{SS} = A_{VSS}$ = 0.0 V	–	0.5	0.8	mA
Non linearity error		$V_{DD} = A_{VDD}$ = 2.7 V V_{SS} = 0.0 V V_{AREF} = 2.7 V	–	–	±2	LSB
Zero point error			–	–	±2	
Full scale error			–	–	±2	
Total error			–	–	±2	

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 "10-Bit AD Converter".

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: The A_{VDD} pin should be fixed on the V_{DD} level even though AD converter is not used.

AC Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = –40 to 70°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.25	–	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 = 16 MHz	–	31.25	–	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					

(V_{SS} = 0 V, V_{DD} = 2.7 to 4.5 V, Topr = –40 to 70°C)

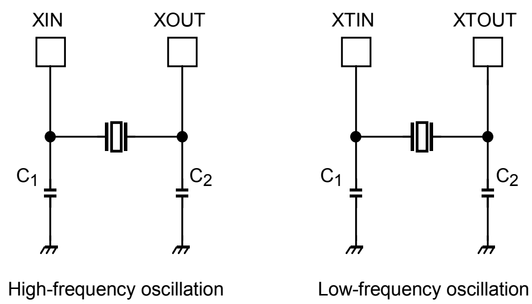
Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.5	–	4	μs
		IDLE1, 2 mode				
		SLOW1, 2 mode	117.6	–	133.3	
		SLEEP1, 2 mode				
High level clock pulse width	twcH	For external clock operation (XIN input), fc = 8 MHz	–	62.5	–	ns
Low level clock pulse width	twcL					
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					

Recommended Oscillating Conditions-1 (V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = −40 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommened Oscillator		Recommended Constant	
					C_1	C_2
High-frequency Oscillation	Ceramic Resonator	16 MHz	MURATA	CSA16.00MXZ040	10 pF	10 pF
		8 MHz	MURATA	CSA8.00MTZ	30 pF	30 pF
				CST8.00MTW	30 pF (built-in)	30 pF (built-in)
		4.19 MHz	MURATA	CSA4.19MG	30 pF	30 pF
				CST4.19MGW	30 pF (built-in)	30 pF (built-in)
Low-frequency Oscillation	Crystal Oscillator	32.768 kHz	SII	VT-200	6 pF	6 pF

Recommended Oscillating Conditions-2 (V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = −40 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommened Oscillator		Recommended Constant	
					C_1	C_2
High-frequency Oscillation	Ceramic Resonator	8 MHz	MURATA	CSA8.00MTZ	30 pF	30 pF
				CST8.00MTW	30 pF (built-in)	30 pF (built-in)
		4.19 MHz	MURATA	CSA4.19MG	30 pF	30 pF
				CST4.19MGW	30 pF (built-in)	30 pF (built-in)



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

Note 2: To ensure stable oscillation, the resonator position, load capacitance, etc. must be appropriate. Because there factors are greatly affected by board patterns, please be sure to evaluate operation on the board on which the device will actually be mounted.

Note 3: 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