CMOS 4-Bit Microcontroller

TMP47C243N, TMP47C443N
TMP47C243M, TMP47C443M
TMP47C243DM, TMP47C443DM

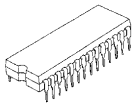
The TMP47C243/443 are the high speed and high performance 4-bit single chip microcomputers, with 8-bit AD converter, 8-bit serial interface, pulse output and zero-cross detector based on the TLCS-470 series.

Part No.	ROM	RAM	Rackage	OTP
TMP47C243N	2048 × 8-bit	128 × 4-bit	P-SDIP28-400-1.78	TMP47P443VN
TMP47C243M			P-SOP28-450-1.27	TMP47P443VM
TMP47C243DM			P-SSOP30-56-0.65	TMP47P443VDM
TMP47C443N	4096 × 8-bit	256 × 4-bit	P-SDIP28-400-1.78	TMP47P443VN
TMP47C443M			P-SOP28-450-1.27	TMP47P443VM
TMP47C443DM			P-SSOP30-56-0.65	TMP47P443VDM

Features

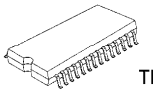
- ◆4-bit single chip microcomputer
- ◆Instruction execution time: 1.0 μs (at 8 MHz)
- ◆Low voltage operation: 2.2 V (at 4.2 MHz)
- ◆92 basic instructions
  - Table look-up instructions
  - 5-bit to 8-bit data conversion instruction
- ◆Subroutine nesting: 15 levels max
- ◆6 interrupt sources (External: 2, Internal: 4)
  All sources have independent latches each, and multiple interrupt control is available.
- ◆I/O port (23 pins)
- ◆Interval Timer
- ◆Two 12-bit Timer/Counters
  Timer, event counter,and pulse width measurement mode
- ◆Serial Interface with 8-bit buffer
  - Simultaneous transmission and reception capability
  - 8/4-bit transfer, external/internal clock, and leading/trailing edge shift mode

P-SDIP28-400-1.78



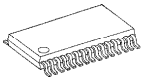
TMP47C243N
TMP47C443N
TMP47P443VN

P-SOP28-450-1.27



TMP47C243M
TMP47C443M
TMP47P443VM

P-SSOP30-56-0.65



TMP47C243DM
TMP47C443DM
TMP47P443VDM

000707EBA1

◆8-bit successive approximate type AD converter
- With sample and hold
- 8 analog inputs
- Conversion time: 24 μs (at 8 MHz)

◆Pulse output
Buzzer drive/Remocon carrier

◆Zero-cross detector

◆High current outputs
LED direct drive capability (typ. 20 mA × 8 bits)

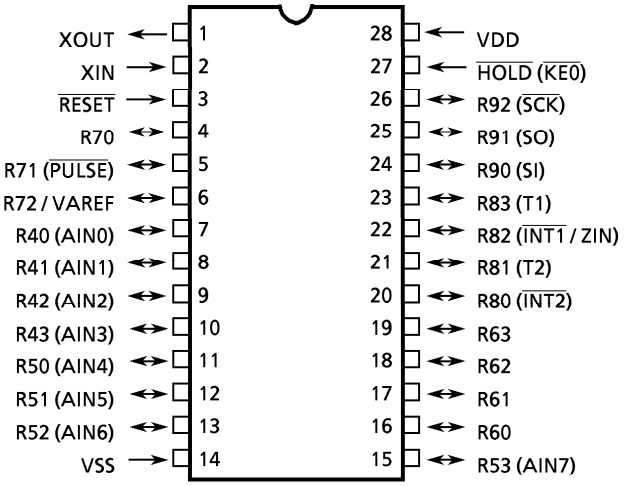
◆RESET function
- Watchdog Timer

◆Hold function
Battery/Capacitor back-up

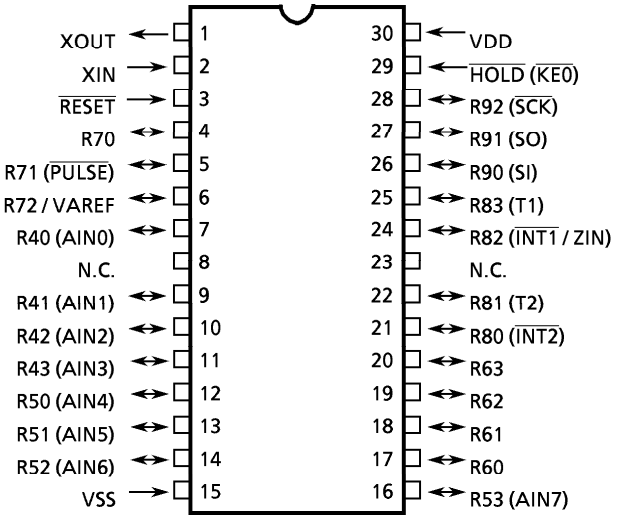
◆Emulation pod: BM47C443

Pin Assignments (Top View)

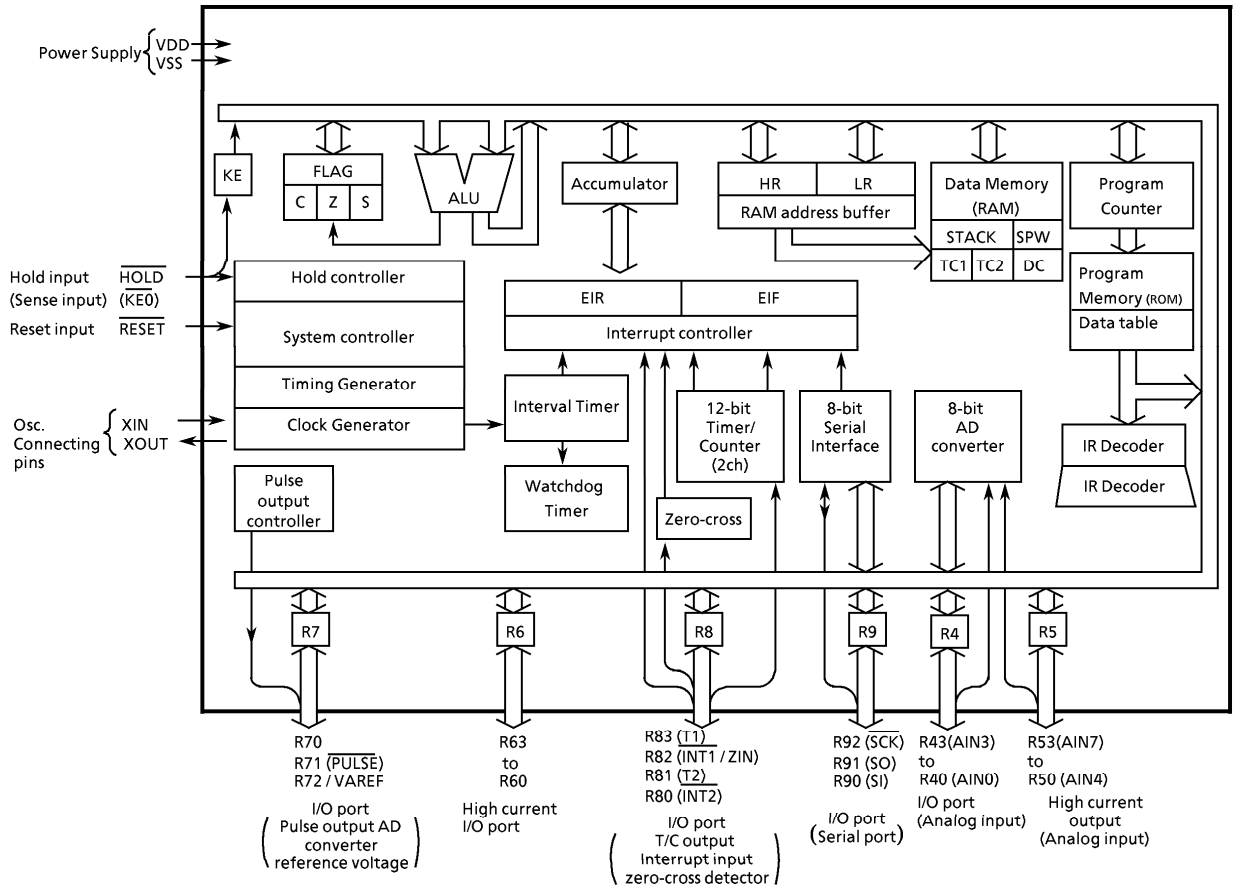
P-SDIP28-400-1.78 / P-SOP28-450-1.27



P-SSOP30-56-0.65



Block Diagram



Pin Function

Pin Name	Input / Output	Functions	
R43 to R40	I/O (input)	4-bit I/O port with latch (R7 port has 3-bit). Every bit data is possible to be set, cleared and tested by the bit manipulation instruction of the L-register indirect addressing. In the R5 and R6 port, 8-bit data are output by the 5-bit to 8-bit data conversion instruction [OUTB @HL] .	AD converter analog input
R53 to R50			
R63 to R60	I/O		
R72 /VAREF	I/O		AD converter reference voltage
R71 ($\overline{\text{PULSE}}$)	I/O (Output)		Pulse output
R70	I/O		
R83 (T1)	I/O (Input)	4-bit I/O port with latch. When used as input port, external interrupt input pin, or timer/counter external input pin, the latch must be set to "1".	Timer/Counter 1 external input
R82 ($\overline{\text{INT1}}$/ZIN)			External interrupt 1 and zero-cross input
R81 (T2)			Timer/Counter 2 external input
R80 ($\overline{\text{INT2}}$)			External interrupt 1 input
R92 ($\overline{\text{SCK}}$)	I/O (I/O)	3-bit I/O port with latch. When used as input port or serial port, the latch must be set to "1".	Serial clock I/O
R91 (SO)	I/O (Output)		Serial data output
R90 (SI)	I/O (Input)		Serial data input
XIN	Input	Resonator connecting pins. For inputting external clock, XIN is used and XOUT is opened.	
XOUT	Output		
$\overline{\text{RESET}}$	Input	Reset signal input	
$\overline{\text{HOLD}}$ ($\overline{\text{KE0}}$)	Input (Input)	Hold request/release signal input	Sense input
VDD	Power Supply	+ 5 V	
VSS		0 V (GND)	

Operational Description

Concerning the TMP47C243/443 the configuration and functions of hardwares are described. The basic instruction of configuration in the TMP47C243/443 is the same as those of TLCS-470 serise.

1. System Configuration

◆Internal CPU Function

- 2.1 Program Counter (PC)
- 2.2 Program Memory (ROM)
- 2.3 H Register, L Register
- 2.4 Data Memory (RAM)
  - a. Stack, b. Stack Pointer Word (SPW), c. Data Counter (DC)
- 2.5 ALU, Accumulator
- 2.6 Flags
- 2.7 Clock Generator and Timing Generator
- 2.8 Interrupt Function
- 2.9 Reset Function
  - · Watchdog Timer Reset

◆Peripheral Hardware Function Watchdog Timer Reset

- 3.1 I/O Ports
- 3.2 Interval Timer
- 3.3 Timer/Counters (TC1, TC2)
- 3.4 AD Converter
- 3.5 Pulse output
- 3.6 Zero-cross detector
- 3.7 Serial Interface

2. Internal CPU Function

2.1 Program Counter (PC)

The program counter is a 12-bit binary counter which indicates the address of the program memory storing the next instruction to be executed. Normally, the PC is incremented by the number of bytes of the instruction every time it is fetched. When a branch instruction or a subroutine instruction has been executed or an interrupt has been accepted, the specified values listed in Table 2-1 are set to the PC. The PC is initialized to "0" during reset.

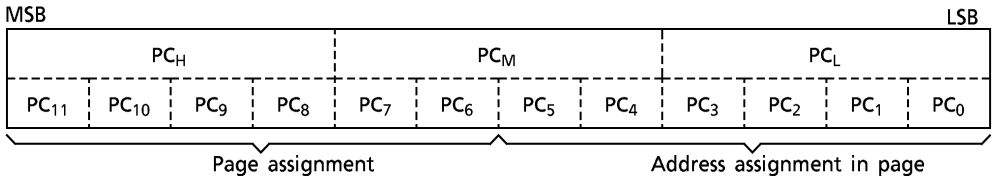


Figure 2-1. Configuration of Program Counter

The PC can directly address a 4096-byte address space. However, with the short branch and subroutine call instructions, the following points must be considered. In the TMP47C243/443, the long branch instruction [BSL a] is invalid.

(1) Short branch instruction [BSS a]

In [BSS a] instruction execution, when the branch condition is satisfied, the value specified in the instruction is set to the lower 6 bits of the PC. That is, [BSS a] becomes the in-page branch instruction. When [BSS a] is stored at the last address of the page, the upper 6 bits of the PC point the next page, so that branch is made to the next page.

(2) Subroutine call instruction [CALL a]

In [CALL a] instruction execution, the contents of the PC are saved to the stack then the value specified in the instruction is set to the PC. The address which can be specified by the instruction consists of 11 bits and the most significant bit of the PC is always "0". Therefore, the entry address of the subroutine should be within an addrress range of 000_H through $7FF_H$.

Table 2-1. Status Change of Program Counter

Instruction or Operation		Condition		Program Counter (PC)											
				PC_{11}	PC_{10}	PC_9	PC_8	PC_7	PC_6	PC_5	PC_4	PC_3	PC_2	PC_1	PC_0
Execution of Instruction	BS a	SF = 1 (Branch condition is satisfied)		Immediate data specified by the instruction											
		SF = 0 (Branch condition is not satisfied)		+ 2											
	BSS a	SF = 1	Lower 6-bit address ≠ 111111	Hold				Immediate data specified by the instruction							
			Lower 6-bit address = 111111 (last address in page)	+ 1				Immediate data specified by the instruction							
		SF = 0		+ 1											
	CALL a			0	Immediate data specified by the instruction										
	CALLS a			0	0	0	0	The data generated by the immediate data specified by the instruction				1	1	0	
	RET			The return address restored from stack											
	RETI			The return address restored from stack											
	Others			Incremented by the number of bytes in the instruction											
Interrupt acceptance				0	0	0	0	0	0	0	0	Interrupt vector			0
Reset				0	0	0	0	0	0	0	0	0	0	0	0

2.2 Program Memory (ROM)

Programs and fixed data are stored in the program memory. The instruction to be executed next is read from the address indicated by the contents of the PC.

The fixed data can be read by using the table look-up instructions or 5-bit to 8-bit data conversion instruction.

(1) Table look-up instructions

[LDL A, @DC], [LDH A, @DC+]

The table look-up instructions read the lower and upper 4 bits of the fixed data stored at the address specified in the data counter (DC) to place them into the accumulator. [LDL A, @DC] instruction reads the lower 4 bits of fixed data, and [LDH A, @DC+] instruction reads the upper 4 bits.

The DC is a 12-bit register, allowing it to address the entire program memory space.

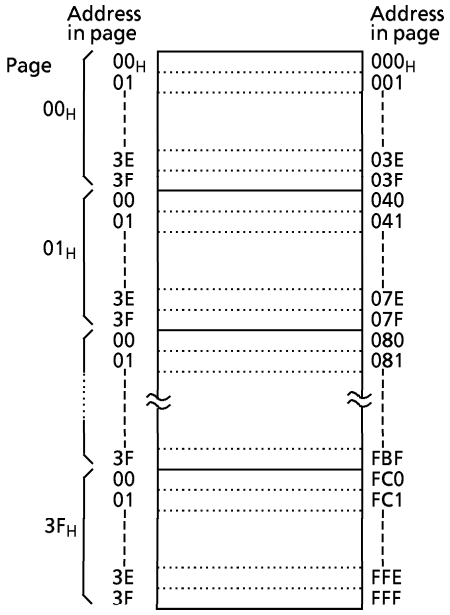


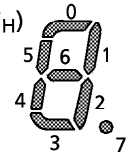
Figure 2-2. Configuration of Program Memory

(2) 5-bit to 8-bit data conversion instruction [OUTB @HL]

The 5-bit to 8-bit data conversion instruction reads the fixed data (8 bits) from the data conversion table in the program memory to output the upper 4 bits to port R6 and the lower 4 bits to port R5. The table is located in the last 32-byte space (addresses,$7E0_H$ through $7FF_H$ for the TMP47C243, $FE0_H$ through FFF_H for the TMP47C443) in the program memory with the lower address consisting of the 5 bits obtained by concatenating the contents of the data memory specified by the HL register pair and the content of the carry flag. This instruction is usable for such applications as converting BCD data into an output code to the 7-segment display elements.

Example: The following shows that the BCD data at address $2F_H$ in the data memory is converted into the 7-segment code (e.g., anode common LED) to be output to ports R6 and R5.

```
LD      HL, #2FH ;  HL←2FH (Data memory address is set)
TEST    CF       ;  CF←0 (The table is specified at addresses FE0H to FEFH)
OUTB    @HL      ;  Ports R6, R5←fixed data
  ⋮
ORG     0FE0H    ;  Data conversion table
DATA    0C0H, 0F9H, 0A4H, 0B0H, 99H, 92H, 82H, 0D8H, 80H, 98H
```

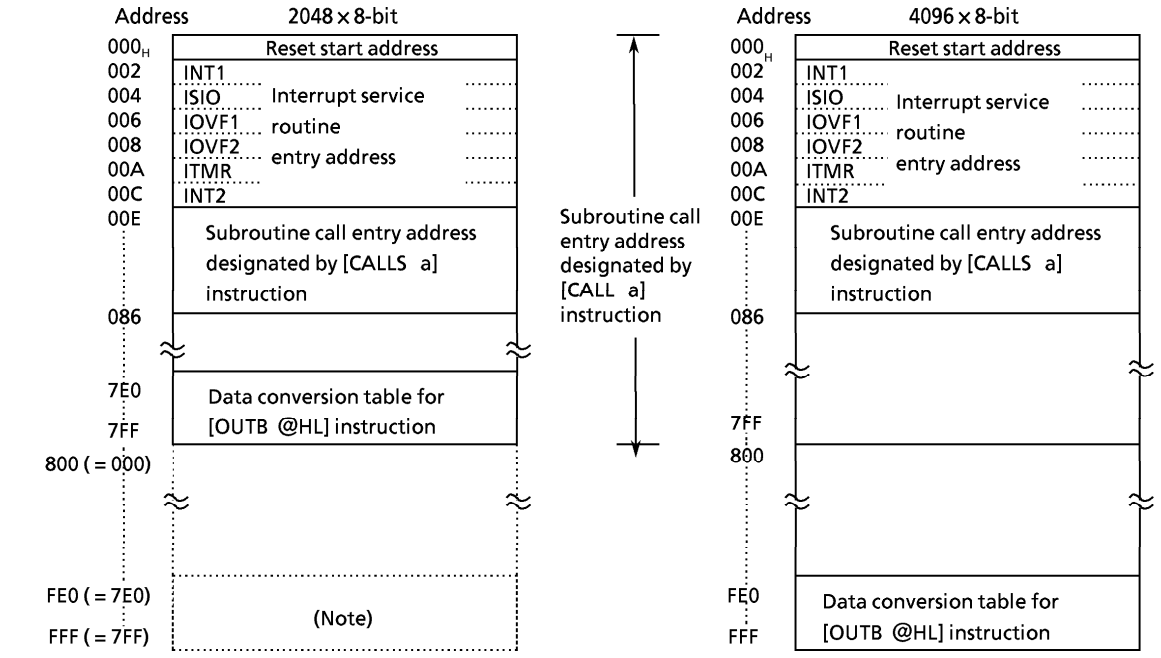


2.2.1 Program Memory Map

Figure 2-3 shows the program memory map. Address 000_H to 086_H and $FE0_H$ to FFF_H (000_H to 086_H and $7E0_H$ to $7FF_H$ for the TMP47C243) of the program memory are also used for special purposes.

2.2.2 Program Memory Capacity

The TMP47C243 has 2048 × 8 bits (addresses 000_H through $7FF_H$) of program memory (mask ROM), the TMP47C443 has 4096 × 8 bits (addresses 000_H through FFF_H).



Note: When the TMP47P443V (OTP) is used, the address from $FE0_H$ to FFF_H are used as the data conversion table area.

(a) TMP47C243 (b) TMP47C443

Figure 2-3. Program Memory Map

On the TMP47C243, no physical program memory exists in the address range 800_H through FFF_H. However, if this space is accessed by program, the most significant bit of each address is always regarded as "0" and the contents of the program memory corresponding to the address 000_H through $7FF_H$ are read.

Electrical Characteristics

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

Parameter	Symbol	Pins		Ratings	Unit
Supply Voltage	V_{DD}			– 0.3 to 6.5	V
Input Voltage	V_{IN}			– 0.3 to V_{DD} + 0.3	V
Output Voltage	V_{OUT}			– 0.3 to V_{DD} + 0.3	V
Output Current (Per 1 pin)	I_{OUT1}	Port R5, R6		30	mA
	I_{OUT2}	Ports R4, R7, R8, R9		3.2	
Output Current (Total)	ΣI_{OUT}	Port R5, R6		120	mA
Power Dissipation [Topr = 70°C]	PD		DIP	300	mW
			SOP	180	
			SSOP	145	
Soldering Temperature (time)	Tsld			260 (10 s)	°C
Storage Temperature	Tstg			– 55 to 125	°C
Operating Temperature	Topr			– 30 to 70	°C

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 Conditions (V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Max	Unit
Supply Voltage	V_{DD}		fc = 8.0 MHz	2.7	5.5	V
			fc = 4.2 MHz	2.2		
			In the HOLD mode	2.0		
Input High Voltage	V_{IH1}	Except Hysteresis Input	In the normal operating area	V_{DD} × 0.7	V_{DD}	V
	V_{IH2}	Hysteresis Input		V_{DD} × 0.75		
	V_{IH3}		In the HOLD mode	V_{DD} × 0.9		
Input Low Voltage	V_{IL1}	Except Hysteresis Input	In the normal operating area	0	V_{DD} × 0.3	V
	V_{IL2}	Hysteresis Input			V_{DD} × 0.25	
	V_{IL3}		In the HOLD mode		V_{DD} × 0.1	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 2.7 to 5.5 V	0.4	8.0	MHz
			V_{DD} = 2.2 to 5.5 V		4.2	
			In the RC oscillation		2.5	

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 = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis Input		–	0.7	–	V
Input Current	I_{IN1}	$\overline{RESET}$, $\overline{HOLD}$	V_{DD} = 5.5 V, V_{IN} = 5.5 V / 0 V	–	–	± 2	μA
	I_{IN2}	Open drain output ports					
Input Resistance	R_{IN}	$\overline{RESET}$		100	220	450	kΩ
Output Leakage Current	I_{LO}	Open drain output ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	–	–	2	μA
Output Low Voltage	V_{OL}	Port R4, R7, R8, R9	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	–	–	0.4	V
			V_{DD} = 2.2 V, I_{OL} = 20 μA	–	–	0.1	
Output Low Current	I_{OL1}	Port R5, R6	V_{DD} = 4.5 V, V_{OL} = 1.0 V	7	20	–	mA
Supply Current (in the Normal operating mode)	I_{DD}		V_{DD} = 5.5 V, fc = 4 MHz	–	2	4	mA
			V_{DD} = 3.0 V, fc = 4 MHz	–	1	2	
			V_{DD} = 3.0 V, fc = 400 kHz	–	0.5	1	
Supply Current (in the HOLD operating mode)	I_{DDH}		V_{DD} = 5.5 V	–	0.5	10	μA

Note 1: Typ. values show those at Topr = 25°C, V_{DD} = 5 V.

Note 2: Input Current I_{IN1}: The current through resistor is not included.

Note 3: Supply Current: V_{IN} = 5.3 V / 0.2 V (V_{DD} = 5.5 V), 2.8 V / 0.2 V (V_{DD} = 3.0 V)

AD Conversion Characteristics

(Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}	(Mask option)	V_{DD} – 1.5	—	V_{DD}	V
Analog Reference Voltage Range	$\triangle V_{AREF}$	V_{AREF} – V_{SS}	2.7	—	—	V
Analog Input Voltage	V_{AIN}		V_{SS}	—	V_{DD}	V
Analog Supply current	I_{REF}		—	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 2.7 to 5.5 V V_{AREF} = V_{DD} ± 0.001 V V_{SS} = ± 0.001 V	—	—	± 1	LSB
Zero Point Error			—	—	± 1	
Full Scale Error			—	—	± 1	
Total Error			—	—	± 2	

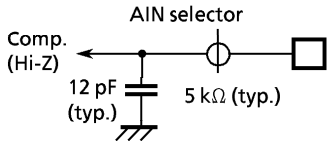
AC Characteristics

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions		Min	Typ.	Max	Unit
Instruction Cycle Time	tcy		V_{DD} = 2.7 to 5.5 V	1.0	–	20	μs
			V_{DD} = 2.2 to 5.5 V	1.9			
			RC oscillation	3.2			
High level clock pulse width	t_{WCH}	For external clock (XIN input)	$V_{DD} \geqq 2.7$ V	60	–	–	ns
			$V_{DD} < 2.7$ V	120			
Low level clock pulse width	t_{WCL}		$V_{DD} \geqq 2.7$ V	60			
			$V_{DD} < 2.7$ V	120			
AD Conversion Time	t_{ADC}			–	24 tcy	–	μs
AD Sampling Time	t_{AIN}			–	2 tcy	–	
Shift data Hold Time	t_{SDH}			0.5 tcy – 0.3	–	–	μs

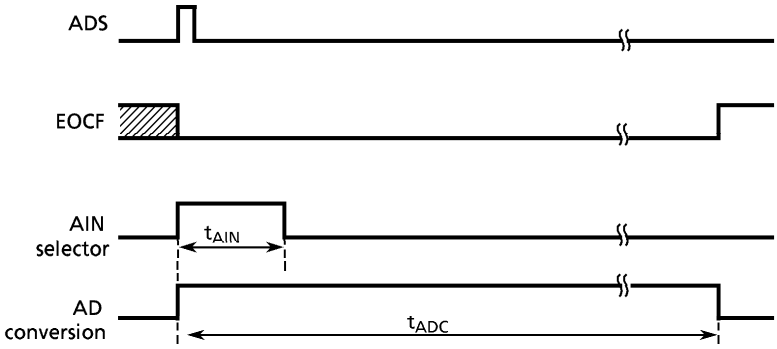
Note 1: AD conversion timing:

Internal circuit for pins AIN0 to 7



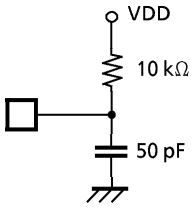
* Electrical change inust be loaded into the buit-in condensen during t_{AIN} for normal AD conversion.

AD conversion timing

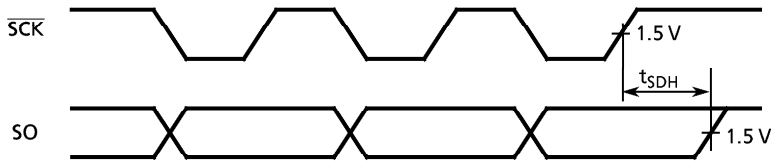


Note 2: Shift data Hold Time:

External circuit for pins SCK and SO



Serial port (completed of transmission)

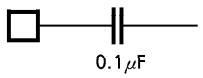


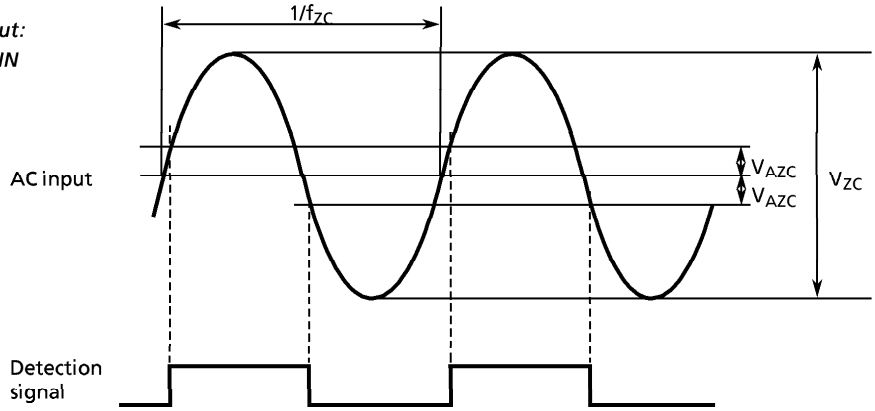
Zero-Cross Detection Characteristics

(Vss = 0 V, Topr = – 30 to 70℃)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Zero-cross Input Voltage	V_{ZC}	AC coupling (C = 0.1 μF)	1.0	—	3.0	V_{P-P}
Zero-cross Accuracy	V_{AZC}	f_{ZC} = 50 to 60 Hz (sine curve)	—	—	± 135	mV
Zero-cross input frequensy	f_{ZC}		40	—	1000	Hz

Note 3: Zero-cross detection input:
External circuit for pin ZIN

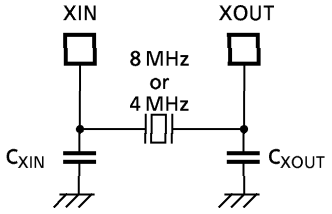




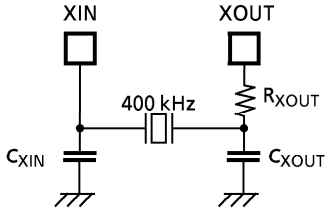
Recommended Oscillating Conditions

(V_{SS} = 0 V, V_{DD} = 2.5 to 5.5 V, Topr = – 30 to 70°C)

(1) 8 MHz (V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 to 70°C)
Ceramic Resonator
KBR-800M (KYOCERA) $C_{XIN} = C_{XOUT}$ = 30 pF
Crystal Oscillator
210B-6F 8.0000 (TOYOCOM) $C_{XIN} = C_{XOUT}$ = 20 pF

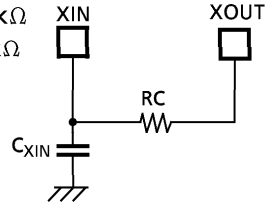


(2) 4 MHz (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 30 to 70°C)
Ceramic Resonator
CSA4.00MG (MURATA) $C_{XIN} = C_{XOUT}$ = 30 pF
KBR-4.00MS (KYOCERA) $C_{XIN} = C_{XOUT}$ = 30 pF
EFOEC4004A4 (NATIONAL) $C_{XIN} = C_{XOUT}$ = 30 pF
Crystal Oscillator
204B-6F 4.0000 (TOYOCOM) $C_{XIN} = C_{XOUT}$ = 20 pF



(3) 400 kHz (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 30 to 70°C)
Ceramic Resonator
CSB400B (MURATA) $C_{XIN} = C_{XOUT}$ = 220 pF, R_{XOUT} = 6.8 kΩ
KBR-400B (KYOCERA) $C_{XIN} = C_{XOUT}$ = 100 pF, R_{XOUT} = 10 kΩ
EFOA400K04B (NATIONAL) $C_{XIN} = C_{XOUT}$ = 470 pF, R_{XOUT} = 0 Ω

(4) RC Oscillation (V_{SS} = 0 V, V_{DD} = 5.0 V, Topr = 25°C)
2 MHz (Typ.) C_{XIN} = 33 pF, R_X = 10 kΩ
400 kHz (Typ.) C_{XIN} = 100 pF, R_X = 30 kΩ



Typical Characteristics