

## CMOS 4-Bit Microcontroller

**TMP47C103N, TMP47C203N  
TMP47C103M, TMP47C203M**

The TMP47C103/203 are high speed and high performance 4-bit single chip micro computers, integrating ROM, RAM, input/output ports and timer/counters on a ship.

The TMP47C103/203 are standard LSI in the TLCS-47E series.

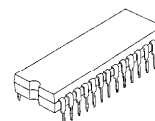
In addition, they have 8 bit SIO, watchdog timer and the output port with LED direct drive capability.

| Part No.   | ROM          | RAM         | Package           | OTP Version |
|------------|--------------|-------------|-------------------|-------------|
| TMP47C103N | 1024 x 8-bit | 64 x 4-bit  | P-SDIP28-400-1.78 | TMP47P403VN |
| TMP47C103M |              |             | P-SOP28-450-1.27  | TMP47P403VM |
| TMP47C203N | 2048 x 8-bit | 128 x 4-bit | P-SDIP28-400-1.78 | TMP47P403VN |
| TMP47C203M |              |             | P-SOP28-450-1.27  | TMP47P403VM |

**Features**

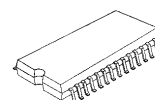
- ◆ 4-bit single chip microcomputer
- ◆ Instruction execution time: 1.3  $\mu$ s (at 6 MHz)
- ◆ Low voltage operation: 2.2 V (at 2 MHz RC)
- ◆ 90 basic instructions
  - ROM table look-up instructions
  - 5-bit to 8-bit data conversion instruction
- ◆ Subroutine nesting: 15 levels max
- ◆ 6 interrupt sources (External: 2, Internal: 4)
  - All sources have independent latches each, and multiple interrupt control is available
- ◆ I/O port (23 pins)
- ◆ Two 12-bit Timer / Counters
  - Timer, event counter, and pulse width measurement mode
- ◆ Interval Timer
- ◆ Watchdog Timer
- ◆ Serial Interface with 8-bit buffer
  - Simultaneous transmission and reception capability
  - 4/8-bit transfer, external / internal clock, and leading/trailing edge shift mode

P-SDIP28-400-1.78



TMP47C103N  
TMP47C203N  
TMP47P403VN

P-SOP28-450-1.27



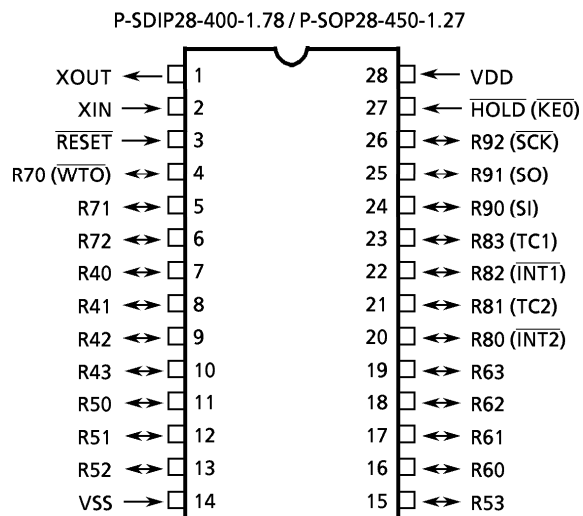
TMP47C103M  
TMP47C203M  
TMP47P403VM

000707EBA1

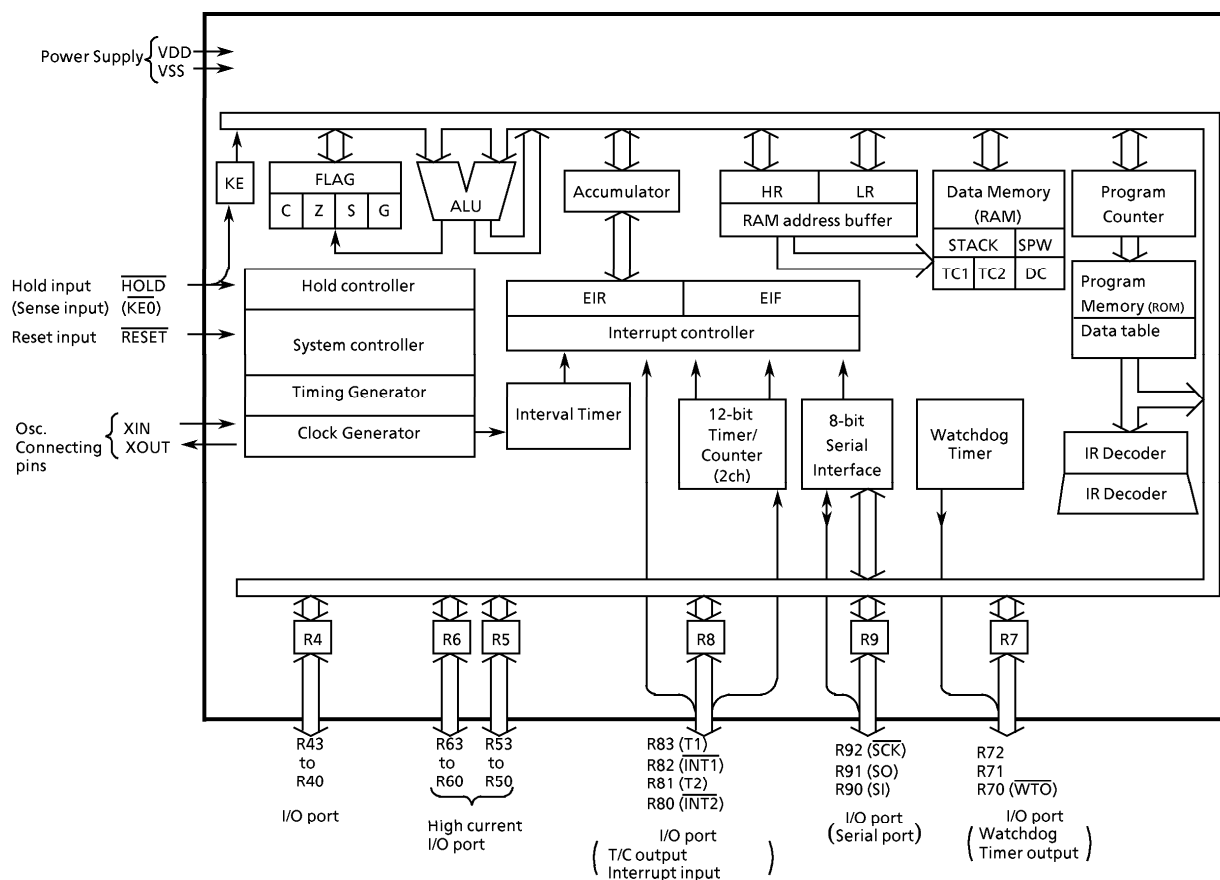
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- ◆ High current outputs
  - LED direct drive capability: typ. 20 mA × 8 bits (port R5, R6)  
typ. 7 mA × 4 bits (port R4)
- ◆ Hold function
  - Battery / Capacitor back-up
- ◆ Real Time Emulator: BM47C203

## Pin Assignment (Top View)



## Block Diagram



## Pin Function

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

## Operational Description

Concerning the TMP47C103/203 the configuration and functions of hardwares are described. The basic instruction of configuration in the TMP47C103/203 is the same those of TLCS-47 serie.

### 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

#### ◆ Peripheral Hardware Function

- 3.1 I/O Ports
- 3.2 Interval Timer
- 3.3 Timer / Counters (TC1, TC2)
- 3.4 Watchdog Timer
- 3.5 Serial Interface

### 2. Internal CPU Function

#### 2.1 Program Counter (PC)

The program counter is a 11-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.

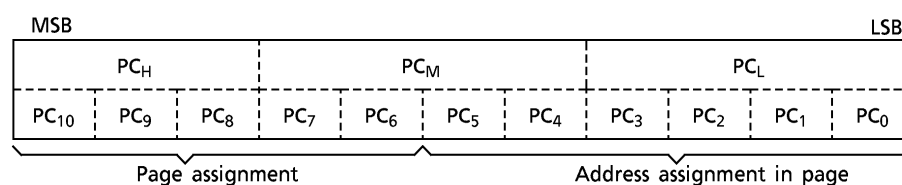


Figure 2-1. Configuration of Program Counter

The PC can directly address a 2048-byte address space. However, with the short branch and subroutine call instructions, the following points must be considered.

(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.

Table 2-1. Status Change of Program Counter

| Instruction or Operation |          | Condition                                     |                                                           | Program Counter (PC)                                  |                 |                 |                                                                       |                                             |                 |                 |                  |                 |                 |                 |
|--------------------------|----------|-----------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------|-----------------|-----------------|-----------------------------------------------------------------------|---------------------------------------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|
|                          |          |                                               |                                                           | PC <sub>10</sub>                                      | PC <sub>9</sub> | PC <sub>8</sub> | PC <sub>7</sub>                                                       | PC <sub>6</sub>                             | PC <sub>5</sub> | PC <sub>4</sub> | PC <sub>3</sub>  | PC <sub>2</sub> | PC <sub>1</sub> | PC <sub>0</sub> |
| Execution of Instruction | BS    a  | SF = 1<br>(Branch condition is satisfied)     |                                                           | Immediate data specified by the instruction           |                 |                 |                                                                       |                                             |                 |                 |                  |                 |                 |                 |
|                          |          | SF = 0<br>(Branch condition is not satisfied) |                                                           | + 2                                                   |                 |                 |                                                                       |                                             |                 |                 |                  |                 |                 |                 |
|                          | BSS   a  | SF = 1                                        | Lower 6-bit address<br>≠ 111111                           | Hold                                                  |                 |                 |                                                                       | Immediate data specified by the instruction |                 |                 |                  |                 |                 |                 |
|                          |          |                                               | Lower 6-bit address<br>= 111111<br>(last address in page) | + 1                                                   |                 |                 |                                                                       | Immediate data specified by the instruction |                 |                 |                  |                 |                 |                 |
|                          |          | SF = 0                                        |                                                           | + 1                                                   |                 |                 |                                                                       |                                             |                 |                 |                  |                 |                 |                 |
|                          | CALL   a |                                               |                                                           | Immediate data specified by the instruction           |                 |                 |                                                                       |                                             |                 |                 |                  |                 |                 |                 |
|                          | CALLS a  |                                               |                                                           | 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               | Interrupt vector |                 |                 | 0               |
| Reset                    |          |                                               |                                                           | 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 used by using the table look-up instructions on 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.

In this case, the upper bit of the DC (MSB) is ignored.

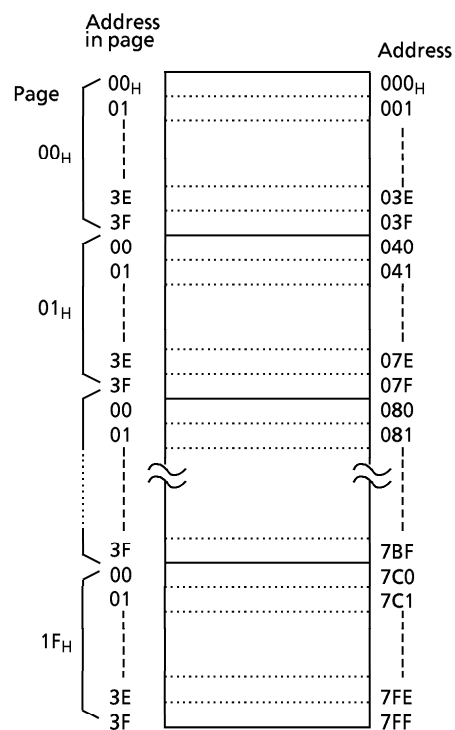


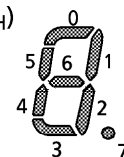
Figure 2-2. Configuration of Program Memory

## (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 P6 and the lower 4 bits to port P5. The table is located in the last 32-byte space (addresses 7E0<sub>H</sub> through 7FF<sub>H</sub> for the TMP47C203, 3E0<sub>H</sub> through 3FF<sub>H</sub> for the TMP47C103) 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<sub>H</sub> in the data memory is converted into the 7-segment code (e.g., anode common LED) to be output to ports P6 and P5.

```
LD      HL, #2FH ; HL←2FH (Data memory address is set)
TEST    CF      ; CF←0 (The table is specified at addresses 7E0H - 7FFH)
OUTB    @HL     ; Ports P6, P5←fixed data
:
ORG      07E0H   ; Data conversion table
DATA     0C0H, 0F9H, 0A4H, 0B0H, 99H, 92H, 82H, 0D8H, 80H, 98H
```



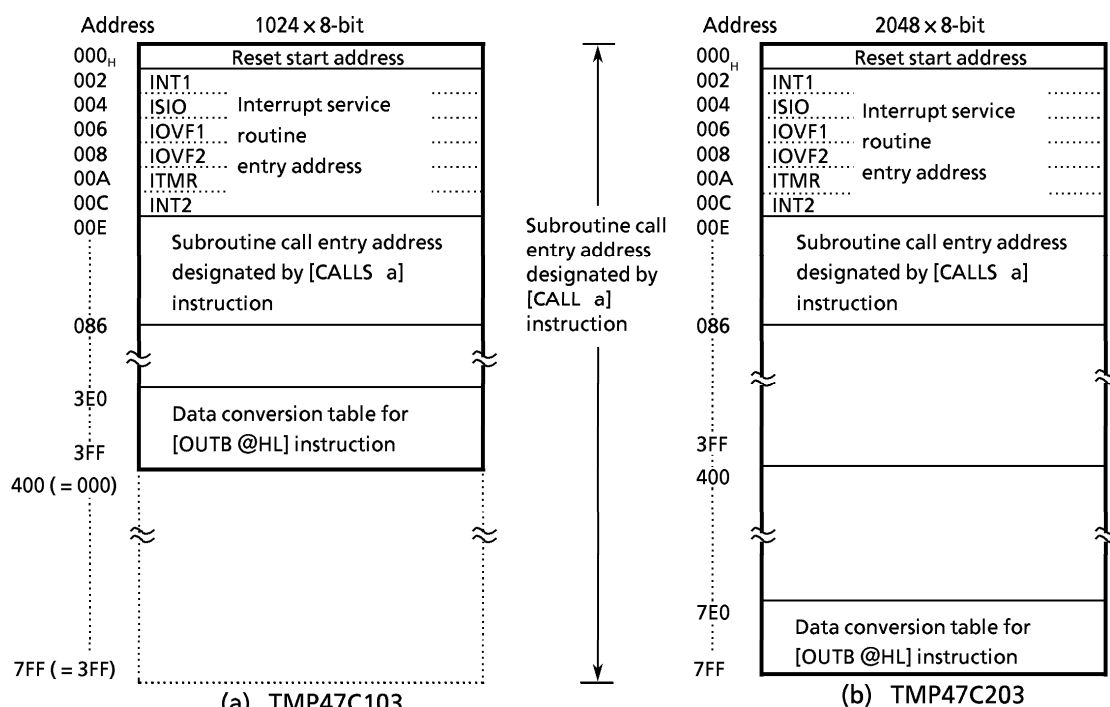
### 2.2.1 Program Memory Map

The TMP47C103 has 1024 × 8 bits (addresses 000<sub>H</sub> through 3FF<sub>H</sub>) of program memory (mask ROM), the TMP47C203 has 2048 × 8 bits (addresses 000<sub>H</sub> through 7FF<sub>H</sub>).

Figure 2-3 shows the program memory map. Address 000<sub>H</sub> to 086<sub>H</sub> and 7E0<sub>H</sub> to 7FF<sub>H</sub> (3E0<sub>H</sub> to 3FF<sub>H</sub> for the TMP47C103) of the program memory are also used for special purposes.

### 2.2.2 Program Memory Capacity

On the TMP47C103, no physical program memory exists in the address range 400<sub>H</sub> through 7FF<sub>H</sub>. 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<sub>H</sub> through 3FF<sub>H</sub> are read.



Note: It is necessary to set two data conversion tables to check operation of TMP47C103/203 using TMP47P403V. For details, see the technical documents of TMP47P403V.

Figure 2-3. Program Memory Map

## Electrical Characteristics

## Absolute Maximum Ratings

(V<sub>SS</sub> = 0 V)

| Parameter                                   | Symbol             | Pins             | Ratings                        | Unit |
|---------------------------------------------|--------------------|------------------|--------------------------------|------|
| Supply Voltage                              | V <sub>DD</sub>    |                  | – 0.3 to 6.5                   | V    |
| Input Voltage                               | V <sub>IN</sub>    |                  | – 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Voltage                              | V <sub>OUT</sub>   |                  | – 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Current (Per 1 pin)                  | I <sub>OUT1</sub>  | Port R5, R6      | 30                             | mA   |
|                                             | I <sub>OUT2</sub>  | Port R4          | 15                             |      |
|                                             | I <sub>OUT3</sub>  | Ports R7, R8, R9 | 3.2                            |      |
| Output Current (Total)                      | Σ I <sub>OUT</sub> | Port R4, R5, R6  | 120                            | mA   |
| Power Dissipation [T <sub>opr</sub> = 70°C] | PD                 | DIP              | 300                            | mW   |
|                                             |                    | SOP              | 180                            |      |
| Soldering Temperature (time)                | T <sub>sld</sub>   |                  | 260 (10 s)                     | °C   |
| Storage Temperature                         | T <sub>stg</sub>   |                  | – 55 to 125                    | °C   |
| Operating Temperature                       | T <sub>opr</sub>   |                  | – 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<sub>SS</sub> = 0 V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter          | Symbol           | Pins                    | Conditions                                     | Min                    | Max                    | Unit |
|--------------------|------------------|-------------------------|------------------------------------------------|------------------------|------------------------|------|
| Supply Voltage     | V <sub>DD</sub>  | Normal mode             | Crystar or ceramic<br>f <sub>c</sub> = 6.0 MHz | 4.5                    | 5.5                    | V    |
|                    |                  |                         | f <sub>c</sub> = 4.2 MHz                       | 2.7                    |                        |      |
|                    |                  |                         | RC<br>f <sub>c</sub> = 2.5 MHz                 | 2.2                    |                        |      |
|                    |                  | HOLD mode               | –                                              | 2.0                    |                        |      |
| Input High Voltage | V <sub>IH1</sub> | Except Hysteresis Input | In the normal operating area                   | V <sub>DD</sub> × 0.7  | V <sub>DD</sub>        | V    |
|                    | V <sub>IH2</sub> | Hysteresis Input        |                                                | V <sub>DD</sub> × 0.75 |                        |      |
|                    | V <sub>IH3</sub> |                         | In the HOLD mode                               | V <sub>DD</sub> × 0.9  |                        |      |
| Input Low Voltage  | V <sub>IL1</sub> | Except Hysteresis Input | In the normal operating area                   | 0                      | V <sub>DD</sub> × 0.3  | V    |
|                    | V <sub>IL2</sub> | Hysteresis Input        |                                                |                        | V <sub>DD</sub> × 0.25 |      |
|                    | V <sub>IL3</sub> |                         | In the HOLD mode                               |                        | V <sub>DD</sub> × 0.1  |      |
| Clock Frequency    | f <sub>c</sub>   | XIN, XOUT               | V <sub>DD</sub> = 4.5 to 5.5 V                 | 0.4                    | 6.0                    | MHz  |
|                    |                  |                         | V <sub>DD</sub> = 2.7 to 5.5 V                 |                        | 4.2                    |      |
|                    |                  |                         | V <sub>DD</sub> = 2.2 to 5.5 V (RC)            |                        | 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<sub>SS</sub> = 0 V, T<sub>opr</sub> = –30 to 70°C)

| Parameter                                           | Symbol           | Pins                    | Conditions                                             | Min | Typ. | Max | Unit |
|-----------------------------------------------------|------------------|-------------------------|--------------------------------------------------------|-----|------|-----|------|
| Hysteresis Voltage                                  | V <sub>HS</sub>  | Hysteresis Input        |                                                        | –   | 0.7  | –   | V    |
| Input Current                                       | I <sub>IN1</sub> | RESET, HOLD             | V <sub>DD</sub> = 5.5 V, V <sub>IN</sub> = 5.5 V / 0 V | –   | –    | ± 2 | μA   |
|                                                     | I <sub>IN2</sub> | Open drain output ports |                                                        |     |      |     |      |
| Input Resistance                                    | R <sub>IN</sub>  | RESET                   |                                                        | 100 | 220  | 450 | kΩ   |
| Input Low Current                                   | I <sub>IL</sub>  | Push-pull output ports  | V <sub>DD</sub> = 5.5 V, V <sub>IN</sub> = 0.4 V       | –   | –    | – 2 | mA   |
| Output Leakage Current                              | I <sub>LO</sub>  | Open drain output ports | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V      | –   | –    | 2   | μA   |
| Output High Voltage                                 | V <sub>OH</sub>  | Push-pull output ports  | V <sub>DD</sub> = 4.5 V, I <sub>OH</sub> = – 200 μA    | 2.4 | –    | –   | V    |
|                                                     |                  |                         | V <sub>DD</sub> = 2.2 V, I <sub>OH</sub> = – 5 μA      | 2.0 | –    | –   |      |
| Output Low Voltage                                  | V <sub>OL</sub>  | Port R7, R8, R9         | V <sub>DD</sub> = 4.5 V, I <sub>OL</sub> = 1.6 mA      | –   | –    | 0.4 | V    |
|                                                     |                  |                         | V <sub>DD</sub> = 2.2 V, I <sub>OL</sub> = 20 mA       | –   | –    | 0.1 |      |
| Output Low Current                                  | I <sub>OL1</sub> | Port R5, R6             | V <sub>DD</sub> = 4.5 V, V <sub>OL</sub> = 1.0 V       | –   | 20   | –   | mA   |
|                                                     | I <sub>OL2</sub> | Port R4                 |                                                        | –   | 7    | –   |      |
| Supply Current<br>(in the Normal<br>operating mode) | I <sub>DD</sub>  |                         | V <sub>DD</sub> = 5.5 V, f <sub>c</sub> = 4 MHz        | –   | 2    | 4   | mA   |
|                                                     |                  |                         | V <sub>DD</sub> = 3.0 V, f <sub>c</sub> = 4 MHz        | –   | 1    | 2   |      |
|                                                     |                  |                         | V <sub>DD</sub> = 3.0 V, f <sub>c</sub> = 400 kHz      | –   | 0.5  | 1   |      |
| Supply Current<br>(in the HOLD<br>operating mode)   | I <sub>DDH</sub> |                         | V <sub>DD</sub> = 5.5 V                                | –   | 0.5  | 10  | μA   |

Note 1: Typ. values show those at T<sub>opr</sub> = 25°C, V<sub>DD</sub> = 5 V.

Note 2: Input Current I<sub>IN1</sub>: The current through resistor is not included.

Note 3: Supply Current: V<sub>IN</sub> = 5.3 V / 0.2 V (V<sub>DD</sub> = 5.5 V), 2.8 V / 0.2 V (V<sub>DD</sub> = 3.0 V)

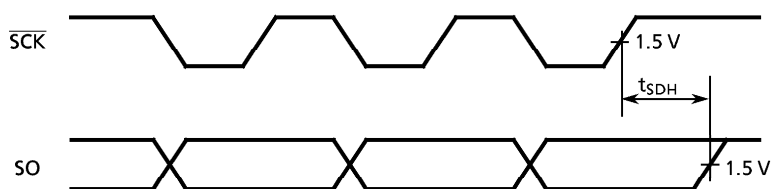
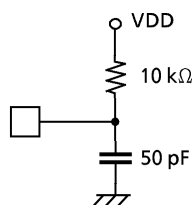
## AC Characteristics

(V<sub>SS</sub> = 0 V, T<sub>opr</sub> = –30 to 70°C)

| Parameter                    | Symbol           | Conditions                     | Min                       | Typ. | Max | Unit |
|------------------------------|------------------|--------------------------------|---------------------------|------|-----|------|
| Instruction Cycle Time       | t <sub>cy</sub>  | V <sub>DD</sub> = 4.5 to 5.5 V | 1.3                       | –    | 20  | μs   |
|                              |                  | V <sub>DD</sub> = 2.7 to 5.5 V | 1.9                       |      |     |      |
|                              |                  | V <sub>DD</sub> = 2.2 to 5.5 V | 3.2                       |      |     |      |
| High level Clock pulse Width | t <sub>WCH</sub> | V <sub>DD</sub> ≥ 2.7 V        | 80                        | –    | –   | ns   |
| Low level Clock pulse Width  | t <sub>WCL</sub> | V <sub>DD</sub> < 2.7 V        | 160                       |      |     |      |
|                              |                  | V <sub>DD</sub> ≥ 2.7 V        | 80                        |      |     |      |
|                              |                  | V <sub>DD</sub> < 2.7 V        | 160                       |      |     |      |
| Shift data Hold Time         | t <sub>SDH</sub> |                                | 0.5 t <sub>cy</sub> – 0.3 | –    | –   | μs   |

**Note:** Shift data Hold Time:External circuit for pins  $\overline{\text{SCK}}$  and SO

Serial port (completed of transmission)



## Recommended Oscillating Conditions

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 5.5 V, T<sub>opr</sub> = –30 to 70°C)

## (1) 6 MHz

Ceramic Resonator

CSA6.00MGU (MURATA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 30 pFKBR-6.00MS (KYOCERA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 30 pF

## (2) 4 MHz

Ceramic Resonator

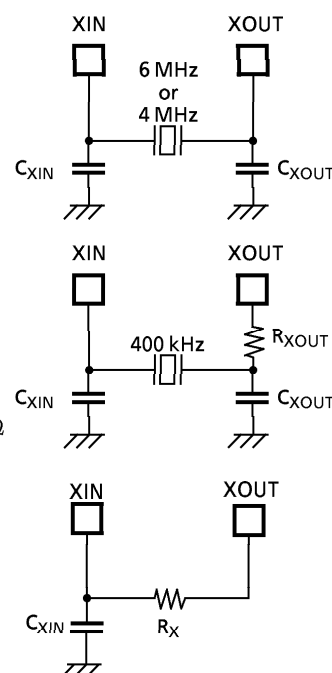
CSA4.00MG (MURATA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 30 pFKBR-4.00MS (KYOCERA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 30 pF

Crystal Oscillator

204B-6F 4.0000 (TOYOCOM) C<sub>XIN</sub> = C<sub>XOUT</sub> = 20 pF

## (3) 400 kHz

Ceramic Resonator

CSB400B (MURATA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 220 pF, R<sub>XOUT</sub> = 6.8 kΩKBR-400B (KYOCERA) C<sub>XIN</sub> = C<sub>XOUT</sub> = 100 pF, R<sub>XOUT</sub> = 10 kΩ(4) RC Oscillation (V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 5.0 V, T<sub>opr</sub> = 25°C)2 MHz (Typ.) C<sub>XIN</sub> = 33 pF, R<sub>X</sub> = 10 kΩ400 kHz (Typ.) C<sub>XIN</sub> = 100 pF, R<sub>X</sub> = 28 kΩ

## Typical Characteristics

