

HD404019/HD4074019

Description

The HD404019 and HD4074019 are HMCS400-series CMOS 4-bit single-chip microcomputers. Each device incorporates a ROM, RAM, I/O, serial interface, and 2 timer/counters, and contains high-voltage I/O pins including high-current output pins to directly drive fluorescent displays.

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Features

- 16384-word × 10-bit ROM
 - Mask ROM: HD404019
 - PROM: HD4074019
- 992-digit × 4-bit RAM
- 58 I/O pins, including 26 high-voltage I/O pins (40 V max.)
- 2 timer/counters
 - 8-bit free-running timer
 - 8-bit auto-reload timer/counter
- Clock synchronous 8-bit serial interface
- Five interrupt sources
 - Two by external sources
 - Two by timer/counters
 - One by serial interface
- Subroutine stack, up to 16 levels including interrupts
- Minimum instruction execution time: 0.89 μ s
- Low-power dissipation modes

—Standby: Stops instruction execution while allowing clock oscillation and interrupt functions to operate

—Stop: Stops instruction execution and clock oscillation while retaining RAM data

- On-chip oscillator
 - Crystal or ceramic filter
 - External clock
- Packages
 - 64-pin shrink type plastic DIP
 - 64-pin flat plastic package
 - 64-pin shrink type ceramic DIP with window

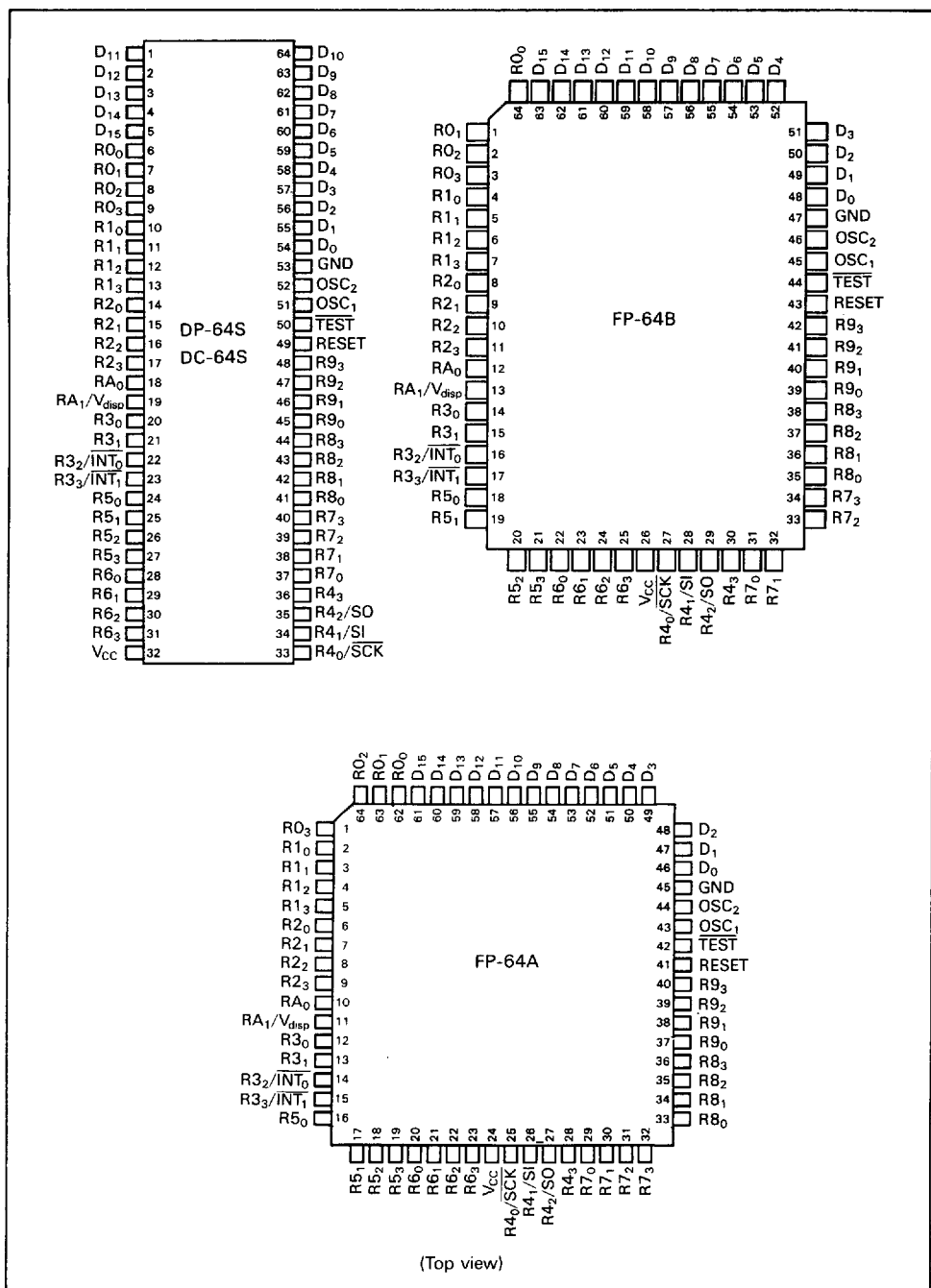
Ordering Information

Type	Part Number	Package
Mask ROM	HD404019S	DP-64S
	HD404019H	FP-64A
	HD404019FS	FP-64B
ZTAT™	HD4074019S	DP-64S
	HD4074019H	FP-64A
	HD4074019FS	FP-64B
	HD4074019C	DC-64S

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Pin Arrangement



(Top view)

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Differences Between In-Package PROM, On-Package EPROM, and Mask ROM Types

Item	ZTAT™ In-Package PROM				On-Package EPPROM		Mask ROM							
	HD4074019	HD4074008	HD614P080S	HD614P0180S	HD404019	HMCS408AC/C/CL HMCS404AC/C/CL HMCS402AC/C/CL								
Typical instruction execution time	1 μ S	1 μ S	1.33 μ S	1.33 μ S	1 μ S	1 μ S	2 μ S	4 μ S	1 μ S	2 μ S	4 μ S	1 μ S	2 μ S	4 μ S
Power supply voltage (V)	4.5-5.5	4.5-5.5	4.5-5.5	4.5-5.5	3.5-6	4.5-6	3.5-6	2.5-6	4.5-6	4.5-6	2.7-6	4.5-6	4-6	2.7-6
ROM	16,384 words \times 10-bit	8,192 words \times 10-bit	HN27C64: 4,096 \times 10-bit HN4827128: 8,192 \times 10-bit HN27C256: 16,384 \times 10-bit	HN27C64: 4,096 \times 10-bit HN4827128: 8,192 \times 10-bit HN27C256: 16,384 \times 10-bit	16,384 words \times 10-bit	8,192 words \times 10-bit	4,096 words \times 10-bit	2,048 words \times 10-bit						
RAM	992 \times 4-bit	512 \times 4-bit	576 \times 4-bit	576 \times 4-bit	992 \times 4-bit	512 \times 4-bit	256 \times 4-bit	160 \times 4-bit						
I/O pin circuit	Standard	NMOS open drain	NMOS open drain	NMOS open drain	Each pin can be without pull-up MOS (NMOS open drain), with pull-up MOS, or CMOS									
High voltage pins	PMOS open drain	PMOS open drain (Typical 5-V use)	PMOS open drain	PMOS open drain	Each pin can be without pull-down MOS (PMOS open drain) or with pull-down MOS									
Clock generation	Crystal	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
	Ceramic	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Resistance	—	—	—	—	—	—	HMCS404C HMCS402C							
Package	Type	DC-64S (Window)	DP-64S	FP-64B	FP-64A	DC-64S (Window)	DP-64S	FP-64S	FP-64S	DP-64S	FP-64S	DP-64S	FP-64S	FP-64S
	Occupied area (mm ²)	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2	18.8 \times 17.2
	Maximum height from stand off (mm)	5.6	5.1	2.9	5.6	5.1	2.9	7.5	5.1	2.9	5.1	2.9	5.1	2.9

Notes:	DC-64S: 64-pin shrink type ceramic DIP with window	DC-64SP: 64-pin shrink type ceramic piggy back
DP-64S:	64-pin shrink type DIP	○: Available
FP-64:	64-pin flat plastic package	—: Not available

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Pin Functions

Power Supply

V_{cc}: Apply the power supply voltage to this pin.

GND: Connect to ground.

V_{diag}: Power supply pin (multiplexed with RA₁) for high-voltage I/O pins with a maximum voltage of 40 V ($V_{cc} - 40$ V). For details, see the Input/Output section.

TEST: For test purposes only. Connect it to V_{cc}.

RESET: Resets the MCU. For details, see the Reset section.

Oscillators

OSC₁, OSC₂: OSC₁ and OSC₂ can be connected to a crystal resonator, ceramic filter resonator or an external oscillator circuit. For details, see the Internal Oscillator Circuit section.

Ports

D₀–D₁₅ (D Port): An input/output port addressed by bits. These 16 pins are all input/output pins. D₀ to D₃ are standard pins and D₄

to D₁₅ are high-voltage pins. The circuit type for each pin can be selected using a mask option. For details, see the Input/Output section.

R0–RA₁ (R Ports): R0 to R9 are 4-bit I/O ports. Only RA is a 2-bit port. R9 and RA are input ports, and R0 to R8 are I/O ports. R0, R1, R2, and RA are high-voltage ports, and R3 to R9 are standard ports. Each pin has a mask option which selects its circuit type. The pins R3₂, R3₃, R4₀, R4₁, and R4₂ are multiplexed with INT₀, INT₁, SCK, SI, and SO, respectively. For details, see the Input/Output section.

Interrupts

INT₀, INT₁: External interrupts for the MCU. INT₁ can be used as an external event input pin for timer B. INT₀ and INT₁ are multiplexed with R3₂ and R3₃, respectively. For details, see the Interrupt section.

Serial Communications Interface

SCK, SI, SO: The transmit clock I/O pin (SCK), serial data input pin (SI), and serial data output pin (SO) are used for serial interface. SCK, SI, and SO are multiplexed with R4₀, R4₁, and R4₂, respectively. For details, see the Serial Interface section.

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Memory Map

ROM Memory Map

The MCU contains a 16,384-word \times 10-bit ROM (mask ROM or PROM). It is described in the following paragraphs and by the ROM memory map in figure 1.

Vector Address Area (\$0000 to \$000F): Locations \$0000 through \$000F are reserved for JMWL instructions to branch to the starting address of the initialization program and of the interrupt programs. After reset or an interrupt routine is processed, the program is executed from the vector address.

Zero-Page Subroutine Area (\$0000 to \$003F): Locations \$0000 through \$003F are reserved for subroutines. The CAL instruction branches to subroutines.

Pattern Area (\$0000 to \$0FFF): Locations \$0000 through \$0FFF are reserved for ROM data. The P instruction can refer to the ROM data as a pattern.

Program Area (\$0000 to \$3FFF): Locations from \$0000 to \$3FFF can be used for program code.

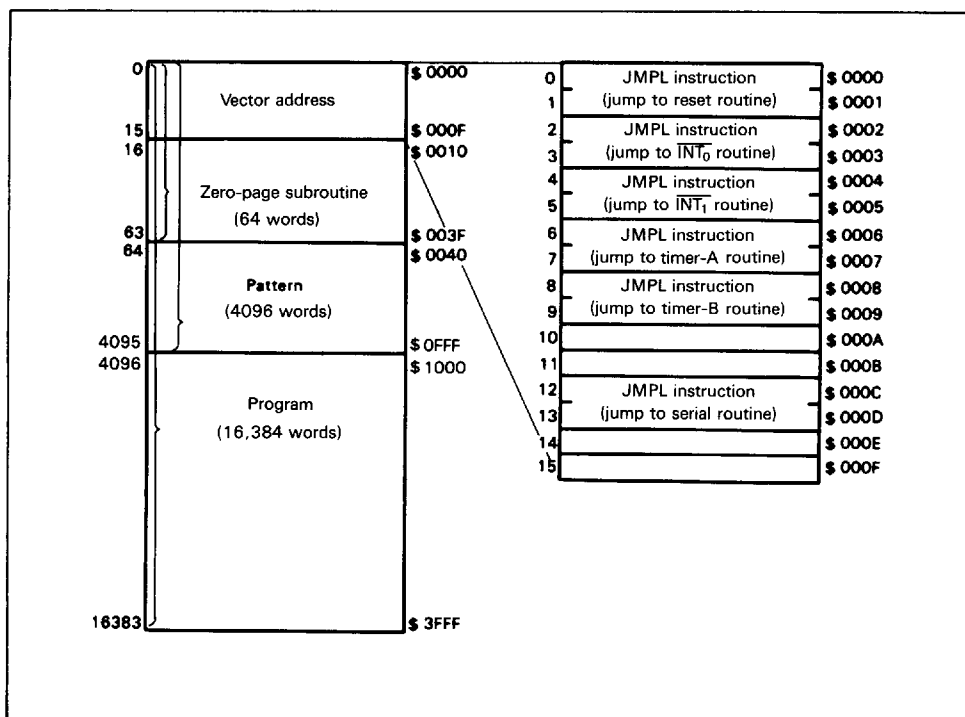


Figure 1 ROM Memory Map

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RAM Memory Map

The MCU also contains a 992-digit \times 4-bit RAM as the data and stack area. In addition to these areas, interrupt control bits and special function registers are also mapped on the RAM memory space. The RAM memory map (figure 2) is described in the following paragraphs.

Interrupt Control Bits Area (\$000 to \$003): The interrupt control bits area (figure 3) is used for interrupt control. It is accessible only by RAM bit manipulation instructions.

However, the interrupt request flag cannot be set by software. The RSP bit is used only to reset the stack pointer.

Special Function Registers Area (\$004 to \$00B): The special function registers are the mode or data registers for the external interrupt, the serial interface, and the timer/counters. These registers are classified into three types: write-only, read-only, and read/write as shown in figure 2. These registers cannot be accessed by RAM bit manipulation instructions.

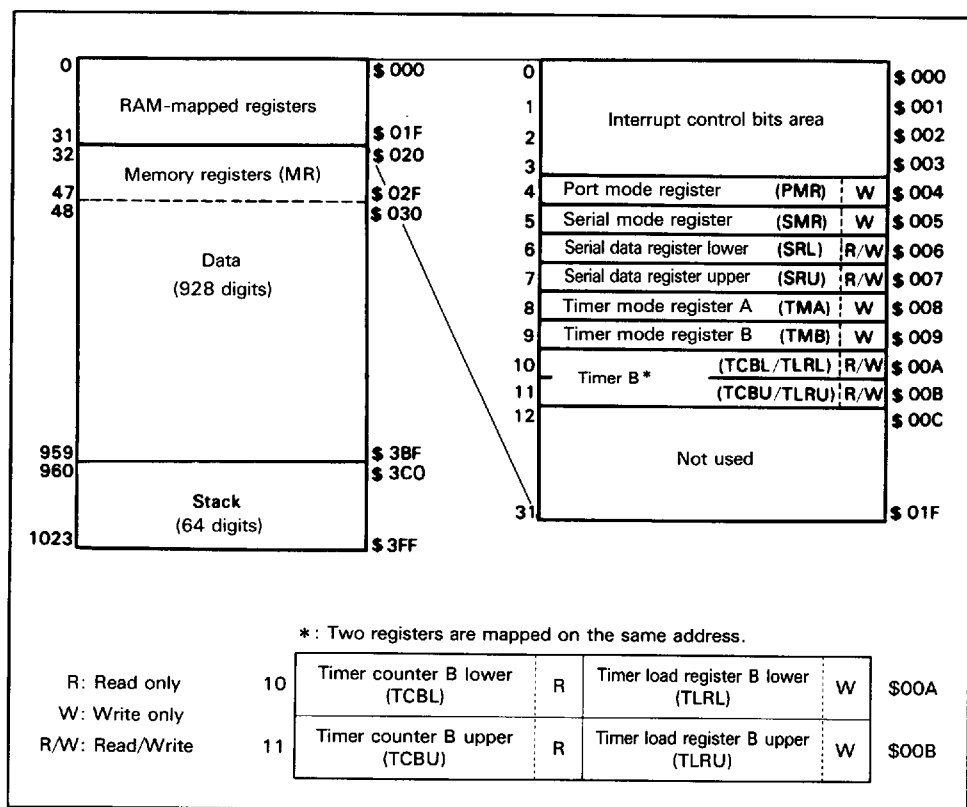


Figure 2 RAM Memory Map

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Data Area (\$020 to \$3BF): The 16 digits, \$020 through \$02F, of the data area are called memory registers (MR) and are accessible by the LAMR and XMRA instructions (figure 4).

Stack Area (\$3C0 to \$3FF): Locations \$3C0 through \$3FF are reserved for LIFO stacks to save the contents of the program counter (PC), status flag (ST), and carry flag (CA) when subroutine calls (CALL instruction,

CALL instruction) or interrupts are processed. This area can be used as a 16-level nesting stack in which one level requires 4 digits. Figure 4 shows the save condition. The program counter is restored by the RTN and RTNI instructions. The status and carry flags are restored only by the RTNI instruction. This area, when not used as a stack, is available as a data area.

	Bit 3	Bit 2	Bit 1	Bit 0	
0	IMO (IM of $\overline{INT_0}$)	IFO (IF of $\overline{INT_0}$)	RSP (Reset SP bit)	IE (Interrupt enable flag)	\$000
1	IMTA (IM of timer A)	IFTA (IF of timer A)	IM1 (IM of $\overline{INT_1}$)	IF1 (IF of $\overline{INT_1}$)	\$001
2	Not used	Not used	IMTB (IM of timer B)	IFTB (IF of timer B)	\$002
3	Not used	Not used	IMS (IM of serial)	IFS (IF of serial)	\$003

IF: Interrupt request flag
IM: Interrupt mask
IE: Interrupt enable flag
SP: Stack pointer

Note: Each bit of the interrupt control bit area is set by the SEM/SEMD instruction, reset by the REM/REMD instruction, and tested by the TM/TMD instruction. It is not affected by other instructions. Furthermore, the interrupt request flag is not affected by the SEM/SEMD instruction.
The value of the status flag becomes invalid when the unusable bits are tested.

Figure 3 Interrupt Control Bits Area Configuration

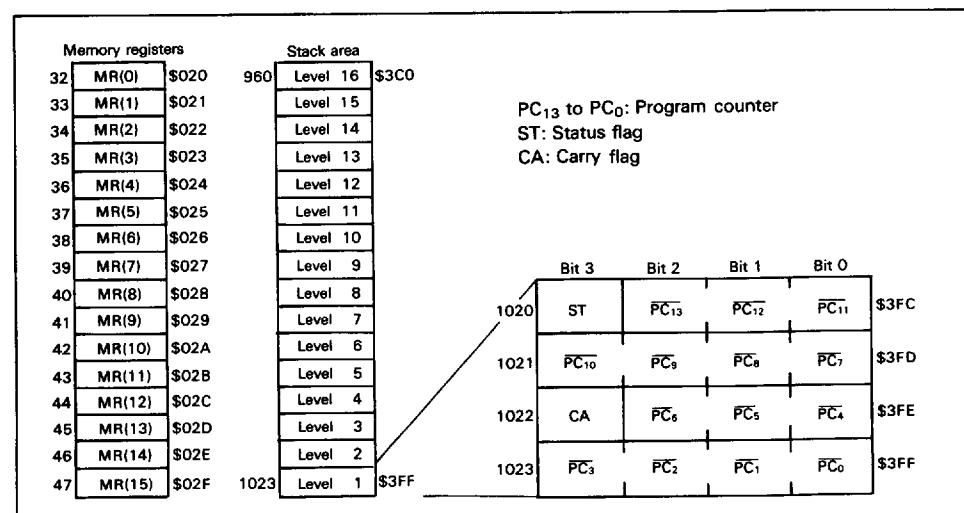


Figure 4 Configuration of Memory Registers, Stack Area, and Stack Position

Functional Description

Registers and Flags

The MCU has nine registers and two flags for the CPU operations (figure 5).

Accumulator (A), B Register (B): The 4-bit accumulator and B register hold the results from the arithmetic logic unit (ALU), and transfer data to/from memory, I/O, and other registers.

W Register (W), X Register (X), Y Register (Y): The 2-bit W register, and the 4-bit X and Y registers indirectly address RAM. The Y register is also used for D-port addressing.

SPX Register (SPX), SPY Register (SPY): The 4-bit registers SPX and SPY assist the X and Y registers, respectively.

Carry Flag (CA): The carry flag (CA) stores the overflow from the ALU generated by an arithmetic operation. It is also affected by the SEC, REC, ROTL, and ROTR instructions.

During an interrupt, a carry is pushed onto the stack. It is restored by the RTNI instruction, but not by the RTN instruction.

Status Flag (ST): The status flag (ST) holds the ALU overflow, ALU non-zero, and the results of a bit test instruction for the arithmetic or compare instructions. It is a branch condition of the BR, BRL, CAL, or CALL instruction. The value for the status flag remains unchanged until the next arithmetic, compare, or bit test instruction is executed. The status becomes a 1 after the BR, BRL, CAL, or CALL instruction was either executed or skipped. During an interrupt, the status is pushed onto the stack. It is restored back from the stack by the RTNI instruction, but not by the RTN instruction.

Program Counter (PC): The program counter is a 14-bit binary counter which controls the sequence in which the instructions stored in ROM are executed.

Stack Pointer (SP): The stack pointer (SP) points to the address of the next stack area (up to 16 levels).

The stack pointer is initialized to RAM address \$3FF. It is decremented by 4 when data is pushed onto the stack, and incremented by 4 when data is restored from it.

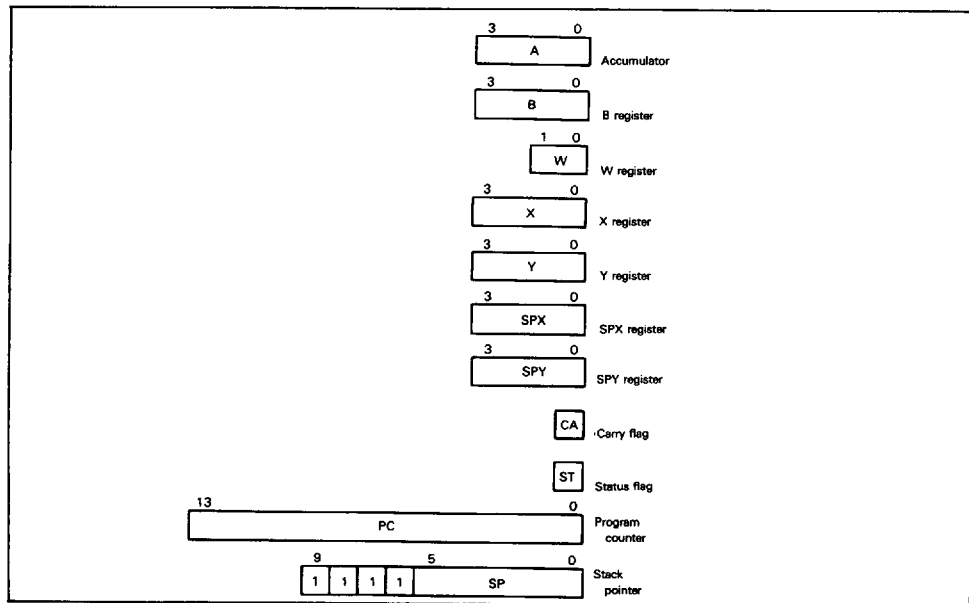


Figure 5 Registers and Flags

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The stack can only be used up to 16 levels deep because the high-order four bits of the stack pointer are fixed at 1111.

The stack pointer is initialized to \$3FF by either MCU reset or by the RSP bit reset from the REM/REMD instruction.

Interrupts

Five interrupt sources are available on the MCU: external requests ($\overline{\text{INT}}_0$, $\overline{\text{INT}}_1$), timer/counters (timer A, timer B), and serial port (serial). For each source, an interrupt request flag (IF), interrupt mask (IM), and interrupt

vector addresses control and maintain the interrupt request. The interrupt enable flag (IE) also controls interrupt operations.

Interrupt Control Bits and Interrupt Processing: The interrupt control bits are mapped on \$000 through \$003 of the RAM space. They are accessible by RAM bit manipulation instructions. (The interrupt request flag (IF) cannot be set by software.) The interrupt enable flag (IE) and IF are cleared to 0, and the interrupt mask (IM) is set to 1 by MCU reset.

Figure 6 is a block diagram of the interrupt

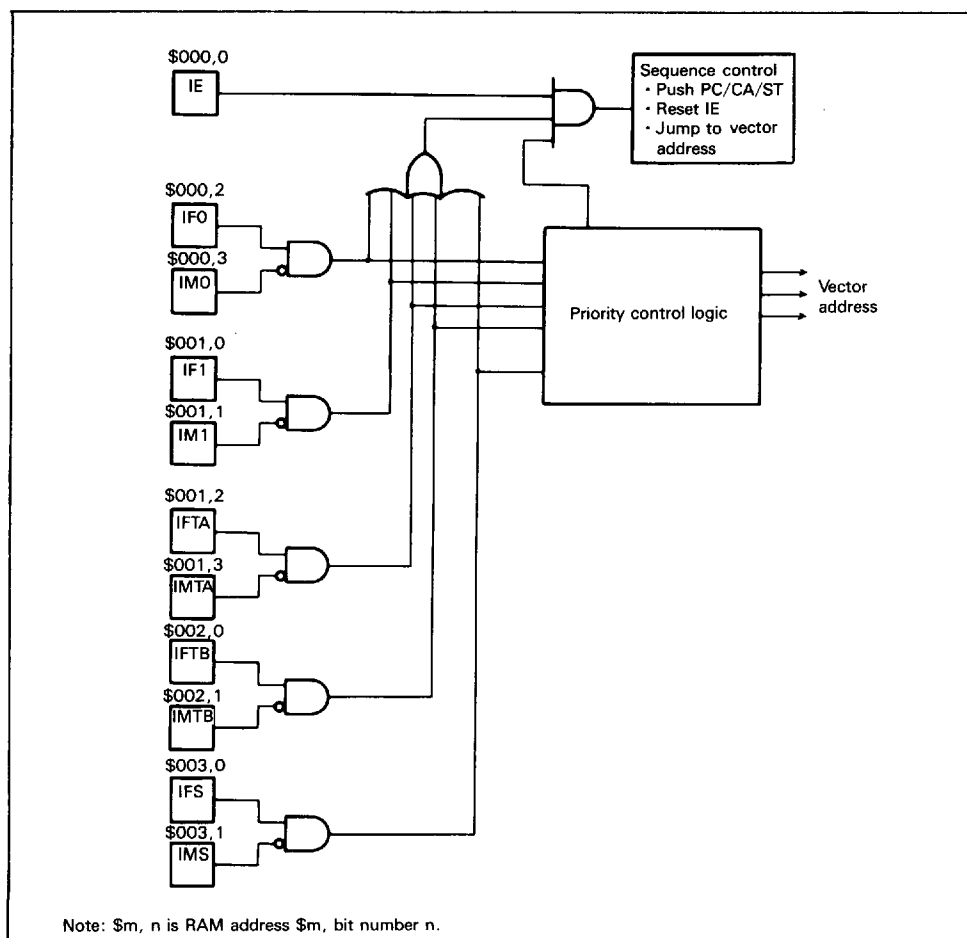


Figure 6 Interrupt Control Circuit Block Diagram

control circuit. Table 1 shows the interrupt priority and vector addresses, and table 2 shows the interrupt conditions corresponding to each interrupt source.

An interrupt request is generated when IF is set to 1 and IM is 0. If IE is 1 at this time, the interrupt will be activated and vector addresses will be generated from the priority PLA corresponding to the interrupt sources.

Figure 7 shows the interrupt processing sequence, and figure 8 shows the interrupt processing flowchart. If an interrupt is re-

quested, the instruction being executed finishes in the first cycle. The IE is reset in the second cycle. In the second and third cycles, the carry flag, status flag, and program counter are pushed onto the stack. In the third cycle, the instruction is re-executed after jumping to the vector address.

At each vector address, program the JMPL instruction to branch to the starting address of the interrupt program. The IF which caused the interrupt must be reset by software in the interrupt program.

Table 1 Vector Addresses and Interrupt Priority

Reset/Interrupt	Priority	Vector Addresses
RESET	—	\$0000
$\overline{\text{INT}}_0$	1	\$0002
$\overline{\text{INT}}_1$	2	\$0004
Timer A	3	\$0006
Timer B	4	\$0008
Serial	5	\$000C

Table 2 Interrupt Conditions

Interrupt Control Bit	Interrupt Source				
	$\overline{\text{INT}}_0$	$\overline{\text{INT}}_1$	Timer A	Timer B	Serial
IE	1	1	1	1	1
IFO·IMO	1	0	0	0	0
IF1· $\overline{\text{IM}}_1$	*	1	0	0	0
IFTA·IMTA	*	*	1	0	0
IFTB·IMTB	*	*	*	1	0
IFS·IMS	*	*	*	*	1

Note: * indicates don't care

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Interrupt Enable Flag (IE: \$000, Bit 0): The interrupt enable flag enables/disables interrupt requests as shown in table 3. It is reset by interrupts and set by the RTNI instruction.

External Interrupts ($\overline{INT_0}$, $\overline{INT_1}$): The external interrupt request inputs ($\overline{INT_0}$, $\overline{INT_1}$) can be selected by the port mode register (PMR: \$004). Setting bit 3 and bit 2 of PMR causes the $R_{3_3}/\overline{INT_1}$ pin and $R_{3_2}/\overline{INT_0}$ pin to be used as $\overline{INT_1}$ and $\overline{INT_0}$, respectively.

The external interrupt request flags (IF0, IF1) are set at the falling edge of $\overline{INT_0}$ and $\overline{INT_1}$ inputs. (Refer to table 4.)

The $\overline{INT_1}$ input can be used as a clock signal input to timer B, in which timer B counts up at each falling edge of the $\overline{INT_1}$ input. When $\overline{INT_1}$ is used as the timer B external event input,

the external interrupt mask (IM1) has to be set so that the interrupt request by $\overline{INT_1}$ will not be accepted. (Refer to table 5.)

External Interrupt Request Flags (IF0: \$000, Bit 2; IF1: \$001, Bit 0): The external interrupt request flags (IF0, IF1) are set at the falling edge of the $\overline{INT_0}$ and $\overline{INT_1}$ inputs, respectively.

External Interrupt Masks (IM0: \$000, Bit 3; IM1: \$001, Bit 1): The external interrupt masks mask the external interrupt requests.

Port Mode Register (PMR: \$004): The port mode register is a 4-bit write-only register which controls the $R_{3_2}/\overline{INT_0}$ pin, $R_{3_3}/\overline{INT_1}$ pin, R_{4_1}/SI pin, and R_{4_2}/SO pin as shown in table 6. The port mode register will be initialized to \$0 by MCU reset. These pins are therefore initially used as ports.

Table 3 Interrupt Enable Flag

IE	Interrupt Enable/Disable
0	Disable
1	Enable

Table 4 External Interrupt Request Flags

IF0, IF1	Interrupt Request
0	No
1	Yes

Table 5 External Interrupt Masks

IM0, IM1	Interrupt Request
0	Enable
1	Disable (Mask)

Table 6 Port Mode Register

PMR3	$R_{3_3}/\overline{INT_1}$ Pin
0	Used as R_{3_3} port input/output pin
1	Used as $\overline{INT_1}$ input pin

PMR2	$R_{3_2}/\overline{INT_0}$ Pin
0	Used as R_{3_2} port input/output pin
1	Used as $\overline{INT_0}$ input pin

PMR1	R_{4_1}/SI Pin
0	Used as R_{4_1} port input/output pin
1	Used as SI input pin

PMR0	R_{4_2}/SO Pin
0	Used as R_{4_2} port input/output pin
1	Used as SO output pin

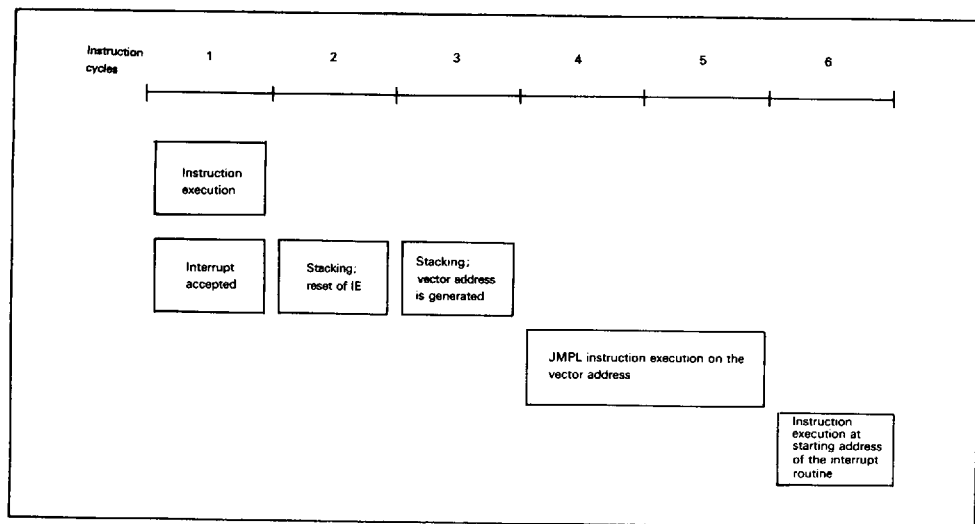


Figure 7 Interrupt Processing Sequence

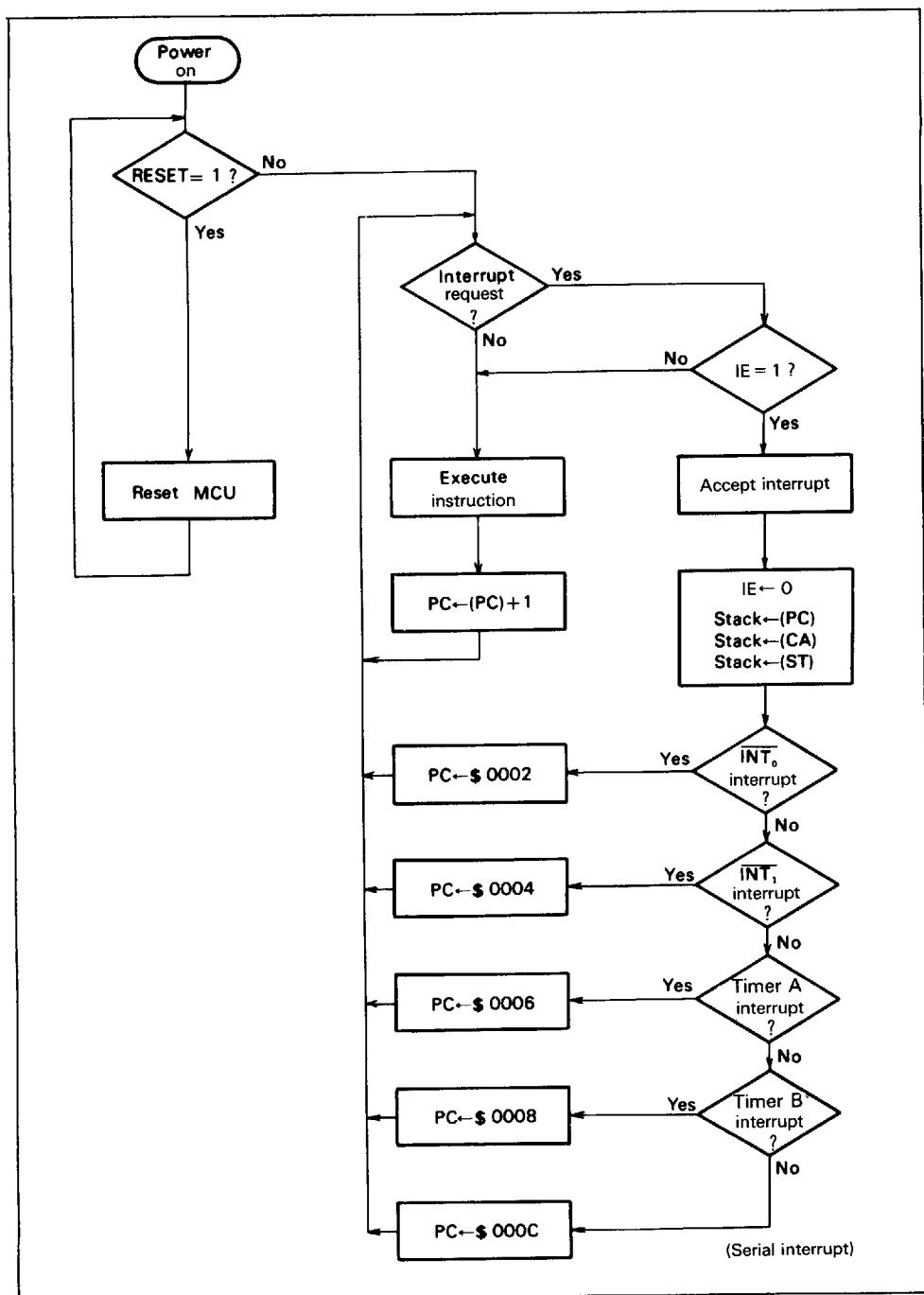


Figure 8 Interrupt Processing Flowchart

Serial Interface

The serial interface is used to transmit/receive 8-bit data serially. It consists of the serial data register, the serial mode register, the octal counter, and the multiplexer as illustrated in figure 9. Pin R4₀/SCK and the transmit clock signal are controlled by the serial mode register. The contents of the serial data register can be written into or read out by software. The data in the serial data register can be shifted synchronously with the transmit clock signal.

The STS instruction initiates serial interface operations and resets the octal counter to \$0. The counter starts to count at the falling edge of the transmit clock (SCK) signal and increments by one at the rising edge of SCK. When the octal counter is reset to \$0 after eight transmit clock signals, or a transmit/receive operation is discontinued, the serial interrupt request flag will be set.

Serial Mode Register (SMR: \$005): The 4-bit write-only serial mode register controls the R4₀/SCK pin, prescaler divide ratio, and transmit clock source as shown in table 7.

The write signal to the serial mode register controls the operating state of the serial interface.

The write signal to the serial mode register stops the serial data register and octal counter from accepting the transmit clock, and it also resets the octal counter to \$0 simultaneously. Therefore, when the serial interface is in the transmit state, the write signal causes the serial mode register to cease the data transmit and to set the serial interrupt request flag.

The contents of the serial mode register will be changed on the second instruction cycle after the serial mode register has been written to. Therefore, the STS instruction must be

executed after the data in the serial mode register has been changed completely. The serial mode register will be reset to \$0 by MCU reset.

Serial Data Register (SRL: \$006, SRU: \$007): The 8-bit read/write serial data register consists of a low-order digit (SRL: \$006) and a high-order digit (SRU: \$007).

The data in the serial data register is output from the SO pin, from LSB to MSB synchronously with the falling edge of the transmit clock signal. At the same time, external data is input from the SI pin to the serial data register, MSB first, synchronously with the rising edge of the transmit clock. Figure 10 shows the I/O timing chart of the transmit clock signal and the data.

The read/write operations of the serial data register should be performed after the completion of data transmit/receive. Otherwise the data cannot be guaranteed.

Serial Interrupt Request Flag (IFS: \$003, Bit 0): The serial interrupt request flag will be set when the octal counter counts eight transmit clock signals, or when data transfer is discontinued by resetting the octal counter. Refer to table 8.

Serial Interrupt Mask (IMS: \$003, Bit 1): The serial interrupt mask masks the interrupt request. Refer to table 9.

Selection and Change of the Operation Mode: Table 10 shows the serial interface operation modes which are determined by a combination of the value in the port mode register and in the serial mode register.

Initialize the serial interface by a write signal to the serial mode register when the operation mode has changed.

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Table 7 Serial Mode Register

SMR3	R4 ₀ /SCK
0	Used as R4 ₀ port input/output pin
1	Used as SCK input/output pin

Transmit Clock

SMR 2	SMR 1	SMR 0	R4 ₀ /SCK Port	Clock Source	Precaler Divide Ratio	System Clock Divide Ratio
0	0	0	SCK Output	Precaler	÷ 2048	÷ 4096
0	0	1	SCK Output	Precaler	÷ 512	÷ 1024
0	1	0	SCK Output	Precaler	÷ 128	÷ 256
0	1	1	SCK Output	Precaler	÷ 32	÷ 64
1	0	0	SCK Output	Precaler	÷ 8	÷ 16
1	0	1	SCK Output	Precaler	÷ 2	÷ 4
1	1	0	SCK Output	System Clock	—	÷ 1
1	1	1	SCK Input	External Clock	—	—

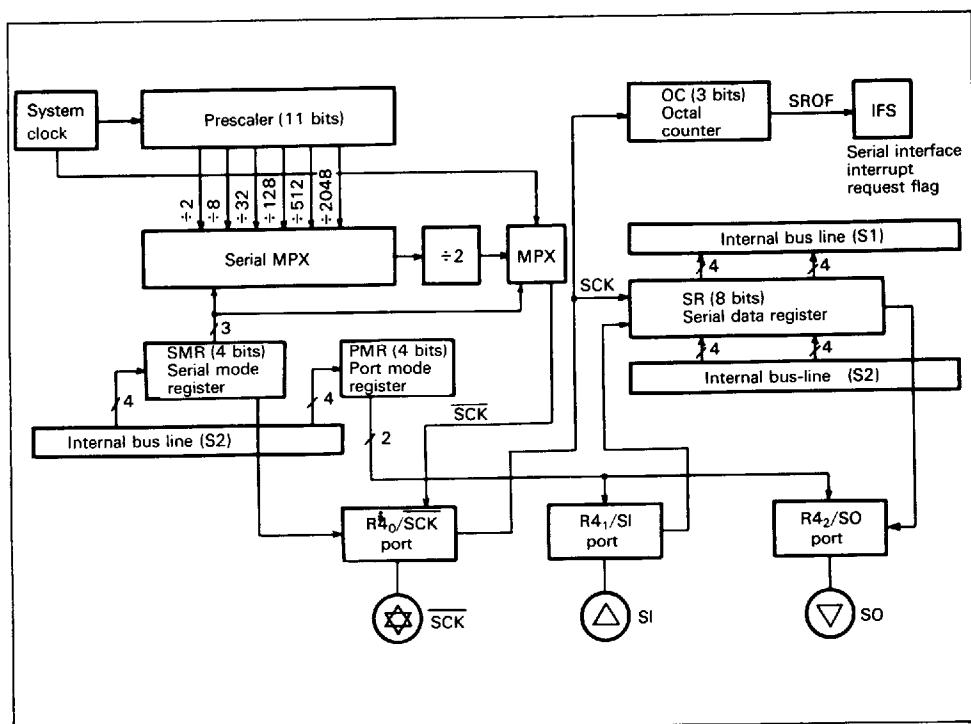


Figure 9 Serial Interface Block Diagram

Operating State of Serial Interface: The serial interface has three operating states, the STS waiting state, transmit clock wait state, and transfer state, as shown in figure 11.

The STS waiting state is the initialization state of the serial interface. The serial interface enters this state in one of two ways: either by the operation mode changing through a change in the data in the port mode register, or by data being written into the serial mode register. In this state, the serial interface does not operate even if the transmit clock is applied. If the STS instruction is executed, the serial interface shifts to the transmit clock wait state.

In the transmit clock wait state the falling

edge of the first transmit clock causes the serial interface to shift to the transfer state. The octal counter then counts up and the serial data register shifts simultaneously. As an exception, if the clock continuous output mode is selected, the serial interface stays in the transmit clock wait state while the transmit clock outputs continuously.

The octal counter becomes 000 again after 8 transmit clocks or the execution of the STS instruction, so the serial interface returns to the transmit clock wait state and the serial interrupt request flag is set simultaneously.

When the internal transmit clock is selected, the transmit clock output is triggered by the execution of the STS instruction, and stops after 8 clocks.

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Table 8 Serial Interrupt Request Flag

IFS	Interrupt Request
0	No
1	Yes

Table 10 Serial Interface Operation Mode

SMR3	PMR1	PMR0	Serial Interface Operating Mode
1	0	0	Clock continuous output mode
1	0	1	Transmit mode
1	1	0	Receive mode
1	1	1	Transmit/receive mode

Table 9 Serial Interrupt Mask

IMS	Interrupt Request
0	Enable
1	Disable (Mask)

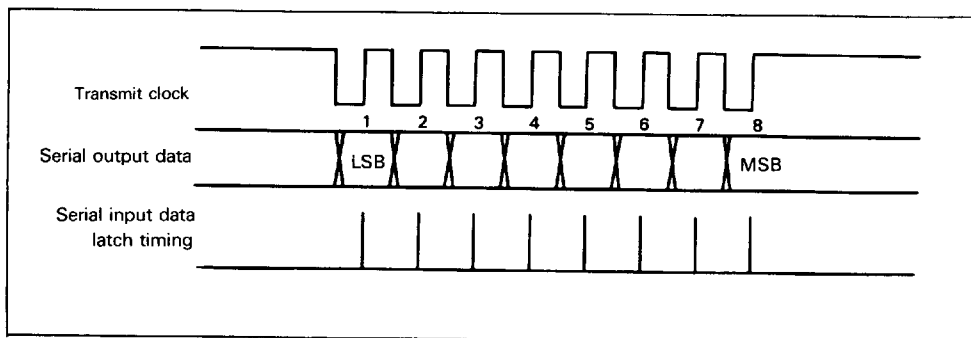


Figure 10 Serial Interface I/O Timing

Transmit Clock Error Detection Example: The serial interface functions abnormally when the transmit clock is disturbed by external noise. Transmit clock errors can be detected by the procedure shown in figure 12.

If more than 8 transmit clocks occur in the transfer state, the state of the serial interface shifts as follows: transfer state, transmit clock wait state, and transfer state. The serial interrupt flag should be reset before entering into the STS state by writing data to SMR. This procedure sets the IFS again.

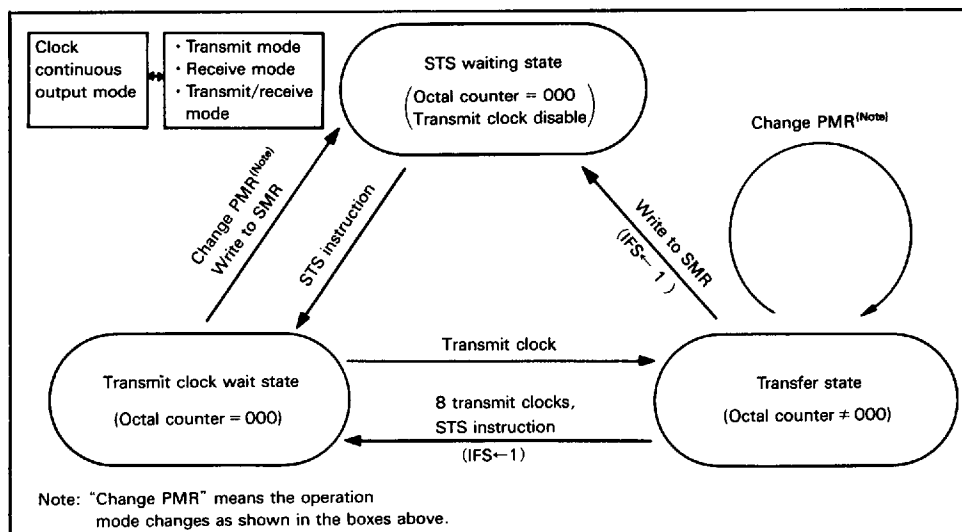


Figure 11 Serial Interface Operation State

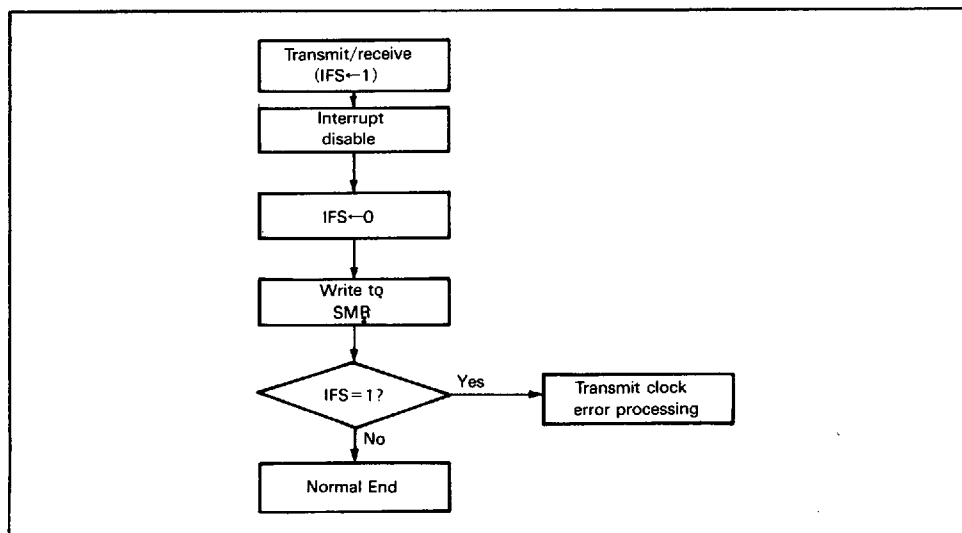


Figure 12 Transmit Clock Error Detection Example

Timers

The MCU contains a prescaler and two timer/counters (timer A, timer B). See figure 13. The prescaler is an 11-bit binary counter, timer A an 8-bit free-running timer, and timer B an 8-bit auto-reload timer/event counter.

Prescaler: The input to the prescaler is the system clock signal. The prescaler is initialized to \$0000 by MCU reset, and it starts to count up the system clock signal as soon as the RESET input goes to logic 0. The prescaler keeps counting up except at MCU reset and stop mode. The prescaler provides clock signals to timer A, timer B, and the serial interface. The prescaler divide ratio is selected by timer mode register A (TMA), timer mode register B (TMB), or the serial mode register (SMR).

Timer A Operation: After timer A is initialized to \$00 by MCU reset, it counts up at every clock input signal. When the next clock signal is applied after timer A becomes \$FF, it generates an overflow and becomes \$00. This overflow causes the timer A interrupt request flag (IFTA: \$001, bit 2) to go to 1. This timer can function as an interval timer periodically

generating overflow output at every 256th clock signal input.

The clock input signals to timer A are selected by timer mode register A (TMA: \$008).

Timer B Operation: Timer mode register B (TMB: \$009) selects the auto-reload function, input clock source, and the prescaler divide ratio of timer B. When the external event input is used as an input clock signal to timer B, select R3₃/INT₁ as INT₁ and set the external interrupt mask (IM1) to prevent an external interrupt request from occurring.

Timer B is initialized according to the data written into timer load register B by software. Timer B counts up at every clock input signal. When the next clock signal is applied to timer B after it is set to \$FF, it will generate an overflow output. In this case, if the auto-reload function is selected, timer B is initialized according to the value of timer load register B. If it is not selected, timer B goes to \$00. The timer B interrupt request flag (IFTB: \$002, bit 0) will be set at this overflow output.

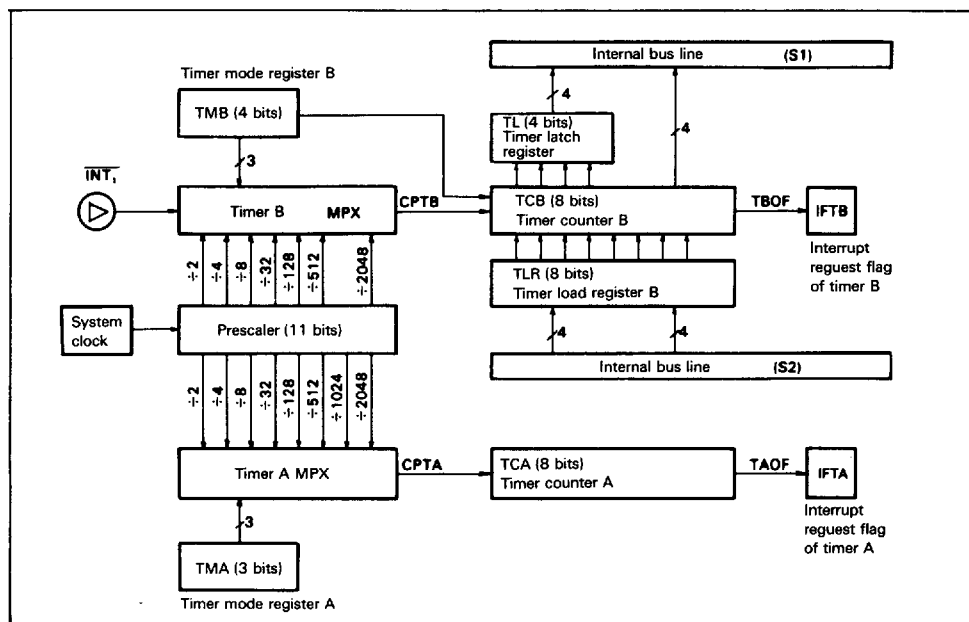


Figure 13 Timer/Counters Block Diagram

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Timer Mode Register A (TMA: \$008): Timer mode register A is a 3-bit write-only register. The TMA controls the prescaler divide ratio of timer A clock input as shown in table 11. Timer mode register A is initialized to \$0 by MCU reset.

Timer Mode Register B (TMB: \$009): Timer mode register B (TMB) is a 4-bit write-only register which selects the auto-reload function, the prescaler divide ratio, and the source of the clock input signal, as shown in table 12. Timer mode register B is initialized to \$0 by MCU reset.

The operation mode of timer B changes at the second instruction cycle after timer mode register B is written to. Timer B should be initialized by writing data into timer load register B after the contents of TMB are changed. The configuration and function of timer mode register B is shown in figure 14.

Timer B (TCBL: \$00A, TCBU: \$00B, TLRL: \$00A, TLRU: \$00B): Timer B consists of an 8-bit write-only timer load register, and an 8-bit read-only timer counter. Each of them has a low-order digit (TCBL: \$00A, TLRL: \$00A) and a high-order digit (TCBU: \$00B, TLRU: \$00B). (Refer to figure 2.)

Timer counter B can be initialized by writing data into timer load register B. Write the low-order digit first, and then the high-order digit. The timer counter is initialized when the high-order digit is written. The timer load register is initialized to \$00 by the MCU reset.

The counter value of timer B can be obtained by reading timer counter B. In this case, read the high-order digit first, and then the low-order digit. The count value of the low-order digit is latched at the time when the high-order digit is read.

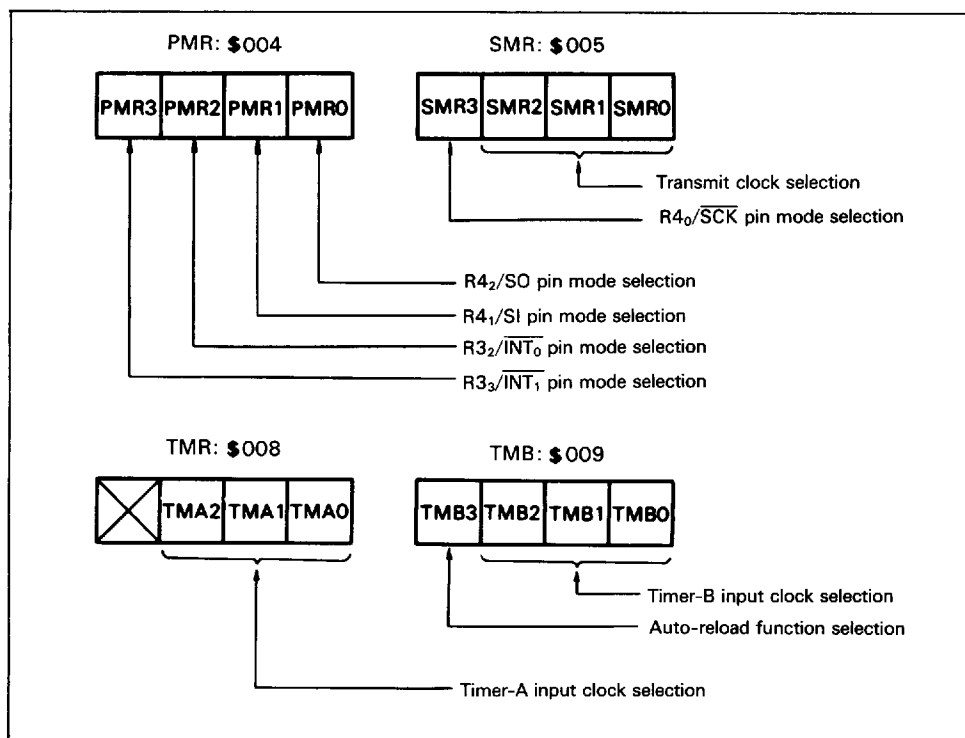


Figure 14 Mode Register Configuration and Function

Timer A Interrupt Request Flag (IFTA: \$001, Bit 2): The timer A interrupt request flag is set by the overflow output of timer A (table 13).

Timer A Interrupt Mask (IMTA: \$001, Bit 3): The timer A interrupt mask prevents an interrupt request from being generated by the timer A interrupt request flag (table 14).

Timer B Interrupt Request Flag (IFTB: \$002, Bit 0): The timer B interrupt request flag is set by the overflow output of timer B (table 15).

Timer B Interrupt Mask (IMTB: \$002, Bit 1): The timer B interrupt mask prevents an interrupt request from being generated by the timer B interrupt request flag (table 16).

Table 11 Timer Mode Register A

TMA2	TMA1	TMA0	Prescaler Divide Ratio
0	0	0	÷ 2048
0	0	1	÷ 1024
0	1	0	÷ 512
0	1	1	÷ 128
1	0	0	÷ 32
1	0	1	÷ 8
1	1	0	÷ 4
1	1	1	÷ 2

Table 12 Timer Mode Register B

TMB3	Auto-Reload Function
0	No
1	Yes

TMB2	TMB1	TMB0	Prescaler Divide Ratio, Clock Input Source
0	0	0	÷ 2048
0	0	1	÷ 512
0	1	0	÷ 128
0	1	1	÷ 32
1	0	0	÷ 8
1	0	1	÷ 4
1	1	0	÷ 2
1	1	1	INT ₁ (External event input)

Table 13 Timer A Interrupt Request Flag

IFTA	Interrupt Request
0	No
1	Yes

Table 14 Timer A Interrupt Mask

IMTA	Interrupt Request
0	Enable
1	Disable (Mask)

Table 15 Timer B Interrupt Request Flag

IFTB	Interrupt Request
0	No
1	Yes

Table 16 Timer B Interrupt Mask

IMTB	Interrupt Request
0	Enable
1	Disable (Mask)

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Input/Output

The MCU has 58 I/O pins, 32 standard and 26 high voltage. One of three circuit types can be selected by the mask option for each standard pin: CMOS, with pull-up MOS, and without pull-up MOS (NMOS open drain); and one of two circuit types can be selected for each high-voltage pin: with pull-down MOS and without pull-down MOS (PMOS open drain). Since the pull-down MOS is connected to the internal V_{disp} line, the RA_1/V_{disp} pin must be selected as V_{disp} via the mask option when the option with pull-down MOS is selected for at least one high-voltage pin. See table 17 for I/O pin circuit types.

When every input/output pin is used as an input pin, the mask option and output data must be selected in the manner specified in table 18.

Output Circuit Operation of With Pull-Up MOS Standard Pins: In the standard pin option with pull-up MOS, the circuit shown in figure 15 is used to shorten the rise time of the output.

When the MCU executes an output instruction, it generates a write pulse to the R port addressed by this instruction. This pulse will switch the PMOS (B) on and shorten the rise time. The write pulse keeps the PMOS in the on state for one-eighth of the instruction cycle time. While the write pulse is 0, a high output level is maintained by the pull-up MOS (C).

When the \overline{HLT} signal becomes 0 in the stop mode, MOS (A), (B), and (C) turn off.

D Port: I/O port D has 16 discrete I/O pins, each of which can be addressed independently. It can be set/reset through the SED/

RED and SEDD/REDD instructions, and can be tested through the TD and TDD instructions. See tables 17 and 18 for the classification of standard pin, high-voltage pin, and the I/O pin circuit types.

R Ports: The eleven R ports in the HD404019/HD4074019 are composed of 36 I/O pins and 6 input-only pins. Data is input through the LAR and LBR instructions and output through the LRA and LRB instructions. The MCU will not be affected by writing into the input-only and/or non-existing ports, while invalid data will be read when the output-only and/or non-existing ports are read.

The R_{32} , R_{33} , R_{40} , R_{41} , and R_{42} pins are multiplexed with the $\overline{INT_0}$, $\overline{INT_1}$, \overline{SCK} , \overline{SI} , and \overline{SO} pins respectively. See tables 17 and 18 for the classification of standard pins, high-voltage pins and selectable circuit types of these I/O pins.

Unused I/O Pins: If unused I/O pins are left floating, the LSI may malfunction because of noise. The I/O pins should be fixed as follows to prevent malfunction.

High-voltage pins: Select without pull-down MOS (PMOS open drain) via the mask option and connect to V_{CC} on the printed circuit board.

Standard pins: Select without pull-up MOS (NMOS open drain) via the mask option and connect to GND on the printed circuit board.

R_{40}/\overline{SCK} and R_{42}/\overline{SO} should be used as R_{40} and R_{42} by the serial mode register and port mode register, respectively.

Table 17 I/O Pin Circuit Types

		Without Pull-Up MOS (NMOS Open Drain) (A)	With Pull-Up MOS (B)	CMOS (C)	Applicable Pins
Standard Pins	I/O Common Pins				D ₀ -D ₃ R ₃₀ -R ₃₃ R ₄₀ -R ₄₃ R ₅₀ -R ₅₃ R ₆₀ -R ₆₃ R ₇₀ -R ₇₃ R ₈₀ -R ₈₃
	Input Pins				

Table 17 I/O Pin Circuit Types (cont)

		Without Pull-Down MOS (PMOS Open Drain) (D)	With Pull-Down MOS (E)	Applicable Pins
High Voltage Pins	I/O Common Pins			D ₄ -D ₁₅ R ₀₀ -R ₀₃ R ₁₀ -R ₁₃ R ₂₀ -R ₂₃
	Input Pins			RA ₀
	Input Pins			

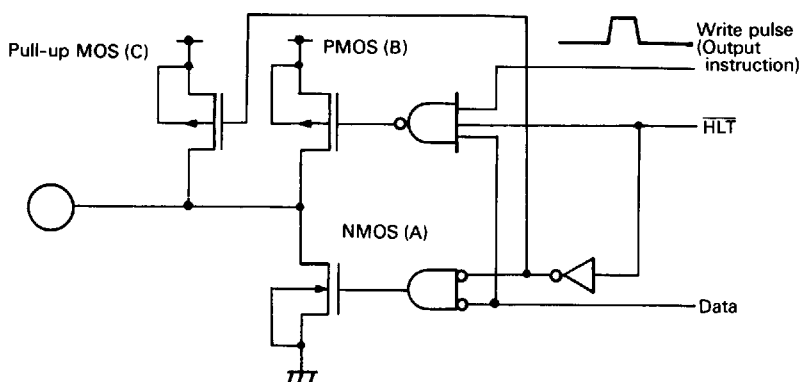
Table 17 I/O Pin Circuit Types (cont)

		Without Pull-Up MOS (NMOS Open Drain) or CMOS (A or C)	With Pull-Up MOS (B)	Applicable Pins
Standard Pins	I/O Common Pins			$\overline{\text{SCK}}$ (Note 2) (Output mode)
	Output Pins			SO
	Input Pins			$\overline{\text{INT}}_0$ $\overline{\text{INT}}_1$ SI $\overline{\text{SCK}}$ (Input mode)

- Notes:
1. In the stop mode, $\overline{\text{HLT}}$ is 0, HLT is 1 and I/O pins are in high impedance.
 2. If the MCU is interrupted by the serial interface in the external clock input mode, the $\overline{\text{SCK}}$ terminal becomes input only.

Table 18 Data Input from Common Input/Output Pins

I/O Pin Circuit Type		Input Possible	Input Pin State
Standard pins	CMOS	No	—
	Without pull-up MOS (NMOS open drain)	Yes	1
	With pull-up MOS	Yes	1
High voltage pins	Without pull-down MOS (PMOS open drain)	Yes	0
	With pull-down MOS	Yes	0



MOS Buffer	On-Resistance Value
A	Approximately 250 Ω
B	Approximately 1 k Ω
C	Approximately 30 k Ω to 160 k Ω ($V_{CC} = 5\text{ V}$)

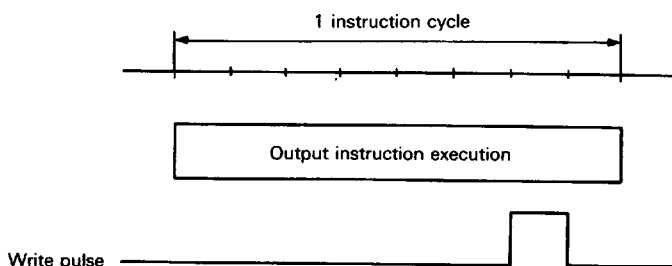


Figure 15 Output Circuit Operation of With Pull-Up MOS Standard Pins

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Reset

Pulling the RESET pin high resets the MCU. At power-on or when cancelling the stop mode, the reset must satisfy t_{RC} for the oscillator to stabilize. In all other cases, at least

two instruction cycles are required for the MCU to be reset.

Table 19 shows the components initialized by MCU reset, and the status of each.

Table 19 Initial Values After MCU Reset

Items		Initial Value by MCU Reset	Contents
Program counter (PC)		\$0000	Execute program from the top of ROM address
Status flag (ST)		1	Enable branching with conditional branch instructions
Stack pointer (SP)		\$3FF	Stack level is 0
I/O pins; Output register	Standard pins (A) Without pull-up MOS	1	Enable to input
	(B) With pull-up MOS	1	Enable to input
	(C) CMOS	1	—
	High-voltage pins (D) Without pull-down MOS	0	Enable to input
	(E) With pull-down MOS	0	Enable to input
Interrupt flag	Interrupt enable flag (IE)	0	Inhibit all interrupts
	Interrupt request flag (IF)	0	No interrupt request
	Interrupt mask (IM)	1	Mask interrupt request
Mode register	Port mode register (PMR)	0000	See Port Mode Register section
	Serial mode register (SMR)	0000	See Serial Mode Register section
	Timer mode register A (TMA)	000	See Timer Mode Register A section
	Timer mode register B (TMB)	0000	See Timer Mode Register B section
Timer/counter	Prescaler	\$000	—
	Timer counter A (TCA)	\$00	—
	Timer counter B (TCB)	\$00	—
	Timer load register (TLR)	\$00	—
	Octal counter	000	—

Table 19 Initial Values After MCU Reset (cont)

Item		After MCU reset to recover from stop mode	After MCU reset to recover from other modes
Carry flag	(CA)	The contents of the items before MCU reset are not retained. It is necessary to initialize them by software.	The contents of the items before MCU reset are not retained. It is necessary to initialize them by software.
Accumulator	(A)		
B register	(B)		
W register	(W)		
X/SPX register	(X/SPX)		
Y/SPY register	(Y/SPY)		
Serial data register	(SR)		
RAM		The contents of RAM before MCU reset (just before STOP instruction) are retained.	Same as above for RAM.

Internal Oscillator Circuit

Figure 16 outlines the internal oscillator circuit. A crystal oscillator or ceramic filter oscil-

lator can be selected as the oscillator type. Refer to table 20 to select the oscillator type. In addition, see figure 17 for the layout of the crystal or ceramic filter.

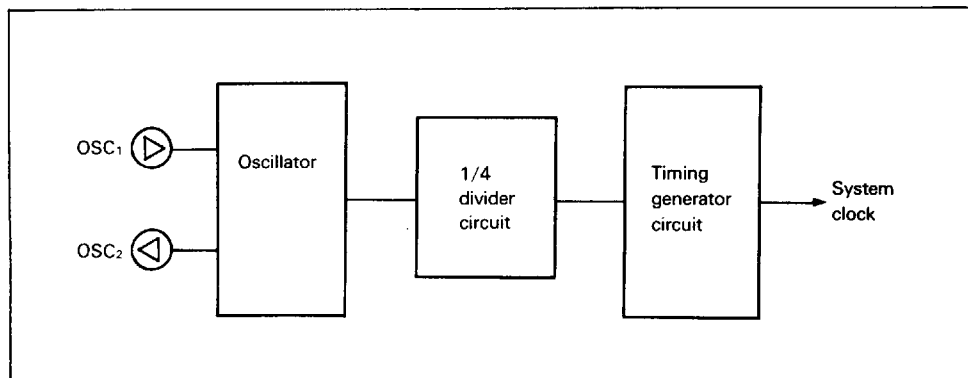


Figure 16 Internal Oscillator Circuit

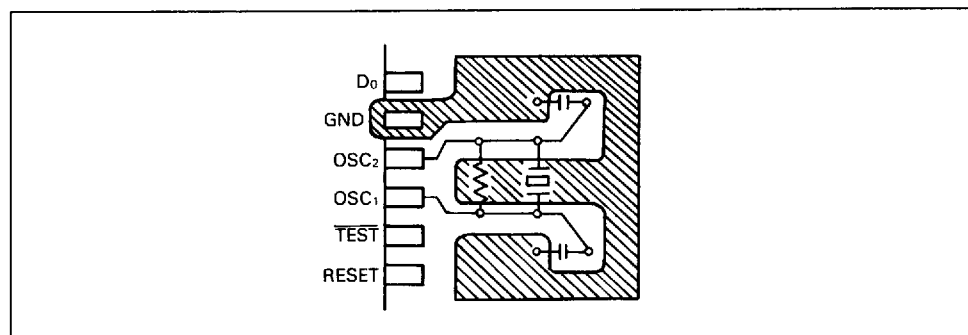
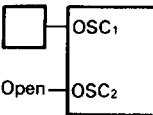
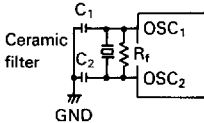
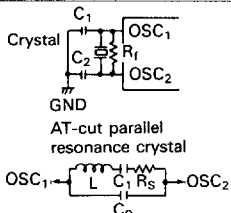


Figure 17 Layout of Crystal and Ceramic Filter

Table 20 Examples of Oscillator Circuits

	Circuit Configuration	Circuit Constants
External Clock Operation	<p>Oscillator</p> 	
Ceramic Filter Oscillator		<p>Ceramic filter CSA4.00MG (Murata)</p> <p>$R_f: 1\text{ M}\Omega \pm 20\%$ $C_1: 30\text{ pF} \pm 20\%$ $C_2: 30\text{ pF} \pm 20\%$</p>
Crystal Oscillator	 <p>AT-cut parallel resonance crystal</p>	<p>$R_f: 1\text{ M}\Omega \pm 20\%$ $C_1: 10\text{-}22\text{ pF} \pm 20\%$ $C_2: 10\text{-}22\text{ pF} \pm 20\%$ Crystal: Equivalent circuit shown at bottom left $C_0: 7\text{ pF max.}$ $R_s: 100\text{ }\Omega\text{ max.}$ $f: 1.0\text{-}4.5\text{ MHz}$</p>

- Notes : 1. The circuit parameters written above are recommended by the crystal or ceramic filter maker. The circuit parameters are affected by the crystal, ceramic filter resonator, and the floating capacitance when designing the board.
 When using the resonator, consult with the crystal or ceramic filter maker to determine the circuit parameters.
2. Wiring among OSC₁, OSC₂, and other elements should be as short as possible, and avoid crossing other wires. Refer to the recommended layout of the crystal and ceramic filter. Refer to figure 17.

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Operating Modes

The MCU has two low-power dissipation modes, standby mode and stop mode (table 21). Figure 18 is a mode transition diagram for these modes.

Standby Mode: Executing the SBY instruction puts the MCU into standby mode. In

standby mode, the oscillator circuit is active, and the interrupts, timer/counters, and serial interface remain working. On the other hand, the CPU stops since the clock related to the instruction execution stops. Registers, RAM, and I/O pins retain the states they were in just before the MCU went into standby mode.

Table 21 Low-Power Dissipation Modes

Condition	Standby Mode	Stop Mode
Instruction	SBY instruction	STOP instruction
Oscillator circuit	Active	Stopped
Instruction execution	Stopped	Stopped
Registers, flags	Retained	Reset ^(Note 1)
Interrupt function	Active	Stopped
RAM	Retained	Retained
Input/output pins	Retained ^(Note 2)	High impedance
Timer/counters, serial interface	Active	Stopped
Cancellation method	RESET input, interrupt request	RESET input

- Notes:
1. The MCU recovers from the stop mode by RESET input. Refer to table 19 for the contents of flags and registers.
 2. When I/O circuits are active, an I/O current may flow in the standby mode, depending on the state of the I/O pins. This is an additional current added to the standby mode current dissipation.

Standby mode may be cancelled by inputting RESET or by asserting an interrupt request. In the former case the MCU is reset. In the later case, the MCU becomes active and executes the next instruction following the SBY instruction. If the interrupt enable flag is 1 when an interrupt request asserted, the interrupt is executed, while if it is 0, the interrupt request is put on hold and normal instruction execution continues.

Figure 19 shows the flowchart of the standby mode.

Stop Mode: Executing the STOP instruction

brings the MCU into stop mode, in which the oscillator circuit and every function of the MCU stop.

The stop mode may be cancelled by resetting the MCU. At this time, as shown in figure 20, reset input must be applied for at least t_{RC} for oscillation to be stabilized. (Refer to the AC Characteristics table.) After the stop mode is cancelled, RAM retains the state it was in just before the MCU went into stop mode, but the accumulator, B register, W register, X/SPX registers, Y/SPY registers, carry flag, and serial data register will not retain their contents.

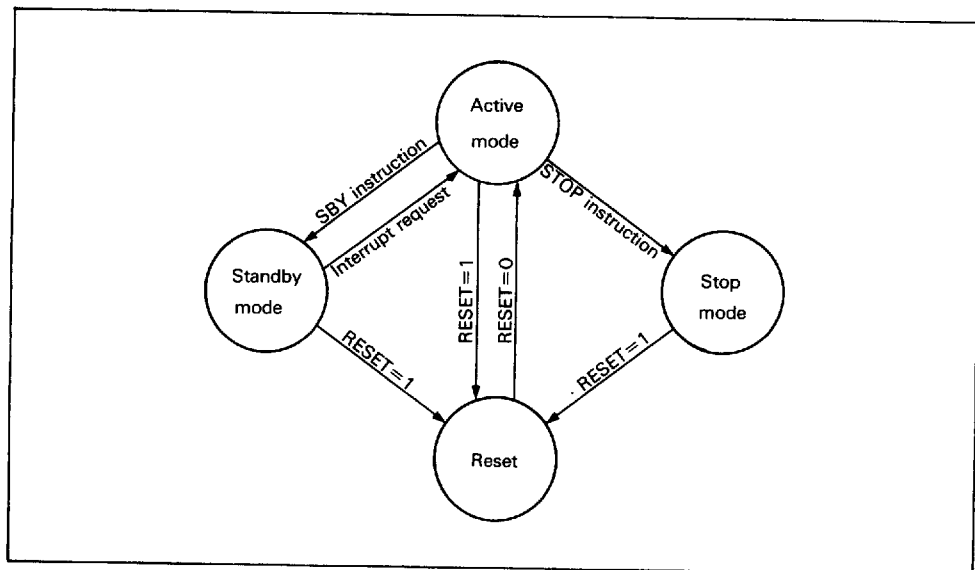


Figure 18 MCU Operation Mode Transition

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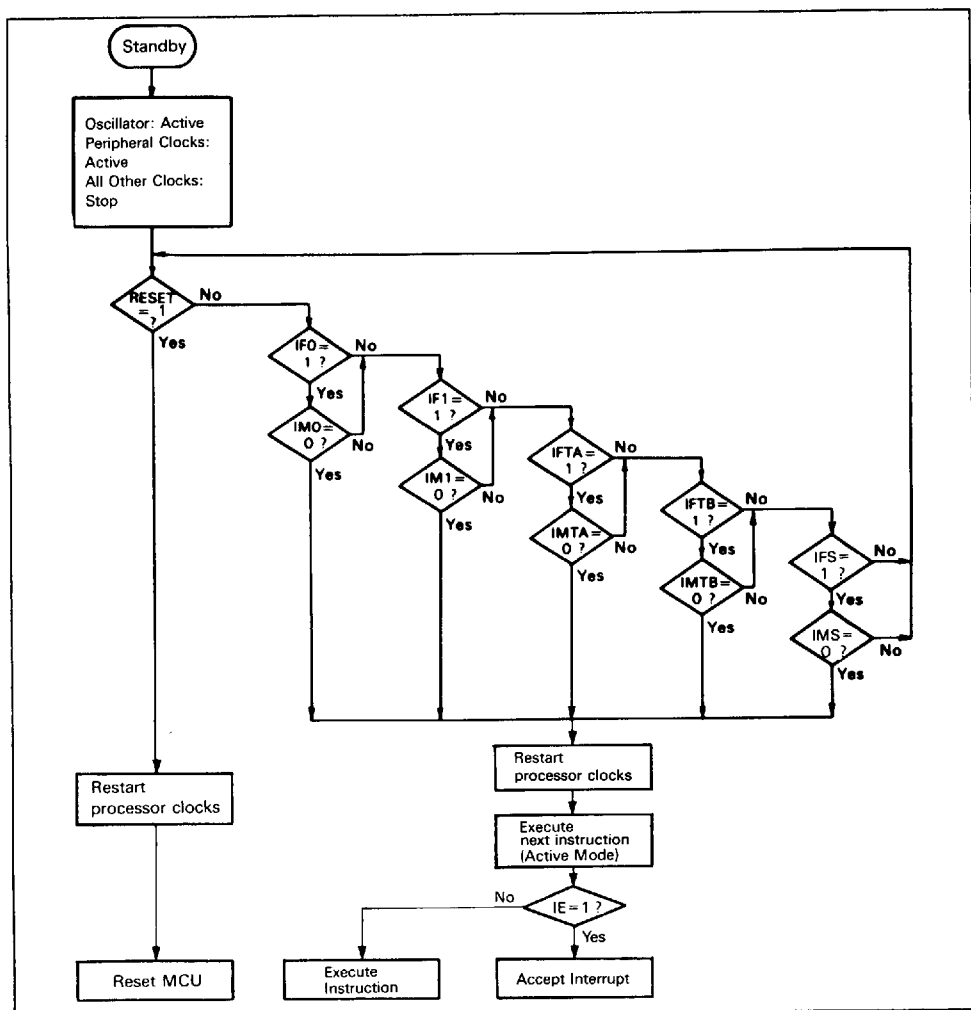


Figure 19 MCU Operating Flowchart in Standby Mode

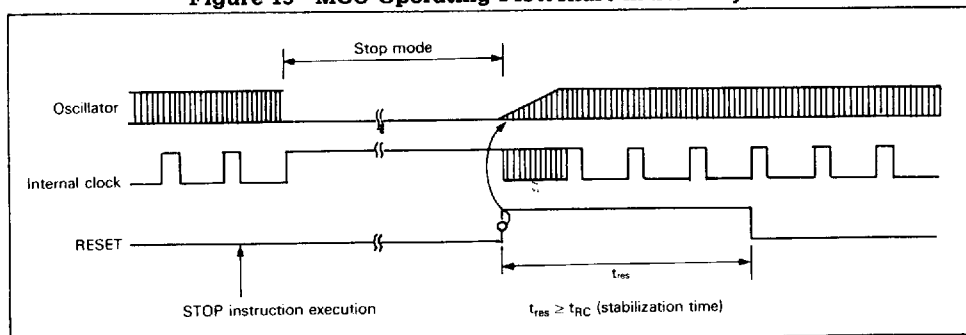


Figure 20 Timing of Stop Mode Cancellation

PROM Mode Pin Description

Table 22 and figure 21 describe the pin functions in PROM mode.

Table 22 PROM Mode Signals

Pin Number	MCU Mode		PROM Mode	
DC-64S, DP-64S	FP-64B	FP-64A	Symbol	I/O
1	59	57	D ₁₁	I/O
2	60	58	D ₁₂	I/O
3	61	59	D ₁₃	I/O
4	62	60	D ₁₄	I/O
5	63	61	D ₁₅	I/O
6	64	62	R ₀	I/O
7	1	63	R ₀	I/O
8	2	64	R ₀	I/O
9	3	1	R ₀	I/O
10	4	2	R ₀	I/O
11	5	3	R ₁	I/O
12	6	4	R ₁	I/O
13	7	5	R ₁	I/O
14	8	6	R ₂	I/O
15	9	7	R ₂	I/O
16	10	8	R ₂	I/O
17	11	9	R ₂	I/O
18	12	10	R _A	I
19	13	11	R _A	I
20	14	12	R ₃	I/O
21	15	13	R ₃	I/O
22	16	14	R ₃ /INT ₀	I/O
23	17	15	R ₃ /INT ₁	I/O
24	18	16	R ₅	I/O
25	19	17	R ₅	I/O
26	20	18	R ₅	I/O
27	21	19	R ₅	I/O
28	22	20	R ₆	I/O
29	23	21	R ₆	I/O
30	24	22	R ₆	I/O
31	25	23	R ₆	I/O
32	26	24	V _{CC}	V _{CC}

Pin Number	MCU Mode		PROM Mode	
DC-64S, DP-64S	FP-64B	FP-64A	Symbol	I/O
33	27	25	R ₄ /SCK	I/O
34	28	26	R ₄ /SI	I/O
35	29	27	R ₄ /SO	I/O
36	30	28	R ₄	I/O
37	31	29	R ₇	I/O
38	32	30	R ₇	I/O
39	33	31	R ₇	I/O
40	34	32	R ₇	I/O
41	35	33	R ₈	I/O
42	36	34	R ₈	I/O
43	37	35	R ₈	I/O
44	38	36	R ₈	I/O
45	39	37	R ₉	I
46	40	38	R ₉	I
47	41	39	R ₉	I
48	42	40	R ₉	I
49	43	41	RESET	I
50	44	42	TEST	I
51	45	43	OSC ₁	I
52	46	44	OSC ₂	
53	47	45	GND	GND
54	48	46	D ₀	I/O
55	49	47	D ₁	I/O
56	50	48	D ₂	I/O
57	51	49	D ₃	I/O
58	52	50	D ₄	I/O
59	53	51	D ₅	I/O
60	54	52	D ₆	I/O
61	55	53	D ₇	I/O
62	56	54	D ₈	I/O
63	57	55	D ₉	I/O
64	58	56	D ₁₀	I/O

Notes: 1. I/O: Input/output pins

I: Input pins

O: Output pins

- Connect each pair of O₄, O₃, O₂, O₁, and O₀. Hitachi supplies the socket adapter on which these pairs are internally connected.

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V_{PP} (Program Voltage): V_{PP} is the input for the program voltage (12.5 V ± 0.3 V) for programming the PROM.

\overline{CE} (Chip Enable): \overline{CE} is the input for allowing programming and verification of the internal PROM.

\overline{OE} (Output Enable): \overline{OE} is the data output control signal to verify input.

A₀–A₁₄ (Address Bus): A₀ to A₁₄ are address input pins for the internal PROM.

O₀–O₇ (PROM Data Bus): O₀ to O₇ are the data bus pins for the internal PROM.

$\overline{M_0}$, $\overline{M_1}$ (Mode): $\overline{M_0}$ and $\overline{M_1}$ set the PROM mode. The PROM mode is set when $\overline{M_0}$, $\overline{M_1}$, and \overline{TEST} pins are low, and the RESET pin is high.

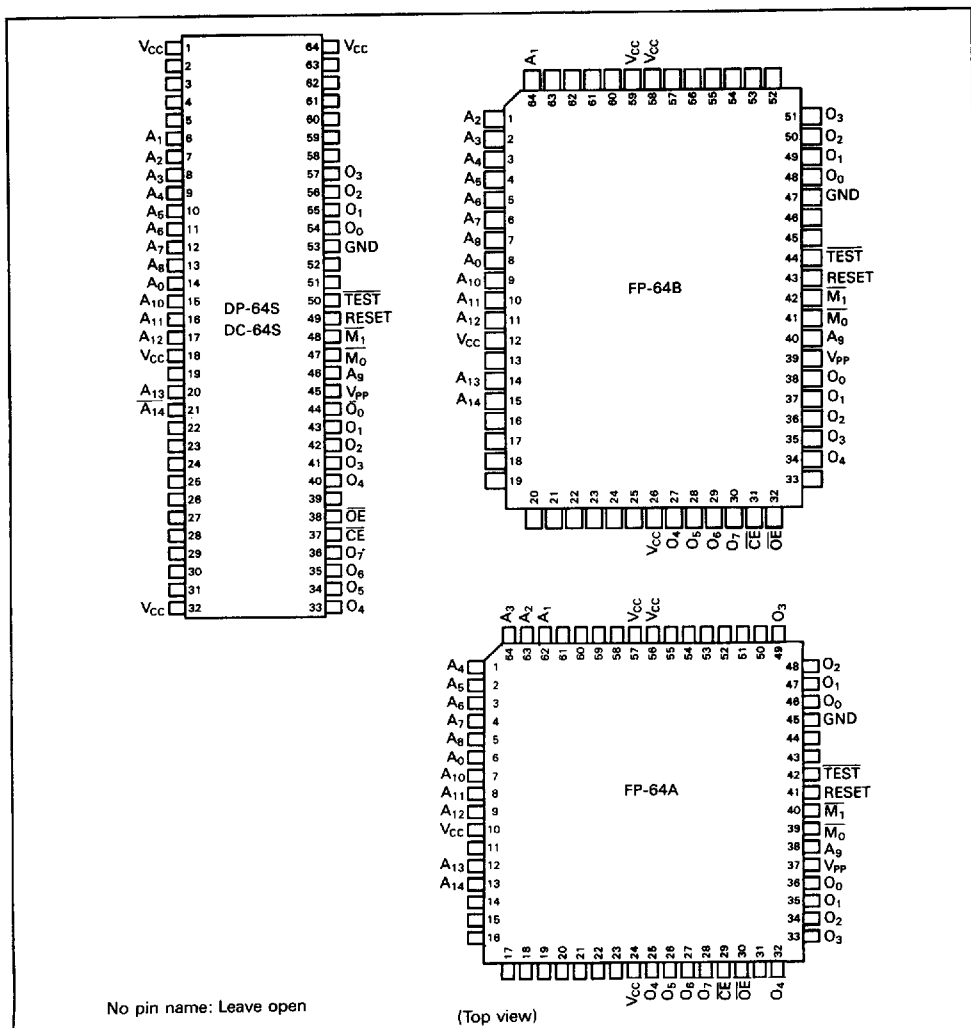


Figure 21 PROM Mode Pin Arrangement

Programmable ROM Operation

The HD4074019's on-chip PROM is programmed in PROM mode (figures 22 to 24). The PROM mode is set by pulling TEST, M_0 , and M_1 low, and RESET high as shown in figure 22. In PROM mode, the MCU does not operate. It can be programmed like a standard 27256 EPROM using a standard PROM programmer and a 64-to-28-pin socket adapter. Table 24 lists the recommended PROM programmers and socket adapters.

Since the instructions of the HMCS400 series consists of 10 bits, the HMCS400-series microcomputer incorporates a conversion circuit used as a general-purpose PROM programmer. By this circuit, an instruction is read or programmed using 2 addresses, the low-order 5 bits and the high-order 5 bits as shown in figure 23. For example, if 8 Kwords of an on-chip PROM are programmed by a general purpose PROM programmer, 16 Kbytes of addresses (\$0000-\$3FFF) should be specified.

Programming and Verification

The HD4074019 can be programmed at high-speed without causing voltage stress or affecting data reliability.

Table 23 shows how programming and verification modes are selected.

Figure 24 is a programming flowchart, and figure 42 is a timing chart. For precautions on PROM programming, refer to the Precautions and PROM Reliability After Programing sections.

Erasing

PROMs with ceramic window packages can be erased by ultraviolet light. All erased bits become 1s.

The erasing specifications are: ultraviolet (UV) light with wavelength 2537 Å with a minimum irradiation of 15 W sec/cm². These conditions are satisfied by exposing the LSI to a 12,000-μW/cm² UV source for 15 to 20 minutes at a distance of 1 inch.

Precautions

1. Addresses \$0000 to \$7FFF should be specified if the PROM is programmed by a PROM programmer. Note that the plastic package type cannot be erased and reprogrammed.
(Only ceramic window packages can be erased and reprogrammed.)
2. Make sure that the PROM programmer, socket adapter, and LSI match properly. Using the wrong programmer for the socket adapter may cause an overvoltage and damage the LSI. Make sure that the LSI is firmly fixed in the socket adapter, and that the socket adapter is firmly fixed to the programmer.
3. The PROM should be programmed with $V_{PP} = 12.5$ V. Other PROMs use 21 V. If 21 V is applied to the HD4074019, the LSI may be permanently damaged. 12.5 V is the voltage for V_{PP} of Intel's 27256.

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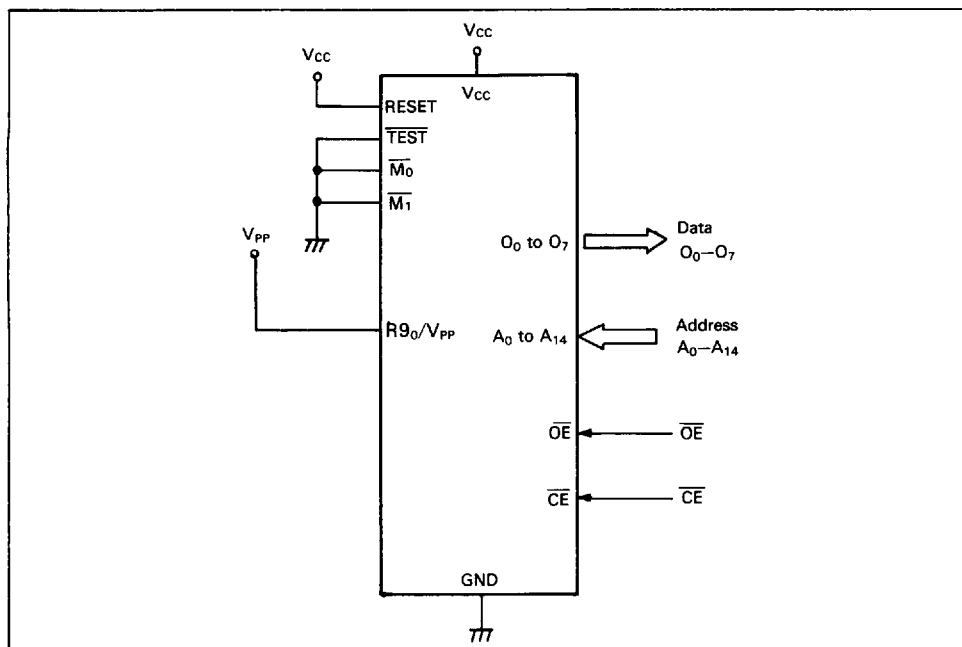


Figure 22 PROM Mode Function Diagram

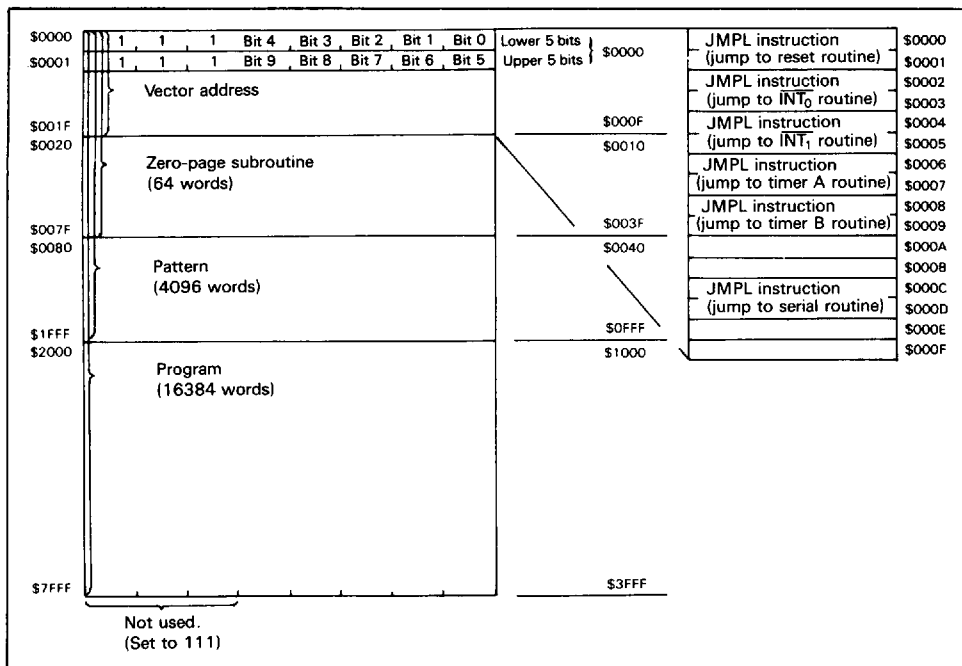


Figure 23 PROM Mode Memory Map

Table 23 PROM Mode Selection

Mode	Pin			$O_0 - O_7$
	CE	OE	V_{PP}	
Programming	Low	High	V_{PP}	Data input
Verify	High	Low	V_{PP}	Data output
Programming inhibited	High	High	V_{PP}	High impedance

Table 24 Recommended PROM Programmers and Socket Adapters

PROM Programmer (Note)		Package	Socket Adapter	
Maker	Type name	Type	Maker	Type name
DATA I/O	280	DP-64S	Hitachi	HS409ESS11H
	201	DC-64S		
	29B+UniPak2B	FP-64B		HS409ESF01H
	S22	FP-64A		HS409ESH01H
AVAL DATA Corp.	PKW-1000	DP-64S	Hitachi	HS409ESS21H
	PKW-1100	DC-64S		
	PKW-1600	FP-64B		HS409ESF01H
	PKW-3100	FP-64A		HS409ESH01H

Note: Since the address pins of the HD4074019 are high voltage pins, errors may occur in device insertion tests if a PROM programmer other than those listed above is used.

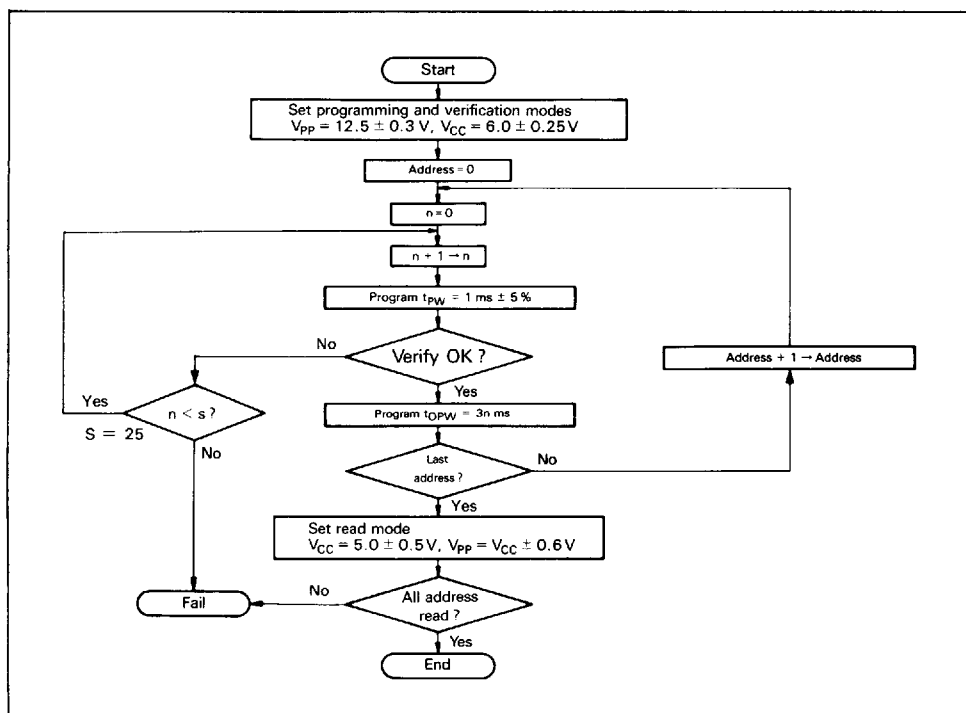


Figure 24 PROM Programming

HD404019/HD4074019

HITACHI/ (MCU/MPU)

Programming Electrical Characteristics for HD4074019**Write and Verify Mode****DC Characteristics****($V_{CC} = 6\text{ V} \pm 0.25\text{ V}$, $V_{PP} = 12.5\text{ V} \pm 0.3\text{ V}$, $V_{SS} = 0\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$, unless otherwise specified)**

Item	Pins	Symbol	Min	Typ	Max	Unit	Test Condition
Input high voltage	O ₀ -O ₇ , A ₀ -A ₁₄ , $\overline{\text{OE}}$, $\overline{\text{CE}}$	V_{IH}	2.2		$V_{CC} + 0.3$	V	
Input low voltage	O ₀ -O ₇ , A ₀ -A ₁₄ , $\overline{\text{OE}}$, $\overline{\text{CE}}$	V_{IL}	-0.3		0.8	V	
Output high voltage	O ₀ -O ₇	V_{OH}	2.4			V	$I_{OH} = -200\text{ }\mu\text{A}$
Output low voltage	O ₀ -O ₇	V_{OL}			0.4	V	$I_{OL} = 1.6\text{ mA}$
Input leakage current	O ₀ -O ₇ , A ₀ -A ₁₄ , $\overline{\text{OE}}$, $\overline{\text{CE}}$	$ I_{IL} $			2	μA	$V_{in} = 5.25\text{ V}/0.5\text{ V}$
V_{CC} current		I_{CC}			30	mA	
V_{PP} current		I_{PP}			40	mA	

AC Characteristics**($V_{CC} = 6\text{ V} \pm 0.25\text{ V}$, $V_{PP} = 12.5\text{ V} \pm 0.3\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$, unless otherwise specified)**

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Address setup time	t_{AS}	2			μs	See figure 25;
$\overline{\text{OE}}$ setup time	t_{OES}	2			μs	Input pulse level:
Data setup time	t_{DS}	2			μs	0.8 to 2.2 V;
Address hold time	t_{AH}	0			μs	Input rise/fall
Data hold time	t_{DH}	2			μs	time $\leq 20\text{ ns}$;
Output disable delay time	t_{DF}			130	ns	Input timing
V_{PP} setup time	t_{VPS}	2			μs	reference level:
Program pulse width	t_{PW}	0.95	1.0	1.05	ms	1.0 V, 2.0 V
$\overline{\text{CE}}$ pulse width when overprogramming	t_{OPW}	2.85		78.75	ms	Output timing
V_{CC} setup time	t_{VCS}	2			μs	reference level:
Data output delay time	t_{OE}	0		500	ns	0.8 V, 2.0 V

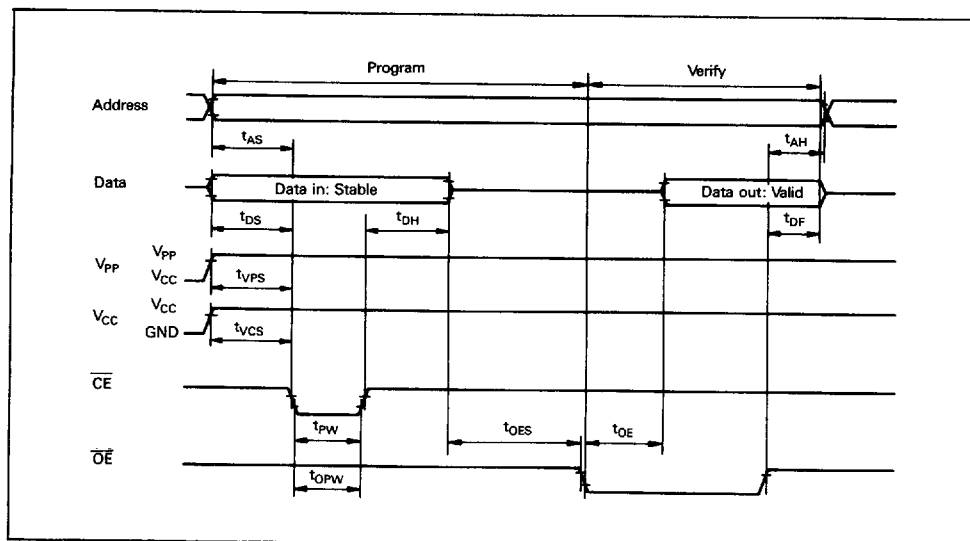


Figure 25 PROM Programming/Verification Timing

HD404019/HD4074019

HITACHI/ (MCU/MPU)

Read Mode

DC Characteristics

($V_{CC} = 5\text{ V} \pm 10\%$, $V_{PP} = V_{CC} \pm 0.6\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Input leakage current	I_{IL}			1	μA	$V_{CC} = 5.5\text{ V}$, $V_{in} = \text{GND to } V_{CC}$
Output leakage current	I_{OL}			1	μA	$V_{CC} = 5.5\text{ V}$, $V_{out} = \text{GND to } V_{CC}$
Program current	I_{PP}		1	100	μA	$V_{PP} = V_{CC} + 0.6\text{ V}$
Current dissipation active mode	I_{CC}			30	mA	$f = 1\text{ MHz}$, $I_{out} = 0\text{ mA}$
Input voltage	V_{IL}	-0.3		0.8	V	
	V_{IH}	2.2		$V_{CC} + 0.3\text{ V}$		
Output voltage	V_{OL}			0.40	V	$I_{OL} = 1.6\text{ mA}$
	V_{OH}	2.4			V	$I_{OH} = -200\text{ }\mu\text{A}$

AC Characteristics

($V_{CC} = 5\text{ V} \pm 10\%$, $V_{PP} = V_{CC} \pm 0.6\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Min	Max	Unit	Test Condition
Access time	t_{ACC}		500	ns	$\overline{CE} = \overline{OE} = V_{IL}$
\overline{CE} output delay time	t_{CE}		500	ns	$\overline{OE} = V_{IL}$
\overline{OE} output delay time	t_{OE}	10	150	ns	$\overline{CE} = V_{IL}$
Output disable delay time*	t_{DF}	0	105	ns	$\overline{CE} = V_{IL}$
Data output hold time	t_{OH}	0		ns	$\overline{CE} = \overline{OE} = V_{IL}$

* T_{DF} is defined when the output becomes an open state and cannot be referenced.

Switching characteristics:

Input pulse level: 0.8 to 2.2 V

Input rise/fall time < 20 ns

Output load: 1 TTL Gate + 100 pF

Input/output timing reference level: Output: 1 V, 2 V

Input: 0.8 V, 2 V

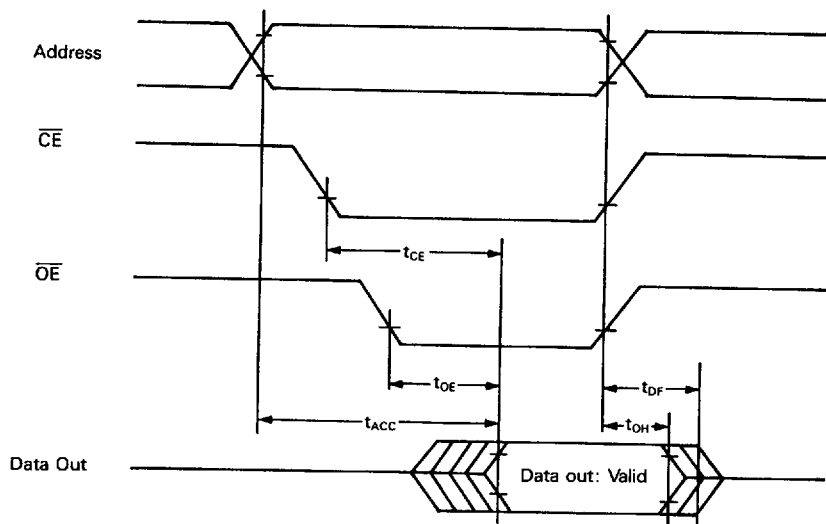


Figure 26 PROM Read Timing

Precautions on PROM Programming

Principles of PROM Programming/Erasing

The ZTAT™ microcomputer has the same type of memory cells as the EPROM. The PROM is programmed by applying a high voltage to the control gate and drain to inject hot electrons into the floating gate similar to EPROM programming. The electrons in the floating gate remain stabilized, surrounded by an energy barrier of SiO_2 film. By these electrons, the threshold voltage in the memory cell changes and the corresponding bit goes to 0.

The hot electrons are reduced over time. This reduction is caused by:

1. Ultraviolet light: The electrons are discharged by ultraviolet light (according to the erasure principle)
2. Heat: The electrons, which are excited by heat, are discharged
3. Application of high voltage: The number of electrons is reduced due to the high voltage which is applied to the control gate and drain

If there is any failure in the oxide film, the charge is markedly reduced; however, in general, such a reduction does not occur, since devices which fail are usually excluded

during screening tests.

When the memory cell does not have any hot electrons in the floating gate, the corresponding bit goes to 1.

PROM Programming

PROM programming should be performed under specified voltage and timing conditions. The higher the program voltage (V_{PP}) and the longer the program pulse width (t_{PW}), the more electrons will be injected into the memory cell. If an overvoltage is applied, a pn junction may be permanently damaged. It is especially important to be aware of overshooting in the PROM writer. Moreover, negative voltage noise causes a parasitic transistor effect, which can reduce the apparent breakdown voltage.

During PROM programming, the ZTAT™ microcomputer is electrically connected with the PROM writer via the socket adapter. The user should ensure the following precautions:

1. Confirm that the socket adapter is firmly connected to the PROM writer before beginning PROM programming.
2. Do not touch the socket adapter and the LSI during programming; this can cause faulty contacts, resulting in programming errors.

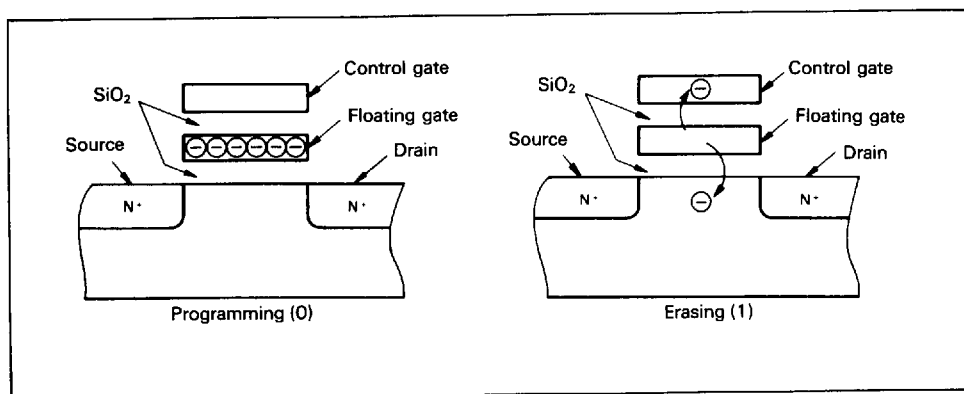


Figure 27 Cross-Sections of a EPROM Memory Cell

PROM Reliability after Programming

In general, semiconductor devices retain their reliability, if initial failures can be rejected. Initial failures can be rejected by adequate screening. Baking the device under high-temperature conditions is a screening method which eliminates initial short-time data hold failures in the memory cell. (See the Principles of PROM Programming/Erasing section). ZTATTM microcomputer devices realize good reliability because they have been subjected to such screening during the wafer fabrication process. It is recommended that the user expose the device to 150°C at one atmosphere after programming in order to verify device performance.

Figure 28 shows the recommended screening procedure.

Window-Type Package Precautions

Glass Erasure Window: If the glass window comes in contact with plastic or anything with a static charge, the LSI may malfunction due to the electrostatic charge on the surface of the window. If this occurs, exposing the LSI to ultraviolet light for a few minutes neutralizes the charge, and restores the LSI to normal operation. However, charge stored in the floating gate decreases at the same time, so reprogramming is recommended.

Electrostatic charge buildup on the window is a fundamental cause of malfunctions. Preventive measures are the same as those for preventing electrostatic breakdown:

1. Operators should be grounded when handling equipment.
2. Do not rub the glass window with plastics.
3. Be careful of coolant sprays which may contain ions.
4. The ultraviolet shading label (which includes conductive material) effectively neutralizes charge.

Ultraviolet Shading Label: If the LSI is exposed to fluorescent light or sunlight, its memory contents may be erased by the small quantity of ultraviolet light in these sources. In strong light, the MCU may fail under the influence of photocurrent. To prevent these problems, it is recommended that the device be used with an ultraviolet shading label covering the erasure window after programming.

Special labels are sold for this purpose. They contain metal to absorb ultraviolet light. When choosing a label, note the following:

1. Adhesion: Reuse and dust reduce adhesion. Peeling off a label may cause static electricity. Therefore, erasing and rewriting is recommended after peeling off a label. Sticking a new label over the old one

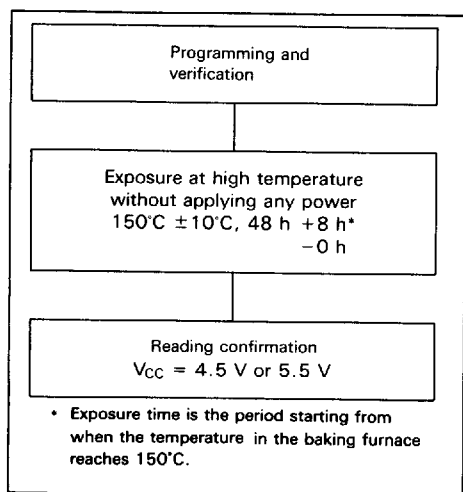


Figure 28 Recommended Screening Procedure

Note: If programming errors occur sequentially during PROM programming, the user should suspend programming and determine whether there is any trouble with the PROM writer or the socket adapter when using the window-package type EPROM. If programming verification indicates errors in programming or after high-temperature exposure, please inform Hitachi of the trouble.

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is preferable than replacing a label.

2. Allowable temperature range: The allowable environmental temperature range of the label should be noted. If it is used under conditions outside this range, the paste may harden or adhere to the label, causing the paste to remain on the window when the label is removed.

3. Moisture resistance: The allowable moisture range and environmental conditions of the label should be noted. It is difficult to find an appropriate label applicable to all conditions. The proper label should be selected according to the intended use of the MCU.

Addressing Modes

RAM Addressing Modes

As shown in figure 29, the MCU has three RAM addressing modes: register indirect addressing, direct addressing, and memory register addressing.

Register Indirect Addressing Mode: The W register, X register, and Y register contents (10 bits) are used as the RAM address.

Direct Addressing Mode: A direct addressing instruction consists of two words, with the word (10 bits) following the opcode used as the RAM address.

Memory Register Addressing Mode: The memory registers (16 digits from \$020 to \$02F) are accessed by executing the LAMR and XMRA instructions.

ROM Addressing Modes and the P Instruction

The MCU has four kinds of ROM addressing modes as shown in figure 30.

Direct Addressing Mode: The program can branch to any address in ROM memory space by executing the JMPL, BRL, or CALL instruction. These instructions replace the 14 program counter bits (PC₁₃ to PC₀) with 14-bit immediate data.

Current Page Addressing Mode: The MCU has 8 pages of ROM with 256 words per page. By executing the BR instruction, the program can branch to an address on the current page. This instruction replaces the low-order eight bits of the program counter (PC₇ to PC₀) with 8-bit immediate data.

When the BR instruction is on a page boundary (256n + 255) (figure 31), executing it transfers the PC contents to the next page, due to the hardware architecture. Consequently, the program branches to the next page when the BR instruction is used on a page boundary. The HMCS400-series cross macroassembler has an automatic paging facility for ROM pages.

Zero-Page Addressing Mode: By executing the CAL instruction, the program can branch to the zero-page subroutine area, which is located at \$0000-\$003F. When the CAL instruction is executed, 6 bits of immediate data are placed in the low-order six bits of the program counter (PC₅ to PC₀) and 0s are placed in the high-order eight bits (PC₁₃ to PC₆).

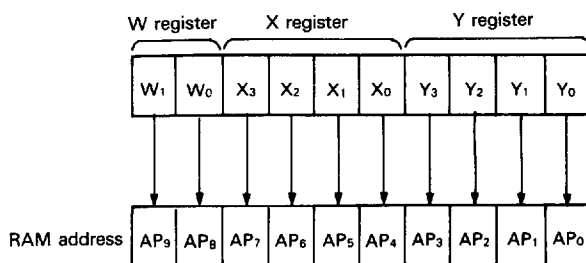
Table Data Addressing Mode: By executing the TBR instruction, the program can branch to the address determined by the contents of the 4-bit immediate data, accumulator, and B register.

P Instruction: ROM data addressed by table data addressing can be referenced by the P instruction (figure 32). When bit 8 in the referenced ROM data is 1, 8 bits of ROM data are written into the accumulator and B register. When bit 9 is 1, 8 bits of ROM data are written into the R1 and R2 port output registers. When both bits 8 and 9 are 1, ROM data are written into the accumulator and B registers, and also to the R1 and R2 port output registers at the same time.

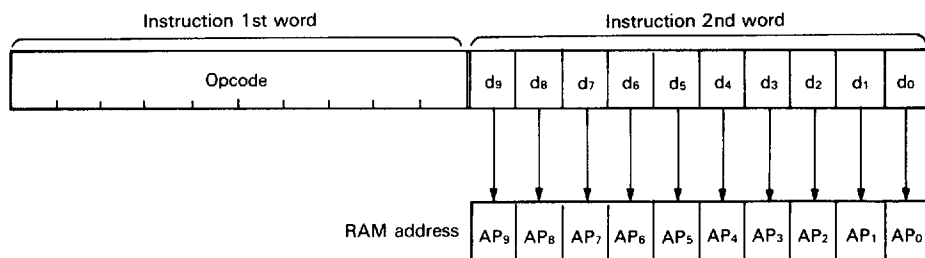
The P instruction has no effect on the program counter.

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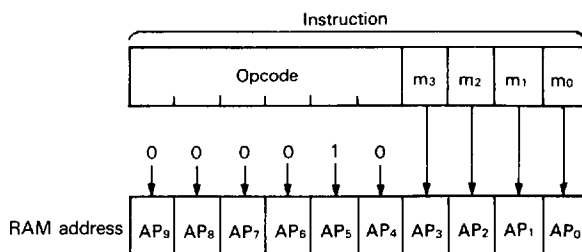
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Register Indirect Addressing



Direct Addressing



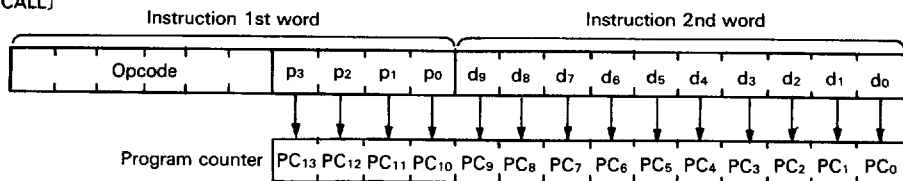
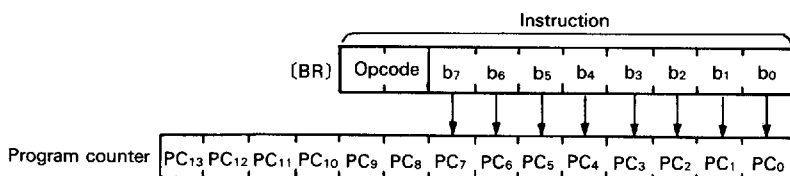
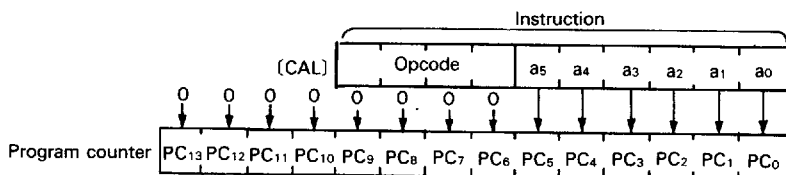
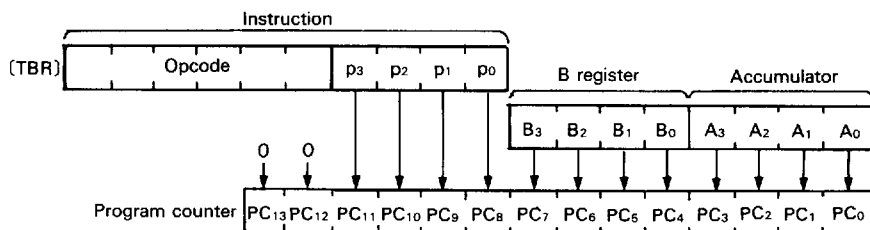
Memory Register Addressing

Figure 29 RAM Addressing Modes

{JMPL}

{BRL}

{CALL}

**Direct Addressing****Current Page Addressing****Zero Page Addressing****Table Data Addressing****Figure 30 ROM Addressing Modes**

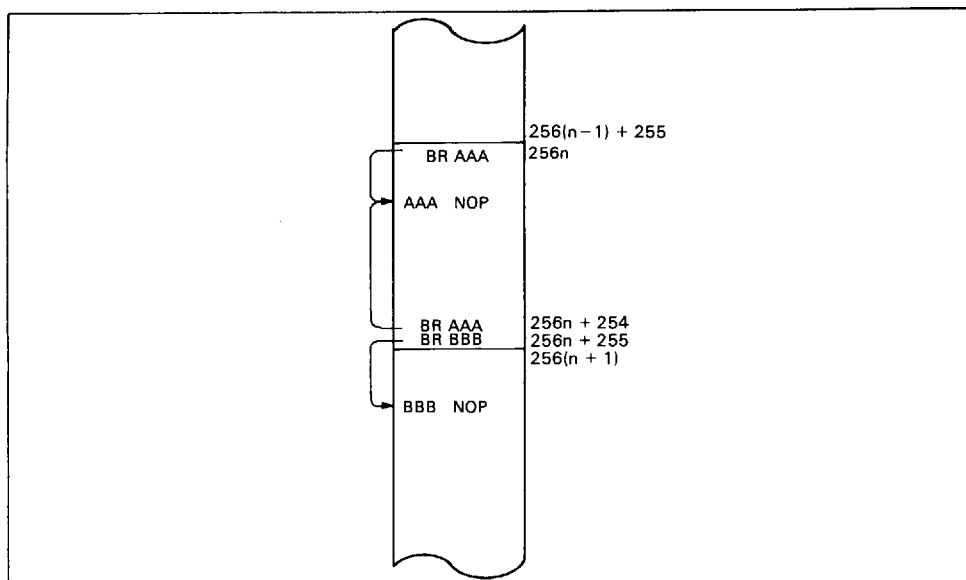


Figure 31 BR Instruction Branch Destination on a Page Boundary

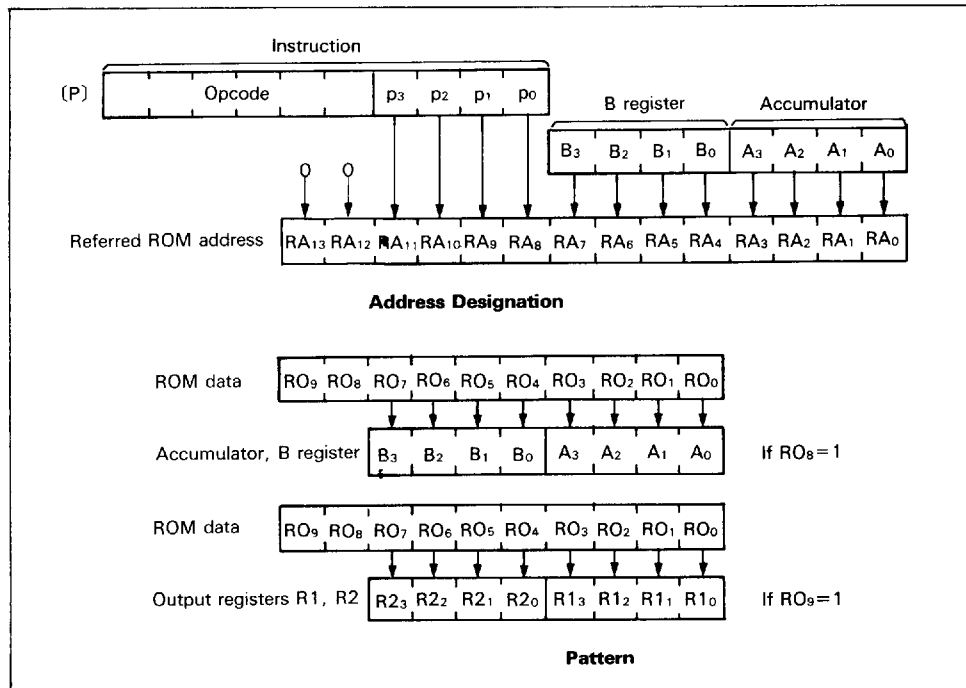


Figure 32 P Instruction

Absolute Maximum Ratings

Item	Symbol	Value	Unit	Note
Supply voltage	V_{CC}	-0.3 to +7.0	V	
Programming voltage	V_{PP}	-0.3 to +14	V	13
Pin voltage	V_T	-0.3 to $V_{CC} + 0.3$	V	3
		$V_{CC} - 45$ to $V_{CC} + 0.3$	V	4
Total permissible input current	ΣI_o	50	mA	5
Maximum input current	I_o	15	mA	7, 8
Maximum output current	$-I_o$	4	mA	9, 10
		6	mA	9, 11
		30	mA	9, 12
Total permissible output current	$-\Sigma I_o$	150	mA	6
Operating temperature	T_{opr}	-20 to +75	°C	
Storage temperature	T_{stg}	-55 to +125	°C	

- Notes:
1. Permanent damage may occur if these absolute maximum ratings are exceeded. Normal operation should be under the conditions of the electrical characteristics. If these conditions are exceeded, it may cause a malfunction or affect the reliability of the LSI.
 2. All voltages are with respect to GND.
 3. Standard pins.
 4. High voltage pins.
 5. Total permissible input current is the total sum of input currents which flow in from all I/O pins to GND simultaneously.
 6. Total permissible output current is the total sum of the output currents which flow out from V_{CC} to all I/O pins simultaneously.
 7. Maximum input current is the maximum amount of input current from each I/O pin to GND.
 8. D₀-D₃ and R3-R8.
 9. Maximum output current is the maximum amount of output current from V_{CC} to each I/O pin.
 10. D₀-D₃ and R3-R8.
 11. R0-R2.
 12. D₄-D₁₅.
 13. Applied to HD4074019.

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HD404019 Electrical Characteristics**DC Characteristics**

($V_{CC} = 3.5 \text{ V to } 6 \text{ V}$, $GND = 0 \text{ V}$, $V_{disp} = V_{CC} - 40 \text{ V to } V_{CC}$, $T_a = -20^\circ\text{C to } +75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition	Note
Input high voltage	V_{IH}	RESET, \overline{SCK} , INT ₀ , INT ₁	0.8V _{CC}	V _{CC} + 0.3	V		
		SI	0.7V _{CC}	V _{CC} + 0.3	V		
		OSC ₁	V _{CC} - 0.5	V _{CC} + 0.3	V		
Input low voltage	V_{IL}	RESET, \overline{SCK} , INT ₀ , INT ₁	-0.3	0.2V _{CC}	V		
		SI	-0.3	0.3V _{CC}	V		
		OSC ₁	-0.3	0.5	V		
Output high voltage	V_{OH}	\overline{SCK} , SO	V _{CC} - 1.0		V	-I _{OH} = 1.0 mA	
			V _{CC} - 0.5		V	-I _{OH} = 0.5 mA	
Output low voltage	V_{OL}	\overline{SCK} , SO		0.4	V	I _{OL} = 1.6 mA	
Input/output leakage current	I _{IL}	RESET, \overline{SCK} , INT ₀ , INT ₁ , SI, SO, OSC ₁		1	μA	V _{in} = 0 V to V _{CC}	1
Current dissipation in active mode	I _{CC}	V _{CC}		8.0	mA	V _{CC} = 5 V; f _{osc} = 4 MHz divide by 4	2, 5

HD404019 Electrical Characteristics**DC Characteristics**

($V_{CC} = 3.5 \text{ V to } 6 \text{ V}$, $GND = 0 \text{ V}$, $V_{disp} = V_{CC} - 40 \text{ V to } V_{CC}$, $T_a = -20^\circ\text{C to } +75^\circ\text{C}$, unless otherwise specified) (cont)

Item	Symbol	Pin	Min	Max	Unit	Test Condition	Note
Current dissipation in standby mode	I_{SBY}	V_{CC}		2.0	mA	$V_{CC} = 5 \text{ V}$; $f_{OSC} = 4 \text{ MHz}$ divide by 4	3, 5
Current dissipation in stop mode	I_{STOP}	V_{CC}		10	μA	$V_{in(\overline{TEST})} = V_{CC} - 0.3 \text{ V to } V_{CC}$; $V_{in(RESET)} = 0 \text{ V to } 0.3 \text{ V}$	4
Stop mode retaining voltage	V_{STOP}	V_{CC}	2		V		

- Notes:
1. Excluding pull-up MOS current and output buffer current.
 2. The MCU is in the reset state. Input/output current does not flow.
 - MCU in reset state, operation mode
 - RESET, TEST: V_{CC}
 - D₀-D₃, R₃-R₉: V_{CC}
 - D₄-D₁₅, R₀-R₂, RA₀, RA₁: V_{disp}
 3. The timer/counter operates with the fastest clock. Input/output current does not flow.
 - MCU in standby mode
 - Input/output in reset state
 - Serial interface: Stop
 - RESET: GND
 - TEST: V_{CC}
 - D₀-D₃, R₃-R₉: V_{CC}
 - D₄-D₁₅, R₀-R₂, RA₀, RA₁: V_{disp}
 4. Excluding pull-down MOS current.
 5. When $f_{OSC} = x \text{ MHz}$, estimate the current dissipation as follows:
 Max. value at $x \text{ MHz} = x/4 \times (\text{max. value at } 4 \text{ MHz})$

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Input/Output Characteristics for Standard Pins

(V_{CC} = 3.5 V to 6 V, GND = 0 V, V_{dis} = V_{CC} - 40 V to V_{CC}, T_a = -20°C to +75°C, unless otherwise specified)

Item	Symbol	Pin	Min	Typ	Max	Unit	Test Condition	Note
Input high voltage	V _{IH}	D0-D3, R3-R9	0.7V _{CC}		V _{CC} + 0.3	V		
Input low voltage	V _{IL}	D0-D3, R3-R9	-0.3		0.3V _{CC}	V		
Output high voltage	V _{OH}	D0-D3, R3-R8	V _{CC} - 1.0			V	-I _{OH} = 1.0 mA	1
		D0-D3, R3-R8	V _{CC} - 0.5			V	-I _{OH} = 0.5 mA	1
Output low voltage	V _{OL}	D0-D3, R3-R8			0.4	V	I _{OL} = 1.6 mA	
Input/output leakage current	I _{IL}	D0-D3, R3-R9			1	μA	V _{in} = 0 V to V _{CC}	2
Pull-up MOS current	-I _p	D0-D3, R3-R9	30		150	μA	V _{CC} = 5 V, V _{in} = 0 V	3

- Notes: 1. Applied to I/O pins selected as CMOS output by mask option.
 2. Pull-up MOS current and output buffer current are excluded.
 3. Applied to I/O pins selected as with pull-up MOS by mask option.

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Input/Output Characteristics for High Voltage Pins

($V_{CC} = 3.5 \text{ V}$ to 6 V , $GND = 0 \text{ V}$, $V_{disp} = V_{CC} - 40 \text{ V}$ to V_{CC} , $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Typ	Max	Unit	Test Condition	Note
Input high voltage	V_{IH}	D4-D15, R0, R1, R2, RA0, RA1	$0.7V_{CC}$		$V_{CC} + 0.3$	V		
Input low voltage	V_{IL}	D4-D15, R0, R1, R2, RA0, RA1	$V_{CC} - 40$		$0.3V_{CC}$	V		
Output high voltage	V_{OH}	D4-D15	$V_{CC} - 3.0$			V	$-I_{OH} = 15 \text{ mA}$, $V_{CC} = 5 \text{ V} \pm 20\%$	
			$V_{CC} - 2.0$			V	$-I_{OH} = 10 \text{ mA}$, $V_{CC} = 5 \text{ V} \pm 20\%$	
			$V_{CC} - 1.0$			V	$-I_{OH} = 4 \text{ mA}$	
		R0-R2	$V_{CC} - 3.0$			V	$-I_{OH} = 3 \text{ mA}$, $V_{CC} = 5 \text{ V} \pm 20\%$	
			$V_{CC} - 2.0$			V	$-I_{OH} = 2 \text{ mA}$, $V_{CC} = 5 \text{ V} \pm 20\%$	
			$V_{CC} - 1.0$			V	$-I_{OH} = 0.8 \text{ mA}$	
Output low voltage	V_{OL}	D4-D15, R0-R2			$V_{CC} - 37$	V	$V_{disp} = V_{CC} - 40 \text{ V}$	1
		D4-D15, R0-R2			$V_{CC} - 37$	V	$150 \text{ k}\Omega$ at $V_{CC} - 40 \text{ V}$	2
Input/output leakage current	$ I_{IL} $	D4-D15, R0-R2, RA0, RA1			20	μA	$V_{in} = V_{CC} - 40 \text{ V}$ to V_{CC}	3
Pull-down MOS current	I_d	D4-D15, R0-R2, RA0, RA1	125		900	μA	$V_{disp} = V_{CC} - 35 \text{ V}$, $V_{in} = V_{CC}$	1

- Notes:
1. Applied to I/O pins selected as with pull-up MOS by mask option.
 2. Applied to I/O pins selected as without pull-up MOS (PMOS open drain) by mask option.
 3. Pull-up MOS current and output buffer current are excluded.

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HITACHI/ (MCU/MPU)

AC Characteristics

($V_{CC} = 3.5 \text{ V to } 6 \text{ V}$, $GND = 0 \text{ V}$, $V_{dlap} = V_{CC} - 40 \text{ V to } V_{CC}$, $T_a = -20^\circ\text{C to } +75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Typ	Max	Unit	Test Condition	Note
Oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	0.2	4	4.5	MHz	Divide by 4	
Instruction cycle time	t_{cyc}		0.89	1	20	μs		
Oscillator stabilization time	t_{RC}	OSC ₁ , OSC ₂			20	ms		1
External clock high and low widths	t_{CPH} , t_{CPL}	OSC ₁	92			ns	Divide by 4	2
External clock rise time	t_{CPr}	OSC ₁			20	ns		2
External clock fall time	t_{CPf}	OSC ₁			20	ns		2
\overline{INT}_0 high width	t_{i0H}	\overline{INT}_0	2			t_{cyc}		3
\overline{INT}_0 low width	t_{i0L}	\overline{INT}_0	2			t_{cyc}		3
\overline{INT}_1 high width	t_{i1H}	\overline{INT}_1	2			t_{cyc}		3
\overline{INT}_1 low width	t_{i1L}	\overline{INT}_1	2			t_{cyc}		3
RESET high width	t_{RSTH}	RESET	2			t_{cyc}		4
Input capacitance	C_{in}	All pins			30	pF	$f = 1 \text{ MHz}$, $V_{in} = 0 \text{ V}$	
RESET fall time	t_{RSTf}				20	ms		4

- Notes:
1. The oscillator stabilization time is the period from when V_{CC} reaches its minimum allowable voltage (3.5 V) at power-on until when the oscillator stabilizes, or after RESET goes high by MCU reset to quit the stop mode. At power-on or recovering from stop mode, apply the RESET input for more than t_{RC} to meet the necessary time for oscillator stabilization. When using a crystal or ceramic filter oscillator, consult with the crystal oscillator maker since the oscillator stabilization time depends on the circuit constant and stray capacitance. (See figure 33.)
 2. See figure 34.
 3. See figure 35.
 4. See figure 36.

HITACHI/ (MCU/MPU)

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Serial Interface Timing Characteristics

($V_{CC} = 3.5 \text{ V to } 6 \text{ V}$, $GND = 0 \text{ V}$, $V_{disp} = V_{CC} - 40 \text{ V to } V_{CC}$, $T_a = -20^\circ\text{C to } +75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition	Note
Transmit clock cycle time	t_{Scyc}	\overline{SCK} (Output)	1		t_{cyc}		1, 2
Transmit clock high and low widths	t_{SCKH} , t_{SCKL}	\overline{SCK} (Output)	0.4		t_{cyc}		1, 2
Transmit clock rise and fall times	t_{SCKr} , t_{SCKf}	\overline{SCK} (Output)		40	ns		1, 2
Transmit clock cycle time	t_{Scyc}	\overline{SCK} (Input)	1		t_{cyc}		1
Transmit clock high and low widths	t_{SCKH} , t_{SCKL}	\overline{SCK} (Input)	0.4		t_{cyc}		1
Transmit clock completion detect time	t_{SCKHD}	\overline{SCK} (Input)	1		t_{cyc}		1, 3
Transmit clock rise and fall times	t_{SCKr} , t_{SCKf}	\overline{SCK} (Input)		40	ns		1
Serial output data delay time	t_{DSO}	SO		300	ns		1, 2
Serial input data setup time	t_{SSI}	SI	100		ns		1
Serial input data hold time	t_{HSI}	SI	200		ns		1

- Notes:
1. See figure 37.
 2. See figure 38.
 3. Transmit clock completion detect time is the high level period after 8 pulses of transmit clock are inputted. The SCI interrupt request flag is not set when the next transmit clock is input before the transmit clock completion detect time has passed.

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HITACHI/ (MCU/MPU)

HD4074019 Electrical Characteristics

DC Characteristics

($V_{CC} = 5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, $V_{disp} = V_{CC} - 40\text{ V}$ to V_{CC} , $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition	Note
Input high voltage	V_{IH}	RESET, \overline{SCK} , INT ₀ , INT ₁	0.8V _{CC}	V _{CC} + 0.3	V		
		OSC ₁	V _{CC} - 0.5	V _{CC} + 0.3	V		
		SI	0.7V _{CC}	V _{CC} + 0.3	V		
Input low voltage	V_{IL}	RESET, \overline{SCK} , INT ₀ , INT ₁	-0.3	0.2V _{CC}	V		
		OSC ₁	-0.3	0.5	V		
		SI	-0.3	0.3V _{CC}	V		
Output high voltage	V_{OH}	\overline{SCK} , SO	V _{CC} - 1.0		V	-I _{OH} = 1.0 mA	
			V _{CC} - 0.5		V	-I _{OH} = 0.5 mA	
Output low voltage	V_{OL}	\overline{SCK} , SO		0.4	V	I _{OL} = 1.6 mA	
Input/output leakage current	I _{IL}	RESET, \overline{SCK} , INT ₀ , INT ₁ , OSC ₁ , SI, SO		1	μA	V _{in} = 0 V to V _{CC}	1
Current dissipation in active mode	I _{CC}	V _{CC}		8.0	mA	V _{CC} = 5 V; f _{OSC} = 4 MHz divide by 4	2, 5
Current dissipation in standby mode	I _{SBY}	V _{CC}		2.0	mA	V _{CC} = 5 V; f _{OSC} = 4 MHz divide by 4	3, 5
Current dissipation in stop mode	I _{STOP}	V _{CC}		10	μA	V _{in} (TEST) = V _{CC} - 0.3 V to V _{CC} ; V _{in} (RESET) = 0 V to 0.3 V	4
Stop mode retaining voltage	V _{STOP}	V _{CC}	2		V		

- Notes:
- Excluding pull-up MOS current and output buffer current.
 - The MCU is in the reset state. Input/output current does not flow.
 - MCU in reset state, operation mode
 - RESET, TEST: V_{CC}
 - D₀-D₃, R₃-R₉: V_{CC}
 - D₄-D₁₅, R₀-R₂, RA₀, RA₁: V_{disp}
 - The timer/counter operates with the fastest clock. Input/output current does not flow.
 - MCU in standby mode
 - Input/output in reset state
 - Serial interface: Stop
 - RESET: GND
 - TEST: V_{CC}
 - D₀-D₃, R₃-R₉: V_{CC}
 - D₄-D₁₅, R₀-R₂, RA₀, RA₁: V_{disp}

Notes for DC Characteristics (cont)

4. Excluding pull-down MOS current.

5. When $f_{osc} = x$ MHz, estimate the current dissipation as follows:

Max. value at x MHz = $x/4 \times$ (max. value at 4 MHz)

Input/Output Characteristics for Standard Pins

($V_{CC} = 5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, $V_{disp} = V_{CC} - 40\text{ V}$ to V_{CC} , $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition
Input high voltage	V_{IH}	D0-D3, R3-R9	$0.7V_{CC}$	$V_{CC} + 0.3$	V	
Input low voltage	V_{IL}	D0-D3, R3-R9	-0.3	$0.3V_{CC}$	V	
Output low voltage	V_{OL}	D0-D3, R3-R8		0.4	V	$I_{OL} = 1.6\text{ mA}$
Input/output leakage current*	$ I_{IL} $	D0-D3, R3-R8, R9 ₁ -R9 ₃		1	μA	$V_{in} = 0\text{ V}$ to V_{CC}
		R9 ₀		20	μA	

* Pull-up MOS current and output buffer current are excluded.

Input/Output Characteristics for High Voltage Pins

($V_{CC} = 5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, $V_{disp} = V_{CC} - 40\text{ V}$ to V_{CC} , $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition
Input high voltage	V_{IH}	D4-D15, R0, R1, R2, RA0, RA1	$0.7V_{CC}$	$V_{CC} + 0.3$	V	
Input low voltage	V_{IL}	D4-D15, R0, R1, R2, RA0, RA1	$V_{CC} - 40$	$0.3V_{CC}$	V	
Output high voltage	V_{OH}	D4-D15	$V_{CC} - 3.0$	V		$-I_{OH} = 15\text{ mA}$, $V_{CC} = 5\text{ V}$
			$V_{CC} - 2.0$	V		$-I_{OH} = 10\text{ mA}$, $V_{CC} = 5\text{ V}$
			$V_{CC} - 1.0$	V		$-I_{OH} = 4\text{ mA}$, $V_{CC} = 5\text{ V}$
		R0-R2	$V_{CC} - 3.0$	V		$-I_{OH} = 3\text{ mA}$, $V_{CC} = 5\text{ V}$
			$V_{CC} - 2.0$	V		$-I_{OH} = 2\text{ mA}$, $V_{CC} = 5\text{ V}$
			$V_{CC} - 1.0$	V		$-I_{OH} = 0.8\text{ mA}$, $V_{CC} = 5\text{ V}$
Output low voltage	V_{OL}	D4-D15, R0-R2		$V_{CC} - 37$	V	$150\text{ k}\Omega$ at $V_{CC} - 40$
Input/output leakage current*	$ I_{IL} $	D4-D15, R0-R2, RA0, RA1	20	μA		$V_{in} = V_{CC} - 40\text{ V}$, V_{CC}

* Pull-down MOS current and output buffer current are excluded.

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HITACHI/ (MCU/MPU)

AC Characteristics

($V_{CC} = 5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, $V_{dlap} = V_{CC} - 40\text{ V}$ to V_{CC} , $T_A = -20^\circ\text{C}$ to $+75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Typ	Max	Unit	Test Condition	Note
Oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	0.2	4	4.5	MHz	Divide by 4	
Instruction cycle time	t_{cyc}		0.89	1	20	μs	Divide by 4	
Oscillator stabilization time	t_{RC}	OSC ₁ , OSC ₂			20	ms		1
External clock high and low widths	t_{CPH} , t_{CPL}	OSC ₁	92			ns	Divide by 4	2
External clock rise time	t_{CPr}	OSC ₁			20	ns		2
External clock fall time	t_{CPf}	OSC ₁			20	ns		2
$\overline{INT_0}$ high width	t_{IOH}	$\overline{INT_0}$	2			t_{cyc}		3
$\overline{INT_0}$ low width	t_{IOL}	$\overline{INT_0}$	2			t_{cyc}		3
$\overline{INT_1}$ high width	t_{11H}	$\overline{INT_1}$	2			t_{cyc}		3
$\overline{INT_1}$ low width	t_{11L}	$\overline{INT_1}$	2			t_{cyc}		3
RESET high width	t_{RSTH}	RESET	2			t_{cyc}		4
Input capacitance	C_{in}	All pins except R9 ₀			30	pF	$f = 1\text{ MHz}$, $V_{in} = 0\text{ V}$	
		R9 ₀			180	pF		
RESET fall time	t_{RSTf}				20	ms		4

- Notes:
1. The oscillator stabilization time is the period from when V_{CC} reaches its minimum allowable voltage at power-on until when the oscillator stabilizes, or after RESET goes high. At power-on or recovering from stop mode, apply the RESET input for more than t_{RC} to meet the necessary time for oscillator stabilization. Since t_{RC} depends on the crystal or ceramic filter's circuit constant and stray capacitance, consult with the crystal or ceramic filter manufacturer when designing the RESET circuit. (See figure 33.)
 2. See figure 34.
 3. See figure 35.
 4. See figure 36.

Serial Interface Timing Characteristics

($V_{CC} = 5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, $V_{disp} = V_{CC} - 40\text{ V to } V_{CC}$, $T_a = -20^\circ\text{C to } +75^\circ\text{C}$, unless otherwise specified)

Item	Symbol	Pin	Min	Max	Unit	Test Condition	Note
Transmit clock cycle time	t_{Scyc}	SCK (Output)	1		t_{cyc}		1, 2
Transmit clock high and low widths	t_{SCKH} , t_{SCKL}	SCK (Output)	0.4		t_{cyc}		1, 2
Transmit clock rise and fall times	t_{SCKr} , t_{SCKf}	SCK (Output)		40	ns		1, 2
Transmit clock cycle time	t_{Scyc}	SCK (Input)	1		t_{cyc}		1
Transmit clock high and low widths	t_{SCKH} , t_{SCKL}	SCK (Input)	0.4		t_{cyc}		1
Transmit clock completion detect time	t_{SCKHD}	SCK (Input)	1		t_{cyc}		1, 3
Transmit clock rise and fall times	t_{SCKr} , t_{SCKf}	SCK (Input)		40	ns		1
Serial output data delay time	t_{DSO}	SO		200	ns		1, 2
Serial input data setup time	t_{SSI}	SI	200		ns		1
Serial input data hold time	t_{HSI}	SI	100		ns		1

- Notes:
1. See figure 37.
 2. See figure 38.
 3. Transmit clock completion detect time is the high level period after 8 pulses of transmit clock are inputted. The SCI interrupt request flag is not set when the next transmit clock is input before transmit clock completion detect time has passed.

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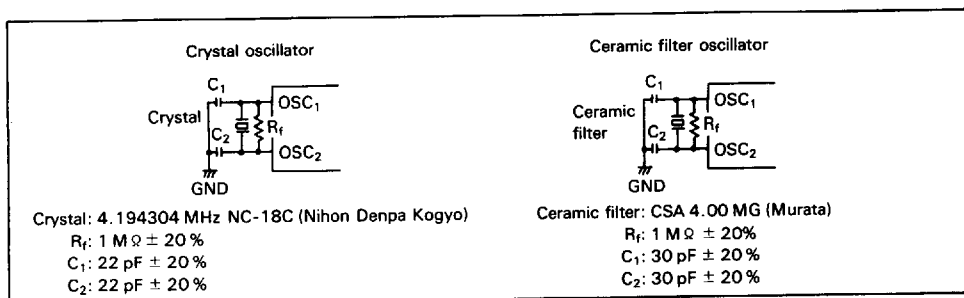


Figure 33 Oscillator Circuit

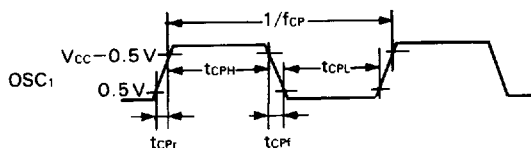


Figure 34 Oscillator Timing

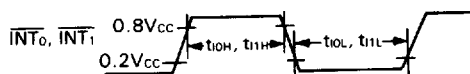


Figure 35 Interrupt Timing

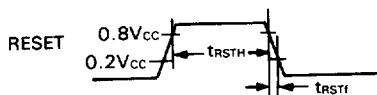
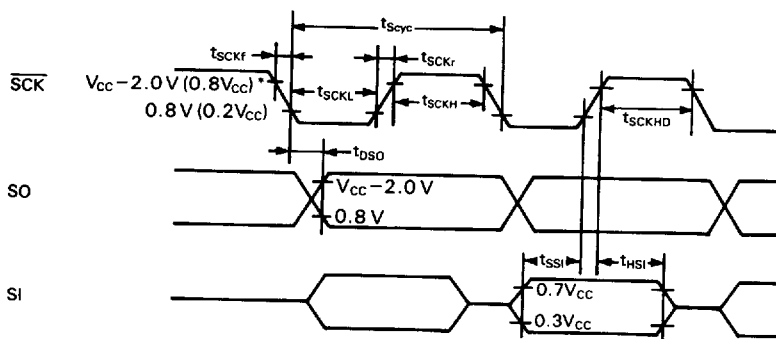


Figure 36 Reset Timing



*Note: $V_{CC} - 2.0V$ and $0.8V$ are the threshold voltages for transmit clock output.
 $0.8V_{CC}$ and $0.2V_{CC}$ are the threshold voltages for transmit clock input.

Figure 37 Timing of Serial Interface

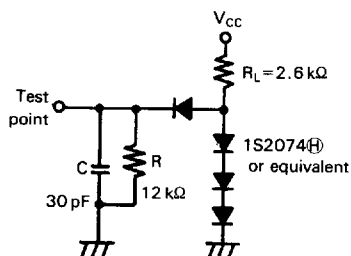


Figure 38 Timing Load Circuit

HD404019/HD4074019

HITACHI/ (MCU/MPU)

HD404019 Mask Option List

Date of order	
Customer	
Dept.	
Name	
ROM code name	
LSI type number (Hitachi's entry)	

1. I/O Option

Note: I/O options masked by ☒ are not available.

			I/O Option								I/O Option					
			A	B	C	D	E				A	B	C	D	E	
D ₀	Standard Pins	Input/Output						R3	R3 ₀	Input/Output						
D ₁		Input/Output							R3 ₁	Input/Output						
D ₂		Input/Output							R3 ₂	Input/Output						
D ₃		Input/Output							R3 ₃	Input/Output						
D ₄	High Voltage Pins	Input/Output						R4	R4 ₀	Input/Output						
D ₅		Input/Output							R4 ₁	Input/Output						
D ₆		Input/Output							R4 ₂	Input/Output						
D ₇		Input/Output							R4 ₃	Input/Output						
D ₈		Input/Output						R5	R5 ₀	Input/Output						
D ₉		Input/Output							R5 ₁	Input/Output						
D ₁₀		Input/Output							R5 ₂	Input/Output						
D ₁₁		Input/Output							R5 ₃	Input/Output						
D ₁₂		Input/Output						R6	R6 ₀	Input/Output						
D ₁₃		Input/Output							R6 ₁	Input/Output						
D ₁₄		Input/Output							R6 ₂	Input/Output						
D ₁₅		Input/Output							R6 ₃	Input/Output						
								R7	R7 ₀	Input/Output						
									R7 ₁	Input/Output						
									R7 ₂	Input/Output						
									R7 ₃	Input/Output						
R0	High Voltage Pins	R0 ₀	Input/Output					R8	R8 ₀	Input/Output						
		R0 ₁	Input/Output						R8 ₁	Input/Output						
		R0 ₂	Input/Output						R8 ₂	Input/Output						
		R0 ₃	Input/Output						R8 ₃	Input/Output						
R1	High Voltage Pins	R1 ₀	Input/Output					R9	R9 ₀	Input						
		R1 ₁	Input/Output						R9 ₁	Input						
		R1 ₂	Input/Output						R9 ₂	Input						
		R1 ₃	Input/Output						R9 ₃	Input						
R2	High Voltage Pins	R2 ₀	Input/Output					RA	RA ₀	Input						
		R2 ₁	Input/Output						RA ₁	Input						
		R2 ₂	Input/Output					Please mark on RA ₁ /V _{disp}								
		R2 ₃	Input/Output													

* Please write 0 under applicable items for I/O option selections.

A: Without pull-up MOS (NMOS open drain)

B: With pull-up MOS

C: CMOS (not be used as input)

D: Without pull-down MOS (PMOS open drain)

E: With pull-down MOS

2. RA₁/V_{disp}

RA ₁ /V _{disp}
<input type="checkbox"/> RA ₁ : Without pull-down MOS (D)
<input type="checkbox"/> V _{disp}

* Please check off applicable items by ■, X, or ✓.

3. Package

Package
<input type="checkbox"/> DP-64S (shrink package)
<input type="checkbox"/> FP-64B
<input type="checkbox"/> FP-64A

* Please check off applicable items by ■, X, or ✓.

Note: The RA₁/V_{disp} pin has to be selected as V_{disp} even if one high voltage pin is specified as "E".

4. Divider (DIV)

Clock divide ratio
<input checked="" type="checkbox"/> Divide by 4

5. ROM code media

ROM code media
<input type="checkbox"/> EPROM: Emulator type
<input type="checkbox"/> EPROM: On-package microcomputer type

Checklist of Application

A. Oscillator (CPG option)

CPG option	
<input type="checkbox"/> Ceramic filter	
<input type="checkbox"/> Crystal	
<input type="checkbox"/> External clock	

* Please check off applicable items by ■, X, or ✓.

B. Voltage applied to high voltage pins

$V_{disp} = V_{CC} - \boxed{} \text{ V}$

* Please insert value in box.