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April 1st, 2010
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RENESAS

MOS INTEGRATED CIRCUIT

μPD6P8, 6P8A, 6P8B

4-BIT SINGLE-CHIP MICROCONTROLLER

FOR INFRARED REMOTE CONTROL TRANSMISSION

DESCRIPTION

The μPD6P8, 6P8A, 6P8B are microcontrollers for infrared remote control transmitters and are provided with a one-time PROM as the program memory.

Because users can write programs for the μPD6P8, 6P8A, 6P8B, they are ideal for program evaluation and small-scale production of application systems that use the μPD67A, 67B, 68A, 68B.

When reading this document, also refer to the following documents.

μPD67, 67A, 68, 68A, 69 Data Sheet:	**U14935E**
μPD67B, 68B Data Sheet:	**U16792E**

FEATURES

- Program memory (one-time PROM): 2026 × 10 bits
- Data memory (RAM): 32 × 4 bits
- On-chip carrier generator for infrared remote control: The high-level and low-level width can be set separately from 250 ns to 64 μs (@ f_X = 4 MHz operation) via modulo registers
- 9-bit programmable timer: 1 channel
- Instruction execution time: 16 μs (@ f_X = 4 MHz)
- Stack level: 1 level (stack RAM is for data memory RF as well)
- I/O pins ($K_{I/O}$): 8 units
- Input pins (K_I): 4 units
- Sense input pins (S): 3 units (μPD6P8, 6P8A), 4 units (μPD6P8B)
- Remote control transmission display output pin ($\overline{LED}$): 1 unit (shared with S_1 pin)
- Power supply voltage: V_{DD} = 1.9 to 3.6 V
- Operating ambient temperature: T_A = –40 to +85°C
- Oscillation frequency: f_X = 3.5 to 4.5 MHz
- On-chip POC circuit and RAM retention detector
- On-chip oscillator (μPD6P8B)

APPLICATIONS

Infrared remote control transmitters (for AV and household electric appliances)

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Document No. U17848EJ5V0DS00 (5th edition)
Date Published January 2009 N
Printed in Japan

The mark <R> shows major revised points.

ORDERING INFORMATION

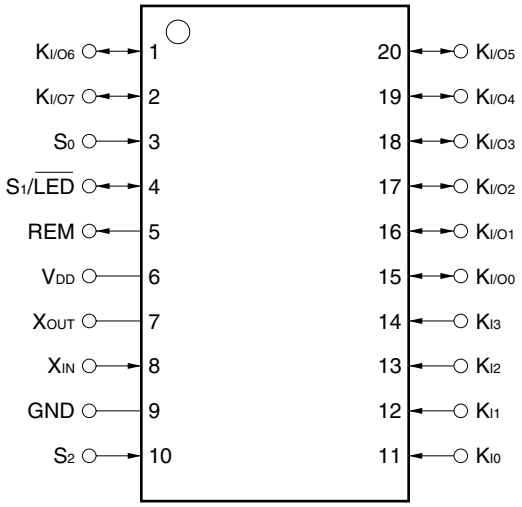
Part Number	Package
μPD6P8MC-5A4-A	20-pin plastic SSOP (7.62 mm (300))
μPD6P8AMC-5A4-A	20-pin plastic SSOP (7.62 mm (300))
μPD6P8BMC-5A4-A	20-pin plastic SSOP (7.62 mm (300))

Remark Products that have the part numbers suffixed by "-A" are lead-free products.

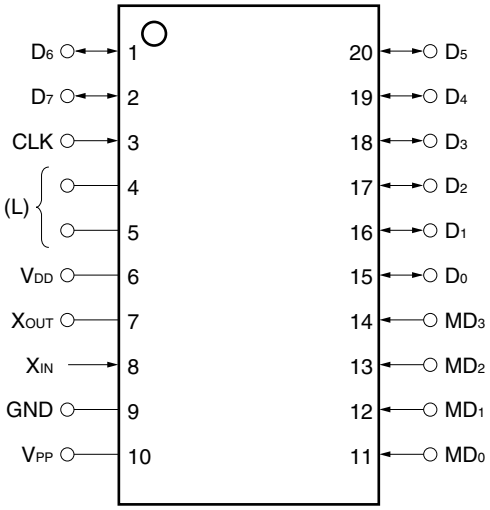
μPD6P8 PIN CONFIGURATION (TOP VIEW)

20-pin plastic SSOP (7.62 mm (300))

(1) Normal operation mode



(2) PROM programming mode



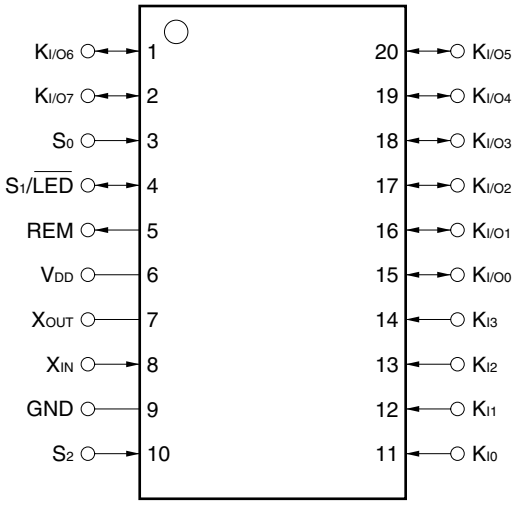
Caution The item in parentheses indicates the processing of pins not used in the PROM programming mode.

L: Connect each of these pins to GND via a pull-down resistor.

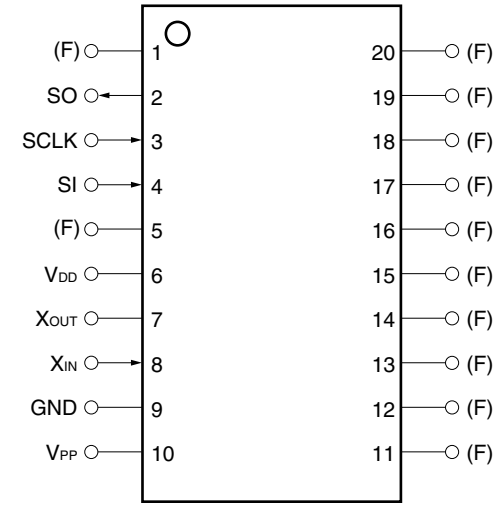
μPD6P8A PIN CONFIGURATION (TOP VIEW)

20-pin plastic SSOP (7.62 mm (300))

(1) Normal operation mode



(2) PROM programming mode



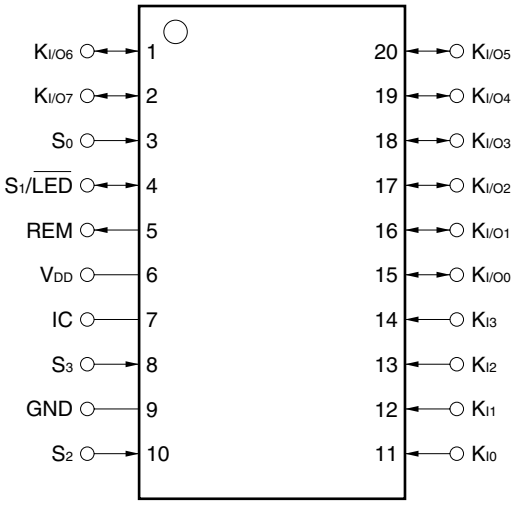
Caution The item in parentheses indicates the processing of pins not used in the PROM programming mode.

F: These pins are pulled down internally, so leave them open.

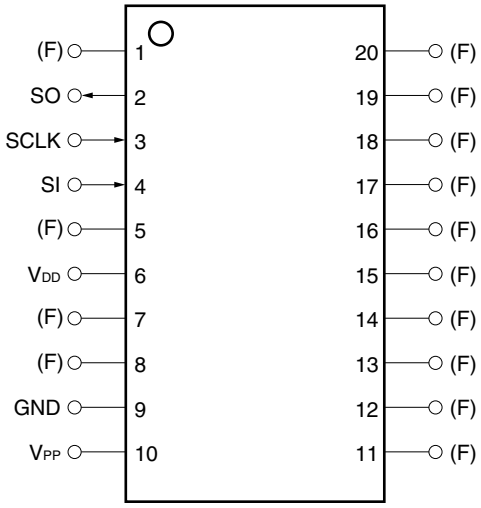
μPD6P8B PIN CONFIGURATION (TOP VIEW)

20-pin plastic SSOP (7.62 mm (300))

(1) Normal operation mode



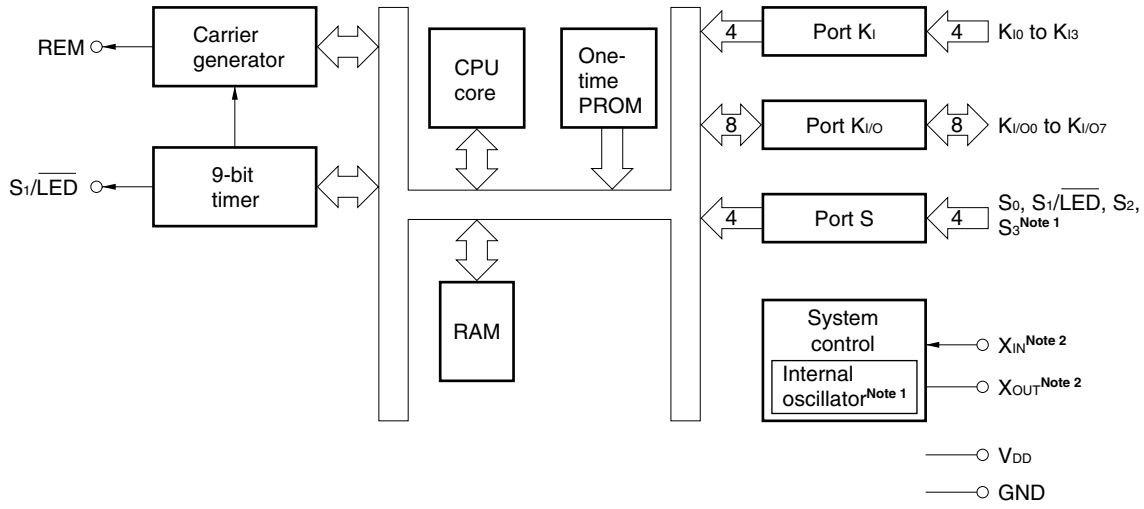
(2) PROM programming mode



Caution The item in parentheses indicates the processing of pins not used in the PROM programming mode.

F: These pins are pulled down internally, so leave them open.

<R> BLOCK DIAGRAM



Notes 1. μPD6P8B only

2. μPD6P8 and 6P8A only

LIST OF FUNCTIONS

Item		μPD6P8	μPD6P8A	μPD6P8B
ROM capacity		2026 × 10 bits One-time PROM		
RAM capacity		32 × 4 bits		
Stack		1 level (shared with RF of RAM)		
I/O pins	Key input (K_I)	4 pins		
	Key I/O ($K_{I/O}$)	8 pins		
	Key expansion input (S)	3 pins		4 pins
	Remote control transmission display output ($\overline{LED}$)	1 pin (shared with S_1 pin)		
Number of keys		32 keys 56 keys (when expanded by key expansion input)		32 keys 64 keys (when expanded by key expansion input)
Clock frequency		Ceramic oscillation f_X = 3.5 to 4.5 MHz		Internal oscillation f_X = 4 MHz (TYP.)
Instruction execution time		16 μs (@ f_X = 4 MHz)		
Carrier frequency		The high-level and low-level width can be set separately from 250 ns to 64 μs (@ f_X = 4 MHz operation) via modulo registers		
Timer		9-bit programmable timer: 1 channel, timer clock: f_X/64		
POC circuit		On chip		
RAM retention detector		On chip		
Internal oscillator		Not available		On chip
Programming method		Parallel	Serial	
Supply voltage		V_{DD} = 1.9 to 3.6 V		
Operating ambient temperature		T_A = –40 to +85°C		
Package		20-pin plastic SSOP (7.62 mm (300))		

CONTENTS

1. PIN FUNCTIONS

1.1 Normal Operation Mode

(1) μPD6P8, 6P8A

Pin No.	Symbol	Function	Output Format	After Reset
1 2 15 to 20	$K_{I/O0}$ to $K_{I/O7}$	8-bit I/O port. I/O mode can be switched in 8-bit units. In input mode, a pull-down resistor is added. In output mode, these pins can be used as a key scan outputs from the key matrix.	CMOS push-pull[Note 1]	High-level output
3	S_0	Input port. This pin can also be used as a key return input from the key matrix. In input mode, the use of a pull-down resistor for the S_0 and S_1 ports can be specified by software in 2-bit units. If input mode is released by software, this pin is placed in the OFF mode and enters a high-impedance state.	—	High-impedance (OFF mode)
4	$S_1/\overline{LED}$	I/O port. In input mode (S_1), this pin can also be used as a key return input from the key matrix. The use of a pull-down resistor for the S_0 and S_1 ports can be specified by software in 2-bit units. In output mode ($\overline{LED}$), this pin becomes the remote control transmission display output (active low). When the remote control carrier is output from the REM output, this pin outputs a low level from the $\overline{LED}$ output in synchronization with the REM signal.	CMOS push-pull	High-level output ($\overline{LED}$)
5	REM	Infrared remote control transmission output. The output is active high. The carrier high-level and low-level width can each be freely set in a range of 250 ns to 64 μs (@ f_X = 4 MHz) using software.	CMOS push-pull	Low-level output
6	V_{DD}	Power supply	—	—
7 8	X_{OUT} X_{IN}	These pins are connected to system clock ceramic resonators.	—	Low level (oscillation stopped)
9	GND	GND pin	—	—
10	S_2	Input port. The use of the STOP mode release of the S_2 port can be specified by software. When using this pin as a key input from the key matrix, enable the use of the STOP mode release (at this time, a pull-down resistor is connected internally.) When the STOP mode release is disabled, this pin can be used as an input port that does not release the STOP mode even if the S_2 port satisfies the release condition (at this time, a pull-down resistor is not connected internally.)	—	Input (high impedance, STOP mode release cannot be used)
11 to 14	K_{I0} to K_{I3}[Note 2]	4-bit input port. These pins can be used as key return inputs to the key matrix. The use of pull-down resistors can be specified by software in 4-bit units.	—	Input (low-level)

Notes 1. Note that the drive capability of the low-level output side is held low.

2. In order to prevent malfunction, do not input a high-level signal to pins K_{I0} to K_{I3} (leaving these pins open is possible, however, when these pins are left open, do not disconnect any connected pull-down resistors) when POC is released due to supply voltage startup.

(2) μPD6P8B

Pin No.	Symbol	Function	Output Format	After Reset
1 2 15 to 20	$K_{I/O0}$ to $K_{I/O7}$	8-bit I/O port. I/O mode can be switched in 8-bit units. In input mode, a pull-down resistor is added. In output mode, these pins can be used as a key scan outputs from the key matrix.	CMOS push-pull[Note 1]	High-level output
3	S_0	Input port. This pin can also be used as a key return input from the key matrix. In input mode, the use of a pull-down resistor for the S_0 and S_1 ports can be specified by software in 2-bit units. If input mode is released by software, this pin is placed in the OFF mode and enters a high-impedance state.	—	High-impedance (OFF mode)
4	$S_1/\overline{LED}$	I/O port. In input mode (S_1), this pin can also be used as a key return input from the key matrix. The use of a pull-down resistor for the S_0 and S_1 ports can be specified by software in 2-bit units. In output mode ($\overline{LED}$), this pin becomes the remote control transmission display output (active low). When the remote control carrier is output from the REM output, this pin outputs a low level from the $\overline{LED}$ output in synchronization with the REM signal.	CMOS push-pull	High-level output ($\overline{LED}$)
5	REM	Infrared remote control transmission output. The output is active high. The carrier high-level and low-level width can each be freely set in a range of 250 ns to 64 μs (@ f_X = 4 MHz) using software.	CMOS push-pull	Low-level output
6	V_{DD}	Power supply	—	—
7	IC	Internally connected pin	—	—
8	S_3	Input port. This pin can also be used as a key return input from the key matrix. In input mode, the use of a pull-down resistor for the S_3 port can be specified by software. If input mode is released by software, this pin is placed in the OFF mode and enters a high-impedance state.	—	High-impedance (OFF mode)
9	GND	GND pin	—	—
10	S_2	Input port. The use of the STOP mode release of the S_2 port can be specified by software. When using this pin as a key input from the key matrix, enable the use of the STOP mode release (at this time, a pull-down resistor is connected internally.) When the STOP mode release is disabled, this pin can be used as an input port that does not release the STOP mode even if the S_2 port satisfies the release condition (at this time, a pull-down resistor is not connected internally.)	—	Input (high impedance, STOP mode release cannot be used)
11 to 14	K_{I0} to K_{I3}[Note 2]	4-bit input port. These pins can be used as key return inputs to the key matrix. The use of pull-down resistors can be specified by software in 4-bit units.	—	Input (low-level)

Notes 1. Note that the drive capability of the low-level output side is held low.

2. In order to prevent malfunction, do not input a high-level signal to pins K_{I0} to K_{I3} (leaving these pins open is possible, however, when these pins are left open, do not disconnect any connected pull-down resistors) when POC is released due to supply voltage startup.

1.2 PROM Programming Mode

(1) μPD6P8

Pin No.	Symbol	Function	I/O
1, 2 15 to 20	D_0 to D_7	8-bit data I/O when writing/verifying program memory	I/O
3	CLK	Clock input for updating address when writing/verifying program memory	Input
6	V_{DD}	Power supply Supply +3 V to this pin when writing/verifying program memory.	–
7	X_{OUT}	Clock necessary for writing program memory. Connect a 4 MHz ceramic resonator to these pins.	–
8	X_{IN}		Input
9	GND	GND	–
10	V_{PP}	Supplies voltage for writing/verifying program memory. Apply +10.5 V to this pin.	–
11 to 14	MD_0 to MD_3	Input for selecting operation mode when writing/verifying program memory	Input

(2) μPD6P8A

Pin No.	Symbol	Function	I/O
2	SO	Serial data output when verifying program memory	Output
3	SCLK	Clock input when writing/verifying program memory	Input
4	SI	Serial data input when writing program memory	Input
6	V_{DD}	Power supply Supply +3 V to this pin when writing/verifying program memory.	–
7	X_{OUT}	Clock necessary for writing program memory. Connect a 4 MHz ceramic resonator to these pins.	–
8	X_{IN}		Input
9	GND	GND	–
10	V_{PP}	Supplies voltage for writing/verifying program memory. Apply +10.5 V to this pin.	–

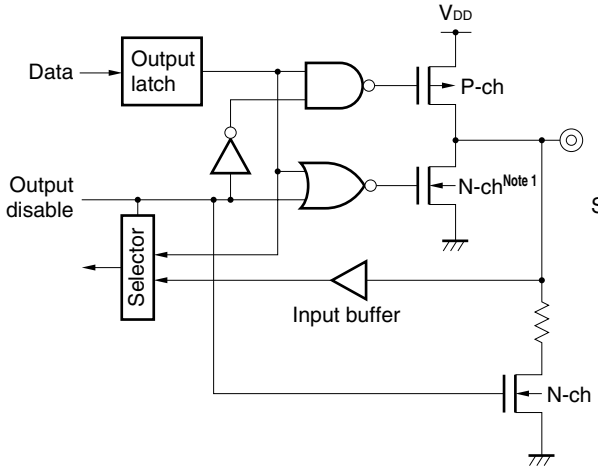
(3) μPD6P8B

Pin No.	Symbol	Function	I/O
2	SO	Serial data output when verifying program memory	Output
3	SCLK	Clock input when writing/verifying program memory	Input
4	SI	Serial data input when writing program memory	Input
6	V_{DD}	Power supply Supply +3 V to this pin when writing/verifying program memory.	–
9	GND	GND	–
10	V_{PP}	Supplies voltage for writing/verifying program memory. Apply +10.5 V to this pin.	–

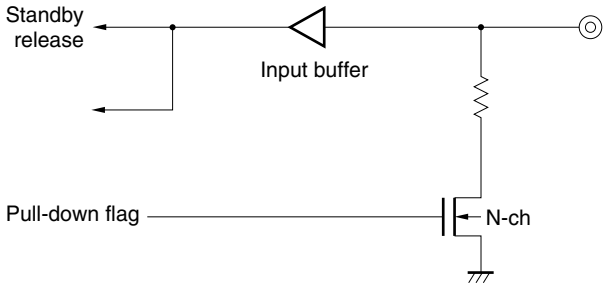
1.3 Pin I/O Circuits

The I/O circuits of the μPD6P8, 6P8A, 6P8B pins are shown in partially simplified forms below.

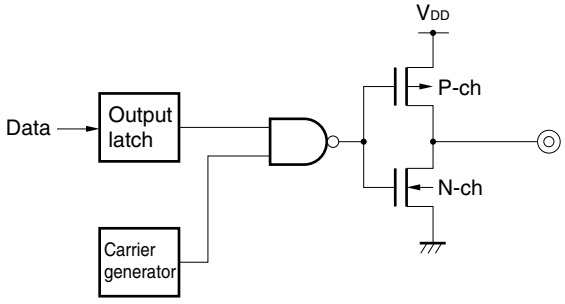
(1) $K_{I/O0}$ to $K_{I/O7}$



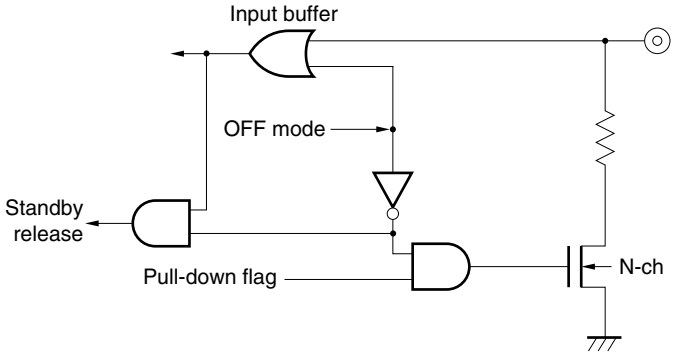
(2) K_{I0} to K_{I3}



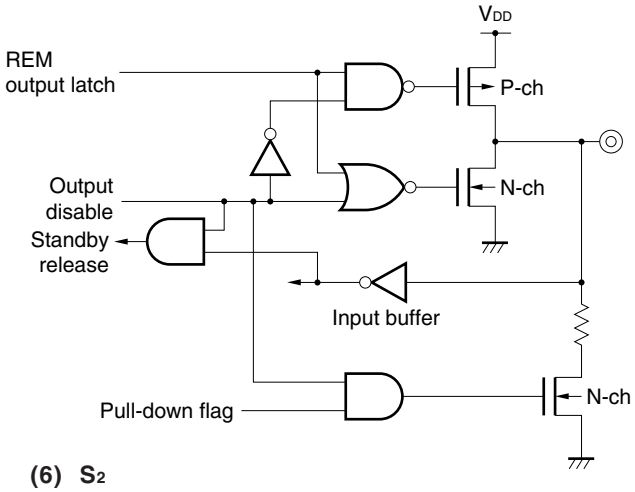
(3) REM



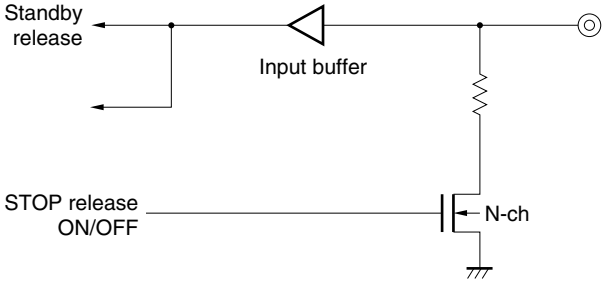
(4) S_0, S_3 Note 2



(5) $S_1/\overline{LED}$



(6) S_2



Notes 1. The drive capability is held low.

2. μPD6P8B only

1.4 Recommended Connection of Unused Pins

The following connections are recommended for unused pins in the normal operation mode.

Table 1-1. Connections for Unused Pins

Pin		Connection	
		Inside the Microcontroller	Outside the Microcontroller
$K_{I/O0}$ to $K_{I/O7}$	Input mode	—	Leave open
	Output mode	High-level output	
REM		—	
IC[Note]		—	
$S_1/\overline{LED}$		Output mode ($\overline{LED}$) setting	
S_0, S_3[Note]		OFF mode setting	Directly connect these pins to GND
S_2		—	
K_{I0} to K_{I3}		—	

Note μPD6P8B only

Caution The I/O mode and the pin output level are recommended to be fixed by setting them repeatedly in each loop of the program.

1.5 Notes on Using K_I Pin After Reset

In order to prevent malfunction, do not input a high-level signal to pins K_{I0} to K_{I3} (leaving these pins open is possible, however, when these pins are left open, do not disconnect any connected pull-down resistors) when POC is released due to supply voltage startup.

2. DIFFERENCES BETWEEN μPD67A, 67B, 68A, 68B, AND μPD6P8, 6P8A, 6P8B

Table 2-1 shows the differences between the μPD67A, 67B, 68A, 68B, and μPD6P8, 6P8A, 6P8B.

The only differences between these models are the program memory, RAM retention detection voltage, internal oscillator, POC detection voltage, and supply voltage; the other CPU functions and internal peripheral hardware are the same.

The electrical specifications also differ slightly. For the electrical specifications, refer to the data sheet of each model.

Table 2-1. Differences Between μPD67A, 67B, 68A, 68B, and μPD6P8, 6P8A, 6P8B

Item	μPD6P8	μPD6P8A	μPD6P8B	μPD67A	μPD67B	μPD68A	μPD68B
ROM	One-time PROM			Mask ROM			
	2026 × 10 bits			1002 × 10 bits		2026 × 10 bits	
POC detection voltage	V_{POC} = 1.8 V (TYP.)			V_{POC} = 1.85 V (TYP.)	V_{POC} = 1.5 V (TYP.)	V_{POC} = 1.85 V (TYP.)	V_{POC} = 1.5 V (TYP.)
RAM retention detection voltage	V_{ID} = 1.8 V (TYP.)	V_{ID} = 1.6 V (TYP.)		V_{ID} = 1.4 V (TYP.)	V_{ID} = 1.5 V (TYP.)	V_{ID} = 1.4 V (TYP.)	V_{ID} = 1.5 V (TYP.)
Internal oscillator	–		f_X = 4 MHz (TYP.)	–			
Supply voltage	V_{DD} = 1.9 to 3.6 V			V_{DD} = 2.0 to 3.6 V	V_{DD} = 1.65 to 3.6 V	V_{DD} = 2.0 to 3.6 V	V_{DD} = 1.65 to 3.6 V
Electrical specifications	Some electrical specifications, such as data retention voltage and current consumption, differ. Refer to data sheet of each model for details.						

3. INTERNAL CPU FUNCTIONS

3.1 Program Counter (PC): 11 Bits

The program counter (PC) is a binary counter that holds the address information of the program memory.

Figure 3-1. Program Counter Configuration

PC	PC10	PC9	PC8	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0

The PC contains the address of the instruction that should be executed next. Normally, the counter contents are automatically incremented in accordance with the instruction length (byte count) each time an instruction is executed.

However, when executing jump instructions (JMP, JC, JNC, JF, JNF), the PC contains the jump destination address written in the operand.

When executing the subroutine call instruction (CALL), the call destination address written in the operand is entered in the PC after the PC contents at the time are saved in the address stack register (ASR). If the return instruction (RET) is executed after the CALL instruction is executed, the address saved in the ASR is restored to the PC.

After reset, the value of the PC becomes “000H”.

3.2 Stack Pointer (SP): 1 Bit

This is a 1-bit register that holds the status of the address stack register.

The stack pointer contents are incremented when the call instruction (CALL) is executed and decremented when the return instruction (RET) is executed.

When reset, the stack pointer contents are cleared to 0.

When the stack pointer overflows (stack level 2 or more) or underflows, the CPU is defined as hung up, a system reset signal is generated, and the PC becomes 000H.

As no instruction is available to set a value directly for the stack pointer, it is not possible to operate the pointer by means of a program.

3.3 Address Stack Register (ASR (RF)): 11 Bits

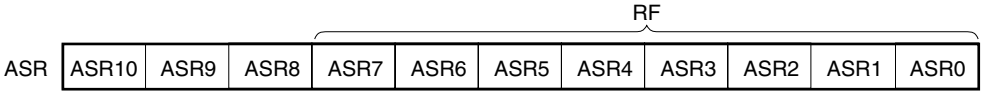
The address stack register saves the return address of the program after a subroutine call instruction is executed.

The lower 8 bits are allocated in RF of the data memory as a alternate-function RAM. The register holds the ASR value even after the RET instruction is executed.

After reset, it holds the previous data (undefined when turning on the power).

Caution If RF is accessed as the data memory, the higher 4 bits become undefined.

Figure 3-2. Address Stack Register Configuration



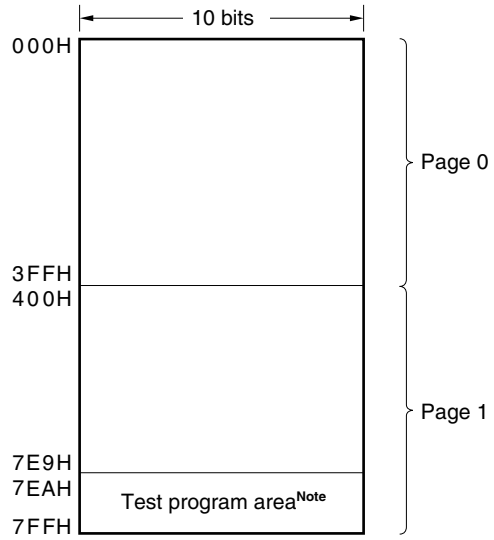
3.4 Program Memory (One-Time PROM): 2,026 Steps × 10 Bits

The one-time PROM consists of 10 bits per step, and is addressed by the program counter.

The program memory stores programs and table data, etc.

The 22 steps from FEAH to FFFH cannot be used in the test program area.

Figure 3-3. Program Memory Map



Note The test program area is designed so that a program or data placed in either of them by mistake is returned to the 000H address.

3.5 Data Memory (RAM): 32 × 4 Bits

The data memory, which is a static RAM consisting of 32 × 4 bits, is used to retain processed data. The data memory is sometimes processed in 8-bit units. R0 can be used as the ROM data pointer.

RF is also used as the ASR.

After reset, R0 is cleared to 00H and R1 to RF retain the previous data (undefined when turning on the power).

Figure 3-4. Data Memory Configuration

R_{1n} (higher 4 bits)	R_{0n} (lower 4 bits)	
R0		→**Note 1**
R_{10}	R_{00}	
R1		
R_{11}	R_{01}	
R2		
R_{12}	R_{02}	
R3		
R_{13}	R_{03}	
R4		
R_{14}	R_{04}	
R5		
R_{15}	R_{05}	
R6		
R_{16}	R_{06}	
R7		
R_{17}	R_{07}	
R8		
R_{18}	R_{08}	
R9		
R_{19}	R_{09}	
RA		
R_{1A}	R_{0A}	
RB		
R_{1B}	R_{0B}	
RC		
R_{1C}	R_{0C}	
RD		
R_{1D}	R_{0D}	
RE		
R_{1E}	R_{0E}	
RF		→**Note 2**
R_{1F}	R_{0F}	

Notes 1. R0 alternately functions as the ROM data pointer (refer to **3.6 Data Pointer (DP)**).

2. RF alternately functions as the PC address stack (refer to **3.3 Address Stack Register (ASR (RF))**.

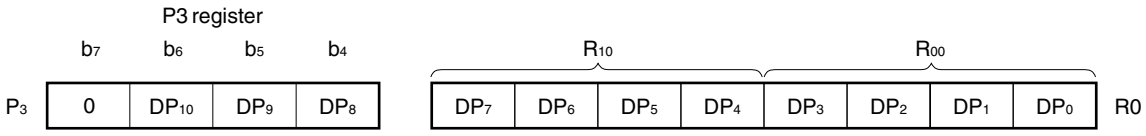
3.6 Data Pointer (DP): 12 Bits

The ROM data table can be referenced by setting the ROM address in the data pointer to call the ROM contents.

The lower 8 bits of the ROM address are specified by R0 of the data memory; and the higher 4 bits by bits 4 to 7 of the P3 register (CR0).

After reset, the pointer contents become 000H.

Figure 3-5. Data Pointer Configuration

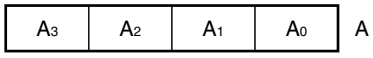


3.7 Accumulator (A): 4 Bits

The accumulator, which refers to a register consisting of 4 bits, plays a leading role in performing various operations.

After reset, the accumulator contents are left undefined.

Figure 3-6. Accumulator Configuration



3.8 Arithmetic and Logic Unit (ALU): 4 Bits

The arithmetic and logic unit (ALU), which refers to an arithmetic circuit consisting of 4 bits, executes simple (mainly logical) operations.

3.9 Flags

3.9.1 Status flag (F)

Pin and timer statuses can be checked by executing the STTS instruction to check the status flag.
The status flag is set (to 1) in the following cases.

- If the condition specified with the operand is met when the STTS instruction is executed
- When standby mode is released.
- When the release condition is met at the point of executing the HALT instruction. (In this case, the system does not enter the standby mode.)

Conversely, the status flag is cleared (to 0) in the following cases:

- If the condition specified with the operand is not met when the STTS instruction is executed.
- When the status flag has been set (to 1), the HALT instruction is executed, but the release condition is not met at the point of executing the HALT instruction. (In this case, the system does not enter the standby mode.)

Table 3-1. Conditions for Status Flag (F) to Be Set by STTS Instruction

Operand Value of STTS Instruction				Condition for Status Flag (F) to Be Set
b_3	b_2	b_1	b_0	
0	0	0	0	High level is input to at least one of K_I pins.
	0	1	1	High level is input to at least one of K_I pins.
	1	1	0	High level is input to at least one of K_I pins.
	1	0	1	The down counter of the timer is 0.
1	Either of the combinations of b_2, b_1, and b_0 above.			[The following condition is added in addition to the above.] High level is input to at least one of S_0**Note 1**, S_1**Note 1**, S_2**Note 2**, or S_3**Notes 1, 3** pins.

Notes 1. The S_0, S_1, and S_3 pins must be set to input mode (bits 0, 2, and 7 of the P4 register are set to 1, 0, and 1, respectively).

2. The use of STOP mode release for the S_2 pin must be enabled (bit 3 of the P4 register is set to 1).

3. μPD6P8B only

3.9.2 Carry flag (CY)

The carry flag is set (to 1) in the following cases:

- If the ANL instruction or the XRL instruction is executed when bit 3 of the accumulator is 1 and bit 3 of the operand is 1.
- If the RL instruction or the RLZ instruction is executed when bit 3 of the accumulator is 1.
- If the INC instruction or the SCAF instruction is executed when the value of the accumulator is 0FH.

The carry flag is cleared (to 0) in the following cases:

- If the ANL instruction or the XRL instruction is executed when at least either bit 3 of the accumulator or bit 3 of the operand is 0.
- If the RL instruction or the RLZ instruction is executed when bit 3 of the accumulator is 0.
- If the INC instruction or the SCAF instruction is executed when the value of the accumulator is other than 0FH.
- If the ORL instruction is executed.
- When data is written to the accumulator by the MOV instruction or the IN instruction.

4. PORT REGISTERS (PX)

The $K_{I/O}$ port, the K_I port, the special ports (S_0, $S_1/\overline{LED}$, S_2, S_3), and the control registers are treated as port registers.

After reset, the port register values are as shown below.

Figure 4-1. Port Register Configuration (μPD6P8, 6P8A)

Port register								After reset
P0								FFH
P_{10}				P_{00}				
$K_{I/O7}$	$K_{I/O6}$	$K_{I/O5}$	$K_{I/O4}$	$K_{I/O3}$	$K_{I/O2}$	$K_{I/O1}$	$K_{I/O0}$	
P1								××××11×1B[Note 1]
P_{11}				P_{01}				
K_{I3}	K_{I2}	K_{I1}	K_{I0}	$S_1/\overline{LED}$	S_0	S_2	1	
P3 (control register 0)								0000×000B[Note 2]
P_{13}				P_{03}				
DP_{11}	DP_{10}	DP_9	DP_8	RAM retention flag	–	–	–	
P4 (control register 1)								26H
P_{14}				P_{04}				
0	0	K_I Pull-down	S_0/S_1 Pull-down	S_2 STOP release	$S_1/\overline{LED}$ mode	$K_{I/O}$ mode	S_0 mode	

Notes 1. ×: Refers to the value based on the K_I and S_2 pin state.

2. ×: Refers to the value based on decrease of power supply voltage (0 when $V_{DD} \leq V_{ID}$)

Remark V_{ID}: RAM retention detection voltage

Table 4-1. Relationship Between Ports and Reading/Writing (μPD6P8, 6P8A)

Port Name	Input Mode		Output Mode	
	Read	Write	Read	Write
$K_{I/O}$	Pin state	Output latch	Output latch	Output latch
K_I	Pin state	—	—	—
S_0	Pin state	—	**Note**	—
$S_1/\overline{LED}$	Pin state	—	Pin state	—
S_2	Pin state	—	—	—

Note When in OFF mode, "1" is always read.

Figure 4-2. Port Register Configuration (μPD6P8B)

Port register								After reset
P0								FFH
P_{10}				P_{00}				
$K_{I/O7}$	$K_{I/O6}$	$K_{I/O5}$	$K_{I/O4}$	$K_{I/O3}$	$K_{I/O2}$	$K_{I/O1}$	$K_{I/O0}$	
<R> P1								××××11×0B[Note 1]
P_{11}				P_{01}				
K_{I3}	K_{I2}	K_{I1}	K_{I0}	$S_1/\overline{LED}$	S_0	S_2	S_3[Note 3]	
P3 (control register 0)								0000×000B[Note 2]
P_{13}				P_{03}				
DP_{11}	DP_{10}	DP_9	DP_8	RAM retention flag	–	–	–	
P4 (control register 1)								26H
P_{14}				P_{04}				
S_3 mode[Note 3]	S_3 pull-down[Note 3]	K_I pull-down	S_0/S_1 pull-down	S_2 STOP release	$S_1/\overline{LED}$ mode	$K_{I/O}$ mode	S_0 mode	

Notes 1. ×: Refers to the value based on the K_I and S_2 pin state.

2. ×: Refers to the value based on decrease of power supply voltage (0 when $V_{DD} \leq V_{ID}$)

3. Use an actual device to emulate the S_3 pin, because the emulator does not support S_3 pin emulation.

Remark V_{ID}: RAM retention detection voltage

Table 4-2. Relationship Between Ports and Reading/Writing (μPD6P8B)

Port Name	Input Mode		Output Mode	
	Read	Write	Read	Write
$K_{I/O}$	Pin state	Output latch	Output latch	Output latch
K_I	Pin state	—	—	—
S_0, S_3	Pin state	—	**Note**	—
$S_1/\overline{LED}$	Pin state	—	Pin state	—
S_2	Pin state	—	—	—

<R> **Note** When in OFF mode, "1" is always read for S_0 and "0" is always read for S_3.

4.1 $K_{I/O}$ Port (P0)

The $K_{I/O}$ port is an 8-bit I/O port for key scan output.

I/O mode is set by bit 1 of the P4 register.

If a read instruction is executed, the pin state can be read in input mode, whereas the output latch contents can be read in output mode.

If a write instruction is executed, data can be written to the output latch regardless of input or output mode.

After reset, the port is placed in output mode and the value of the output latch (P0) becomes 1111 1111B.

The $K_{I/O}$ port incorporates a pull-down resistor, allowing pull-down in input mode only.

Caution When a key is double-pressed, a high-level output and a low-level output may conflict at the $K_{I/O}$ port. To avoid this, the low-level output current of the $K_{I/O}$ port is held low. Therefore, be careful when using the $K_{I/O}$ port for purposes other than key scan output.
The $K_{I/O}$ port is designed so that even when connected directly to V_{DD} within the normal supply voltage range (V_{DD} = 1.9 to 3.6 V), no problem occurs.

Table 4-3. $K_{I/O}$ Port (P0)

Bit	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name	$K_{I/O7}$	$K_{I/O6}$	$K_{I/O5}$	$K_{I/O4}$	$K_{I/O3}$	$K_{I/O2}$	$K_{I/O1}$	$K_{I/O0}$

b_0 to b_7: When reading: In input mode, the $K_{I/O}$ pin's state is read.
In output mode, the $K_{I/O}$ pin's output latch contents are read.
When writing: Data is written to the $K_{I/O}$ pin's output latch regardless of input or output mode.

4.2 K_I Port/Special Ports (P1)

4.2.1 K_I port (P_{11}: bits 4 to 7 of P1)

The K_I port is a 4-bit input port for key input. The pin state can be read.

The use of a pull-down resistor for the K_I port can be specified in 4-bit units by software using bit 5 of the P4 register. After reset, a pull-down resistor is connected.

4.2.2 S_0 port (bit 2 of P1)

The S_0 port is an input/OFF mode port.

The pin state can be read by setting this port to input mode using bit 0 of the P4 register.

In input mode, the use of a pull-down resistor for the S_0 and $S_1/\overline{LED}$ port can be specified in 2-bit units by software using bit 4 of the P4 register.

If input mode is released (thus set to OFF mode), the pin becomes high-impedance but is configured so that through current does not flow internally. In OFF mode, 1 can be read regardless of the pin state.

After reset, S_0 is set to OFF mode, thus becoming high-impedance.

4.2.3 $S_1/\overline{LED}$ port (bit 3 of P1)

The $S_1/\overline{LED}$ port is an I/O port.

Input or output mode can be set using bit 2 of the P4 register. The pin state can be read in both input mode and output mode.

When in input mode, the use of a pull-down resistor for the S_0 and $S_1/\overline{LED}$ ports can be specified in 2-bit units by software using bit 4 of the P4 register.

When in output mode, the pull-down resistor is automatically disconnected and this pin becomes the remote control transmission display pin (refer to **5. TIMER**).

After reset, $S_1/\overline{LED}$ is placed in output mode, and a high level is output.

4.2.4 S_2 port (bit 1 of P1)

The S_2 port is an input port.

Use of STOP mode release for the S_2 port can be specified by bit 3 of the P4 register.

When using the pin as a key input from a key matrix, enable (bit 3 of the P4 register is set to 1) the use of STOP mode release (at this time, a pull-down resistor is connected internally.) When STOP mode release is disabled (bit 3 of the P4 register is set to 0), it can be used as an input port that does not release the STOP mode even if the release condition is met (at this time, a pull-down resistor is not connected internally.)

The state of the pin can be read in both cases.

After reset, S_2 is set to input mode where the STOP mode release is disabled, and enters a high-impedance state.

4.2.5 S_3 port (bit 0 of P1) (μPD6P8B only)

The S_3 port is an input/OFF mode port.

The pin state can be read by setting this port to input mode using bit 7 of the P4 register.

In input mode, the use of a pull-down resistor for the S_3 port can be specified using bit 6 of the P4 register.

If input mode is released (thus set to OFF mode), the pin becomes high-impedance but is configured so that
<R> through current does not flow internally. In OFF mode, 0 can be read regardless of the pin state.

After reset, S_3 is set to OFF mode, thus becoming high-impedance.

Table 4-4. K_I/Special Port Register (P1)

(1) μPD6P8 and 6P8A

Bit	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name	K_{I3}	K_{I2}	K_{I1}	K_{I0}	$S_1/\overline{LED}$	S_0	S_2	Fixed to "1"

(2) μPD6P8B

Bit	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name	K_{I3}	K_{I2}	K_{I1}	K_{I0}	$S_1/\overline{LED}$	S_0	S_2	S_3

b_0: μPD6P8, 6P8A: Fixed to 1
μPD6P8B: In input mode, the state of the S_3 pin is read (read only).
<R> In OFF mode, this bit is fixed to 0.

b_1: The state of the S_2 pin is read (read only).

b_2: In input mode, the state of the S_0 pin is read (read only).
In OFF mode, this bit is fixed to 1.

b_3: The state of the $S_1/\overline{LED}$ pin is read regardless of input/output mode (read only).

b_4 to b_7: The state of the K_I pin is read (read only).

Caution In order to prevent malfunction, be sure to input a low level to one or more of pins K_{I0} to K_{I3} when POC is released by supply voltage rising (Can be left open. When open, leave the pull-down resistor connected).

4.3 Control Register 0 (P3)

Control register 0 consists of 8 bits. The contents that can be controlled are as shown below.
After reset, the register becomes 0000 ×000B[Note].

Note ×: Refers to the value based on a decrease of power supply voltage (0 when $V_{DD} \leq V_{ID}$)

Remark V_{ID}: RAM retention detection voltage

Table 4-5. Control Register 0 (P3)

Bit		b_7[Note]	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name		DP (Data Pointer)				RAM retention flag	—		
		DP_{11}	DP_{10}	DP_9	DP_8				
Setting	0	0	0	0	0	Not retainable	Fixed to 0		
	1	1	1	1	1	Retainable			
After reset		0	0	0	0	0	0	0	0

b_3: RAM retention flag. For function details, refer to **4.3.1 RAM retention flag (bit 3 of P3)**.
b_4 to b_7: Specify the higher bits of the ROM data pointer (DP_8 to DP_{11}).

Note Set b_7 to 0 in the case of the μPD6P8, 6P8A, 6P8B.

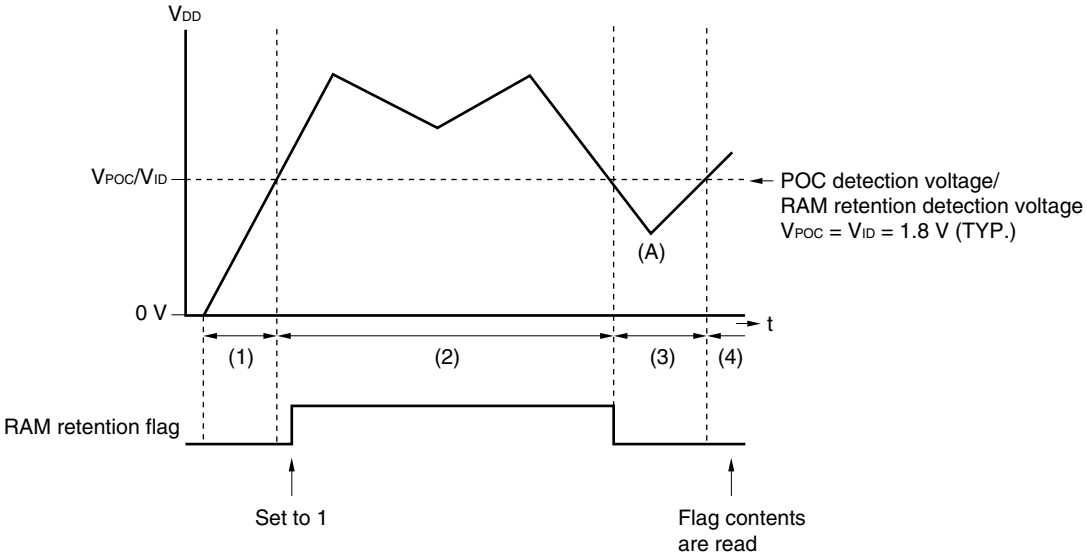
4.3.1 RAM retention flag (bit 3 of P3)

The RAM retention flag indicates whether the supply voltage has fallen below the level at which the contents of the RAM are lost while the battery is being exchanged or when the battery voltage has dropped.

This flag is at bit 3 of control register 0 (P3).

It is cleared to 0 if the supply voltage drops below the RAM retention detection voltage. If this flag is 0, it can be judged that the RAM contents have been lost or that power has just been applied. This flag can be used to initialize the RAM via software. After initializing the RAM and writing the necessary data to it, set this RAM retention flag to 1 by software. At this time, 1 means that data has been set to the RAM.

Figure 4-3. Supply Voltage Transition and Detection Voltage (μPD6P8)



(1) If the supply voltage rises after the battery has been set, and exceeds V_{POC} (POC detection voltage), reset is cleared. Because the supply voltage rises from 0 V, which is lower than V_{ID} (RAM retention detection voltage), the RAM retention flag remains in the initial status 0.

(2) The supply voltage has now risen to the level at which the device can operate. Write the necessary data to the RAM and set the RAM retention flag to 1.

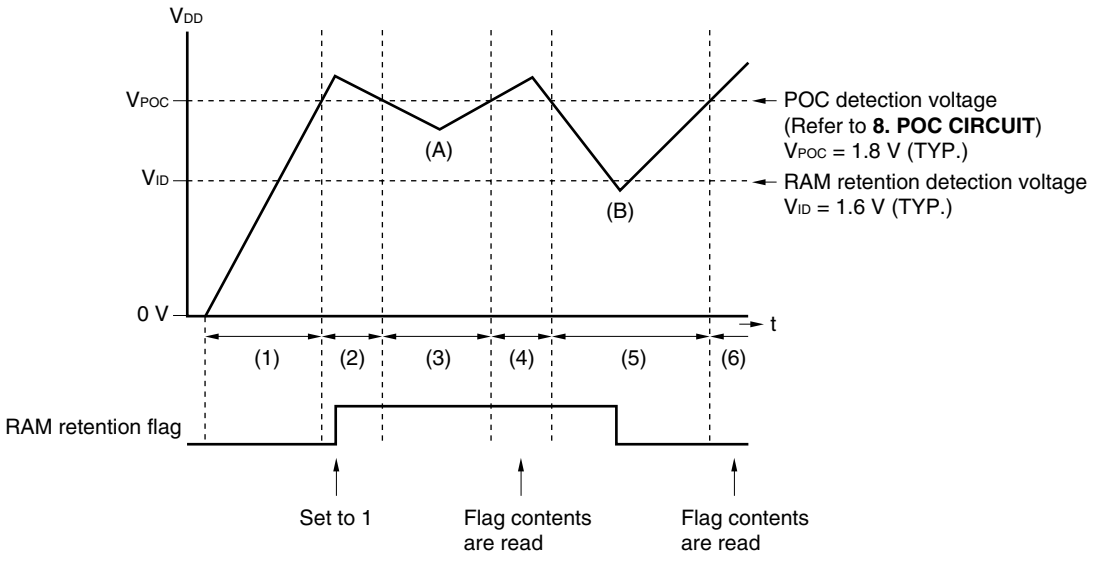
(3) The device is reset if the supply voltage drops below V_{POC}. At point (A) in the figure, the voltage is lower than V_{ID}. Consequently, the RAM retention flag is cleared to 0.

(4) If the RAM retention flag is checked by software after reset has been cleared, it is 0. This means that the contents of the RAM may have been lost. If this case, initialize the RAM by software.

Cautions 1. The software developed for the μPD67A, 68A and 69A (using the RAM retention flag) can be used for the μPD6P8 as is.

2. Unlike the μPD67A, 68A and 69A, the RAM retention detection voltage of the μPD6P8 is the same as the POC detection voltage. When software is newly developed, it is not necessary to use the RAM retention flag if only the RAM is initialized by reset.

Figure 4-4. Supply Voltage Transition and Detection Voltage (μPD6P8A, 6P8B)



(1) If the supply voltage rises after the battery has been set, and exceeds V_{POC} (POC detection voltage), reset is cleared. Because the supply voltage rises from 0 V, which is lower than V_{ID} (RAM retention detection voltage), the RAM retention flag remains in the initial status 0.

(2) The supply voltage has now risen to the level at which the device can operate. Write the necessary data to the RAM and set the RAM retention flag to 1.

(3) The device is reset if the supply voltage drops below V_{POC}. At point (A) in the above figure, the RAM retention flag remains 1 because the supply voltage is higher than V_{ID} at this point.

(4) If the RAM retention flag is checked by software after reset has been cleared, it is 1. This means that the contents of the RAM have not been lost. It is therefore not necessary to initialize the RAM by software.

(5) The device is reset if the supply voltage drops below V_{POC}. At point (B) in the figure, the voltage is lower than V_{ID}. Consequently, the RAM retention flag is cleared to 0.

(6) If the RAM retention flag is checked by software after reset has been cleared, it is 0. This means that the contents of the RAM may have been lost. If this case, initialize the RAM by software.

4.4 Control Register 1 (P4)

Control register 1 consists of 8 bits. The contents that can be controlled are as shown below.

After reset, the register becomes 0010 0110B.

Table 4-6. Control Register 1 (P4)

(1) μPD6P8 and 6P8A

Bit		b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name		—	—	K_I Pull-down	S_0/S_1 Pull-down	S_2 STOP release	$S_1/\overline{LED}$ mode	$K_{I/O}$ mode	S_0 mode
Setting	0	Fixed	Fixed	OFF	OFF	Disable	S_1	IN	OFF
	1	to 0	to 0	ON	ON	Enable	$\overline{LED}$	OUT	IN
After reset		0	0	1	0	0	1	1	0

(2) μPD6P8B

Bit		b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Name		S_3 mode	S_3 Pull-down	K_I Pull-down	S_0/S_1 Pull-down	S_2 STOP release	$S_1/\overline{LED}$ mode	$K_{I/O}$ mode	S_0 mode
Setting	0	OFF	OFF	OFF	OFF	Disable	S_1	IN	OFF
	1	IN	ON	ON	ON	Enable	$\overline{LED}$	OUT	IN
After reset		0	0	1	0	0	1	1	0

b_0: Specifies the input mode of the S_0 port. 0 = OFF mode (high impedance); 1 = IN (input mode).

b_1: Specifies the I/O mode of the $K_{I/O}$ port. 0 = IN (input mode); 1 = OUT (output mode).

b_2: Specifies the I/O mode of the $S_1/\overline{LED}$ port. 0 = S_1 (input mode); 1 = $\overline{LED}$ (output mode).

b_3: Specifies the use of STOP mode release by S_2 port (with/without pull-down resistor). 0 = disable (without pull-down); 1 = enable (with pull-down).

b_4: Specifies the use of a pull-down resistor in S_0/S_1 port input mode. 0 = OFF (not used); 1 = ON (used).

b_5: Specifies the use of a pull-down resistor for the K_I port. 0 = OFF (not used); 1 = ON (used).

b_6: μPD6P8, 6P8A: Fixed to 0

μPD6P8B: Specifies the use of a pull-down resistor in S_3 port input mode. 0 = OFF (not used); 1 = ON (used).

b_7: μPD6P8, 6P8A: Fixed to 0

μPD6P8B: Specifies the input mode of the S_3 port. 0 = OFF mode (high impedance); 1 = IN (input mode).

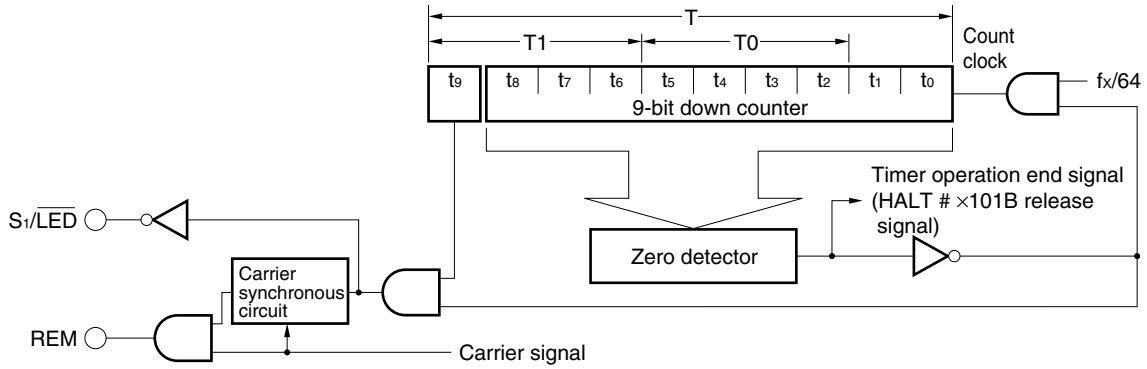
Remark In output mode or in OFF mode, all the pull-down resistors are automatically disconnected.

5. TIMER

5.1 Timer Configuration

The timer is the block used for creating a remote control transmission pattern. As shown in Figure 5-1, it consists of a 9-bit down counter (t_8 to t_0), a flag (t_9) permitting the 1-bit timer output, and a zero detector.

Figure 5-1. Timer Configuration



5.2 Timer Operation

The timer starts (counting down) when a value other than 0 is set for the down counter with a timer manipulation instruction. The timer manipulation instructions for making the timer start operation are shown below:

```
MOV T0, A
MOV T1, A
MOV T, #data10
MOV T, @R0
```

The down counter is decremented (–1) in the cycle of 64/fx. If the value of the down counter becomes 0, the zero detector generates the timer operation end signal to stop the timer operation. At this time, if the timer is in HALT mode (HALT #×101B) waiting for the timer to stop its operation, the HALT mode is released and the instruction following the HALT instruction is executed. The output of the timer operation end signal is continued while the down counter is 0 and the timer is stopped. The following relational expression applies between the timer's output time and the down counter's set value.

Timer output time = (Set value + 1) × 64/fx – 4/fx

In addition, when the timer is set successively, the timer output time is also 4/fx shorter than the total time. An example is shown below.

Example When fx = 4 MHz

```
MOV T, #3FFH
STTS #05H
HALT #05H
MOV T, #232H
STTS #05H
HALT #05H
```

In the case above, the timer output time is as follows.

(Set value + 1) × 64/fx + (Set value + 1) × 64/fx – 4/fx
= (511 + 1) × 64/4 + (50 + 1) × 64/4 – 4/4
= 9.007 ms

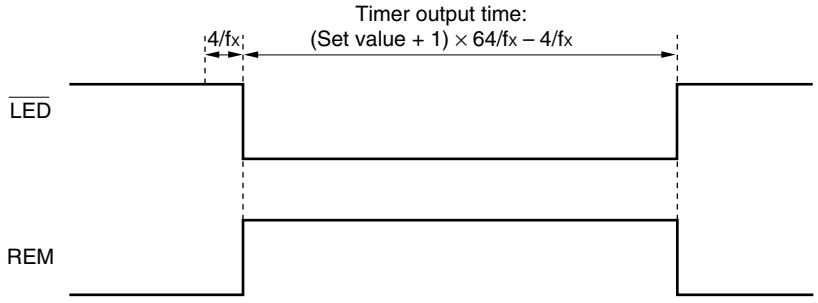
By setting the flag (t_9) that enables the timer output to 1, the timer can output its operation status from the $S_1/\overline{LED}$ pin and the REM pin. The REM pin can also output the carrier while the timer is in operation.

Table 5-1. Timer Output (at t_9 = 1)

	$S_1/\overline{LED}$ Pin	REM Pin
Timer operating	Low level	High level (or carrier output[Note])
Timer halting	High level	Low level

Note The carrier output results if bit 9 (CARY) of the high-level period setting modulo register (MOD1) is cleared (to 0).

Figure 5-2. Timer Output (When Carrier Is Not Output)

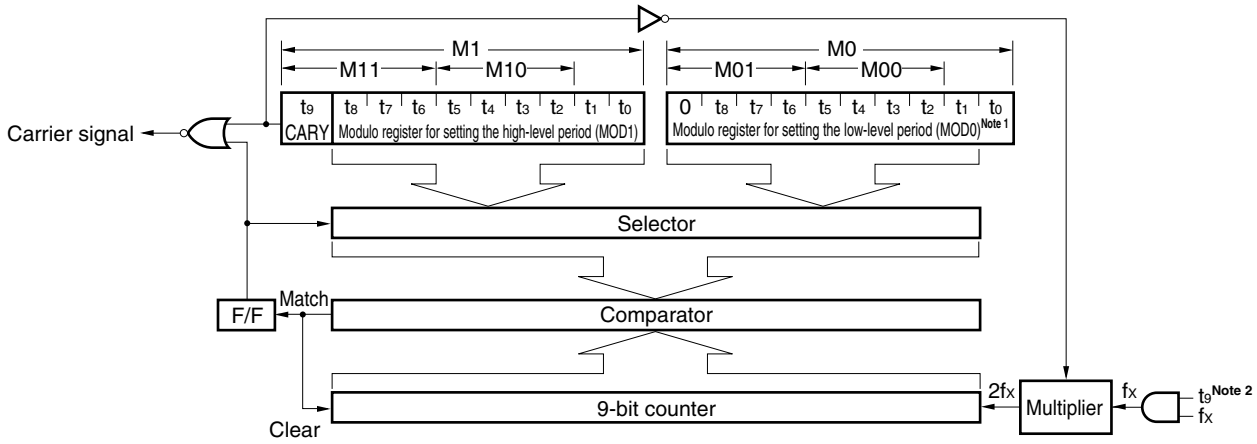


5.3 Carrier Output

5.3.1 Carrier output generator

The carrier generator consists of a 9-bit counter and two modulo registers for setting the high- and low-level periods (MOD1 and MOD0 respectively).

Figure 5-3. Configuration of Remote Controller Carrier Generator



Notes 1. Bit 9 of the modulo register for setting the low-level period (MOD0) is fixed to 0.

2. t_9: Flag that enables timer output (timer block) (see **Figure 5-1 Timer Configuration**)

The carrier duty ratio and carrier frequency can be determined by setting the high- and low-level widths using the respective modulo registers. Each of these widths can be set in a range of 250 ns to 64 μs (@ f_X = 4 MHz).

The system clock multiplied by 2 is used for the 9-bit counter input (8 MHz when f_X = 4 MHz). MOD0 and MOD1 are read and written using timer manipulation instructions.

MOV A, M00	MOV M00, A	MOV M0, #data10
MOV A, M01	MOV M01, A	MOV M1, #data10
MOV A, M10	MOV M10, A	MOV M0, @R0
MOV A, M11	MOV M11, A	MOV M1, @R0

The values of MOD0 and MOD1 can be calculated from the following expressions.

$$MOD0 = (2 \times f_X \times (1 - D) \times T) - 1$$
$$MOD1 = (2 \times f_X \times D \times T) - 1$$

Caution Be sure to input values in range of 001H to 1FFH to MOD0 and MOD1.

Remark D: Carrier duty ratio (0 < D < 1)
f_X: Input clock (MHz)
T: Carrier cycle (μs)

5.3.2 Carrier output control

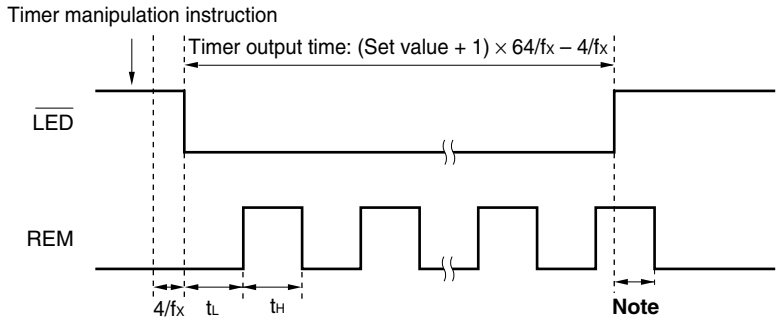
Remote controller carrier can be output from the REM pin by clearing (0) bit 9 (CARY) of the modulo register for setting the high-level period (MOD1).

When performing carrier output, be sure to set the timer operation after setting the MOD0 and MOD1 values. Note that a malfunction may occur if the values of MOD0 and MOD1 are changed while carrier is being output from the REM pin.

Executing the timer manipulation instruction starts the carrier output from the low level.

If the timer's down counter reaches 0 during carrier output, carrier output is stopped and the REM pin becomes low level. If the down counter reaches 0 while the carrier output is high level, carrier output will stop after first becoming low level following the set period of high level.

Figure 5-4. Timer Output (When Carrier Is Output)



Note If the down counter reaches 0 while the carrier output is high level, carrier output will stop after becoming low level.

Output from the REM pin is as follows, in accordance with the values set to bit 9 (CARY) of MOD1 and the timer output enable flag (t_9), and the value of the timer block's 9-bit down counter (t_0 to t_8).

Table 5-2. REM Pin Output

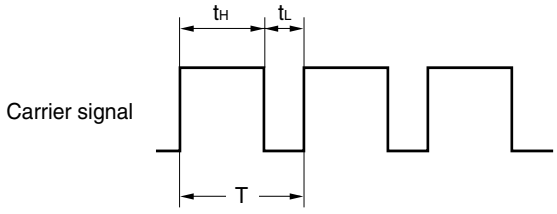
MOD1 Bit 9 (CARY)	Timer Output Enable Flag (Timer Block t_9)	9-bit Down Counter (Timer Block t_0 to t_8)	REM Pin
—	—	0	Low-level output
—	0	Other than 0	
0	1		Carrier output[Note]
1			High-level output

Note Input values in the range of 001H to 1FFH to MOD0 and MOD1.

Caution MOD0 and MOD1 must be set while the REM pin is low level (t_9 = 0 or t_0 to t_8 = 0).

Table 5-3. Example of Carrier Frequency Settings (f_X = 4 MHz)

Setting Value		t_H (μs)	t_L (μs)	T (μs)	f_C (kHz)	Duty
MOD1	MOD0					
01H	01H	0.25	0.25	0.5	2,000	1/2
07H	0BH	1.0	1.5	2.5	400	2/5
13H	13H	2.5	2.5	5.0	200	1/2
27H	27H	5.0	5.0	10	100	1/2
41H	41H	8.25	8.25	16.5	60.6	1/2
41H	85H	8.25	16.75	25	40	1/3
45H	89H	8.75	17.25	26.0	38.5	1/3
45H	8BH	8.75	17.5	26.25	38.10	1/3
45H	8CH	8.75	17.625	26.375	37.9	1/3
47H	91H	9.0	18.25	27.25	36.7	1/3
48H	94H	9.125	18.625	27.75	36.0	1/3
69H	D5H	13.25	26.75	40.0	25	1/3
77H	77H	15.0	15.0	30.0	33.3	1/2
C7H	C7H	25.0	25.0	50.0	20	1/2
FFH	FFH	32.0	32.0	64.0	15.6	1/2

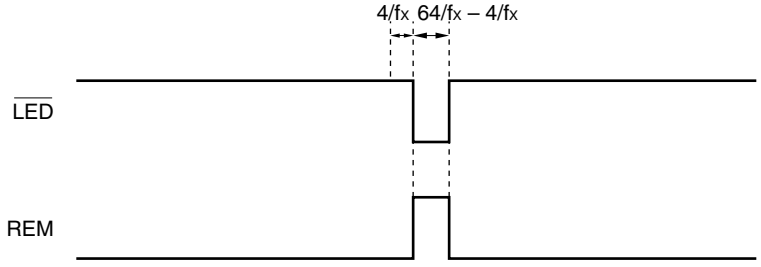


5.4 Software Control of Timer Output

The timer output can be controlled by software. As shown in Figure 4-5, a pulse with a minimum width of 64/fx – 4/fx can be output.

Figure 5-5. Output of Pulse of 1-Instruction Cycle Width

```
      .
      .
      .
MOV   T, #0000000000B; low-level output from the REM pin
      .
      .
      .
MOV   T, #1000000000B; high-level output from the REM pin
MOV   T, #0000000000B; low-level output from the REM pin
      .
      .
      .
```



6. STANDBY FUNCTION

6.1 Outline of Standby Function

To save current consumption, two types of standby modes, i.e., HALT mode and STOP mode, have been provided available.

In STOP mode, the system clock stops oscillation. At this time, the X_{IN} and X_{OUT} pins are fixed to a low level.

In HALT mode, CPU operation halts, while the system clock continues oscillation. When in HALT mode, the timer (including REM output and $\overline{LED}$ output) operates.

In either STOP mode or HALT mode, the statuses of the data memory, accumulator, and port registers, etc. immediately before the standby mode is set are retained. Therefore, make sure to set the port status for the system so that the current consumption of the whole system is suppressed before the standby mode is set.

Table 6-1. Statuses During Standby Mode

			STOP Mode	HALT Mode
Setting instruction			HALT instruction	
Clock oscillator			Oscillation stopped	Oscillation continued
Operation statuses	CPU		• Operation halted	
	Data memory		• Immediately preceding status retained	
	Accumulator		• Immediately preceding status retained	
	Flag	F	• 0 (When 1, the flag is not placed in the standby mode.)	
		CY	• Immediately preceding status retained	
	Port register		• Immediately preceding status retained	
	Timer		• Operation halted (The count value is reset to “0”)	• Operable

Cautions 1. Write the NOP instruction as the first instruction after STOP mode is released.

2. When standby mode is released, the status flag (F) is set (to 1).

3. If, at the point the standby mode has been set, its release condition is met, then the system does not enter the standby mode. However, the status flag (F) is set (1).

6.2 Standby Mode Setting and Release

The standby mode is set with the HALT #$b_3b_2b_1b_0$B instruction for both STOP mode and HALT mode. For the standby mode to be set, the status flag (F) is required to have been cleared (to 0).

The standby mode is released by the release condition specified with the reset (POC) or the operand of HALT instruction. If the standby mode is released, the status flag (F) is set (to 1).

Even when the HALT instruction is executed in the state that the status flag (F) has been set (to 1), the standby mode is not set. If the release condition is not met at this time, the status flag is cleared (to 0). If the release condition is met, the status flag remains set (to 1).

Even in the case when the release condition has been already met at the point that the HALT instruction is executed, the standby mode is not set. Here, also, the status flag (F) is set (to 1).

Caution Depending on the status of the status flag (F), the HALT instruction may not be executed. Be careful about this. For example, when setting HALT mode after checking the key status with the STTS instruction, the system does not enter HALT mode as long as the status flag (F) remains set (to 1) and thus sometimes performs an unintended operation. In this case, the intended operation can be realized by executing the STTS instruction immediately after setting the timer to clear (to 0) the status flag.

Example

```
STTS    #03H        ;To check the KI pin status.
  ⋮
MOV     T, #0xxH    ;To set the timer
STTS    #05H        ;To clear the status flag
  ⋮                 (During this time, be sure not to execute an instruction that may set the status flag.)
HALT    #05H        ;To set HALT mode
```

Table 6-2. Addresses Executed After Standby Mode Release

Release Condition	Address Executed After Release
Reset	Address 0
Release condition shown in Table 6-3	The address following the HALT instruction

Table 6-3. Standby Mode Setup (HALT #$b_3b_2b_1b_0$B) and Release Conditions

Operand Value of HALT Instruction				Setting Mode	Precondition for Setup	Release Condition
b_3	b_2	b_1	b_0			
0	0	0	0	STOP	All $K_{I/O}$ pins are high-level output.	High level is input to at least one of K_I pins.
	0	1	1	STOP	All $K_{I/O}$ pins are high-level output.	High level is input to at least one of K_I pins.
	1	1	0	STOP[Note 1]	The $K_{I/O0}$ pin is high-level output.	High level is input to at least one of K_I pins.
1	Any of the combinations of $b_2b_1b_0$ above			STOP	[The following condition is added in addition to the above.]	
					—	High level is input to at least one of S_0, S_1, S_2, and S_3[Note 3] pins[Note 2].
0/1	1	0	1	HALT	—	When the timer's down counter is 0

Notes 1. When setting HALT #×110B, configure a key matrix by using the $K_{I/O0}$ pin and the K_I pin so that the standby mode can be released.

2. At least one of the S_0, S_1, S_2, and S_3 pins (the pin used for releasing the standby mode) must be specified as follows:

S_0, S_1, S_3 pins: Input mode (specified by bits 0, 2, and 7 of the P4 register)

S_2 pin: Use of STOP mode release enabled (specified by bit 3 of the P4 register)

3. μPD6P8B only

Cautions 1. The internal reset takes effect when the HALT instruction is executed with an operand value other than that above or when the precondition has not been satisfied when executing the HALT instruction.

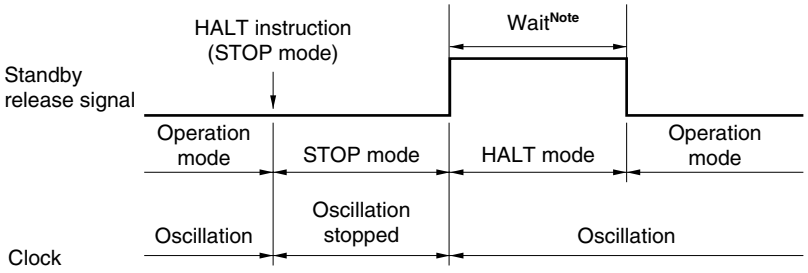
2. If STOP mode is set when the timer's down counter is not 0 (timer operating), the system is placed in STOP mode only after all the 10 bits of the timer's down counter and the timer output permit flag are cleared to 0.

3. Write the NOP instruction as the first instruction after STOP mode is released.

6.3 Standby Mode Release Timing

(1) STOP mode release timing

Figure 6-1. STOP Mode Release by Release Condition



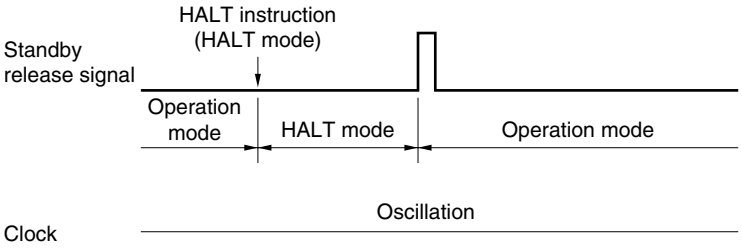
Note The wait time is as follows.

- μPD6P8: 10 + 286/fx + Oscillation growth time (μs)
- μPD6P8A: 10 + 1024/fx + Oscillation growth time (μs)
- μPD6P8B: 10 + 1024/fx (μs)

Caution When a release condition is met in the STOP mode, the device is released from the STOP mode, and goes into a wait state. At this time, if the release condition is not held, the device goes into STOP mode again after the wait time has elapsed. Therefore, when releasing the STOP mode, it is necessary to hold the release condition longer than the wait time.

(2) HALT mode release timing

Figure 6-2. HALT Mode Release by Release Condition



7. RESET

A system reset is effected by the following causes:

- When the POC circuit has detected low power-supply voltage
- When the operand value is illegal or does not satisfy the precondition when the HALT instruction is executed
- When the accumulator is 0H when the RLZ instruction is executed
- When stack pointer overflows or underflows

Table 7-1. Hardware Statuses After Reset

Hardware			• Reset by On-Chip POC Circuit During Operation • Reset by Other Factors[Note 1]	• Reset by the On-Chip POC Circuit During Standby Mode
PC			000H	
SP (1 bit)			0B	
Data memory	R0 = DP		000H	
	R1 to RF		Undefined	
Accumulator (A)			Undefined	
Status flag (F)			0B	
Carry flag (CY)			0B	
Timer (10 bits)			000H	
Port register		P0	FFH	
<R>		P1	μPD6P8, 6P8A: ××××11×1B[Note 2], μPD6P8B: ××××11×0B[Note 2]	
Control register		P3	0000×000B[Note 3]	
		P4	26H	

Notes 1. The following resets are available.
- Reset when executing the HALT instruction (when the operand value is illegal or does not satisfy the precondition)
- Reset when executing the RLZ instruction (when A = 0)
- Reset by stack pointer's overflow or underflow

2. ×: Refers to the value by the K_I or S_2 pin status.
In order to prevent malfunction, be sure to input a low level to one or more of pins K_{I0} to K_{I3} when POC is released by supply voltage rising (Can be left open. When open, leave the pull-down resistor connected).

3. ×: Refers to the value based on a decrease of power supply voltage (0 when $V_{DD} \leq V_{ID}$).

Remark V_{ID}: RAM retention detection voltage

8. POC CIRCUIT

The POC circuit monitors the power supply voltage and applies an internal reset to the microcontroller when the battery is replaced.

Cautions 1. There are cases in which the POC circuit cannot detect a low power supply voltage of less than 1 ms. Therefore, if the power supply voltage has become low for a period of less than 1 ms, the POC circuit may malfunction because it does not generate an internal reset signal.

2. Clock oscillation is stopped by the resonator due to low power supply voltage before the POC circuit generates the internal reset signal. In this case, malfunction may result when the power supply voltage is recovered after the oscillation is stopped. This type of phenomenon takes place because the POC circuit does not generate an internal reset signal (because the power supply voltage recovers before the low power supply voltage is detected) even though the clock has stopped. If, by any chance, a malfunction has taken place, remove the battery for a short time and put it back. In most cases, normal operation will be resumed.

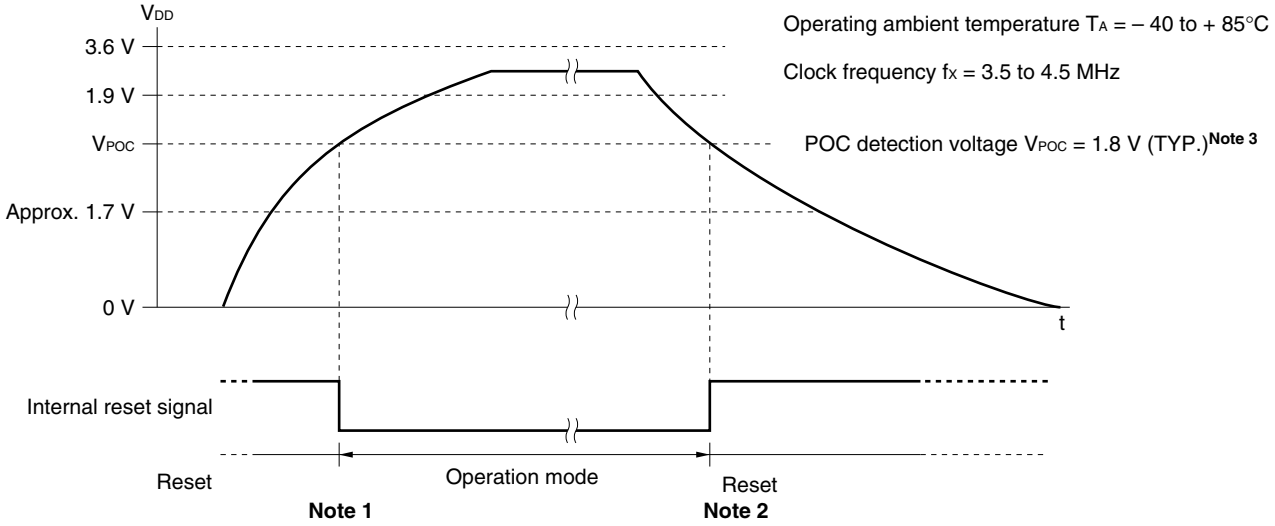
3. In order to prevent malfunction, be sure to input a low level to one or more of pins K_{I0} to K_{I3} when POC is released due to supply voltage rising (Can be left open. When open, leave the pull-down resistor connected).

8.1 Functions of POC Circuit

The POC circuit has the following functions:

- Generates an internal reset signal when $V_{DD} \leq V_{POC}$.
- Cancels an internal reset signal when $V_{DD} > V_{POC}$.

Here, V_{DD}: power supply voltage, V_{POC}: POC detection voltage.



Notes 1. Actually, oscillation stabilization wait time must elapse before the circuit is switched to operation mode. The oscillation stabilization wait time is about 534/fx to 918/fx (when about 134 to 230 μs; @ fx = 4 MHz).

2. For the POC circuit to generate an internal reset signal when the power supply voltage has fallen, it is necessary for the power supply voltage to be kept less than the V_{POC} for the period of 1 ms or more. Therefore, in reality, there is the time lag of up to 1 ms until the reset takes effect.

3. The POC detection voltage (V_{POC}) varies between approximately 1.7 to 1.9 V; thus, the reset may be canceled at a power supply voltage smaller than the guaranteed range (V_{DD} = 1.9 to 3.6 V). However, as long as the conditions for operating the POC circuit are met, the actual lowest operating power supply voltage becomes lower than the POC detection voltage. Therefore, there is no malfunction occurring due to a shortage of power supply voltage. However, malfunction for such reasons as the clock not oscillating due to low power supply voltage may occur (refer to **Caution 3** in **8. POC CIRCUIT**).

8.2 Oscillation Check at Low Supply Voltage

A reliable reset operation can be expected of the POC circuit if it satisfies the condition that the clock can oscillate even at low power supply voltage (the oscillation start voltage of the resonator being even lower than the POC detection voltage). Whether this condition is met or not can be checked by measuring the oscillation status in a product that actually includes a POC circuit, as follows.

<1> Connect a storage oscilloscope to the X_{OUT} pin so that the oscillation status can be measured.

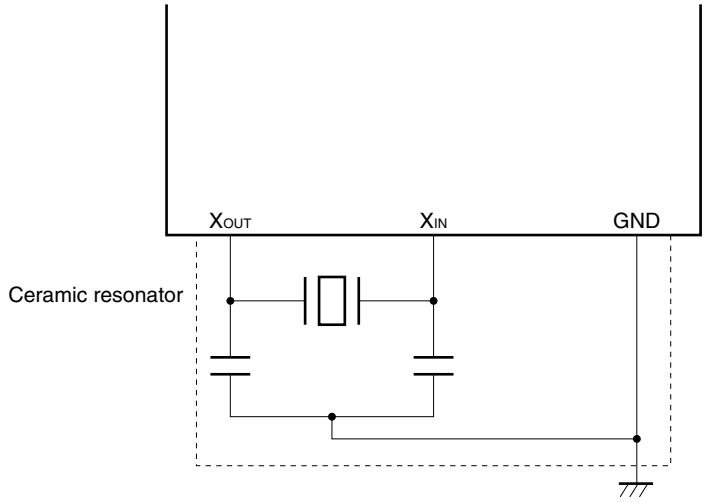
<2> Connect a power supply whose output voltage can be varied and then gradually raise the power supply voltage V_{DD} from 0 V (making sure to avoid V_{DD} > 3.6V).

At first (during V_{DD} < approx. 1.7 V), the X_{OUT} pin is 0 V regardless of the V_{DD}. However, at the point that V_{DD} reaches the POC detection voltage (V_{POC} = 1.8 V (TYP.)), the voltage of the X_{OUT} pin jumps to about 0.5V_{DD}. Maintain this power supply voltage for a while to measure the waveform of the X_{OUT} pin. If by any chance the oscillation start voltage of the resonator is lower than the POC detection voltage, the growing oscillation of the X_{OUT} pin can be confirmed within several ms after the V_{DD} has reached the V_{POC}.

9. SYSTEM CLOCK OSCILLATOR (μPD6P8, 6P8A)

The system clock oscillator consists of oscillators for ceramic resonators (fx = 3.5 to 4.5 MHz).

Figure 9-1. System Clock



The system clock oscillator stops oscillating when a reset is applied or in STOP mode.

Caution When using the system clock oscillator, wire as follows in the area enclosed by the broken lines in the above figure to avoid an adverse effect from wiring capacitance.

- **Keep the wiring length as short as possible.**
- **Do not cross the wiring with the other signal lines. Do not route the wiring near a signal line through which a high fluctuating current flows.**
- **Always make the ground point of the oscillator capacitor the same potential as GND. Do not ground the capacitor to a ground pattern through which a high current flows.**
- **Do not fetch signals from the oscillator.**

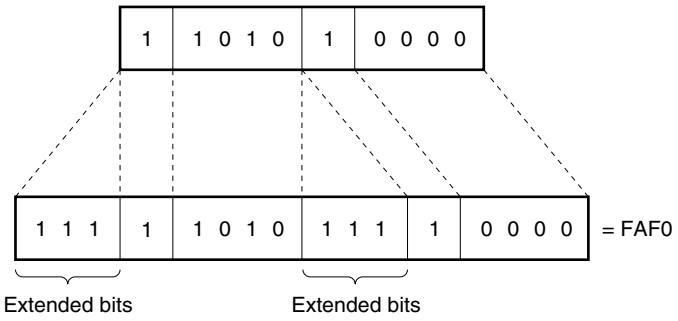
10. INSTRUCTION SET

10.1 Machine Language Output by Assembler

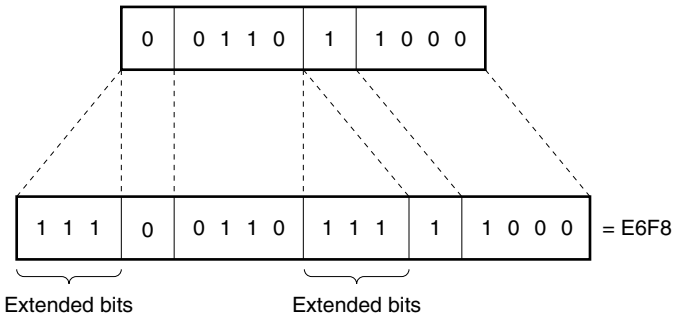
The bit length of the machine language of this product is 10 bits per word. However, the machine language that is output by the assembler is extended to 16 bits per word. As shown in the example below, the extension is made by inserting 3-bit extended bits (111) in two locations.

Figure 10-1. Example of Assembler Output (10 Bits Extended to 16 Bits)

<1> In the case of "ANL A, @R0H"



<2> In the case of "OUT P0, #data8"



10.2 Circuit Symbol Description

A:	Accumulator
ASR:	Address stack register
addr:	Program memory address
CY:	Carry flag
data4:	4-bit immediate data
data8:	8-bit immediate data
data10:	10-bit immediate data
F:	Status flag
M0:	Modulo register for setting the low-level period
M00:	Modulo register for setting the low-level period (lower 4 bits)
M01:	Modulo register for setting the low-level period (higher 4 bits)
M1:	Modulo register for setting the high-level period
M10:	Modulo register for setting the high-level period (lower 4 bits)
M11:	Modulo register for setting the high-level period (higher 4 bits)
PC:	Program Counter
Pn:	Port register pair (n = 0, 1, 3, 4)
P0n:	Port register (lower 4 bits)
P1n:	Port register (higher 4 bits)
ROMn:	Bit n of the program memory's (n = 0 to 9)
Rn:	Register pair
R0n:	Data memory (General-purpose register; n = 0 to F)
R1n:	Data memory (General-purpose register; n = 0 to F)
SP:	Stack Pointer
T:	Timer register
T0:	Timer register (lower 4 bits)
T1:	Timer register (higher 4 bits)
(×):	Content addressed with ×

10.3 Mnemonic to/from Machine Language (Assembler Output) Contrast Table

Accumulator Operation Instructions

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
ANL	A, R0n	FBEn			(A) ← (A) ∧ (Rmn) m = 0, 1 n = 0 to F	1	1
	A, R1n	FAEn			CY ← A_3 • Rmn_3		
	A, @R0H	FAF0			(A) ← (A) ∧ ((P13), (R0))$_{7-4}$		
					CY ← A_3 • ROM_7		
	A, @R0L	FBF0			(A) ← (A) ∧ ((P13), (R0))$_{3-0}$		
					CY ← A_3 • ROM_3		
	A, #data4	FBF1	data4		(A) ← (A) ∧ data4	2	
					CY ← A_3 • $data4_3$		
ORL	A, R0n	FDEn			(A) ← (A) ∨ (Rmn) m = 0, 1 n = 0 to F	1	
	A, R1n	FCEn			CY ← 0		
	A, @R0H	FCF0			(A) ← (A) ∨ ((P13), (R0))$_{7-4}$		
					CY ← 0		
	A, @R0L	FDF0			(A) ← (A) ∨ ((P13), (R0))$_{3-0}$		
					CY ← 0		
	A, #data4	FDF1	data4		(A) ← (A) ∨ data4	2	
					CY ← 0		
XRL	A, R0n	F5En			(A) ← (A) ∀ (Rmn) m = 0, 1 n = 0 to F	1	
	A, R1n	F4En			CY ← A_3 • Rmn_3		
	A, @R0H	F4F0			(A) ← (A) ∀ ((P13), (R0))$_{7-4}$		
					CY ← A_3 • ROM_7		
	A, @R0L	F5F0			(A) ← (A) ∀ ((P13), (R0))$_{3-0}$		
					CY ← A_3 • ROM_3		
	A, #data4	F5F1	data4		(A) ← (A) ∀ data4	2	
					CY ← A_3 • $data4_3$		
INC	A	F4F3			(A) ← (A) + 1	1	
					if (A) = 0 CY ← 1		
					else CY ← 1		
RL	A	FCF3			(A_{n+1}) ← (A_n), (A_0) ← (A_3)		
					CY ← A_3		
RLZ	A	FEF3			if A = 0 reset		
					else (A_{n+1}) ← (A_n), (A_0) ← (A_3)		
					CY ← A_3		

I/O Instructions

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
IN	A, P0n	FFF8 + n	—	—	(A) ← (Pmn) m = 0, 1 n = 0, 1, 3, 4	1	1
	A, P1n	FEF8 + n	—	—	CY ← 0		
OUT	P0n, A	E5F8 + n	—	—	(Pmn) ← (A) m = 0, 1 n = 0, 1, 3, 4		
	P1n, A	E4F8 + n	—	—			
ANL	A, P0n	FBF8 + n	—	—	(A) ← (A) ∧ (Pmn) m = 0, 1 n = 0, 1, 3, 4		
	A, P1n	FAF8 + n	—	—	CY ← A_3 • Pmn_3		
ORL	A, P0n	FDF8 + n	—	—	(A) ← (A) ∨ (Pmn) m = 0, 1 n = 0, 1, 3, 4		
	A, P1n	FCF8 + n	—	—	CY ← 0		
XRL	A, P0n	F5F8 + n	—	—	(A) ← (A) ∀ (Pmn) m = 0, 1 n = 0, 1, 3, 4		
	A, P1n	F4F8 + n	—	—	CY ← A_3 • Pmn_3		

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
OUT	Pn, #data8	E6F8 + n	data8		(Pn) ← data8 n = 0, 1, 3, 4	2	1

Remark Pn: P1n to P0n are handled in pairs.

Data Transfer Instruction

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
MOV	A, R0n	FFEn			(A) ← (Rmn) m = 0, 1 n = 0 to F	1	1
	A, R1n	FEEn			CY ← 0		
	A, @R0H	FEF0			(A) ← ((P13), (R0))$_{7\text{-}4}$ CY ← 0		
	A, @R0L	FFF0			(A) ← ((P13), (R0))$_{3\text{-}0}$ CY ← 0		
	A, #data4	FFF1	data4		(A) ← data4 CY ← 0	2	
	R0n, A	E5En			(Rmn) ← (A) m = 0, 1 n = 0 to F	1	
	R1n, A	E4En					

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
MOV	Rn, #data8	E6En	data8	—	(R1n to R0n) ← data8 n = 0 to F	2	1
	Rn, @R0	E7En	—	—	(R1n to R0n) ← ((P13), (R0))n = 1 to F	1	

Remark Rn: R1n to R0n are handled in pairs.

Branch Instructions

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
JMP	addr (Page 0)	E8F1	addr		PC ← addr	2	1
	addr (Page 1)	E9F1	addr				
	addr (Page 2)	E8F4	addr				
	addr (Page 3)	E9F4	addr				
JC	addr (Page 0)	ECF1	addr		if CY = 1 PC ← addr else PC ← PC + 2		
	addr (Page 1)	EAF1	addr				
	addr (Page 2)	ECF4	addr				
	addr (Page 3)	EAF4	addr				
JNC	addr (Page 0)	EDF1	addr		if CY = 0 PC ← addr else PC ← PC + 2		
	addr (Page 1)	EBF1	addr				
	addr (Page 2)	EDF4	addr				
	addr (Page 3)	EBF4	addr				
JF	addr (Page 0)	EEF1	addr		if F = 1 PC ← addr else PC ← PC + 2		
	addr (Page 1)	F0F1	addr				
	addr (Page 2)	EEF4	addr				
	addr (Page 3)	F0F4	addr				
JNF	addr (Page 0)	EFF1	addr		if F = 0 PC ← addr else PC ← PC + 2		
	addr (Page 1)	F1F1	addr				
	addr (Page 2)	EFF4	addr				
	addr (Page 3)	F1F4	addr				

Caution 0 to 4, which refer to PAGE0 to 4, are not written when describing mnemonics.

Subroutine Instructions

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
CALL	addr (Page 0)	E6F2	E8F1	addr	SP ← SP + 1, ASR ← PC, PC ← addr	3	2
	addr (Page 1)	E6F2	E9F1	addr			
	addr (Page 2)	E6F2	E8F4	addr			
	addr (Page 3)	E6F2	E9F4	addr			
RET		E8F2			PC ← ASR, SP ← SP – 1	1	1

Caution 0 to 4, which refer to PAGE0 to 4, are not written when describing mnemonics.

Timer Operation Instructions

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
MOV	A, T0	FFFF			(A) ← (Tn) n = 0, 1	1	1
	A, T1	FEFF			CY ← 0		
	A, M00	FFF6			(A) ← (M0n) n = 0, 1		
	A, M01	FEF6			CY ← 0		
	A, M10	FFF7			(A) → (M1n) n = 0, 1		
	A, M11	FEF7			CY → 0		
	T0, A	E5FF			(Tn) ← (A) n = 0, 1		
	T1, A	F4FF			(T) n ← 0		
	M00, A	E5F6			(M0n) ← (A) n = 0, 1		
	M01, A	E4F6			CY ← 0		
	M10, A	E5F7			(M1n) ← (A) n = 0, 1		
	M11, A	E4F7			CY ← 0		

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
MOV	T, #data10	E6FF	data10		(T) ← data10	2	1
	M0, #data10	E6F6	data10		(M0) ← data10		
	M1, #data10	E6F7	data10		(M1) ← data10		
	T, @R0	F4FF			(T) ← ((P13), (R0))	1	
	M0, @R0	E7F6			(M0) ← ((P13), (R0))		
	M1, @R0	E7F7			(M1) ← ((P13), (R0))		

Others

Mnemonic	Operand	Instruction Code			Operation	Instruction Length	Instruction Cycle
		1st Word	2nd Word	3rd Word			
HALT	#data4	E2F1	data4		Standby mode	2	1
STTS	#data4	E3F1	data4		if statuses match F ← 1 else F ← 0		
	R0n	E3En			if statuses match F ← 1 else F ← 0 n = 0 to F	1	
SCAF		FAF3			if A = 0FH CY ← 1 else CY ← 0		
NOP		E0E0			PC ← PC + 1		

10.4 Accumulator Manipulation Instructions

ANL A, R0n

ANL A, R1n

<1> Instruction code:

1	1	0	1	R_4	0	R_3	R_2	R_1 R_0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∧ (Rmn) m = 0, 1 n = 0 to F

CY ← A_3 • Rmn_3

The accumulator contents and the register Rmn contents are ANDed and the results are entered in the accumulator.

ANL A, @R0H

ANL A, @R0L

<1> Instruction code:

1	1	0	1	0/1	1	0	0	0 0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∧ ((P13), (R0))$_{7\text{-}4}$ (in the case of ANL A, @R0H)

CY ← A_3 • ROM_7

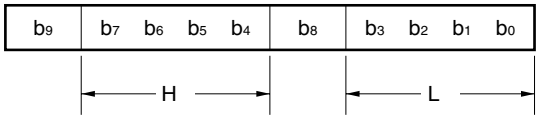
(A) ← (A) ∧ ((P13), (R0))$_{3\text{-}0}$ (in the case of ANL A, @R0L)

CY ← A_3 • ROM_3

The accumulator contents and the program memory contents specified by the control register P13 and register pair R_{10} to R_{00} are ANDed and the results are entered in the accumulator.

If H is specified, b_7, b_6, b_5 and b_4 take effect. If L is specified, b_3, b_2, b_1 and b_0 take effect.

- **Program memory (ROM) organization**



Valid bits at the time of accumulator manipulation

ANL A, #data4

<1> Instruction code:

1	1	0	1	1	1	0	0	0 1
0	0	0	0	0	0	d_3	d_2	d_1 d_0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∧ data4

CY ← A_3 • $data4_3$

The accumulator contents and the immediate data are ANDed and the results are entered in the accumulator.

ORL A, R0n
ORL A, R1n

<1> Instruction code:

1	1	1	0	R_4	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∨ (Rmn) m = 0, 1 n = 0 to F

CY ← 0

The accumulator contents and the register Rmn contents are ORed and the results are entered in the accumulator.

ORL A, @R0H
ORL A, @R0L

<1> Instruction code:

1	1	1	0	0/1	1	0	0	0	0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∨ (P13), $(R0))_{7\text{-}4}$ (in the case of ORL A, @R0H)

(A) ← (A) ∨ (P13), $(R0))_{3\text{-}0}$ (in the case of ORL A, @R0L)

CY ← 0

The accumulator contents and the program memory contents specified by the control register P13 and register pair R_{10}-R_{00} are ORed and the results are entered in the accumulator.

If H is specified, b_7, b_6, b_5 and b_4 take effect. If L is specified, b_3, b_2, b_1 and b_0 take effect.

ORL A, #data4

<1> Instruction code:

1	1	1	0	1	1	0	0	0	1
0	0	0	0	0	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∨ data4

CY ← 0

The accumulator contents and the immediate data are exclusive-ORed and the results are entered in the accumulator.

XRL A, R0n
XRL A, R1n

<1> Instruction code:

1	0	1	0	R_4	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: (A) ← (A) ∀ (Rmn) m = 0, 1 n = 0 to F

CY ← A_3 • Rmn_3

The accumulator contents and the register Rmn contents are ORed and the results are entered in the accumulator.

XRL A, @R0H

XRL A, @R0L

<1> Instruction code:

1	0	1	0	0/1	1	0	0	0	0

<2> Cycle count: 1

<3> Function: $(A) \leftarrow (A) \veebar (P13), (R0))_{7\text{-}4}$ (in the case of XRL A, @R0H)

$CY \leftarrow A_3 \bullet ROM_7$

$(A) \leftarrow (A) \veebar (P13), (R0))_{3\text{-}0}$ (in the case of XRL A, @R0L)

$CY \leftarrow A_3 \bullet ROM_3$

The accumulator contents and the program memory contents specified by the control register P13 and register pair R_{10}-R_{00} are exclusive-ORed and the results are entered in the accumulator.

If H is specified, b_7, b_6, b_5, and b_4 take effect. If L is specified, b_3, b_2, b_1, and b_0 take effect.

XRL A, #data4

<1> Instruction code:

1	0	1	0	1	1	0	0	0	1
0	0	0	0	0	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: $(A) \leftarrow (A) \veebar data4$

$CY \leftarrow A_3 \bullet data4_3$

The accumulator contents and the immediate data are exclusive-ORed and the results are entered in the accumulator.

INC A

<1> Instruction code:

1	0	1	0	0	1	0	0	1	1

<2> Cycle count: 1

<3> Function: $(A) \leftarrow (A) + 1$

if A = 0 $CY \leftarrow 1$

else $CY \leftarrow 0$

The accumulator contents are incremented (+1).

RL A

<1> Instruction code:

1	1	1	0	0	1	0	0	1	1

<2> Cycle count: 1

<3> Function: $(A_{n+1}) \leftarrow (An), (A_0) \leftarrow (A_3)$

$CY \leftarrow A_3$

The accumulator contents are rotated anticlockwise bit by bit.

RLZ A

<1> Instruction code:

1	1	1	1	0	1	0	0	1	1

<2> Cycle count: 1

<3> Function: if A = 0 reset

else $(A_{n+1}) \leftarrow (An), (A_0) \leftarrow (A_3)$

$CY \leftarrow A_3$

The accumulator contents are rotated anticlockwise bit by bit.

If A = 0H at the time of command execution, an internal reset takes effect.

10.5 I/O Instructions

IN A, P0n
IN A, P1n

<1> Instruction code: | 1 | 1 1 1 P_4 | 1 | 1 P_2 P_1 P_0 |

<2> Cycle count: 1

<3> Function: (A) ← (Pmn) m = 0, 1 n = 0, 1, 3, 4
CY ← 0

The port Pmn data is loaded (read) onto the accumulator.

OUT P0n, A
OUT P1n, A

<1> Instruction code: | 0 | 0 1 0 P_4 | 1 | 1 P_2 P_1 P_0 |

<2> Cycle count: 1

<3> Function: (Pmn) ← (A) m = 0, 1 n = 0, 1, 3, 4

The accumulator contents are transferred to port Pmn to be latched.

ANL A, P0n
ANL A, P1n

<1> Instruction code: | 1 | 1 0 1 P_4 | 1 | 1 P_2 P_1 P_0 |

<2> Cycle count: 1

<3> Function: (A) ← (A) ∧ (Pmn) m = 0, 1 n = 0, 1, 3, 4
CY ← A_3 • Pmn

The accumulator contents and the port Pmn contents are ANDed and the results are entered in the accumulator.

ORL A, P0n
ORL A, P1n

<1> Instruction code: | 1 | 1 1 0 P_4 | 1 | 1 P_2 P_1 P_0 |

<2> Cycle count: 1

<3> Function: (A) ← (A) ∨ (Pmn) m = 0, 1 n = 0, 1, 3, 4
CY ← 0

The accumulator contents and the port Pmn contents are ORed and the results are entered in the accumulator.

XRL A, P0n
XRL A, P1n

<1> Instruction code: | 1 | 0 1 0 P_4 | 1 | 1 P_2 P_1 P_0 |

<2> Cycle count: 1

<3> Function: (A) ← (A) ∀ (Pmn) m = 0, 1 n = 0, 1, 3, 4
CY ← A_3 • Pmn

The accumulator contents and the port Pmn contents are exclusive-ORed and the results are entered in the accumulator.

OUT Pn, #data8

<1> Instruction code:

0	0	1	1	0	1	1	P_2	P_1	P_0
0	d_7	d_6	d_5	d_4	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: (Pn) ← data8 n = 0, 1, 3, 4

The immediate data is transferred to port Pn. In this case, port Pn refers to P_{1n} to P_{0n} operating in pairs.

10.6 Data Transfer Instructions

MOV A, R0n

MOV A, R1n

<1> Instruction code:

1	1	1	1	R_4	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: (A) ← (Rmn) m = 0, 1 n = 0 to F

CY ← 0

The register Rmn contents are transferred to the accumulator.

MOV A, @R0H

<1> Instruction code:

1	1	1	1	0	1	0	0	0	0

<2> Cycle count: 1

<3> Function: (A) ← ((P13), (R0))$_{7\text{-}4}$

CY ← 0

The higher 4 bits (b_7 b_6 b_5 b_4) of the program memory specified by control register P13 and register pair R_{10}-R_{00} are transferred to the accumulator. b_9 is ignored.

MOV A, @R0L

<1> Instruction code:

1	1	1	1	1	1	0	0	0	0

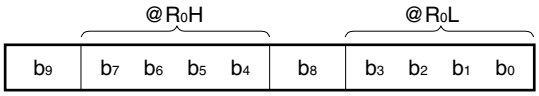
<2> Cycle count: 1

<3> Function: (A) ← ((P13), (R0))$_{3\text{-}0}$

CY ← 0

The lower 4 bits (b_3 b_2 b_1 b_0) of the program memory specified by control register P13 and register pair R_{10} to R_{00} are transferred to the accumulator. b_8 is ignored.

- **Program memory (ROM) contents**



MOV A, #data4

<1> Instruction code:

1	1	1	1	1	1	0	0	0	1
0	0	0	0	0	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: (A) ← data4

CY ← 0

The immediate data is transferred to the accumulator.

MOV R0n, A

MOV R1n, A

<1> Instruction code:

0	0	1	0	R_4	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: (Rmn) ← (A) m = 0, 1 n = 0 to F

The accumulator contents are transferred to register Rmn.

MOV Rn, #data8

<1> Instruction code:

0	0	1	1	0	0	R_3	R_2	R_1	R_0
:									
0	d_7	d_6	d_5	d_4	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: (R1n-R0n) ← data8 n = 0 to F

The immediate data is transferred to the register. Using this instruction, registers operate as register pairs.

The pair combinations are as follows:

R_0: R_{10} - R_{00}

R_1: R_{11} - R_{01}

:

R_E: R_{1E} - R_{0E}

R_F: R_{1F} - R_{0F}

Lower column

Higher column

MOV Rn, @R0

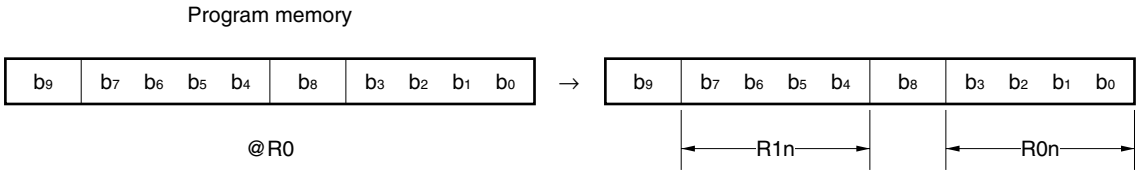
<1> Instruction code:

0	0	1	1	1	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: (R1n-R0n) ← ((P13), R0)) n = 1 to F

The program memory contents specified by control register P13 and register pair R_{10} to R_{00} are transferred to register pair R1n to R0n. The program memory consists of 10 bits and has the following state after the transfer to the register.



The higher 2 to 4 bits of the program memory address are specified by the control register (P13).

10.7 Branch Instructions

The program memory consists of pages in steps of 1K (000H to 3FFH). However, as the assembler automatically performs page optimization, it is unnecessary to designate pages. The pages allowed for each product are as follows.

μPD6P8, 6P8A, 6P8B (ROM: 2K steps): Pages 0, 1

JMP addr

<1> Instruction code: Page 0 | 0 | 1 0 0 0 | 1 | 0 0 0 1 | ; page 1 | 0 | 1 0 0 1 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 0 0 0 | 1 | 0 1 0 0 | ; page 3 | 0 | 1 0 0 1 | 1 | 0 1 0 0 |

a_9	a_7 a_6 a_5 a_4	a_8	a_3 a_2 a_1 a_0

<2> Cycle count: 1

<3> Function: PC ← addr

The 10 bits (PC_{9-0}) of the program counter are replaced directly by the specified address addr (a_9 to a_0).

JC addr

<1> Instruction code: Page 0 | 0 | 1 1 0 0 | 1 | 0 0 0 1 | ; page 1 | 0 | 1 0 1 0 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 1 0 0 | 1 | 0 1 0 0 | ; page 3 | 0 | 1 0 1 0 | 1 | 0 1 0 0 |

a_9	a_7 a_6 a_5 a_4	a_8	a_3 a_2 a_1 a_0

<2> Cycle count: 1

<3> Function: if CY = 1 PC ← addr

else PC ← PC + 2

If the carry flag CY is set (to 1), a jump is made to the address specified by addr (a_9 to a_0).

JNC addr

<1> Instruction code: Page 0 | 0 | 1 1 0 1 | 1 | 0 0 0 1 | ; page 1 | 0 | 1 0 1 1 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 1 0 1 | 1 | 0 1 0 0 | ; page 3 | 0 | 1 0 1 1 | 1 | 0 1 0 0 |

a_9	a_7 a_6 a_5 a_4	a_8	a_3 a_2 a_1 a_0

<2> Cycle count: 1

<3> Function: if CY = 0 PC ← addr

else PC ← PC + 2

If the carry flag CY is cleared (to 0), a jump is made to the address specified by addr (a9 to a0).

JF addr

<1> Instruction code: Page 0 | 0 | 1 1 1 0 | 1 | 0 0 0 1 | ; page 1 | 1 | 0 0 0 0 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 1 1 0 | 1 | 0 1 0 0 | ; page 3 | 1 | 0 0 0 0 | 1 | 0 1 0 0 |

a_9	a_7 a_6 a_5 a_4	a_8	a_3 a_2 a_1 a_0

<2> Cycle count: 1

<3> Function: if F = 1 PC ← addr

else PC ← PC + 2

If the status flag F is set (to 1), a jump is made to the address specified by addr (a_9 to a_0).

JNF addr

<1> Instruction code: Page 0 | 0 | 1 1 1 1 | 1 | 0 0 0 1 | ; page 1 | 1 | 0 0 0 1 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 1 1 1 | 1 | 0 1 0 0 | ; page 3 | 1 | 0 0 0 1 | 1 | 0 1 0 0 |

| a_9 | a_7 a_6 a_5 a_4 | a_8 | a_3 a_2 a_1 a_0 |

<2> Cycle count: 1

<3> Function: if F = 0 PC ← addr

else PC ← PC + 2

If the status flag F is cleared (to 0), a jump is made to the address specified by addr (a_9 to a_0).

10.8 Subroutine Instructions

The program memory consists of pages in steps of 1K (000H to 3FFH). However, as the assembler automatically performs page optimization, it is unnecessary to designate pages. The pages allowed for each product are as follows.

μPD6P8, 6P8A, 6P8B (ROM: 2K steps): Pages 0, 1

CALL addr

<1> Instruction code: | 0 | 0 1 1 0 | 1 | 0 0 1 0 |

Page 0 | 0 | 1 0 0 0 | 1 | 0 0 0 1 | ; page 1 | 0 | 1 0 0 1 | 1 | 0 0 0 1 |

Page 2 | 0 | 1 0 0 0 | 1 | 0 1 0 0 | ; page 3 | 0 | 1 0 0 1 | 1 | 0 1 0 0 |

| a_9 | a_7 a_6 a_5 a_4 | a_8 | a_3 a_2 a_1 a_0 |

<2> Cycle count: 2

<3> Function: SP ← SP + 1

ASR ← PC

PC ← addr

Increments (+1) the stack pointer value and saves the program counter value in the address stack register. Then, enters the address specified by the operand addr (a_9 to a_0) into the program counter.

If a carry is generated when the stack pointer value is incremented (+1), an internal reset takes effect.

RET

<1> Instruction code: | 0 | 1 0 0 0 | 1 | 0 0 1 0 |

<2> Cycle count: 1

<3> Function: PC ← ASR

SP ← SP – 1

Restores the value saved in the address stack register to the program counter. Then, decrements (–1) the stack pointer.

If a borrow is generated when the stack pointer value is decremented (–1), an internal reset takes effect.

10.9 Timer Operation Instructions

MOV A, T0

MOV A, T1

<1> Instruction code:

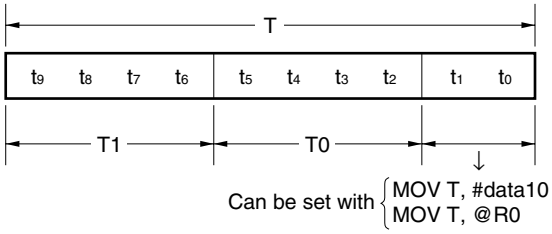
1	1 1 1 0/1	1	1 1 1 1

<2> Cycle count: 1

<3> Function: (A) ← (Tn) n = 0, 1

CY ← 0

The timer register Tn contents are transferred to the accumulator. T1 corresponds to (t_9, t_8, t_7, t_6); T0 corresponds to (t_5, t_4, t_3, t_2).



MOV A, M00

MOV A, M01

<1> Instruction code:

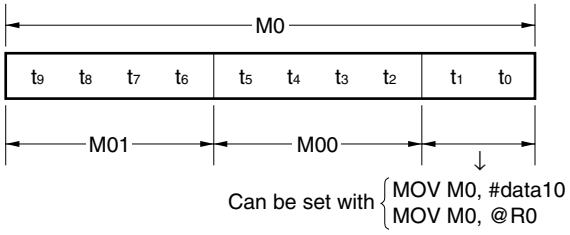
1	1 1 1 0/1	1	0 1 1 0

<2> Cycle count: 1

<3> Function: (A) ← (M0n) n = 0, 1

CY ← 0

The modulo register M0n contents are transferred to the accumulator. M01 corresponds to (t_9, t_8, t_7, t_6); M00 corresponds to (t_5, t_4, t_3, t_2).



MOV A, M10

MOV A, M11

<1> Instruction code:

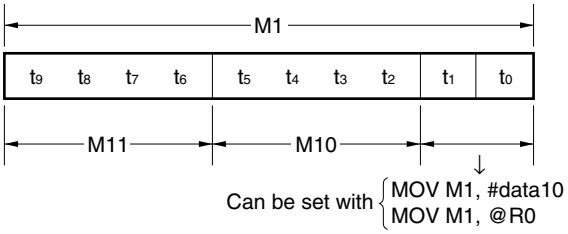
1	1 1 1 0/1	1	0 1 1 1

<2> Cycle count: 1

<3> Function: (A) ← (M1n) n = 0, 1

CY ← 0

The modulo register M1n contents are transferred to the accumulator. M11 corresponds to (t_9, t_8, t_7, t_6); M10 corresponds to (t_5, t_4, t_3, t_2).



MOV T0, A

MOV T1, A

<1> Instruction code:

0	0 1 0 0/1	1	1 1 1 1

<2> Cycle count: 1

<3> Function: (Tn) ← (A) n = 0, 1

The accumulator contents are transferred to the timer register Tn. T1 corresponds to (t_9, t_8, t_7, t_6); T0 corresponds to (t_5, t_4, t_3, t_2). **After executing this instruction, if data is transferred to T1, t_1 becomes 0; if data is transferred to T0, t_0 becomes 0.**

MOV M00, A

MOV M01, A

<1> Instruction code:

0	0 1 0 0/1	1	0 1 1 0

<2> Cycle count: 1

<3> Function: (M0n) ← (A) n = 0, 1

CY ← 0

The accumulator contents are transferred to the modulo register M0n. M01 corresponds to (t_9, t_8, t_7, t_6); M00 corresponds to (t_5, t_4, t_3, t_2). **After executing this instruction, if data is transferred to M01, t_1 becomes 0; if data is transferred to M00, t_0 becomes 0.**

MOV M10, A

MOV M11, A

<1> Instruction code:

0	0 1 0 0/1	1	0 1 1 1

<2> Cycle count: 1

<3> Function: (M1n) ← (A) n = 0, 1

CY ← 0

The accumulator contents are transferred to the modulo register M1n. M11 corresponds to (t_9, t_8, t_7, t_6); M10 corresponds to (t_5, t_4, t_3, t_2). **After executing this instruction, if data is transferred to M11, t_1 becomes 0; if data is transferred to M10, t_0 becomes 0.**

MOV T, #data10

<1> Instruction code:

0	0	1	1	0	1	1	1	1	1
t_1	t_9	t_8	t_7	t_6	t_0	t_5	t_4	t_3	t_2

<2> Cycle count: 1

<3> Function: (T) ← data10

The immediate data is transferred to the timer register T (t_9 to t_0).

Remark The timer time is set as follows.
(Set value + 1) × 64/fx – 4/fx

MOV M0, #data10

<1> Instruction code:

0	0	1	1	0	1	0	1	1	0
t_1	t_9	t_8	t_7	t_6	t_0	t_5	t_4	t_3	t_2

<2> Cycle count: 1

<3> Function: (M0) ← data10

The immediate data is transferred to the modulo register M0 (t_9 to t_0).

MOV M1, #data10

<1> Instruction code:

0	0	1	1	0	1	0	1	1	1
t_1	t_9	t_8	t_7	t_6	t_0	t_5	t_4	t_3	t_2

<2> Cycle count: 1

<3> Function: (M1) ← data10

The immediate data is transferred to the modulo register M1 (t_9 to t_0).

MOV T, @R0

<1> Instruction code:

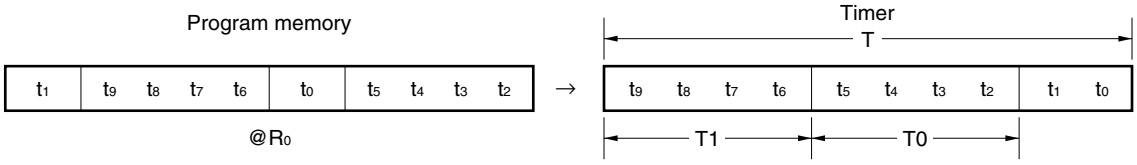
0	0	1	1	1	1	1	1	1	1

<2> Cycle count: 1

<3> Function: (T) ← ((P13), (R0))

Transfers the program memory contents to the timer register T (t_9 to t_0) specified by the control register P13 and the register pair R_{10} to R_{00}.

The program memory, which consists of 10 bits, is placed in the following state after the transfer to the register.



The higher 2 to 4 bits of the program memory address are specified by the control register (P13).

Caution When setting a timer value in the program memory, be sure to use the DT quasi-directive.

MOV M0, @R0

<1> Instruction code:

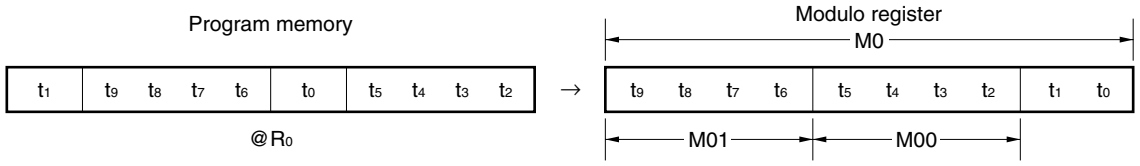
0	0 1 1 1	1	0 1 1 0

<2> Cycle count: 1

<3> Function: (M0) ← ((P13), (R0))

Transfers the program memory contents to the modulo register M0 (t_9 to t_0) specified by the control register P13 and the register pair R_{10} to R_{00}.

The program memory, which consists of 10 bits, is placed in the following state after the transfer to the register.



The higher 2 to 4 bits of the program memory address are specified by the control register (P13).

Caution When setting a timer value in the program memory, be sure to use the DT quasi-directive.

MOV M1, @R0

<1> Instruction code:

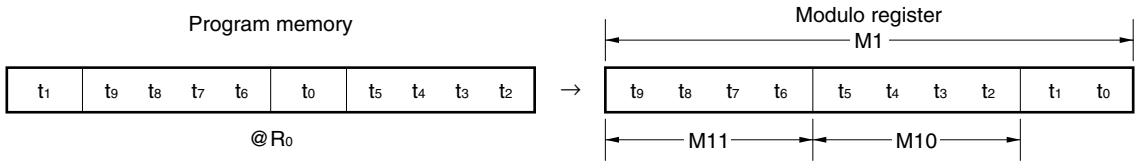
0	0 1 1 1	1	0 1 1 1

<2> Cycle count: 1

<3> Function: (M1) ← ((P13), (R0))

Transfers the program memory contents to the modulo register M1 (t_9 to t_0) specified by the control register P13 and the register pair R_{10} to R_{00}.

The program memory, which consists of 10 bits, is placed in the following state after the transfer to the register.



The higher 2 to 4 bits of the program memory address are specified by the control register (P13).

Caution When setting a timer value in the program memory, be sure to use the DT quasi-directive.

10.10 Others

HALT #data4

<1> Instruction code:

0	0 0 1 0	1	0 0 0 1
0	0 0 0 0	0	d_3 d_2 d_1 d_0

<2> Cycle count: 1

<3> Function: Standby mode

Places the CPU in standby mode.

The condition for having the standby mode (HALT/STOP mode) canceled is specified by the immediate data.

STTS R0n

<1> Instruction code:

0	0	0	1	1	0	R_3	R_2	R_1	R_0

<2> Cycle count: 1

<3> Function: if statuses match F ← 1
else F ← 0 n = 0 to F

Compares the S_0, S_1, S_2, S_3[Note], $K_{I/O}$, K_I, and TIMER statuses with the register R_{0n} contents. If at least one of the statuses matches the bits that have been set, the status flag F is set (to 1).
If none of them match, the status flag F is cleared (to 0).

Note μPD6P8B only

STTS #data4

<1> Instruction code:

0	0	0	1	1	1	0	0	0	1

:

0	0	0	0	0	0	d_3	d_2	d_1	d_0

<2> Cycle count: 1

<3> Function: if statuses match F ← 1
else F ← 0

Compares the S_0, S_1, S_2, S_3[Note], $K_{I/O}$, K_I, and TIMER statuses with the immediate data contents. If at least one of the statuses matches the bits that have been set, the status flag F is set (to 1).
If none of them match, the status flag F is cleared (to 0).

Note μPD6P8B only

SCAF (Set Carry If $A_{CC} = F_H$)

<1> Instruction code:

1	1	0	1	0	1	0	0	1	1

<2> Cycle count: 1

<3> Function: if A = 0FH CY ← 1
else CY ← 0

Sets the carry flag CY (to 1) if the accumulator contents are FH.
The accumulator values after executing the SCAF instruction are as follows:

Accumulator Value		Carry Flag
Before Execution	After Execution	
×××0	0000	0 (clear)
××01	0001	0 (clear)
×011	0011	0 (clear)
0111	0111	0 (clear)
1111	1111	1 (set)

Remark ×: don't care

NOP

<1> Instruction code:

0	0	0	0	0	0	0	0	0	0

<2> Cycle count: 1

<3> Function: PC ← PC + 1

No operation

11. ASSEMBLER RESERVED WORDS

11.1 Mask Option Directives

To create a program for the μPD6P8, 6P8A, or 6P8B, a mask option quasi-directive must be used in the assembler source program, but since the μPD6P8, 6P8A, or 6P8B does not have a mask option, describe NOUSECAP.

11.1.1 OPTION and ENDOP quasi-directives

The quasi-directives from the OPTION quasi-directive down to the ENDOP quasi-directive are called the mask option definition block. The format of the mask option definition block is as follows:

Format

Symbol field	Mnemonic field	Operand field	Comment field
[Label:]	OPTION		[; Comment]
	:		
	:		
	ENDOP		

11.1.2 Mask option definition quasi-directives

The quasi-directives that can be used in the mask option definition block are listed in Table 10-1.

The mask option definition can only be specified as follows. Be sure to specify the following quasi-directives.

Example

Symbol field	Mnemonic field	Operand field	Comment field
	OPTION		
	NOUSECAP		; Capacitor for oscillation
	ENDOP		; not incorporated

Table 11-1. Mask Option Definition Directives

Name	Mask Option Definition Quasi-Directive	PRO File	
		Address Value	Data Value
CAP	NOUSECAP (Capacitor for oscillation not incorporated)	2043H	00

12. WRITING AND VERIFYING ONE-TIME PROM (PROGRAM MEMORY) (μPD6P8)

The program memory of the μPD6P8 is a one-time PROM of 2026 × 10 bits.

To write or verify this one-time PROM, the pins shown in Table 12-1 are used. Note that no address input pin is used. Instead, the address is updated by using the clock input from the CLK pin.

Table 12-1. Pins Used to Write/Verify Program Memory

Pin Name	Function
V_{PP}	Supplies voltage when writing/verifying program memory. Apply +10.5 V to this pin.
V_{DD}	Power supply. Supply +3 V to this pin when writing/verifying program memory.
CLK	Inputs clock to update address when writing/verifying program memory. By inputting a pulse four times to the CLK pin, the address of the program memory is updated.
MD_0 to MD_3	Input to select the operation mode when writing/verifying program memory.
D_0 to D_7	Inputs/outputs 8-bit data when writing/verifying program memory.
X_{IN}, X_{OUT}	Clock necessary for writing program memory. Connect a 4 MHz ceramic resonator to this pin.

12.1 Operating Mode When Writing/Verifying Program Memory

The μPD6P8 is set in the program memory write/verify mode when +10.5 V is applied to the V_{PP} pin after the μPD6P8 has been in the reset status (V_{DD} = 3 V, V_{PP} = 0 V) for a specific time. In this mode, the operating modes shown in Table 12-2 can be set by setting the MD_0 through MD_3 pins. Connect all the pins other than those shown in Table 12-1 to GND via pull-down resistors.

Table 12-2. Setting Operating Mode

Setting of Operating Mode						Operating Mode
V_{PP}	V_{DD}	MD_0	MD_1	MD_2	MD_3	
+10.5 V	+3 V	H	L	H	L	Clear program memory address to 0
		L	H	H	H	Write mode
		L	L	H	H	Verify mode
		H	×	H	H	Program inhibit mode

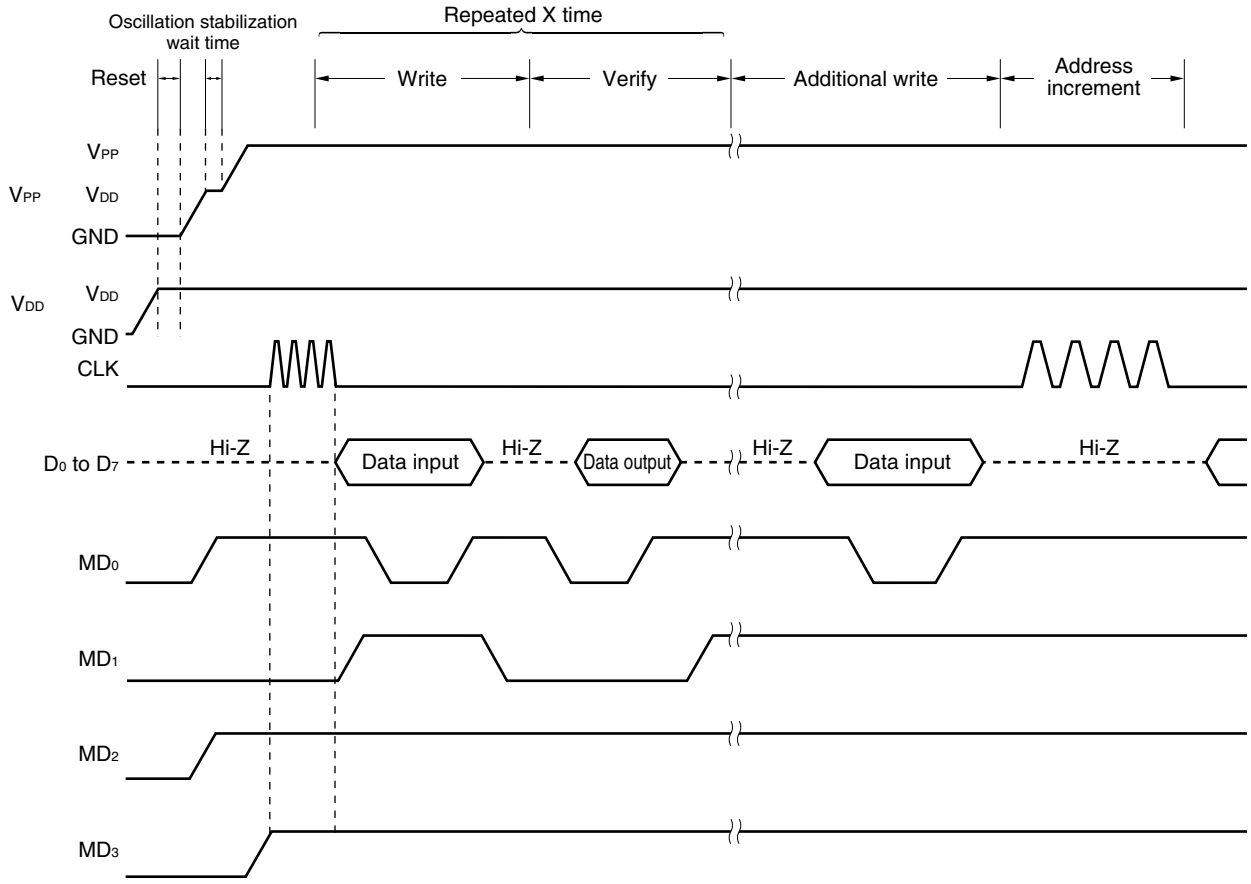
×: don't care (L or H)

12.2 Program Memory Writing Procedure

The program memory is written at high speed by the following procedure.

(1) Pull down the pins not used to GND via a resistor. Keep the CLK pin low.
(2) Supply 3 V to the V_{DD} pin. Keep the V_{PP} pin low.
(3) Supply 3 V to the V_{PP} pin after waiting for 10 μs.
(4) Wait for 2 ms until oscillation of the ceramic resonator connected across the X_{IN} and X_{OUT} pins stabilizes.
(5) Set the program memory address 0 clear mode by using the mode setting pins.
(6) Supply 10.5 V to V_{PP}.
(7) Set the program inhibit mode.
Input a pulse to the CLK pin four times.
(8) Write data to the program memory in the 100 μs write mode.
(9) Set the program inhibit mode.
(10) Set the verify mode. If the data have been written to the program memory, proceed to (11). If not, repeat steps (8) through (10).
(11) Additional writing of (number of times of writing in (8) through (10): X) × 100 μs.
(12) Set the program inhibit mode.
(13) Input a pulse to the CLK pin four times to update the program memory address (+1).
(14) Repeat steps (8) through (13) up to the last address.
(15) Set the 0 clear mode of the program memory address.
(16) Change the voltages on the V_{PP} pin to 3 V.
(17) Turn off the power.

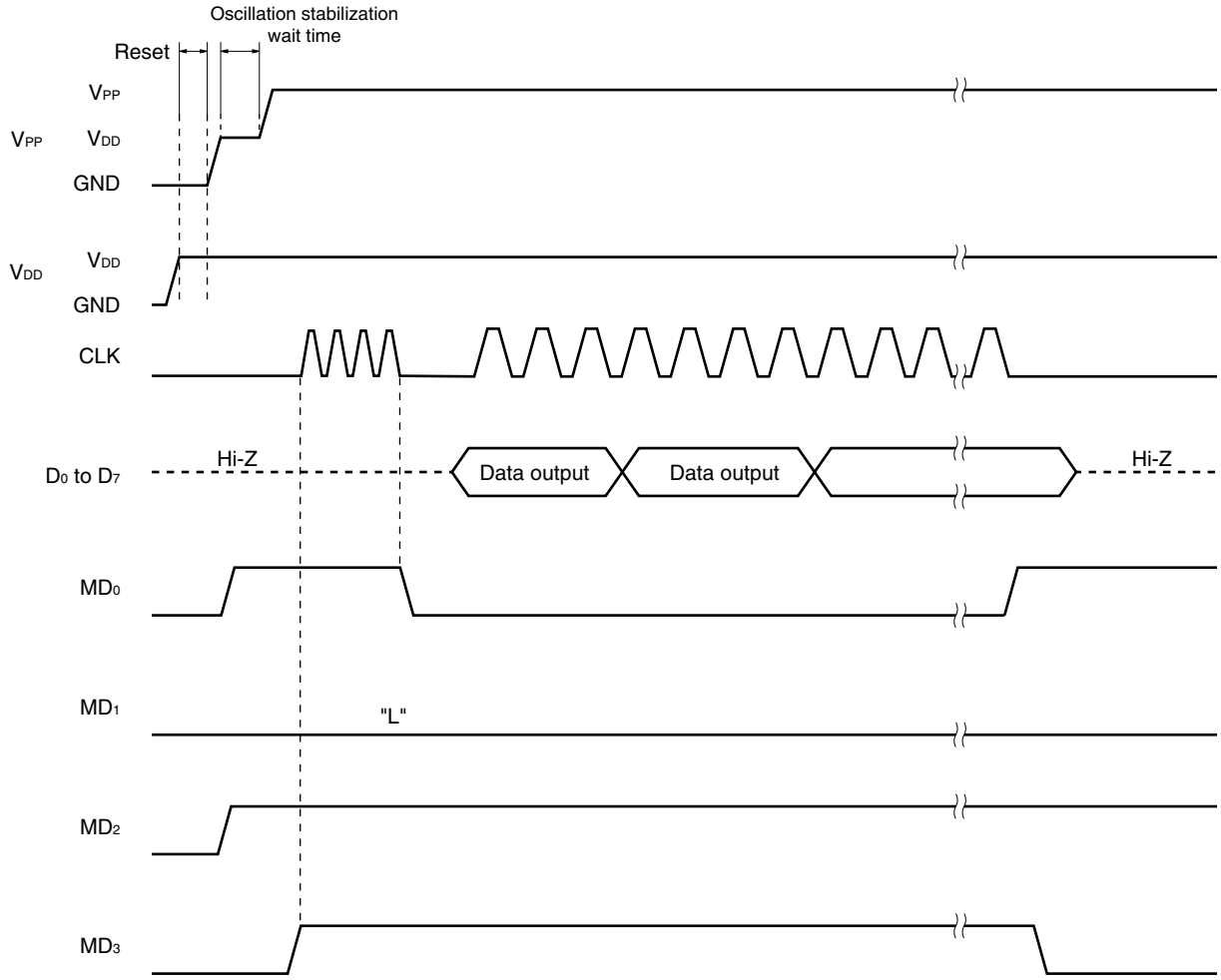
The following figure illustrates steps (2) through (13) above.



12.3 Program Memory Reading Procedure

(1) Pull down the pins not used to GND via a resistor. Keep the CLK pin low.
(2) Supply 3 V to the V_{DD} pin. Keep the V_{PP} pin low.
(3) Supply 3 V to the V_{PP} pin after waiting for 10 μs.
(4) Wait for 2 ms until oscillation of the ceramic resonator connected across the X_{IN} and X_{OUT} pins stabilizes.
(5) Set the program memory address 0 clear mode by using the mode setting pins.
(6) Supply 10.5 V to V_{PP}.
(7) Set the program inhibit mode.
Input a pulse to the CLK pin four times.
(8) Set the verify mode. Data of each address is output sequentially each time the clock pulse is input to the CLK pin four times.
(9) Set the program inhibit mode.
(10) Set the program memory address 0 clear mode.
(11) Change the voltage on the V_{PP} pin to 3 V.
(12) Turn off the power.

The following figure illustrates steps (2) through (10) above.



13. WRITING AND VERIFYING ONE-TIME PROM (PROGRAM MEMORY) (μPD6P8A, 6P8B)

The program memory built into the μPD6P8A and 6P8B is a one-time PROM of 2026 × 10 bits.

Writing or verification of this one-time PROM is performed using the pins listed in Table 13-1, and a 5-bit instruction and 5-bit data via serial communication. The assembler output has an 8-bit configuration, so mask the higher three bits and program the lower five bits.

Table 13-1. Pins Used During Program Memory Writing/Verification

Pin No.	Symbol	Function	I/O
2	SO	Serial data output during program memory verification	Output
3	SCLK	Clock input during program memory writing or verification	Input
4	SI	Serial data input during program memory writing	Input
6	V_{DD}	Power supply Supply +3 V to this pin during program memory writing or verification.	–
7	X_{OUT}**Note**	Clock required during program memory writing or verification. Connect a	–
8	X_{IN}**Note**	4 MHz ceramic resonator to these pins.	Input
9	GND	GND	–
10	V_{PP}	Voltage application pin during program memory writing or verification. Apply +10.5 V to this pin.	–

Note μPD6P8A only

13.1 Initialization

When a high voltage (10.5 V) is supplied to V_{PP}, the programming mode is set after about 1 ms.

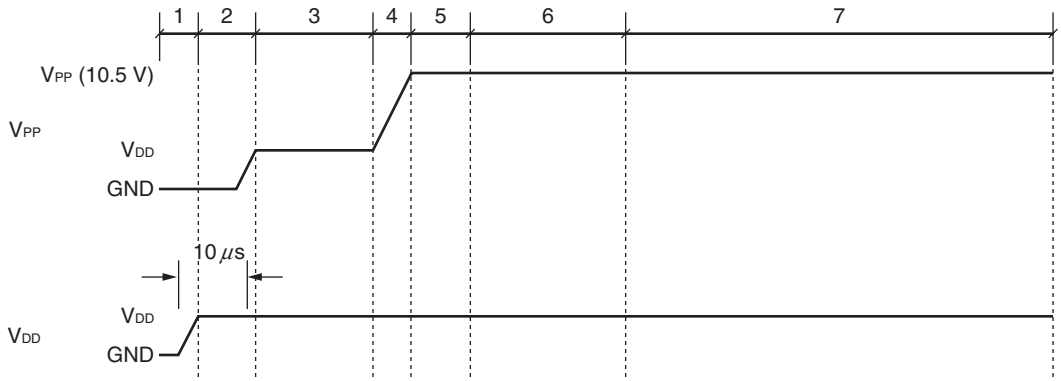
In the programming mode, pins not used for programming are pulled down internally, so leave them open.

$S_1/\overline{LED}$ is set to output mode (H) when 3 V is supplied to V_{DD} and V_{PP}. When a high voltage (10.5 V) is supplied to V_{PP}, the input mode is set after about 1 ms.

Serial communication is performed in 5-bit units, starting from the MSB.

Perform initialization according to the following procedure.

(1) Supply 3 V to the V_{DD} pin. Set the V_{PP} pin to low level.
(2) Supply 3 V (same potential as V_{DD}) to the V_{PP} pin after waiting for 10 μs.
(3) Wait for 2 ms until oscillation stabilizes.
(4) Supply 10.5 V to the V_{PP} pin.
(5) Wait for 1 ms until oscillation stabilizes.
(6) Transmit the PCRESET instruction from the programmer.
(7) Transmit the SSVERIFY instruction from the programmer for silicon signature verification.



13.2 Serial Communication Format

Instruction	Data

All instructions consist of a 5-bit instruction and 5-bit data.

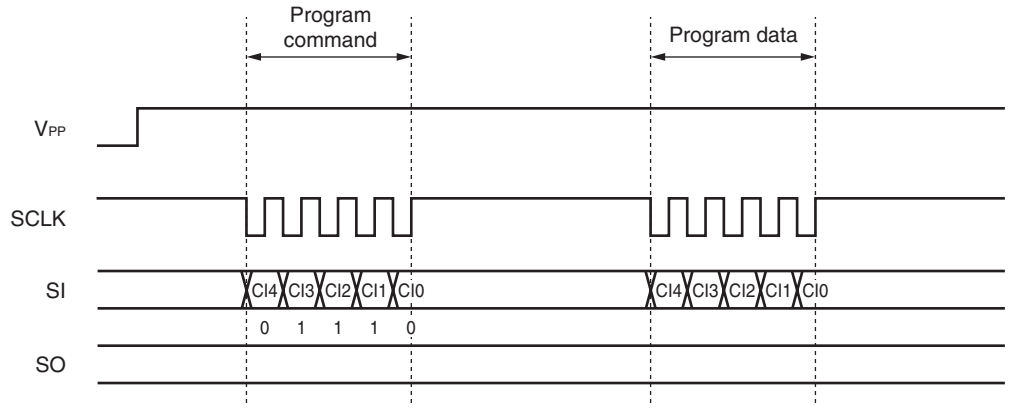
The data from the programmer is latched at the rising edge of SCLK. The μPD6P8A and 6P8B output data is output at the falling edge of SCLK.

Instruction format

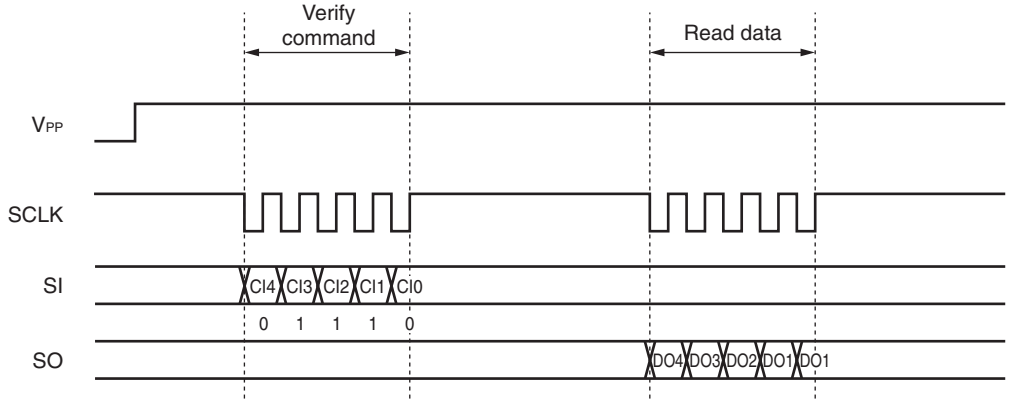
4	3	2	1	0
MD4	MD3	MD2	MD1	MD0

MD4 to MD0	Instruction	Function
05	Reset	Clearing the program memory address to 0
0C	Verify	Verify mode
0E	Program	Write mode
11	Increment	Incrementing of the program memory address
08	Signature verify	Silicon signature verify mode
01	Inhibit	Program inhibit mode

13.3 Writing of Program Memory



13.4 Reading of Program Memory



14. ELECTRICAL SPECIFICATIONS (μPD6P8)

Absolute Maximum Ratings (T_A = +25°C)

Parameter	Symbol	Conditions		Rating	Unit
Power supply voltage	V_{DD}			–0.3 to +5.0	V
	V_{PP}			–0.3 to +11.0	V
Input voltage	V_I	$K_{I/O0}$-$K_{I/O7}$, K_{I0}-K_{I3}, S_0, S_1, S_2		–0.3 to V_{DD} + 0.3	V
Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
Output current, high	I_{OH}[Note]	REM	Peak value	–30	mA
			rms	–20	mA
		$\overline{LED}$	Peak value	–7.5	mA
			rms	–5	mA
		Per $K_{I/O0}$-$K_{I/O7}$ pin	Peak value	–13.5	mA
			rms	–9	mA
		Total for $\overline{LED}$ and $K_{I/O0}$-$K_{I/O7}$ pins	Peak value	–18	mA
			rms	–12	mA
Output current, low	I_{OL}[Note]	REM	Peak value	7.5	mA
			rms	5	mA
		$\overline{LED}$	Peak value	7.5	mA
			rms	5	mA
Operating ambient temperature	T_A			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

Note Calculate the rms with: [rms] = [Peak value] × $\sqrt{\text{Duty}}$.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Power Supply Voltage Range (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage	V_{DD}	f_X = 3.5 to 4.5 MHz	1.9	3.0	3.6	V

DC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Item	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	$K_{I/O0}$-$K_{I/O7}$		0.7V_{DD}		V_{DD}	V
	V_{IH2}	K_{I0}-K_{I3}, S_0, S_1, S_2		0.65V_{DD}		V_{DD}	V
Input voltage, low	V_{IL1}	$K_{I/O0}$-$K_{I/O7}$		0		0.3V_{DD}	V
	V_{IL2}	K_{I0}-K_{I3}, S_0, S_1, S_2		0		0.15V_{DD}	V
Input leakage current, high	I_{LIH1}	K_{I0}-K_{I3} V_I = V_{DD}, pull-down resistor not incorporated				3	μA
	I_{LIH2}	S_0, S_1, S_2 V_I = V_{DD}, pull-down resistor not incorporated				3	μA
Input leakage current, low	I_{LIL1}	K_{I0}-K_{I3} V_I = 0 V				–3	μA
	I_{LIL2}	$K_{I/O0}$-$K_{I/O7}$ V_I = 0 V				–3	μA
	I_{LIL3}	S_0, S_1, S_2 V_I = 0 V				–3	μA
Output voltage, high	V_{OH1}	REM, $\overline{LED}$, $K_{I/O0}$-$K_{I/O7}$	I_{OH} = –0.3 mA	0.8V_{DD}			V
Output voltage, low	V_{OL1}	REM, $\overline{LED}$	I_{OL} = 0.3 mA			0.3	V
	V_{OL2}	$K_{I/O0}$-$K_{I/O7}$	I_{OL} = 15 μA			0.4	V
Output current, high	I_{OH1}	REM	V_{DD} = 3.0 V, V_{OH} = 1.0 V	–5	–9		mA
	I_{OH2}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OH} = 2.2 V	–2.5	–5		mA
Output current, low	I_{OL1}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OL} = 0.4 V	30	70		μA
			V_{DD} = 3.0 V, V_{OL} = 2.2 V	100	220		μA
On-chip pull-down resistor	R_1	K_{I0}-K_{I3}, S_0, S_1, S_2		75	150	300	kΩ
	R_2	$K_{I/O0}$-$K_{I/O7}$		130	250	500	kΩ
Data retention power supply voltage	V_{DDDR}	In STOP mode		1.2		3.6	V
RAM retention detection voltage	V_{ID}				1.8	1.9	V
Supply current	I_{DD1}	Operation mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		1.1	2.2	mA
	I_{DD2}	HALT mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		1.0	2.0	mA
	I_{DD3}	STOP mode	V_{DD} = 3 V ±10%		2.2	9.5	μA
			V_{DD} = 3 V ±10%, T_A = 25°C		2.2	3.5	μA

AC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Instruction execution time	t_{CY}			14	16	18.5	μs
K_{I0}-K_{I3}, S_0, S_1, S_2 high-level width	t_H			10			μs
		When releasing standby mode	In HALT mode	10			μs
			In STOP mode	**Note**			μs
$\overline{\text{RESET}}$ low-level width	t_{RSL}			10			μs

Note 10 + 286/fx + oscillation growth time

Remark t_{CY} = 64/fx (fx: System clock oscillation frequency)

POC Circuit (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
POC detection voltage[Note]	V_{POC}			1.8	1.9	V

Note Refers to the voltage with which the POC circuit releases an internal reset. If $V_{POC} < V_{DD}$, the internal reset is released.
From the time of $V_{POC} \geq V_{DD}$ until the internal reset takes effect, lag of up to 1 ms occurs. When the period of $V_{POC} \geq V_{DD}$ lasts less than 1 ms, the internal reset may not take effect.

System Clock Oscillator Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

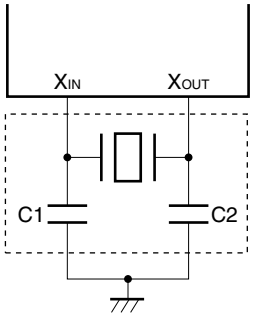
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Oscillation frequency (ceramic resonator)	fx		3.5	4.0	4.5	MHz

RECOMMENDED OSCILLATOR CONSTANT

Ceramic Resonator (T_A = –40 to +85°C)

Manufacturer	Part Number	Frequency (MHz)	Recommended Constant (pF)		Oscillation Voltage Range (V_{DD})		Remark
			C1	C2	MIN.	MAX.	
Murata Mfg. Co., Ltd.	CSTCC3M50G56-R0	3.50	Unnecessary (on-chip C type)		1.9	3.6	–
	CSTLS3M50G56-B0						
	CSTCC3M64G56-R0	3.64					
	CSTLS3M64G56-B0						
	CSTCR4M00G55-R0	4.00					
	CSTLS4M00G56-B0						
	CSTCR4M19G55-R0	4.19					
	CSTLS4M19G56-B0						
	CSTCR4M50G55-R0	4.50					
	CSTLS4M50G56-B0						

External circuit example



Caution These oscillator constants are reference values based on evaluation by the manufacturer of the resonator under a specific environment.
If optimization of the oscillator characteristics is required for the actual application, apply to the resonator manufacturer for evaluation on the mounting circuit.
The oscillation voltage and oscillation frequency only indicate the oscillator characteristics; the oscillator must be used within the ratings of the DC and AC characteristics specified under the internal operation conditions of the μPD6P8.

PROM Programming Mode

DC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	Other than CLK	0.7V_{DD}		V_{DD}	V
	V_{IH2}	CLK	V_{DD} – 0.5		V_{DD}	V
Input voltage, low	V_{IL1}	Other than CLK	0		0.3V_{DD}	V
	V_{IL2}	CLK	0		0.4	V
Input leakage current	I_{LI}	V_{IN} = V_{IL} or V_{IH}			10	μA
Output voltage, high	V_{OH}	I_{OH} = –1 mA	V_{DD} – 1.0			V
Output voltage, low	V_{OL}	I_{OL} = 1.6 mA			0.4	V
V_{DD} supply current	I_{DD}				30	mA
V_{PP} supply current	I_{PP}	MD_0 = V_{IL}, MD_1 = V_{IH}			30	mA

Cautions 1. Keep V_{PP} to within +11.0 V including overshoot.

2. Apply V_{DD} before V_{PP} and turns it off after V_{PP}.

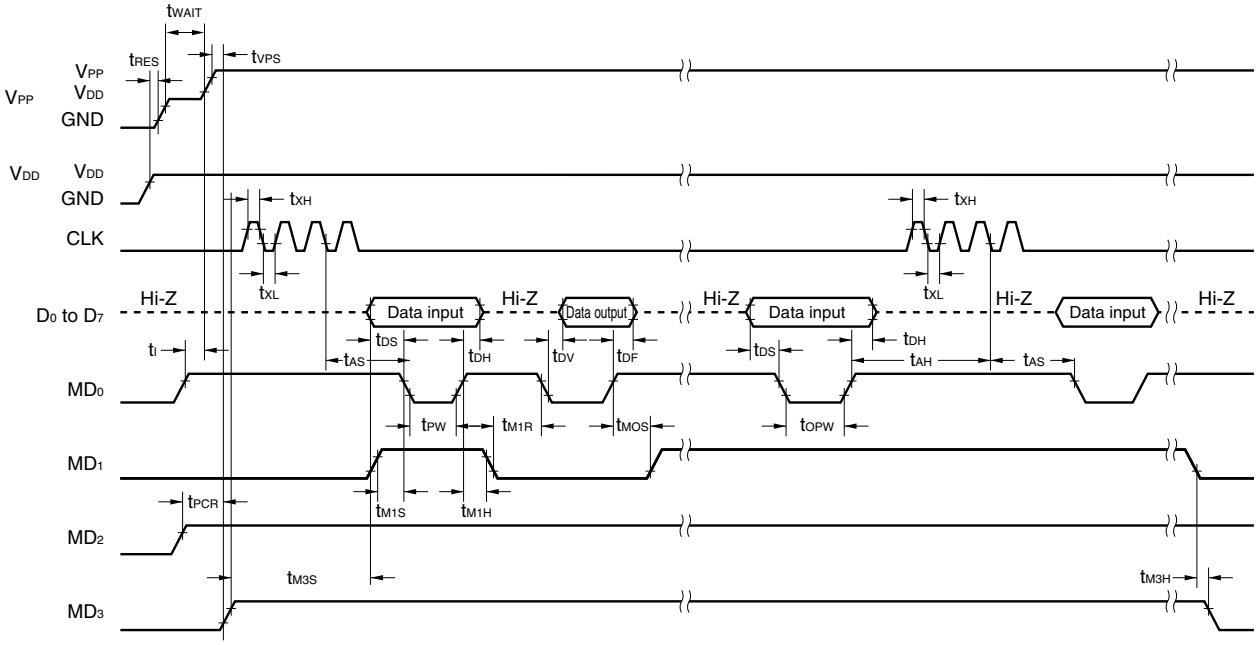
AC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Address setup time[Note 1] (to MD_0↓)	t_{AS}		2			μs
MD_1 setup time (to MD_0↓)	t_{M1S}		2			μs
Data setup time (to MD_0↓)	t_{DS}		2			μs
Address hold time[Note 1] (from MD_0↑)	t_{AH}		2			μs
Data hold time (from MD_0↑)	t_{DH}		2			μs
Delay time from MD_0↑ to data output float	t_{DF}		0		4	μs
V_{PP} setup time (to MD_3↑)	t_{VPS}		2			μs
V_{DD} setup time (to MD_3↑)	t_{VDS}		2			μs
Initial program pulse width	t_{PW}		0.095	0.1	0.105	ms
Additional program pulse width	t_{OPW}		0.095		2.1	ms
MD_0 setup time (to MD_1↑)	t_{MOS}		2			μs
Delay time from MD_0↓ to data output	t_{DV}	MD0 = MD1 = V_{IL}			4	μs
MD_1 hold time (from MD_0↑)	t_{M1H}	$t_{M1H}+t_{M1R} \geq 50$ μs	2			μs
MD_1 recovery time (to MD_0↓)	t_{M1R}		2			μs
Program counter reset time	t_{PCR}		10			μs
CLK input high-/low-level width	t_{XH}, t_{XL}		0.125			μs
CLK input frequency	f_X				4.19	MHz
Initial mode set time	t_I		2			μs
MD_3 setup time (to MD_1↑)	t_{M3S}		2			μs
MD_3 hold time (from MD_1↓)	t_{M3H}		2			μs
MD_3 setup time (to MD_0↓)	t_{M3SR}	When program memory is read	2			μs
Delay time from address[Note 1] to data output	t_{DAD}	When program memory is read			4	μs
Hold time from address[Note 1] to data output	t_{HAD}	When program memory is read	0		4	μs
MD_3 hold time (from MD_0↑)	t_{M3HR}	When program memory is read	2			μs
Delay time from MD_3↓ to data output float	t_{DFR}	When program memory is read			4	μs
Reset setup time	t_{RES}		10			μs
Oscillation stabilization wait time[Note 2]	t_{WAIT}		2			ms

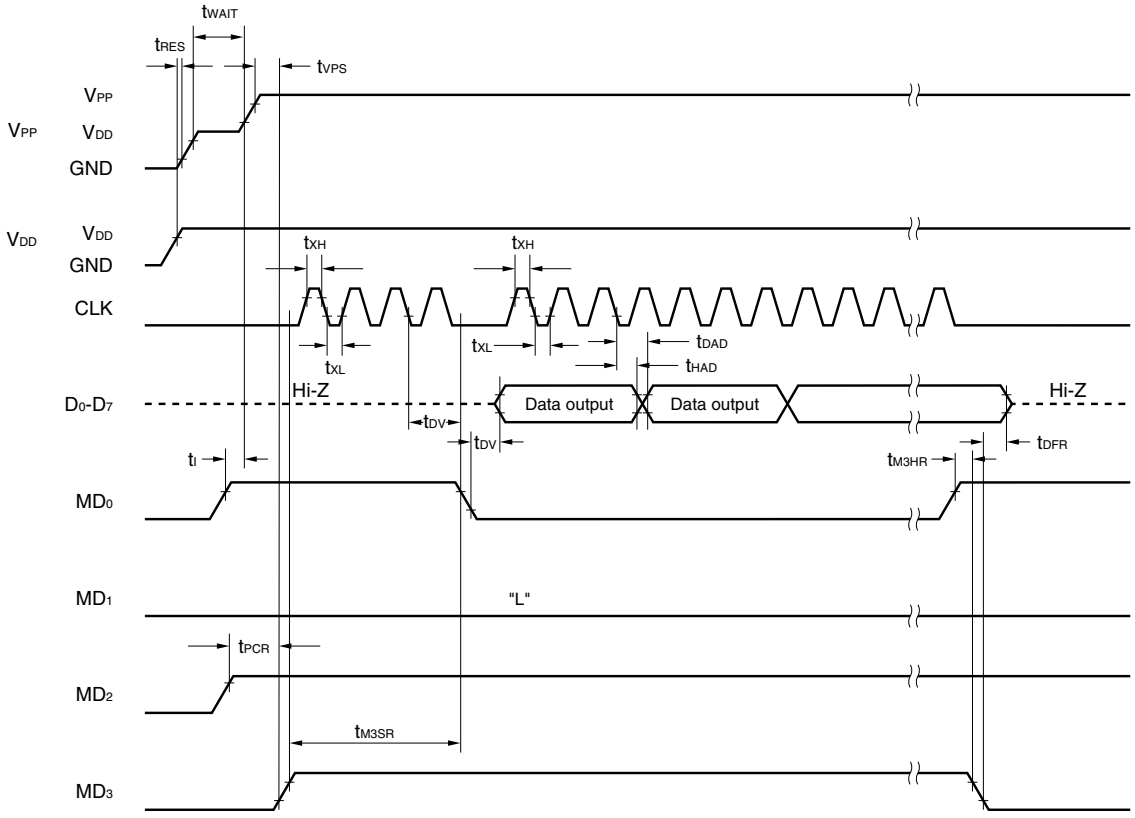
Notes 1. The internal address signal is incremented at the falling edge of the third clock of CLK.

2. Connect a 4 MHz ceramic resonator between the X_{IN} and X_{OUT} pins.

Program Memory Write Timing



Program Memory Read Timing



15. ELECTRICAL SPECIFICATIONS (μPD6P8A)

Absolute Maximum Ratings (T_A = +25°C)

Parameter	Symbol	Conditions		Rating	Unit
Power supply voltage	V_{DD}			–0.3 to +5.0	V
	V_{PP}			–0.3 to +11.0	V
Input voltage	V_I	$K_{I/O0}$-$K_{I/O7}$, K_{I0}-K_{I3}, S_0, S_1, S_2		–0.3 to V_{DD} + 0.3	V
Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
Output current, high	I_{OH}[Note]	REM	Peak value	–30	mA
			rms	–20	mA
		$\overline{LED}$	Peak value	–7.5	mA
			rms	–5	mA
		Per $K_{I/O0}$-$K_{I/O7}$ pin	Peak value	–13.5	mA
			rms	–9	mA
		Total for $\overline{LED}$ and $K_{I/O0}$-$K_{I/O7}$ pins	Peak value	–18	mA
			rms	–12	mA
Output current, low	I_{OL}[Note]	REM	Peak value	7.5	mA
			rms	5	mA
		$\overline{LED}$	Peak value	7.5	mA
			rms	5	mA
Operating ambient temperature	T_A			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

Note Calculate the rms with: [rms] = [Peak value] × $\sqrt{\text{Duty}}$.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Power Supply Voltage Range (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage	V_{DD}	f_X = 3.5 to 4.5 MHz	1.9	3.0	3.6	V

DC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Item	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	$K_{I/O0}$-$K_{I/O7}$		0.7V_{DD}		V_{DD}	V
	V_{IH2}	K_{I0}-K_{I3}, S_0, S_1, S_2		0.65V_{DD}		V_{DD}	V
Input voltage, low	V_{IL1}	$K_{I/O0}$-$K_{I/O7}$		0		0.3V_{DD}	V
	V_{IL2}	K_{I0}-K_{I3}, S_0, S_1, S_2		0		0.15V_{DD}	V
Input leakage current, high	I_{LIH1}	K_{I0}-K_{I3} V_I = V_{DD}, pull-down resistor not incorporated				3	μA
	I_{LIH2}	S_0, S_1, S_2 V_I = V_{DD}, pull-down resistor not incorporated				3	μA
Input leakage current, low	I_{LIL1}	K_{I0}-K_{I3} V_I = 0 V				–3	μA
	I_{LIL2}	$K_{I/O0}$-$K_{I/O7}$ V_I = 0 V				–3	μA
	I_{LIL3}	S_0, S_1, S_2 V_I = 0 V				–3	μA
Output voltage, high	V_{OH1}	REM, $\overline{LED}$, $K_{I/O0}$-$K_{I/O7}$	I_{OH} = –0.3 mA	0.8V_{DD}			V
Output voltage, low	V_{OL1}	REM, $\overline{LED}$	I_{OL} = 0.3 mA			0.3	V
	V_{OL2}	$K_{I/O0}$-$K_{I/O7}$	I_{OL} = 15 μA			0.4	V
Output current, high	I_{OH1}	REM	V_{DD} = 3.0 V, V_{OH} = 1.0 V	–5	–9		mA
	I_{OH2}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OH} = 2.2 V	–2.5	–5		mA
Output current, low	I_{OL1}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OL} = 0.4 V	30	70		μA
			V_{DD} = 3.0 V, V_{OL} = 2.2 V	100	220		μA
On-chip pull-down resistor	R_1	K_{I0}-K_{I3}, S_0, S_1, S_2		75	150	300	kΩ
	R_2	$K_{I/O0}$-$K_{I/O7}$		130	250	500	kΩ
Data retention power supply voltage	V_{DDDR}	In STOP mode		1.2		3.6	V
RAM retention detection voltage	V_{ID}				1.6	1.7	V
Supply current	I_{DD1}	Operation mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		0.7	1.4	mA
	I_{DD2}	HALT mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		0.65	1.3	mA
	I_{DD3}	STOP mode	V_{DD} = 3 V ±10%		2.2	9.5	μA
			V_{DD} = 3 V ±10%, T_A = 25°C		2.2	3.5	μA

AC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Instruction execution time	t_{CY}			14	16	18.5	μs
K_{I0}-K_{I3}, S_0, S_1, S_2 high-level width	t_H			10			μs
		When releasing standby mode	In HALT mode	10			μs
			In STOP mode	**Note**			μs
$\overline{RESET}$ low-level width	t_{RSL}			10			μs

Note 10 + 1024/f_X + oscillation growth time

Remark t_{CY} = 64/f_X (f_X: System clock oscillation frequency)

POC Circuit (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
POC detection voltage[Note]	V_{POC}			1.8	1.9	V

Note Refers to the voltage with which the POC circuit releases an internal reset. If $V_{POC} < V_{DD}$, the internal reset is released.
From the time of $V_{POC} \geq V_{DD}$ until the internal reset takes effect, lag of up to 1 ms occurs. When the period of $V_{POC} \geq V_{DD}$ lasts less than 1 ms, the internal reset may not take effect.

System Clock Oscillator Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

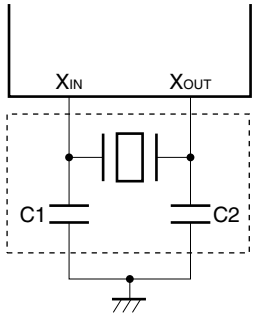
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Oscillation frequency (ceramic resonator)	f_X		3.5	4.0	4.5	MHz

<R> RECOMMENDED OSCILLATOR CONSTANT

Ceramic Resonator (T_A = –40 to +85°C)

Manufacturer	Part Number	Frequency (MHz)	Recommended Constant (pF)		Oscillation Voltage Range (V_{DD})		Remark
			C1	C2	MIN.	MAX.	
Murata Mfg. Co., Ltd.	CSTLS3M64G56-B0	3.64	Unnecessary (on-chip C type)		1.9	3.6	–
	CSTLS4M00G53-B0	4.0					
	CSTLS4M19G53-B0	4.19					
TDK Corporation	FCR3.64MXC5	3.64					
	FCR4.0MXC5	4.0					
	FCR4.19MXC5	4.19					
TOKO, Inc.	DCRHTC (P) 3.64MLL	3.64					
	DCRHTC (P) 4.00MLL	4.0					
	DCRHTC (P) 4.19MLL	4.19					

External circuit example



Caution These oscillator constants are reference values based on evaluation by the manufacturer of the resonator under a specific environment.
If optimization of the oscillator characteristics is required for the actual application, apply to the resonator manufacturer for evaluation on the mounting circuit.
The oscillation voltage and oscillation frequency only indicate the oscillator characteristics; the oscillator must be used within the ratings of the DC and AC characteristics specified under the internal operation conditions of the μPD6P8A.

PROM Programming Mode

DC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	Other than SCLK	0.7V_{DD}		V_{DD}	V
	V_{IH2}	SCLK	V_{DD} – 0.5		V_{DD}	V
Input voltage, low	V_{IL1}	Other than SCLK	0		0.3V_{DD}	V
	V_{IL2}	SCLK	0		0.4	V
Input leakage current	I_{LI}	V_{IN} = V_{IL} or V_{IH}			10	μA
Output voltage, high	V_{OH}	I_{OH} = –1 mA	V_{DD} – 1.0			V
Output voltage, low	V_{OL}	I_{OL} = 1.6 mA			0.4	V
V_{DD} supply current	I_{DD}				2	mA
V_{PP} supply current	I_{PP}				0.3	mA

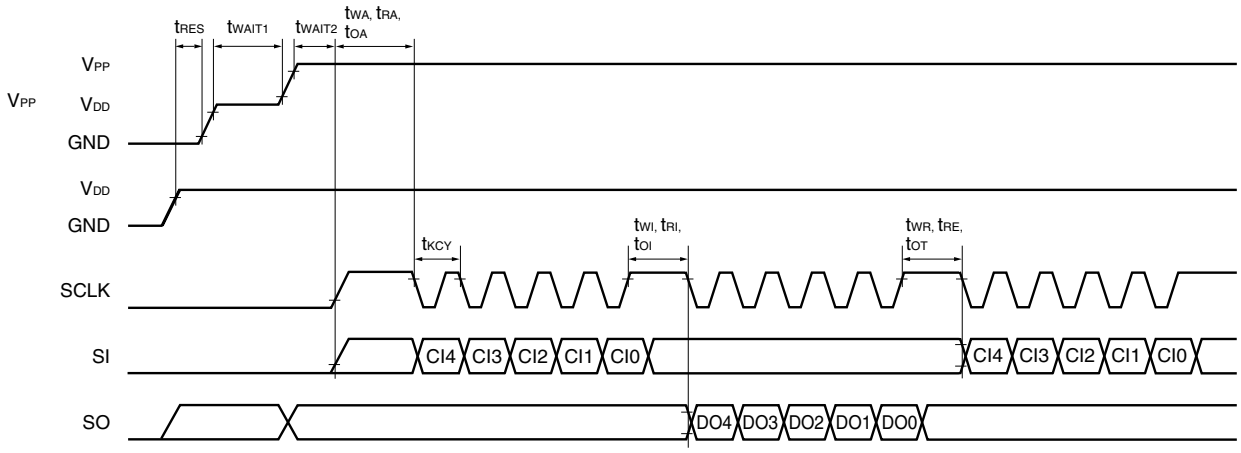
Cautions 1. Keep V_{PP} to within +11.0 V including overshoot.

2. Apply V_{DD} before V_{PP} and turns it off after V_{PP}.

AC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Reset setup time	t_{RES}		10			μs
Oscillation stabilization wait time1	t_{WAIT1}		2			ms
Oscillation stabilization wait time2	t_{WAIT2}		1			ms
SCLK cycle time	t_{KCY}				1	MHz
V_{PP} setup time (to Program command)	t_{WA}		1.8			ms
Program command → Data input wait time	t_{WI}		0.25			μs
Program data → Command input wait time	t_{WR}		90			μs
V_{PP} setup time (to Verify command)	t_{RA}		1.8			ms
Verify command → Data output wait time	t_{RI}		5			μs
Verify data → Command input wait time	t_{RE}		0.25			μs
V_{PP} setup time (to Reset, Increase, Inhibit command)	t_{OA}		1.8			ms
Reset, Increase, Inhibit command → Data (NULL) input wait time	t_{OI}		0.25			μs
Reset, Increase, Inhibit command → Command input wait time	t_{OT}		0.25			μs

Program Memory Access Timing



16. ELECTRICAL SPECIFICATIONS (μPD6P8B)

Absolute Maximum Ratings (T_A = +25°C)

Parameter	Symbol	Conditions		Rating	Unit
Power supply voltage	V_{DD}			–0.3 to +5.0	V
	V_{PP}			–0.3 to +11.0	V
Input voltage	V_I	$K_{I/O0}$-$K_{I/O7}$, K_{I0}-K_{I3}, S_0, S_1, S_2, S_3		–0.3 to V_{DD} + 0.3	V
Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
Output current, high	I_{OH}[Note]	REM	Peak value	–30	mA
			rms	–20	mA
		$\overline{LED}$	Peak value	–7.5	mA
			rms	–5	mA
		Per $K_{I/O0}$-$K_{I/O7}$ pin	Peak value	–13.5	mA
			rms	–9	mA
		Total for $\overline{LED}$ and $K_{I/O0}$-$K_{I/O7}$ pins	Peak value	–18	mA
			rms	–12	mA
Output current, low	I_{OL}[Note]	REM	Peak value	7.5	mA
			rms	5	mA
		$\overline{LED}$	Peak value	7.5	mA
			rms	5	mA
Operating ambient temperature	T_A			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

Note Calculate the rms with: [rms] = [Peak value] × $\sqrt{\text{Duty}}$.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Power Supply Voltage Range (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage	V_{DD}	f_X = 3.5 to 4.5 MHz	1.9	3.0	3.6	V

DC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Item	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	$K_{I/O0}$-$K_{I/O7}$		0.7V_{DD}		V_{DD}	V
	V_{IH2}	K_{I0}-K_{I3}, S_0, S_1, S_2, S_3		0.65V_{DD}		V_{DD}	V
Input voltage, low	V_{IL1}	$K_{I/O0}$-$K_{I/O7}$		0		0.3V_{DD}	V
	V_{IL2}	K_{I0}-K_{I3}, S_0, S_1, S_2, S_3		0		0.15V_{DD}	V
Input leakage current, high	I_{LIH1}	K_{I0}-K_{I3} V_I = V_{DD}, pull-down resistor not incorporated				3	μA
	I_{LIH2}	S_0, S_1, S_2, S_3 V_I = V_{DD}, pull-down resistor not incorporated				3	μA
Input leakage current, low	I_{LIL1}	K_{I0}-K_{I3} V_I = 0 V				–3	μA
	I_{LIL2}	$K_{I/O0}$-$K_{I/O7}$ V_I = 0 V				–3	μA
	I_{LIL3}	S_0, S_1, S_2, S_3 V_I = 0 V				–3	μA
Output voltage, high	V_{OH1}	REM, $\overline{LED}$, $K_{I/O0}$-$K_{I/O7}$	I_{OH} = –0.3 mA	0.8V_{DD}			V
Output voltage, low	V_{OL1}	REM, $\overline{LED}$	I_{OL} = 0.3 mA			0.3	V
	V_{OL2}	$K_{I/O0}$-$K_{I/O7}$	I_{OL} = 15 μA			0.4	V
Output current, high	I_{OH1}	REM	V_{DD} = 3.0 V, V_{OH} = 1.0 V	–5	–9		mA
	I_{OH2}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OH} = 2.2 V	–2.5	–5		mA
Output current, low	I_{OL1}	$K_{I/O0}$-$K_{I/O7}$	V_{DD} = 3.0 V, V_{OL} = 0.4 V	30	70		μA
			V_{DD} = 3.0 V, V_{OL} = 2.2 V	100	220		μA
On-chip pull-down resistor	R_1	K_{I0}-K_{I3}, S_0, S_1, S_2, S_3		75	150	300	kΩ
	R_2	$K_{I/O0}$-$K_{I/O7}$		130	250	500	kΩ
Data retention power supply voltage	V_{DDDR}	In STOP mode		1.2		3.6	V
RAM retention detection voltage	V_{ID}				1.6	1.7	V
Supply current	I_{DD1}	Operation mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		0.7	1.4	mA
	I_{DD2}	HALT mode	f_X = 4.0 MHz, V_{DD} = 3 V ±10%		0.65	1.3	mA
	I_{DD3}	STOP mode	V_{DD} = 3 V ±10%		2.4	9.5	μA
			V_{DD} = 3 V ±10%, T_A = 25°C		2.4	3.5	μA

AC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Instruction execution time	t_{CY}			14	16	18.5	μs
K_{I0}-K_{I3}, S_0, S_1, S_2, S_3 high-level width	t_H			10			μs
		When releasing standby mode	In HALT mode	10			μs
			In STOP mode	**Note**			μs
$\overline{RESET}$ low-level width	t_{RSL}			10			μs

Note 10 + 1024/f_X

Remark t_{CY} = 64/f_X (f_X: System clock oscillation frequency)

POC Circuit (T_A = –40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
POC detection voltage[Note]	V_{POC}			1.8	1.9	V

Note Refers to the voltage with which the POC circuit releases an internal reset. If $V_{POC} < V_{DD}$, the internal reset is released.
From the time of $V_{POC} \geq V_{DD}$ until the internal reset takes effect, lag of up to 1 ms occurs. When the period of $V_{POC} \geq V_{DD}$ lasts less than 1 ms, the internal reset may not take effect.

Internal Oscillator Characteristics (T_A = –40 to +85°C, V_{DD} = 1.9 to 3.6 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Oscillation frequency	f_{X1}		3.5		4.5	MHz
	f_{X2}	T_A = –10 to +70°C	3.92		4.08	MHz
	f_{X3}	T_A = –10 to +60°C	3.928		4.072	MHz

PROM Programming Mode

DC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	Other than SCLK	0.7V_{DD}		V_{DD}	V
	V_{IH2}	SCLK	V_{DD} – 0.5		V_{DD}	V
Input voltage, low	V_{IL1}	Other than SCLK	0		0.3V_{DD}	V
	V_{IL2}	SCLK	0		0.4	V
Input leakage current	I_{LI}	V_{IN} = V_{IL} or V_{IH}			10	μA
Output voltage, high	V_{OH}	I_{OH} = –1 mA	V_{DD} – 1.0			V
Output voltage, low	V_{OL}	I_{OL} = 1.6 mA			0.4	V
V_{DD} supply current	I_{DD}				2	mA
V_{PP} supply current	I_{PP}				0.3	mA

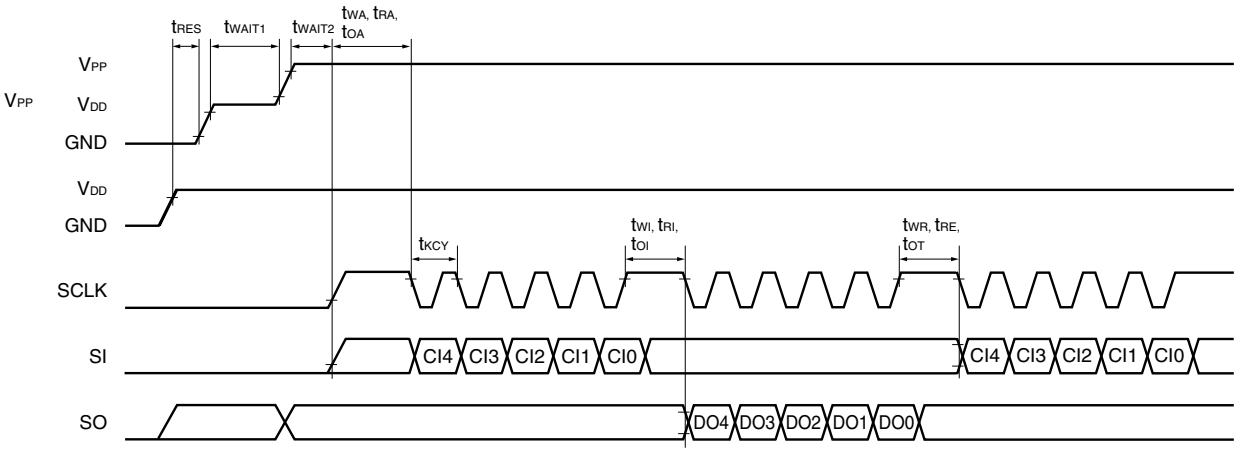
Cautions 1. Keep V_{PP} to within +11.0 V including overshoot.

2. Apply V_{DD} before V_{PP} and turns it off after V_{PP}.

AC programming characteristics (T_A = 25°C, V_{DD} = 3.0 ±0.3 V, V_{PP} = 10.5 ±0.3 V)

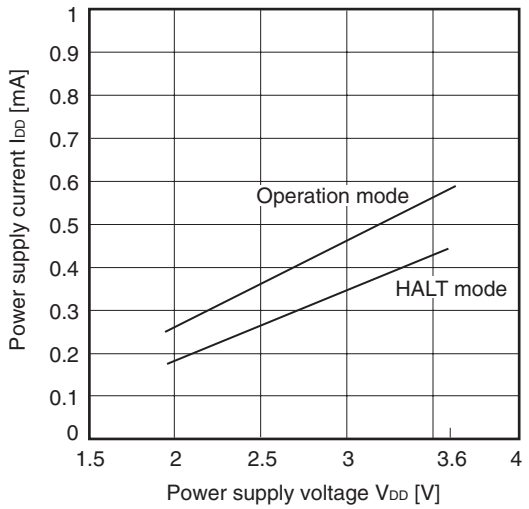
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Reset setup time	t_{RES}		10			μs
Oscillation stabilization wait time1	t_{WAIT1}		2			ms
Oscillation stabilization wait time2	t_{WAIT2}		1			ms
SCLK cycle time	t_{KCY}				1	MHz
V_{PP} setup time (to Program command)	t_{WA}		1.8			ms
Program command → Data input wait time	t_{WI}		0.25			μs
Program data → Command input wait time	t_{WR}		90			μs
V_{PP} setup time (to Verify command)	t_{RA}		1.8			ms
Verify command → Data output wait time	t_{RI}		5			μs
Verify data → Command input wait time	t_{RE}		0.25			μs
V_{PP} setup time (to Reset, Increase, Inhibit command)	t_{OA}		1.8			ms
Reset, Increase, Inhibit command → Data (NULL) input wait time	t_{OI}		0.25			μs
Reset, Increase, Inhibit command → Command input wait time	t_{OT}		0.25			μs

Program Memory Access Timing

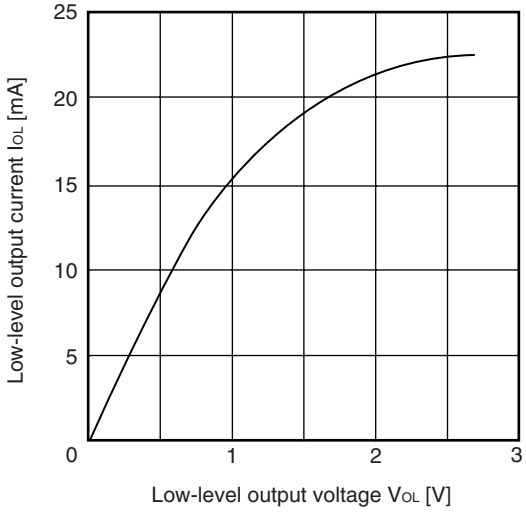


17. CHARACTERISTIC CURVES (REFERENCE VALUES) (μPD6P8)

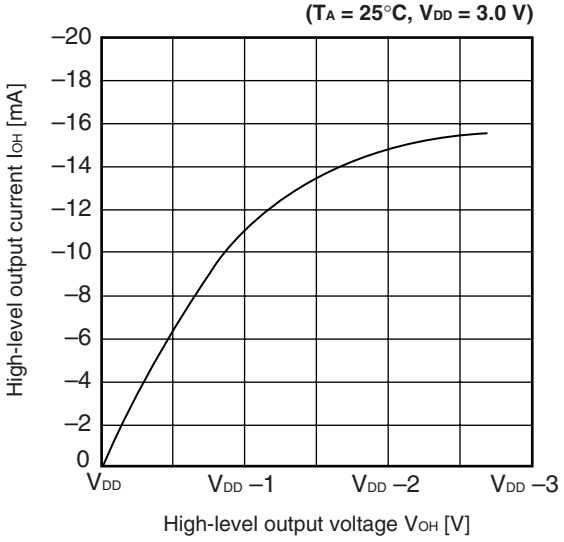
I_{DD} vs. V_{DD} (fx = 4 MHz)
(T_A = 25°C)



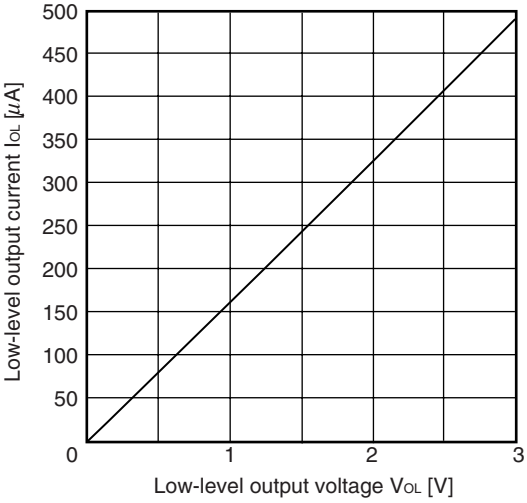
I_{OL} vs. V_{OL} (REM, $\overline{LED}$)
(T_A = 25°C, V_{DD} = 3.0 V)



I_{OH} vs. V_{OH} (REM, $\overline{LED}$, $K_{I/O}$)
(T_A = 25°C, V_{DD} = 3.0 V)



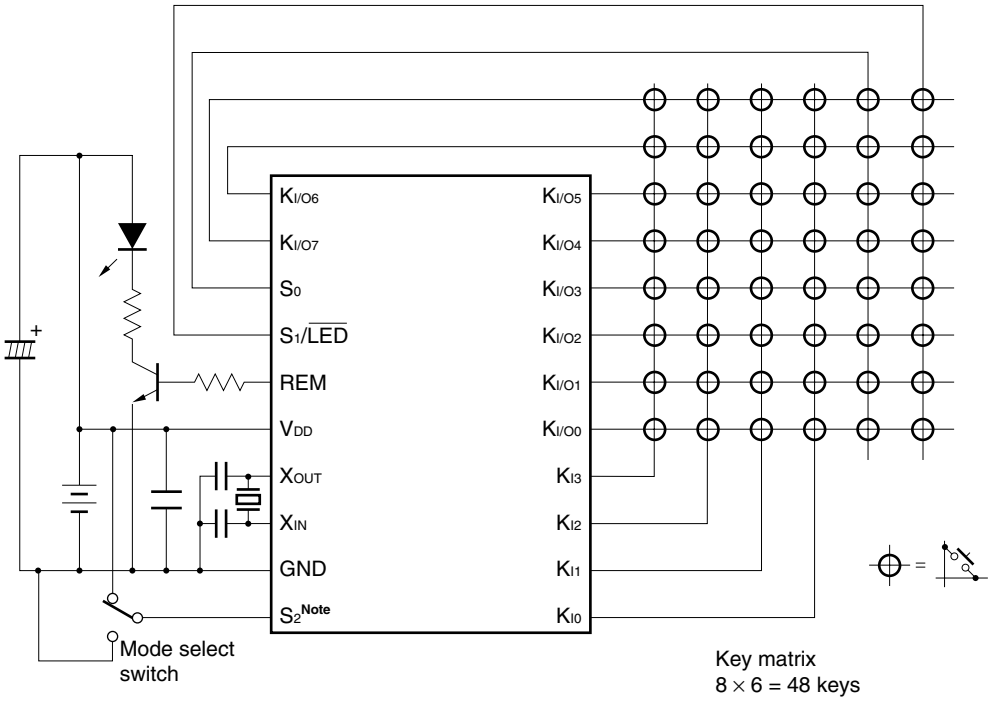
I_{OL} vs. V_{OL} ($K_{I/O}$)
(T_A = 25°C, V_{DD} = 3.0 V)



18. APPLICATION CIRCUIT EXAMPLE

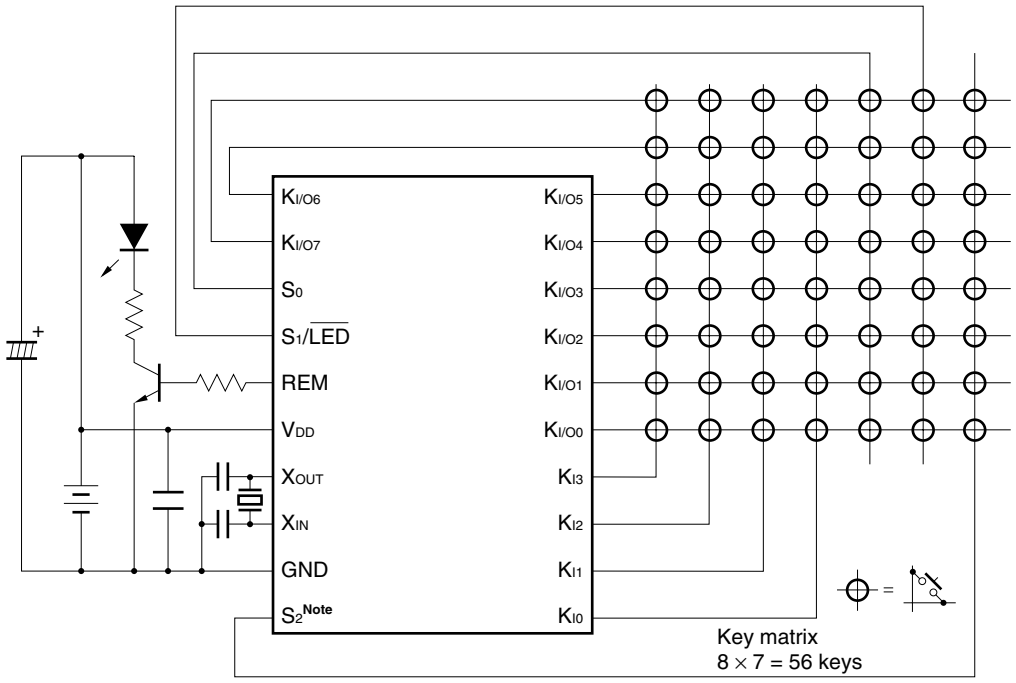
Example of Application to System

- **Remote-control transmitter (48 keys accommodated, mode selection switch accommodated)**



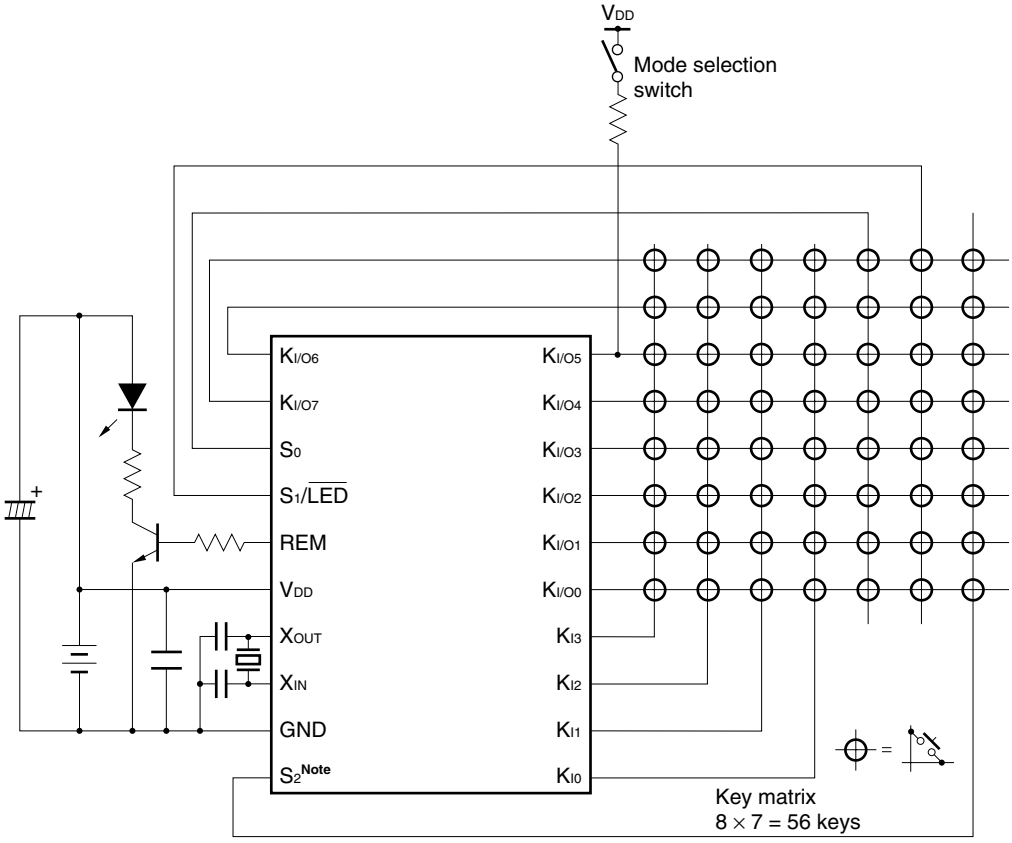
Note S_2: Set to STOP mode release disabled

• **Remote-control transmitter (56 keys accommodated)**



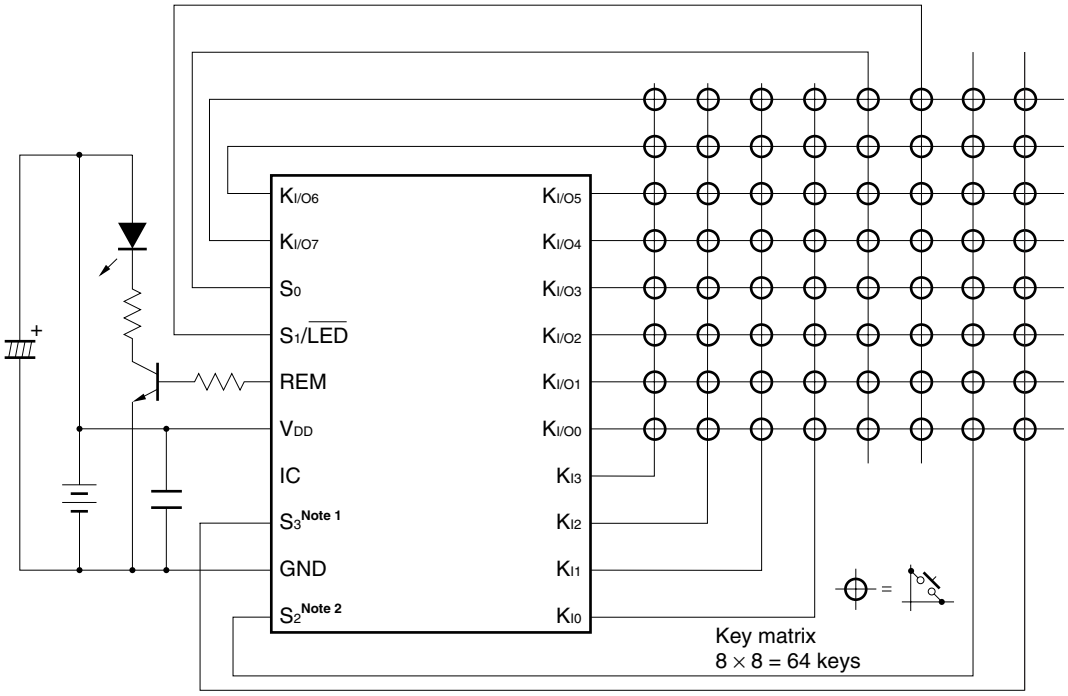
Note S_2: Set to STOP mode release enabled

- **Remote-control transmitter (56 keys accommodated, mode selection switch accommodated)**
  Data can be read from the $K_{I/O0}$ to $K_{I/O7}$ pins by connecting a pull-up resistor of approx. 50 kΩ and a switch to these pins (which then become high level when the switch is on and low level when off). Set the $K_{I/O0}$ to $K_{I/O7}$ pins to input mode at this time. Reading data from these pins enables multiple output data to be obtained for the same key input.
  A pull-up resistor can be connected to any of pins $K_{I/O0}$ to $K_{I/O7}$ (the figure below shows an example of when a pull-up resistor is connected to the $K_{I/O5}$ pin).



Note S_2: Set to STOP mode release enabled

• **Remote-control transmitter (64 keys accommodated, μPD6P8B only)**

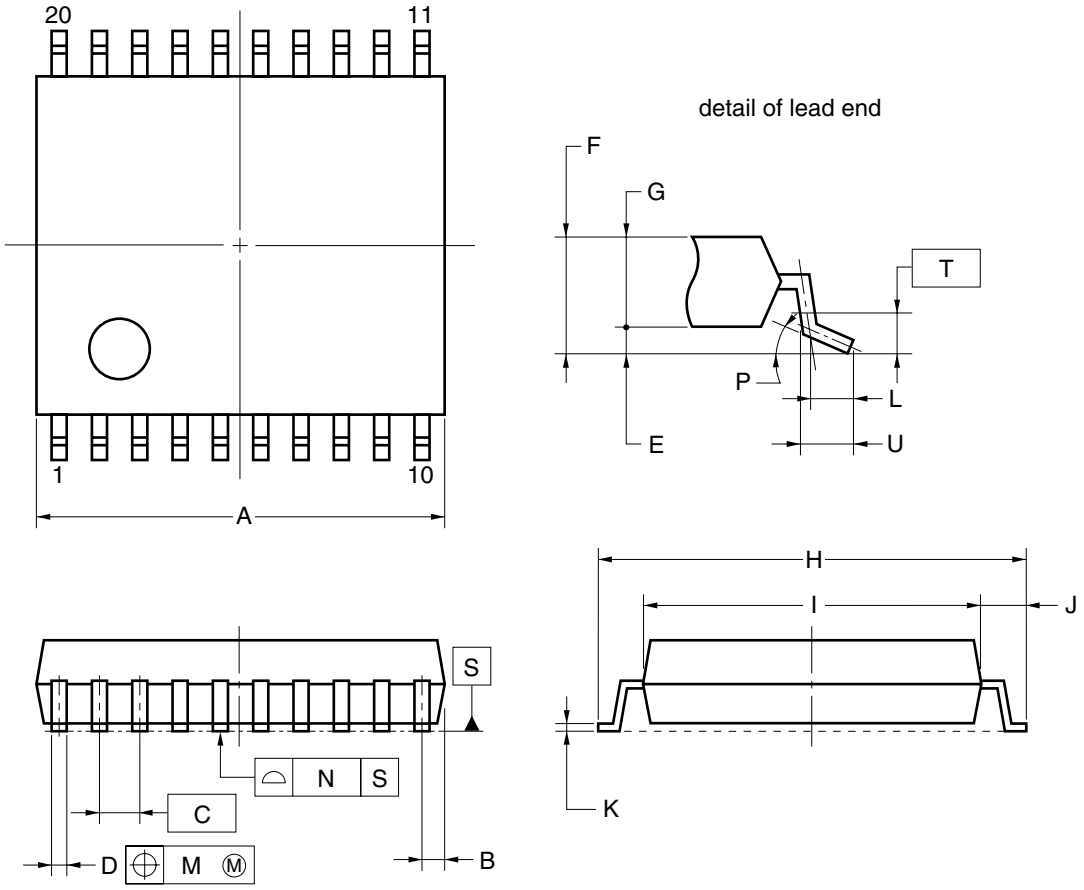


Notes 1. Use an actual device to emulate the S_3 pin, because the emulator does not support S_3 pin emulation.

2. S_2: Set to STOP mode release enabled

19. PACKAGE DRAWING

20-PIN PLASTIC SSOP (7.62 mm (300))



NOTE

Each lead centerline is located within 0.13 mm of its true position (T.P.) at maximum material condition.

(UNIT:mm)

ITEM	MILLIMETERS
A	6.65±0.15
B	0.475 MAX.
C	0.65 (T.P.)
D	$0.24^{+0.08}_{-0.07}$
E	0.1±0.05
F	1.3±0.1
G	1.2
H	8.1±0.2
I	6.1±0.2
J	1.0±0.2
K	0.17±0.03
L	0.5
M	0.13
N	0.10
P	$3^{\circ}{}^{+5^{\circ}}_{-3^{\circ}}$
T	0.25
U	0.6±0.15

S20MC-65-5A4-2

20. RECOMMENDED SOLDERING CONDITIONS

The μPD6P8, 6P8A, and 6P8B must be soldered and mounted under the following recommended conditions.

For soldering methods and conditions other than those recommended below, contact an NEC Electronics sales representative.

For technical information, see the following website.

Semiconductor Device Mount Manual (http://www.necel.com/pkg/en/mount/index.html)

Table 20-1. Surface Mounting Soldering Conditions

μPD6P8MC-5A4-A, 6P8AMC-5A4-A, 6P8BMC-5A4-A: 20-pin plastic SSOP (7.62 mm (300))

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 260°C, Time: 60 seconds max. (at 220°C or higher), Count: Three times or less, Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 to 72 hours)	IR60-207-3
Wave soldering	For details, contact an NEC Electronics sales representative.	–
Partial heating	Pin temperature: 350°C max., Time: 3 seconds max. (per pin row)	–

Note After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

Caution Do not use different soldering methods together (except for partial heating).

Remark Products that have the part numbers suffixed by “-A” are lead-free products.

APPENDIX A. DEVELOPMENT TOOLS

A PROM programmer, program adapter, and an emulator are provided for the μPD6P8, 6P8A, 6P8B.

Hardware

- **PROM programmer (AF-9709C[Note], AF-9723B[Note])**
  These PROM programmers support the μPD6P8, 6P8A, 6P8B.
  By connecting a program adapter to this PROM programmer, the μPD6P8, 6P8A, 6P8B can be programmed.

  Note These are products of Flash Support Group, Inc. For details, consult Flash Support Group, Inc. (TEL: +81-53-459-1050).

- **Program adapter**
  (1) TEF340-6P8[Note]
  This is used to program the μPD6P8 in combination with the AF-9709C or AF-9723B.

  (2) TEF340-6P8A[Note]
  This is used to program the μPD6P8A, 6P8B in combination with the AF-9709C or AF-9723B.

  Note These are products of Flash Support Group, Inc. For details, consult Flash Support Group, Inc. (TEL: +81-53-459-1050).

- **Emulator (EB-69A[Note])**
  This is used to emulate the μPD6P8, 6P8A, 6P8B.
<R> Use an actual device to emulate the S_3 pin, because the emulator does not support S_3 pin emulation of the μPD6P8B.

  Note These are products of Naito Densei Machida Mfg. Co., Ltd. For details, contact Naito Densei Machida Mfg. Co., Ltd. (+81-42-750-4172).

Software

- **Assembler (AS6133 Ver. 2.22 or later)**
  This is a development tool for remote control transmitter software.

Part Number List of AS6133

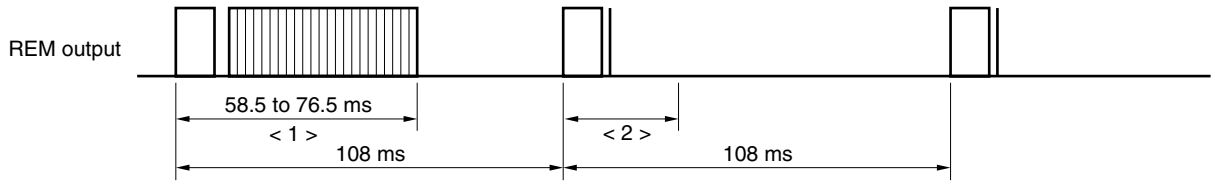
Host Machine	OS	Supply Medium	Part Number
PC-9800 series (CPU: 80386 or later)	MS-DOS™ (Ver. 5.0 to Ver. 6.2)	3.5-inch 2HD	μS5A13AS6133
IBM PC/AT™ compatible	MS-DOS (Ver. 6.0 to Ver. 6.22)	3.5-inch 2HC	μS7B13AS6133
	PC DOS™ (Ver. 6.1 to Ver. 6.3)		

Caution Although Ver.5.0 or later has a task swap function, this function cannot be used with this software.

APPENDIX B. EXAMPLE OF REMOTE CONTROL TRANSMISSION FORMAT
(In the case of NEC transmission format in command one-shot transmission mode)

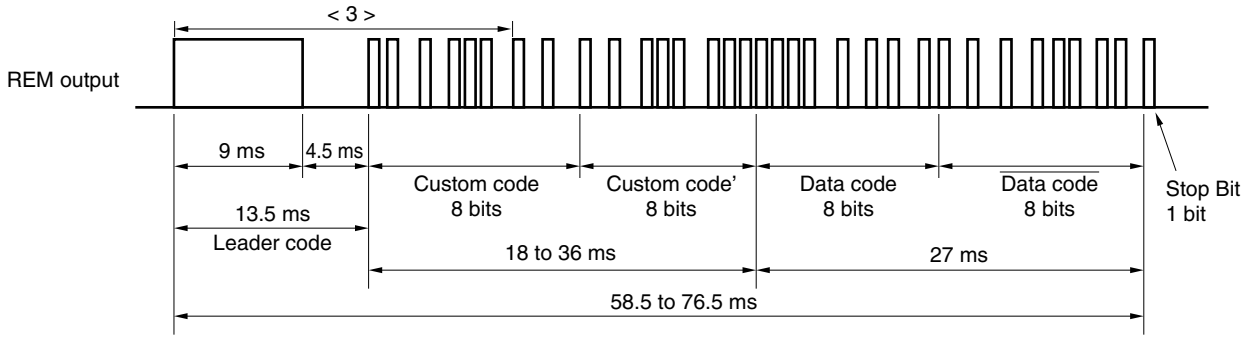
Caution When using the NEC transmission format, please apply for a custom code at NEC Electronics.

(1) REM output waveform (from <2> on, the output is made only when the key is kept pressed)

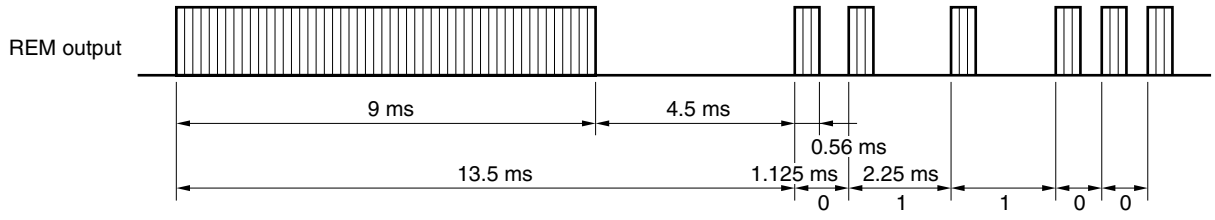


Remark If the key is repeatedly pressed, the power consumption of the infrared light-emitting diode (LED) can be reduced by sending the reader code and the stop bit from the second time.

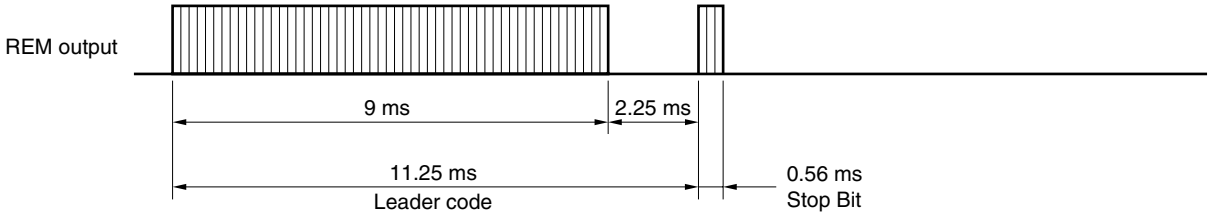
(2) Enlarged waveform of <1>



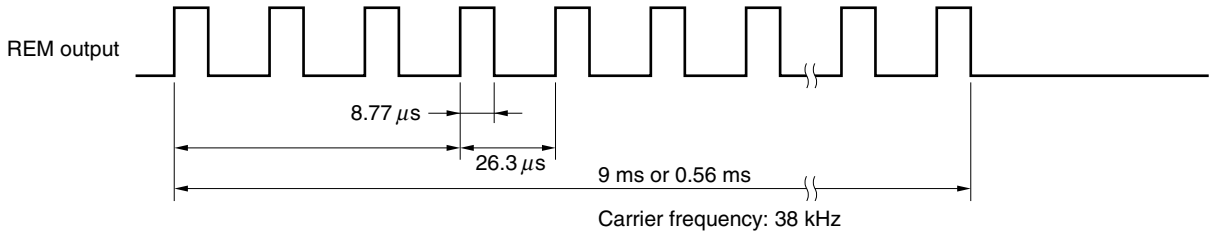
(3) Enlarged waveform of <3>



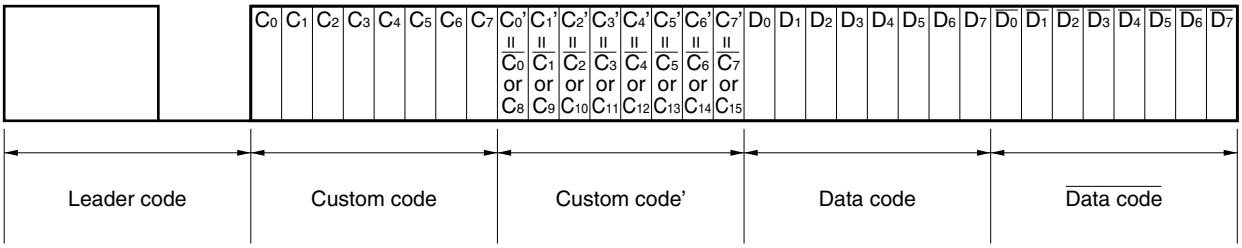
(4) Enlarged waveform of <2>



(5) Carrier waveform (enlarged waveform of each code's high period)



(6) Bit array of each code



Caution To prevent malfunction with other systems when receiving data in the NEC transmission format, not only fully decode (make sure to check Data Code as well) the total 32 bits of the 16-bit custom codes (Custom Code, Custom Code') and the 16-bit data codes (Data Code, Data Code) but also check to make sure that no signals are present.

NOTES FOR CMOS DEVICES

① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements.

Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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