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4-BIT SINGLE CHIP MICROCOMPUTERS

HMS38112/39112

USER`S MANUAL

- HMS38112
- HMS39112

VER. 1.00
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CHAPTER 1. HMS38112

Outline of characteristics

The HMS38112 is remote control transmitter which uses CMOS technology
This enables transmission code outputs of different configurations, multiple custom code output, and double push key output for easy fabrication.
The HMS38112 is suitable for remote control of TV, VCR, FANS, Air-conditioners, Audio Equipments, Toys, Games etc.

Characteristics

- Program memory : 1,024 bytes
- Data memory : 32 × 4 bits
- 43 types of instruction set
- 3 levels of subroutine nesting
- Operating frequency : 2.4MHz ~ 4MHz
- Instruction cycle : $f_{OSC}/48$
- CMOS process (Single 3.0V power supply)
- Stop mode (Through internal instruction)
- Released stop mode by key input(mask option)
- Built in Power-on Reset circuit
- Built in Transistor for I.R LED Drive : I_{OL}=250mA at V_{DD}=3V and V_O=0.3V
- Built in Low Voltage reset circuit
- Built in a watch dog timer (WDT)
- Low operating voltage : 2.0 ~ 3.6V
- 20 pin PDIP/SOP/SSOP package

Block Diagram

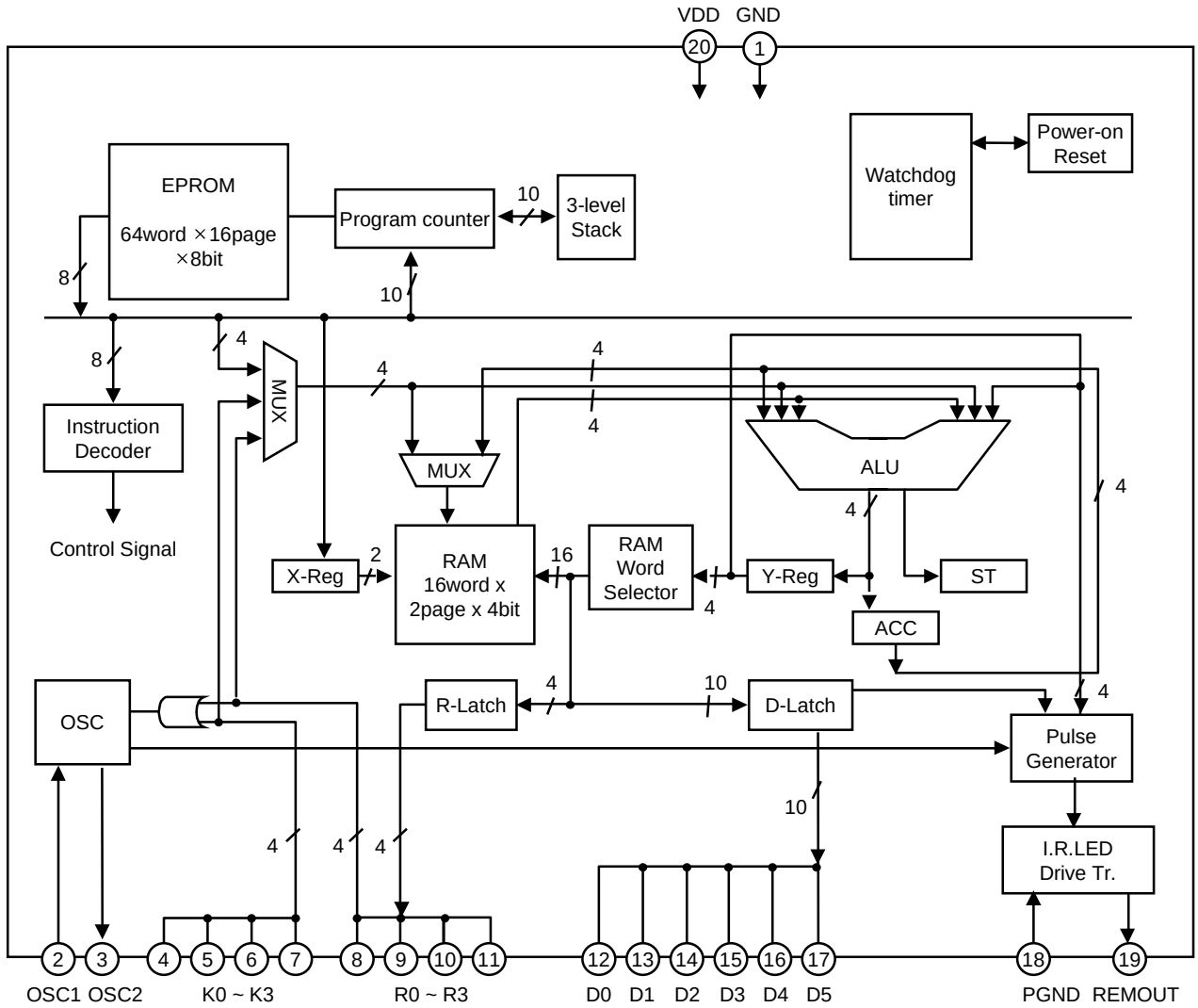


Fig 1-1 Block Diagram

Pin Assignment

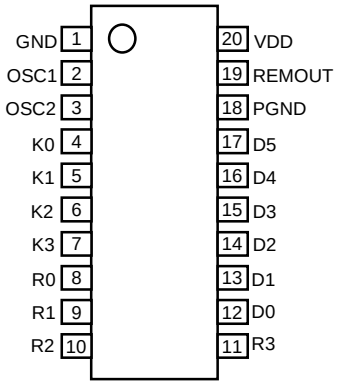
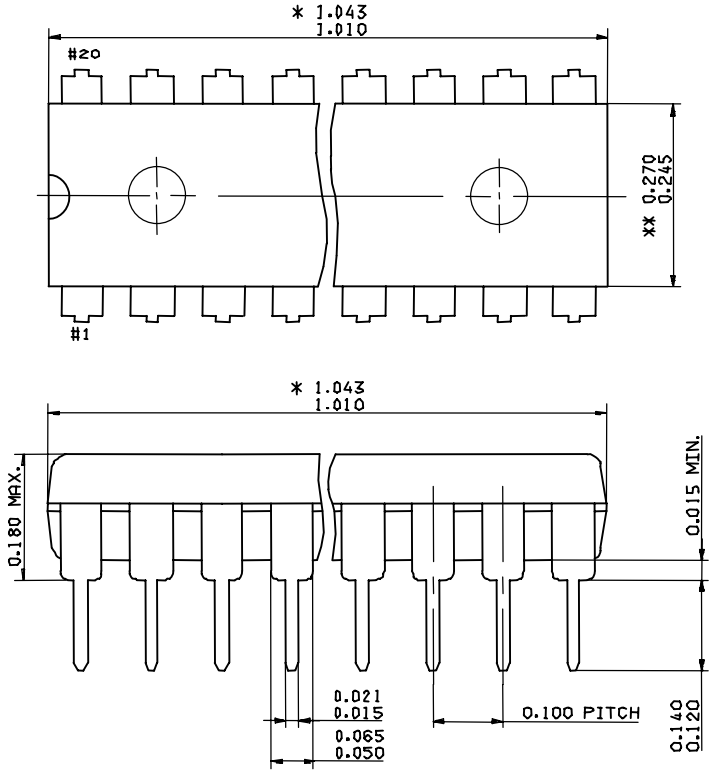


Fig 1-2 HMS38112 Pin Assignment
(20 PIN)

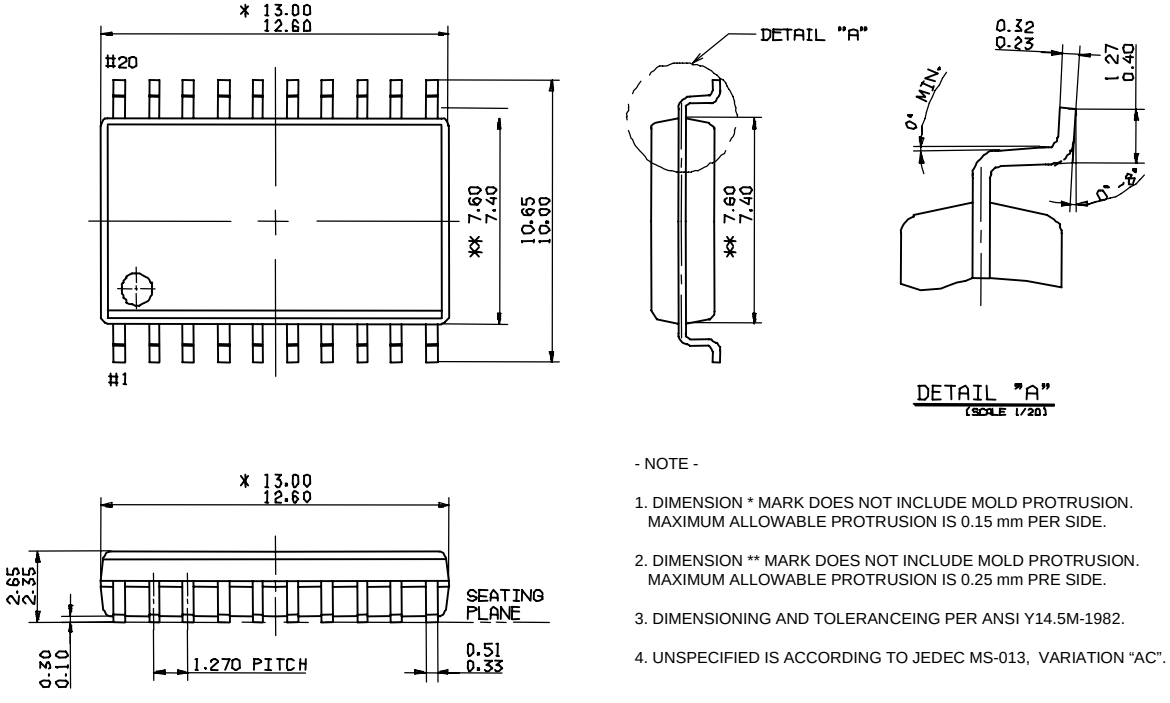
Pin Dimension



- NOTE -

1. DIMENSION * MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.010 INCH PER SIDE.
2. DIMENSION ** MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.010 INCH PRE SIDE.
3. UNSPECIFIED IS ACCORDING TO JEDEC MS-001 VARIATION AE.

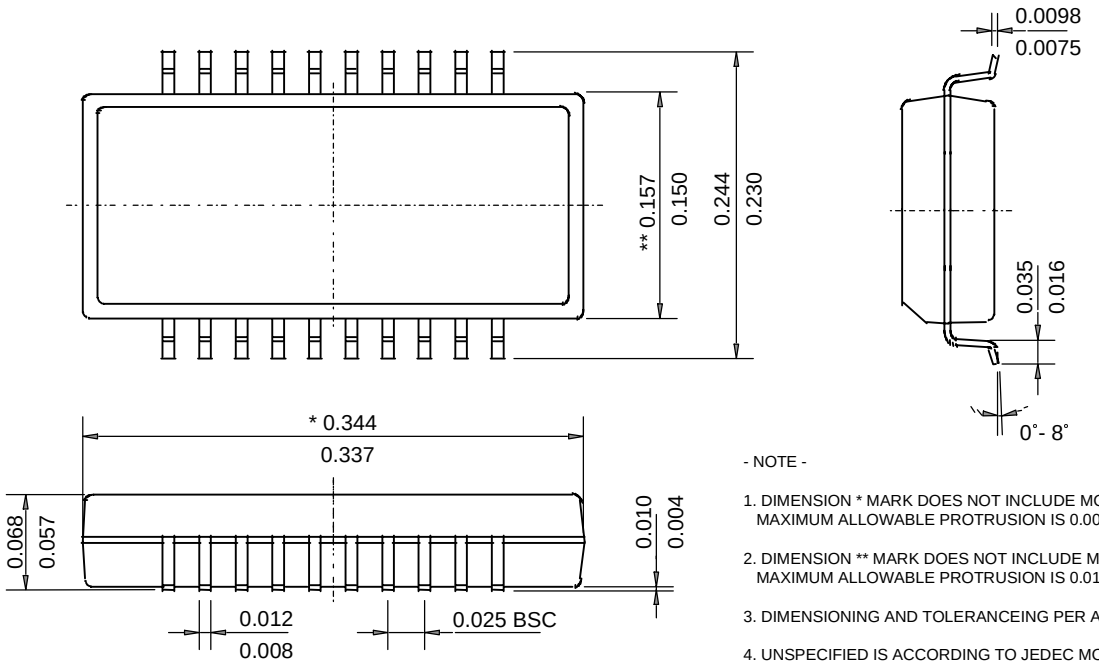
Fig 1-3. 20PDIP (300MIL) Pin Dimension (UNIT : INCH)



- NOTE -

1. DIMENSION * MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.15 mm PER SIDE.
2. DIMENSION ** MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.25 mm PRE SIDE.
3. DIMENSIONING AND TOLERANCEING PER ANSI Y14.5M-1982.
4. UNSPECIFIED IS ACCORDING TO JEDEC MS-013, VARIATION “AC”.

Fig 1-4. 20SOP (300MIL) Pin Dimension (UNIT : mm)



- NOTE -

1. DIMENSION * MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.006 INCH PER SIDE.

2. DIMENSION ** MARK DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM ALLOWABLE PROTRUSION IS 0.010 INCH PRE SIDE.

3. DIMENSIONING AND TOLERANCEING PER ANSI Y14.5M-1982.

4. UNSPECIFIED IS ACCORDING TO JEDEC MO-137, VARIATION “AD”.

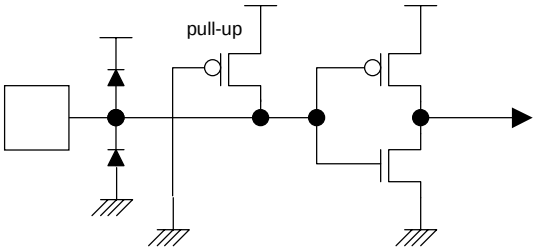
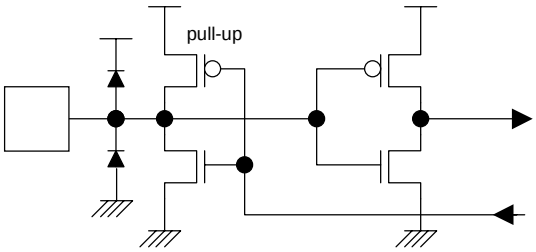
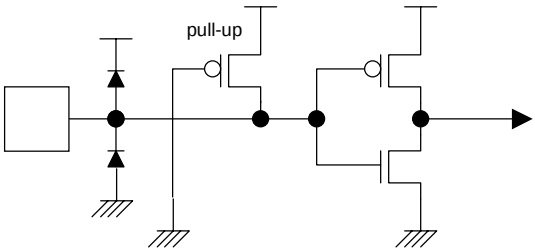
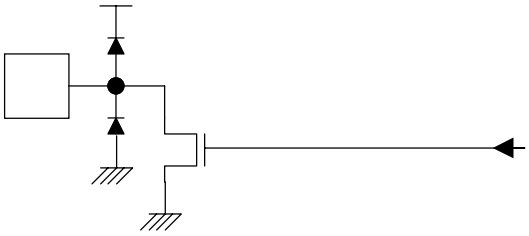
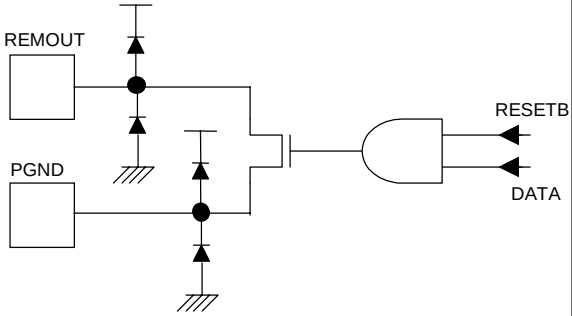
Fig 1-5. 20SSOP (150MIL) Pin Dimension (UNIT : inch)

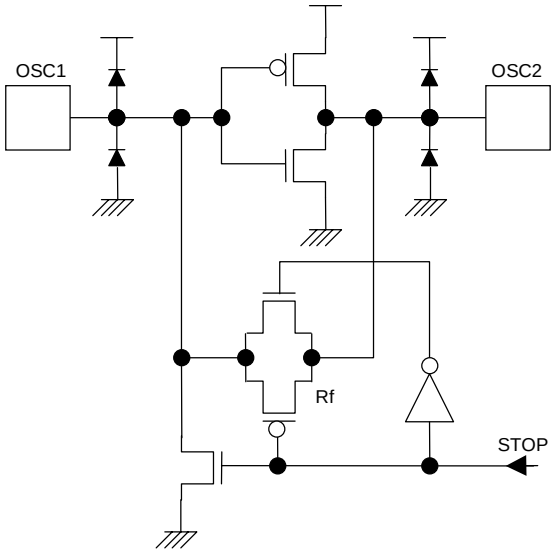
Pin Description and Circuit

Pin Description

Pin	I/O	Function
VDD	-	Connected to 2.0~ 3.6V power supply
GND	-	Connected to 0V power supply.
K0 ~ K3	Input	4-bit input port with built in pull-up resistor. STOP mode is released by "L" input of each pin.
D0 ~ D5	Output	Each can be set and reset independently. The output is the structure of N-channel-open-drain.
R0 ~ R1	Input	2-bit input port with built in pull-up resistor. STOP mode is released by "L" input of each pin.
R2 ~ R3	I/O	2-bit I/O port. (Input mode is set only when each of them output "H".) In outputting, each can be set and reset independently(or at once.) The output is in the form of C-MOS. STOP mode is released by "L" input of each pin.
OSC1	Input	Oscillator input. Input to the oscillator circuit and connection point for ceramic resonator. A feedback resistor is connected between this pin and OSC2.
OSC2	Output	Connect a resonator between this pin and OSC1.
PGND	-	Ground pin for internal high current N-channel transistor. (connected to GND)
REMOUT	Output	High current output port for driving I.R.LED. The output is in the form N-channel open drain.

Pin Circuit

Pin	I/O	I/O circuit	Note
R0 ~ R1	I		- Built in MOS Tr for pull-up, about 140kΩ.
R2 ~ R3	I/O		- CMOS output. - "H" output at reset. - Built in MOS Tr for pull-up, about 140kΩ.
K0 ~ K3	I		- Built in MOS Tr for pull-up, about 140kΩ.
D0 ~ D5	O		- Open drain output. - "L" output at reset. - D0~D3 are “L” output at STOP MODE.. - D4 ~D5 pins “Low” or keep before stop mode at STOP MODE (option)
REMOUT	O		- Open drain output - Output Tr. Disable at reset.

Pin	I/O	I/O circuit	Note
OSC2	O		- Built in feedback-resistor about 1㏁
OSC1	I		

Optional Features

The HMS38112 offers the following optional features.

These options are masked.

- I/O terminals having pull-up resistor : R2 ~ R3
- Input terminals having STOP release mode : K0 ~ K3, R0 ~ R3
- Output form at STOP mode : D4 ~D5 pins “L” or keep before stop mode

Electrical Characteristics

Absolute maximum ratings (Ta = 25℃)

Parameter	Symbol	Max. rating	Unit
Supply Voltage	V_{DD}	-0.3 ~ 5.0	V
Power dissipation	P_D	700 *	mW
Storage temperature range	Tstg	-55 ~ 125	℃
Input voltage	V_{IN}	-0.3 ~ V_{DD}+0.3	V
Output voltage	V_{OUT}	-0.3 ~ V_{DD}+0.3	V

* Thermal derating above 25℃ : 6mW per degree ℃ rise in temperature.

Recommended operating condition

Parameter	Symbol	Condition	Rating	Unit
Supply Voltage	V_{DD}	2.4MHz ~ 4MHz	2.0 ~ 3.6	V
Operating temperature	Topr	-	-20 ~ +70	℃

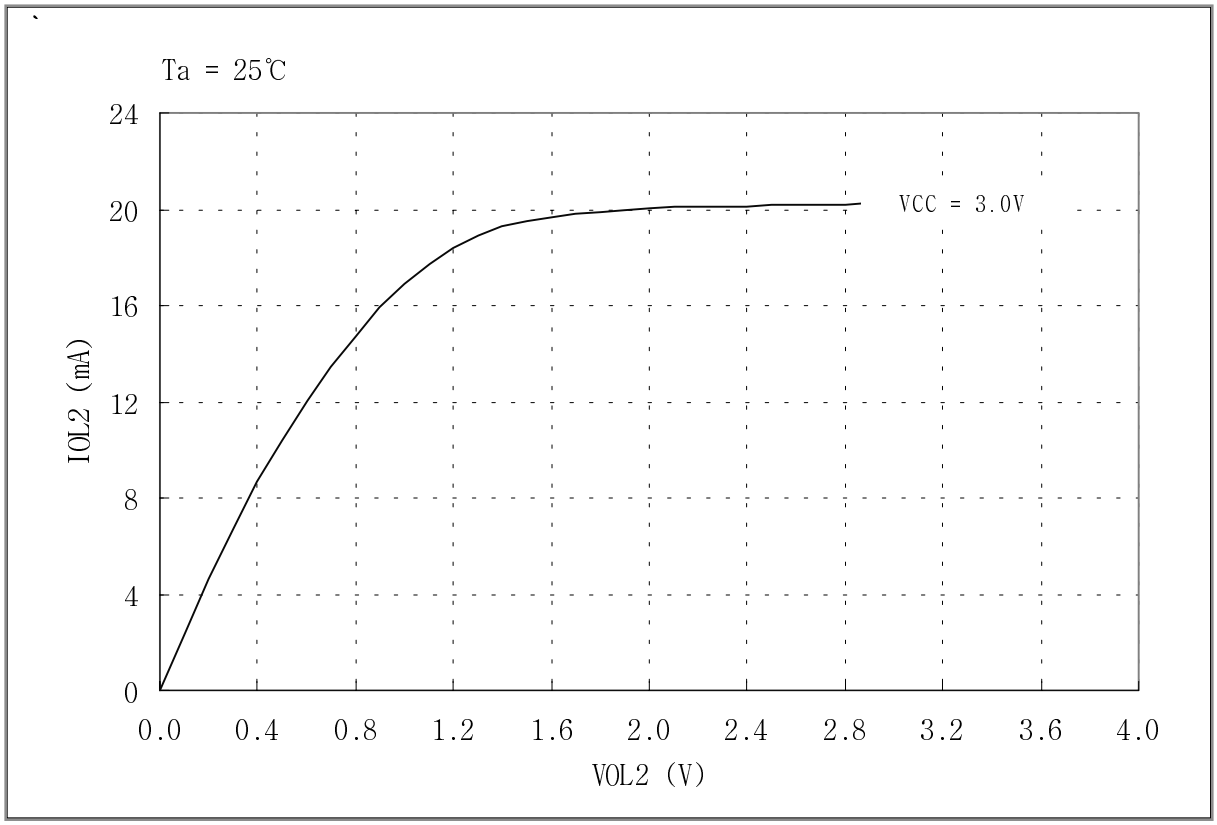
Electrical characteristics (Ta=25℃, V_{DD}= 3V)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input H current	I_{IH}	-	-	1	uA	VI=V_{DD}
K Pull-up Resistance	R_{PU1}	70	140	300	kΩ	VI=GND
R Pull-up Resistance	R_{PU2}	70	140	300	kΩ	VI=GND, Output off
Feedback Resistance	R_{FD}	0.3	1.0	3.0	MΩ	V_{OSC1}=GND, V_{OSC2}=VDD
K, R input H voltage	V_{IH1}	2.1	-	-	V	-
K, R input L voltage	V_{IL1}	-	-	0.9	V	-
D. R output L voltage	V_{OL2}*1	-	0.15	0.4	V	I_{OL}=3mA
OSC2 output L voltage	V_{OL3}	-	0.4	0.9	V	I_{OL}=150uA
OSC2 output H voltage	V_{OH3}	2.1	2.5	-	V	I_{OH}=-150uA
REMOUT output L current	I_{OL1}		250		mA	V_{OL}=0.3V
REMOUT leakage current	I_{OLK1}	-	-	1	uA	V_{0UT}=V_{DD}, Output off
D, R output leakage current	I_{OLK2}	-	-	1	uA	V_{0UT}=V_{DD}, Output off
Current on STOP mode	I_{STP}	-	-	1	uA	At STOP mode
Operating supply current	I_{DD} *2	-	0.5	1.5	mA	f_{OSC}=4MHz
System clock frequency f_{OSC}/48	f_{OSC}	2.4	-	4	MHz	MHZ version

*1 Refer to Fig.1-6 < I_{OL2} vs. V_{OL2} Graph>

*2 I_{DD} is measured at RESET mode.

Fig 1-6. I_{OL2} vs. V_{OL2} Graph. (D, R Port)



CHAPTER 2. HMS39112

Outline of characteristics

The HMS39112 is remote control transmitter which uses CMOS technology
This enables transmission code outputs of different configurations, multiple custom code output, and double push key output for easy fabrication.
The HMS39112 is suitable for remote control of TV, VCR, FANS, Air-conditioners, Audio Equipments, Toys, Games etc.
It is possible to structure the 8 x 7 key matrix.

Characteristics

- Program memory : 1,024 bytes
- Data memory : 32 × 4 bits
- 43 types of instruction set
- 3 levels of subroutine nesting
- Operating frequency : 2.4MHz ~ 4MHz
- Instruction cycle : $f_{OSC}/48$
- CMOS process (Single 3.0V power supply)
- Stop mode (Through internal instruction)
- Released stop mode by key input(mask option)
- Built in Power-on Reset circuit
- Built in Low Voltage reset circuit
- Built in a watch dog timer (WDT)
- Low operating voltage : 2.0 ~ 3.6V
- 20 pin PDIP/SOP/SSOP package

Block Diagram

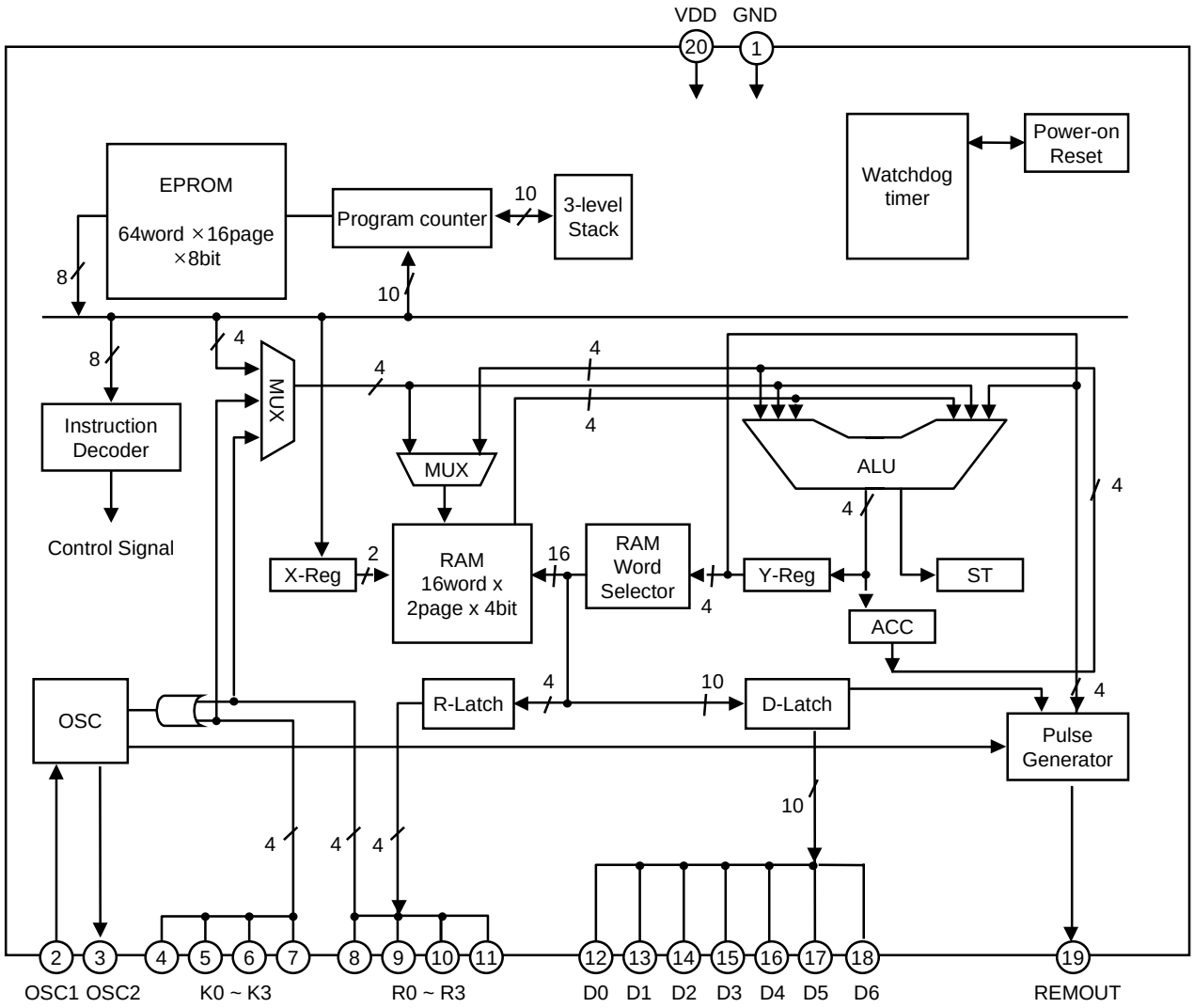


Fig 2-1 Block Diagram

Pin Assignment

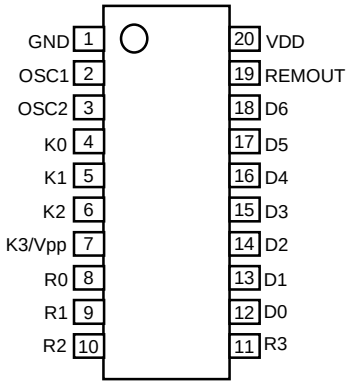


Fig 2-2 HMS39112 Pin Assignment
(20 PIN)

Pin Dimension

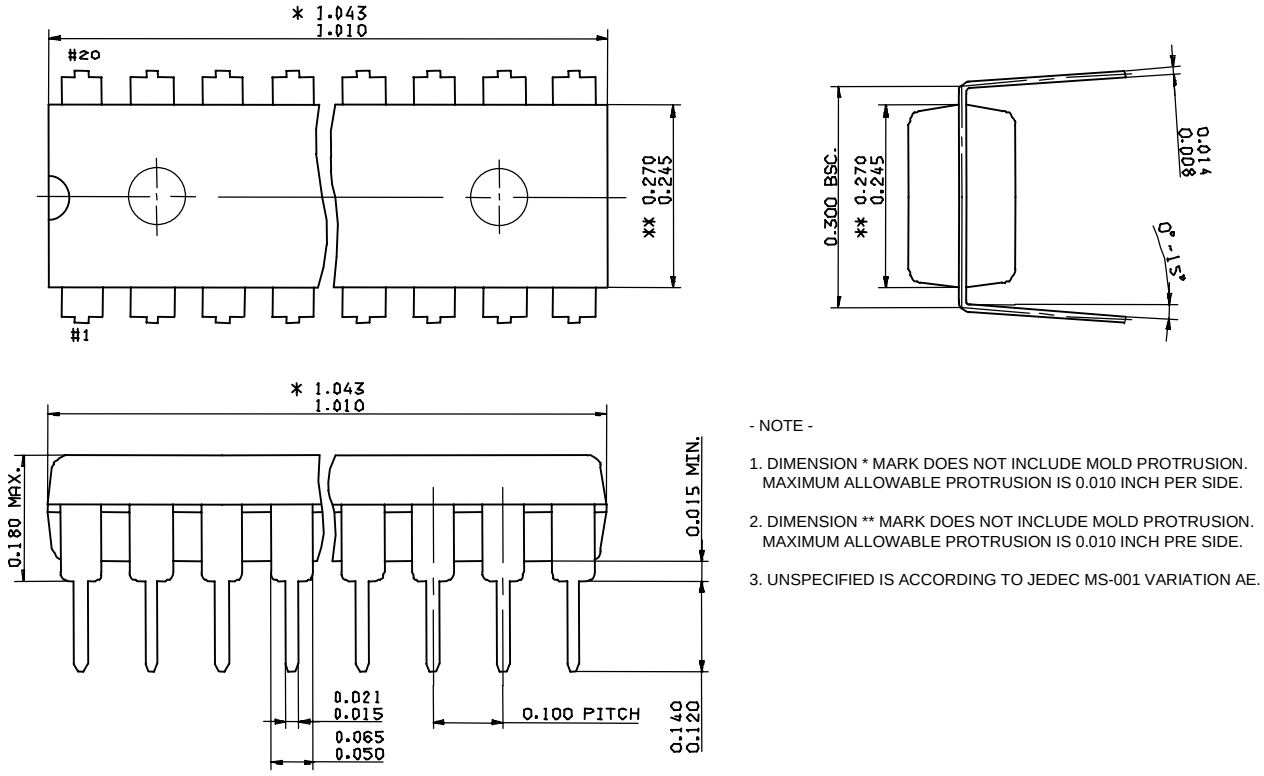


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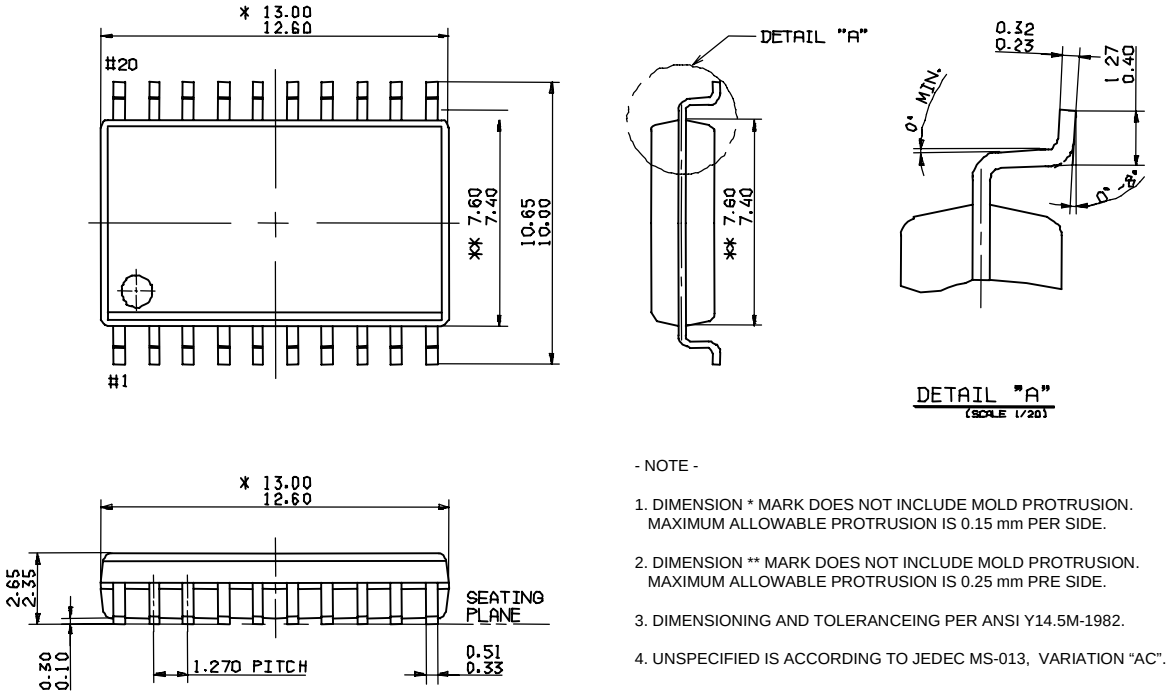
Fig 2-3. 20PDIP (300MIL) Pin Dimension (UNIT : INCH)



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3. DIMENSIONING AND TOLERANCEING PER ANSI Y14.5M-1982.
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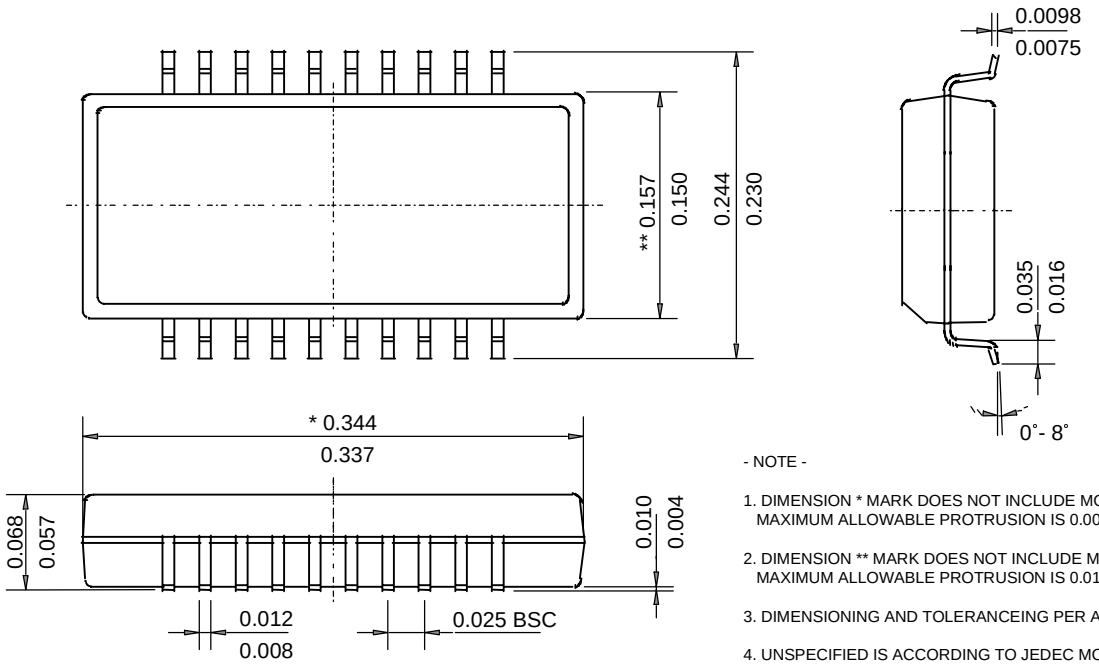
Fig 2-4. 20SOP (300MIL) Pin Dimension (UNIT : mm)



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4. UNSPECIFIED IS ACCORDING TO JEDEC MO-137, VARIATION “AD”.

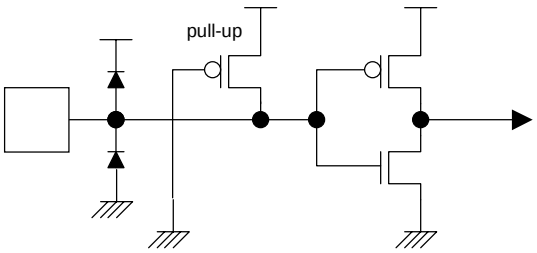
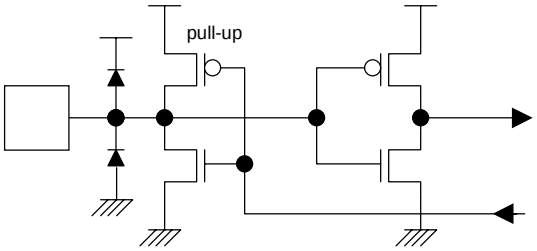
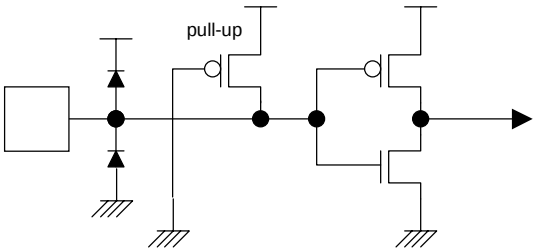
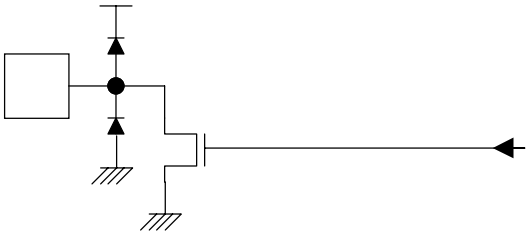
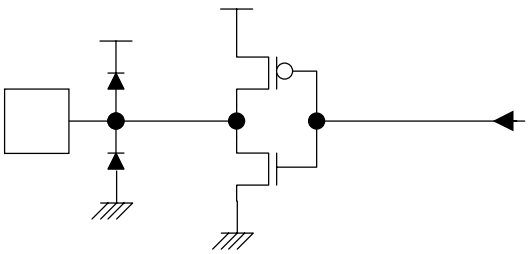
Fig 2-5. 20SSOP (150MIL) Pin Dimension (UNIT : INCH)

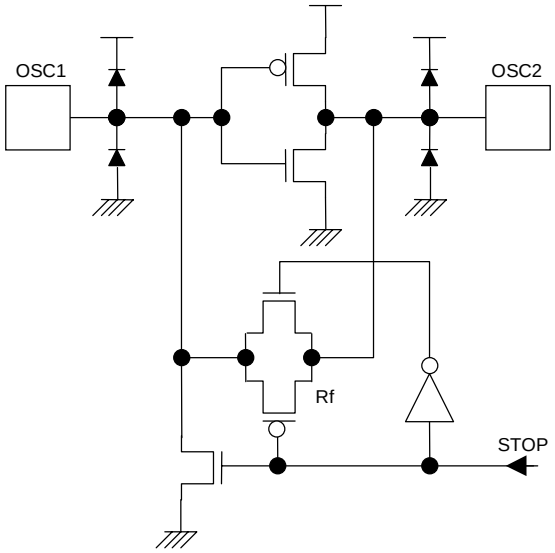
Pin Description and Circuit

Pin Description

Pin	I/O	Function
VDD	-	Connected to 2.0~ 3.6V power supply
GND	-	Connected to 0V power supply.
K0 ~ K3	Input	4-bit input port with built in pull-up resistor. STOP mode is released by "L" input of each pin.(masked option)
D0 ~ D6	Output	Each can be set and reset independently. The output is the structure of N-channel-open-drain.
R0 ~ R1	Input	2-bit input port with built in pull-up resistor. STOP mode is released by "L" input of each pin.(masked option)
R2 ~ R3	I/O	2-bit I/O port. (Input mode is set only when each of them output "H".) In outputting, each can be set and reset independently(or at once.) The output is in the form of C-MOS. STOP mode is released by "L" input of each pin. Pull-up resistor and STOP release mode can be respectively selected as masked option for each pin.(It is released by “L” input at STOP)
OSC1	Input	Oscillator input. Input to the oscillator circuit and connection point for ceramic resonator. A feedback resistor is connected between this pin and OSC2.
OSC2	Output	Connect a resonator between this pin and OSC1.
REMOUT	Output	High current output port for driving I.R.LED. The output is in the form N-channel open drain.

Pin Circuit

Pin	I/O	I/O circuit	Note
R0 ~ R1	I		- Built in MOS Tr for pull-up, about 140kΩ.
R2 ~ R3	I/O		- CMOS output. - "H" output at reset. - Built in MOS Tr for pull-up, about 140kΩ.
K0 ~ K3	I		- Built in MOS Tr for pull-up, about 140kΩ.
D0 ~ D6	O		- Open drain output. - "L" output at reset. - D0~D3 are “L” output at STOP MODE. -D4 ~D6 pins “L” or keep before stop mode At STOP MODE(option)
REMOUT	O		- Open drain output - “L” output at reset. - High current output source.

Pin	I/O	I/O circuit	Note
OSC2	O		- Built in feedback-resistor about 1㏁
OSC1	I		

Optional Features

The HMS39112 offers the following optional features.

These options are masked.

- I/O terminals having pull-up resistor : R2 ~ R3
- Input terminals having STOP release mode : K0 ~ K3, R0 ~ R3
- Output form at STOP mode : D4 ~D6 pins “L” or keep before stop mode

Electrical Characteristics

Absolute maximum ratings (Ta = 25℃)

Parameter	Symbol	Max. rating	Unit
Supply Voltage	V_{DD}	-0.3 ~ 5.0	V
Power dissipation	P_D	700 *	mW
Storage temperature range	Tstg	-55 ~ 125	℃
Input voltage	V_{IN}	-0.3 ~ V_{DD}+0.3	V
Output voltage	V_{OUT}	-0.3 ~ V_{DD}+0.3	V

* Thermal derating above 25℃ : 6mW per degree ℃ rise in temperature.

Recommended operating condition

Parameter	Symbol	Condition	Rating	Unit
Supply Voltage	V_{DD}	2.4MHz ~ 4MHz	2.0 ~ 3.6	V
Operating temperature	Topr	-	-20 ~ +70	℃

Electrical characteristics (Ta=25℃, V_{DD}= 3V)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input H current	I_{IH}	-	-	1	uA	VI=V_{DD}
K Pull-up Resistance	R_{PU1}	70	140	300	kΩ	VI=GND
R Pull-up Resistance	R_{PU2}	70	140	300	kΩ	VI=GND, Output off
Feedback Resistance	R_{FD}	0.3	1.0	3.0	MΩ	V_{OSC1}=GND, V_{OSC2}=VDD
K, R input H voltage	V_{IH1}	2.1	-	-	V	-
K, R input L voltage	V_{IL1}	-	-	0.9	V	-
D. R output L voltage	V_{OL2}*1	-	0.15	0.4	V	I_{OL}=3mA
OSC2 output L voltage	V_{OL3}	-	0.4	0.9	V	I_{OL}=150uA
OSC2 output H voltage	V_{OH3}	2.1	2.5	-	V	I_{OH}=-150uA
REMOUT output L current	I_{OL1}*2	0.5	1.1	3	mA	V_{OL1}=0.4V
REMOUT output H current	I_{OH1}*3	-5	-15	-30	mA	V_{OH1}=2V
D, R output leakage current	I_{OLK2}	-	-	1	uA	V_{0UT}=V_{DD}, Output off
Current on STOP mode	I_{STP}	-	-	1	uA	At STOP mode
Operating supply current	I_{DD} *4	-	0.5	1.5	mA	f_{OSC}=4MHz
System clock frequency f_{OSC}/48	f_{OSC}	2.4	-	4	MHz	MHZ version

*1 Refer to Fig.2-6 < I_{OL2} vs. V_{OL2} Graph>

*2 Refer to Fig.2-7 < I_{OL1} vs. V_{OL1} Graph>

*3 Refer to Fig.2-8 < I_{OH1} vs. V_{OH1} Graph>

*4 I_{DD} is measured at RESET mode.

Fig 2-6. I_{OL2} vs. V_{OL2} Graph. (D, R Port)

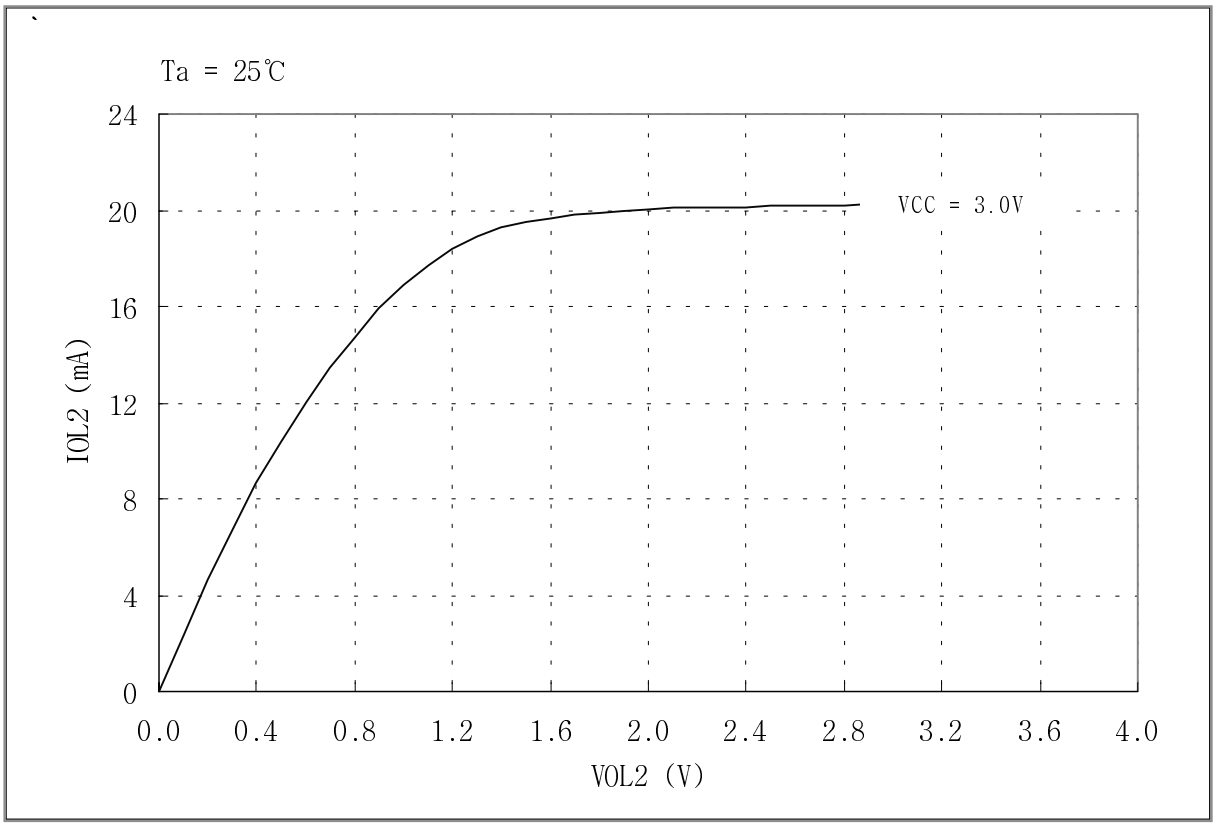


Fig 2-7. I_{OL1} vs V_{OL1} Graph (REMOUT Port)

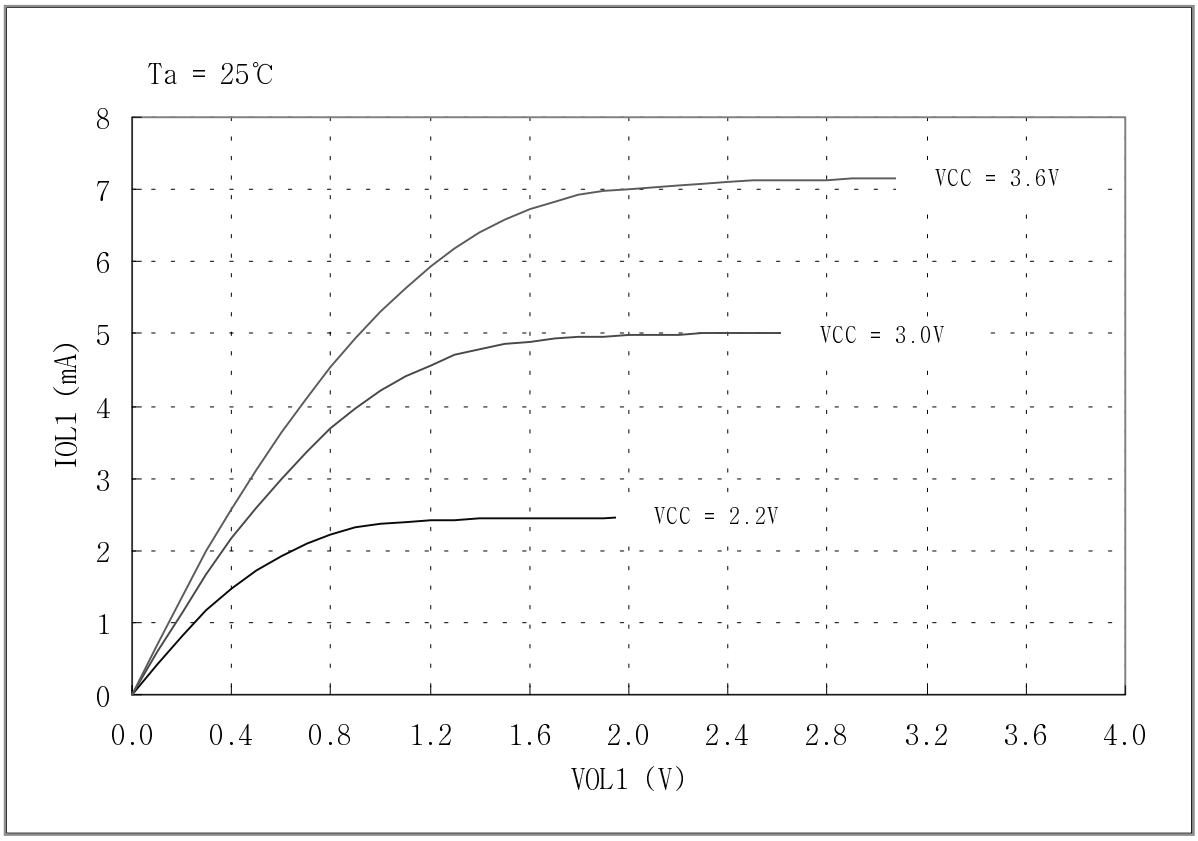
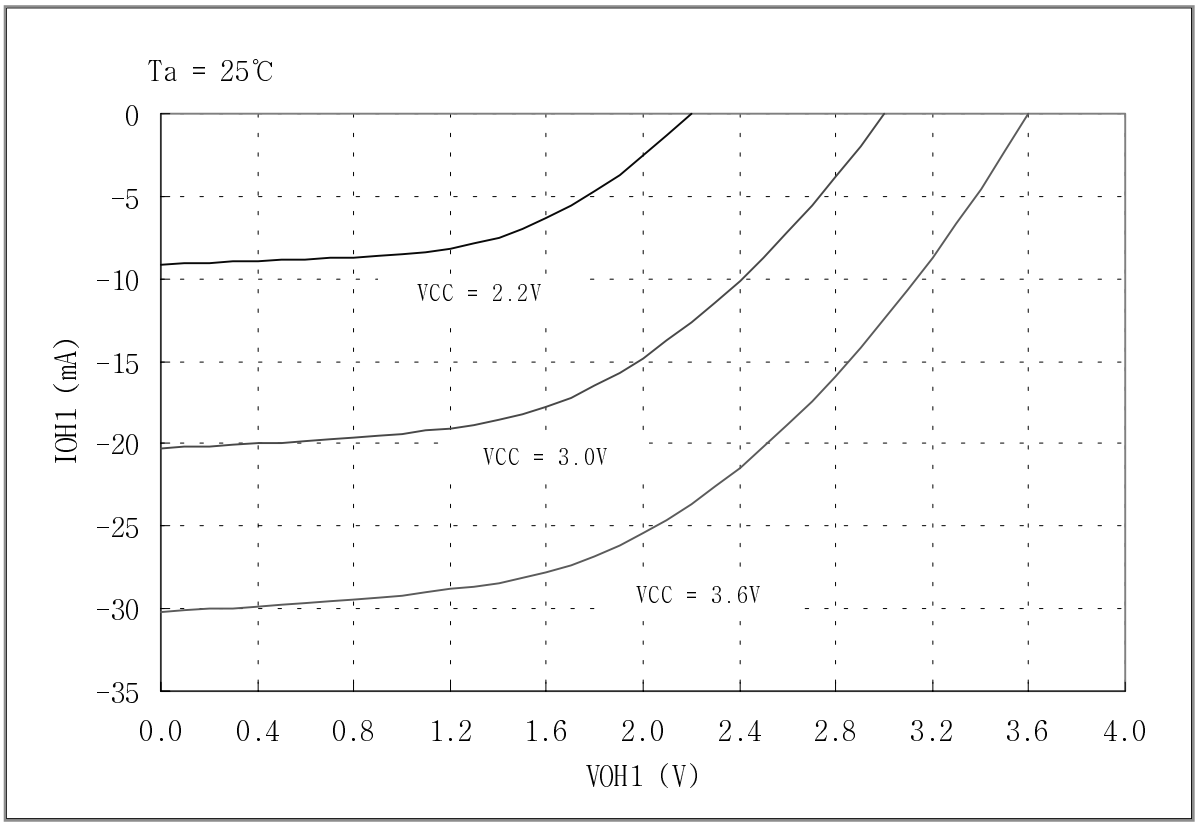


Fig 2-8. I_{OH1} vs V_{OH1} Graph (REMOUT Port)



CHAPTER 3. Architecture

Program Memory

The HMS38112/39112 can incorporate maximum 1,024 words (64 words×16 pages×8bits) for program memory. Program counter PC (A0~A5) and page address register (A6~A9) are used to address the whole area of program memory having an instruction (8bits) to be next executed.

The program memory consists of 64 words on each page, and thus each page can hold up to 64 steps of instructions.

The program memory is composed as shown below.

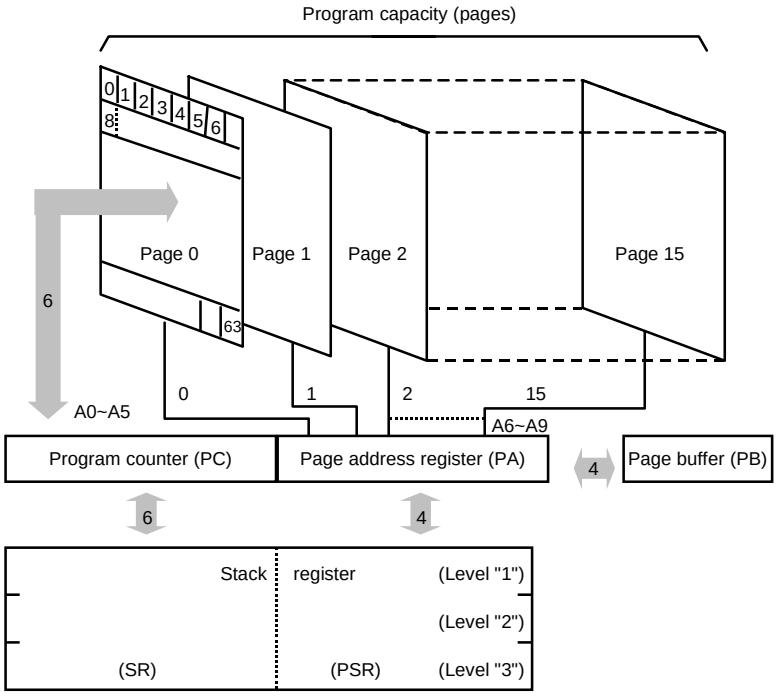


Fig 3-1 Configuration of Program Memory

Address Register

The following registers are used to address the ROM.

- Page address register (PA) :
  Holds ROM's page number (0~Fh) to be addressed.
- Page buffer register (PB) :
  Value of PB is loaded by an LPBI command when newly addressing a page. Then it is shifted into the PA when rightly executing a branch instruction (BR) and a subroutine call (CAL).
- Program counter (PC) :
  Available for addressing word on each page.
- Stack register (SR) :
  Stores returned-word address in the subroutine call mode.

(1) Page address register and page buffer register :

Address one of pages #0 to #15 in the EPROM by the 4-bit binary counter. Unlike the program counter, the page address register is usually unchanged so that the program will repeat on the same page unless a page changing command is issued. To change the page address, take two steps such as (1) writing in the page buffer what page to jump (execution of LPBI) and (2) execution of BR or CAL, because instruction code is of eight bits so that page and word can not be specified at the same time.

In case a return instruction (RTN) is executed within the subroutine that has been called in the other page, the page address will be changed at the same time.

(2) Program counter :

This 6-bit binary counter increments for each fetch to address a word in the currently addressed page having an instruction to be next executed.
For easier programming, at turning on the power, the program counter is reset to the zero location. The PA is also set to "0". Then the program counter specifies the next address in random sequence.
When BR, CAL or RTN instructions are decoded, the switches on each step are turned off not to update the address. Then, for BR or CAL, address data are taken in from the instruction operands (a_0 to a_5), or for RTN, and address is fetched from stack register No. 1.

(3) Stack register :

This stack register provides two stages each for the program counter (6bits) and the page address register (4bits) so that subroutine nesting can be made on two levels.

Data Memory (RAM)

Up to 32 nibbles (16 words × 2pages × 4bits) is incorporated for storing data. The whole data memory area is indirectly specified by a data pointer (X,Y). Page number is specified by zero bit of X register, and words in the page by 4 bits in Y-register. Data memory is composed in 16 nibbles/page. Figure 4-2 shows the configuration.

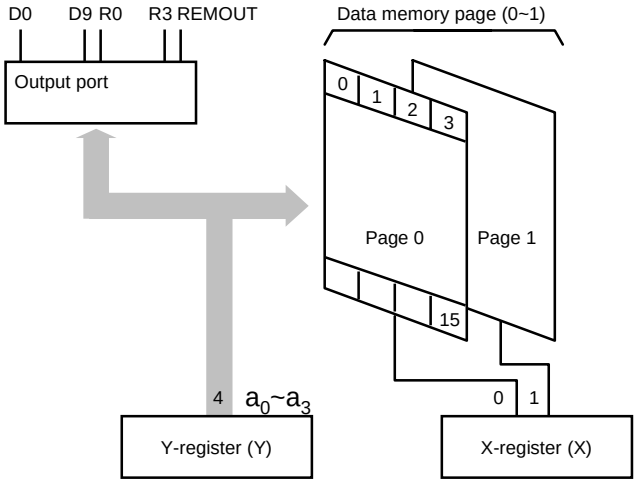


Fig 3-2 Composition of Data Memory

X-register (X)

X-register is consist of 2bit, X0 is a data pointer of page in the RAM, X1 is reserved.

	X1=0	X1=1
Y=0	D0	Reserved
Y=1	D1	Reserved

Table 3-1 Mapping table between X and Y register

Y-register (Y)

Y-register has 4 bits. It operates as a data pointer or a general-purpose register. Y-register specifies an address (a_0~a_3) in a page of data memory, as well as it is used to specify an output port. Further it is used to specify a mode of carrier signal outputted from the REMOUT port. It can also be treated as a general-purpose register on a program.

Accumulator (A_{CC})

The 4-bit register for holding data and calculation results.

Arithmetic and Logic Unit (ALU)

In this unit, 4bits of adder/comparator are connected in parallel as it's main components and they are combined with status latch and status logic (flag.)

(1) Operation circuit (ALU) :

The adder/comparator serves fundamentally for full addition and data comparison. It executes subtraction by making a complement by processing an inversed output of A_{CC} (A_{CC}+1)

(2) Status logic :

This is to bring an ST, or flag to control the flow of a program. It occurs when a specified instruction is executed in three cases such as overflow or underflow in operation and two inputs unequal.

State Counter (SC)

A fundamental machine cycle timing chart is shown below. Every instruction is one byte length. Its execution time is the same. Execution of one instruction takes 6 clocks for fetch cycle and 6 clocks for execute cycle (12 clocks in total). Virtually these two cycles proceed simultaneously, and thus it is apparently completed in 6 clocks (one machine cycle). Exceptionally BR, CAL and RTN instructions is normal execution time since they change an addressing sequentially. Therefore, the next instruction is prefetched so that its execution is completed within the fetch cycle.

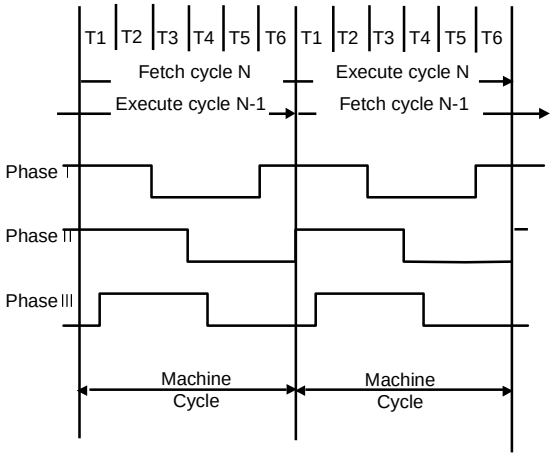
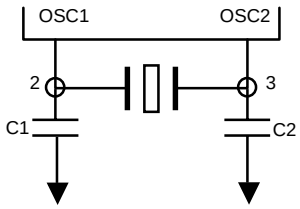


Fig. 3-3 Fundamental timing chart

Clock Generator

The HMS38112/39112 have an internal clock oscillator. The oscillator circuit is designed to operate with an external ceramic resonator.
Oscillator circuit is able to organize by connecting
ceramic resonator to outside.

* It is necessary to connect capacitor to outside in order to change ceramic resonator, you must refer to a manufacturer`s resonator matching guide.

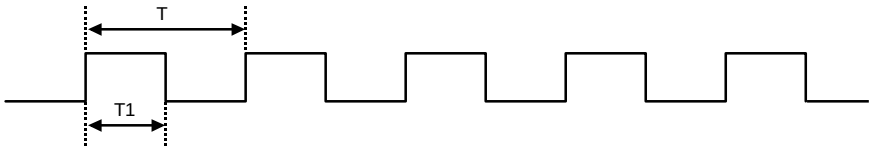


HMS38112	3.64MHz	4.00MHz
MURATA	CSTLS3M64G56-B0	CSTLS3M64G56-B0
CORETECH	CRTL3.64MR	CRTL4.00MR
TDK	FCR3.64MC5	FCR4.0MC5

* All type have the built-in loading capacitors.

Pulse Generator

The following frequency and duty ratio are selected for carrier signal outputted from the REMOUT port depending on a PMR (Pulse Mode Register) value set in a program.



PMR	REMOUT signal
0	$T=1/f_{PUL} = 96/f_{OSC}$, T1/T = 1/2
1	$T=1/f_{PUL} = 96/f_{OSC}$, T1/T = 1/3
2	$T=1/f_{PUL} = 64/f_{OSC}$, T1/T = 1/2
3	$T=1/f_{PUL} = 64/f_{OSC}$, T1/T = 1/4
4	$T=1/f_{PUL} = 88/f_{OSC}$, T1/T = 4/11
5	No Pulse (same to D0 ~ D9)
6	$T=1/f_{PUL} = 96/f_{OSC}$, T1/T = 1/4
7	No pulse (same to D0 ~ D9)

* Default value is "0"

Table 3-2 PMR selection table

Reset Operation

HMS38112/39112 have three reset sources. One is a built-in Power-on reset circuit, another is a built-in Low VDD Detection circuit, the other is the overflow of Watch Dog Timer (WDT). All reset operations are internal in the HMS38112.

Built-in Power On Reset Circuit

HMS38112/39112 has a built-in Power-on reset circuit consisting of an about 1㏁ Resistor and a 3pF Capacitor. When the Power-on reset pulse occurs, system reset signal is latched and WDT is cleared. After the overflow time of WDT (2^{13} x System clock time), system reset signal is released.

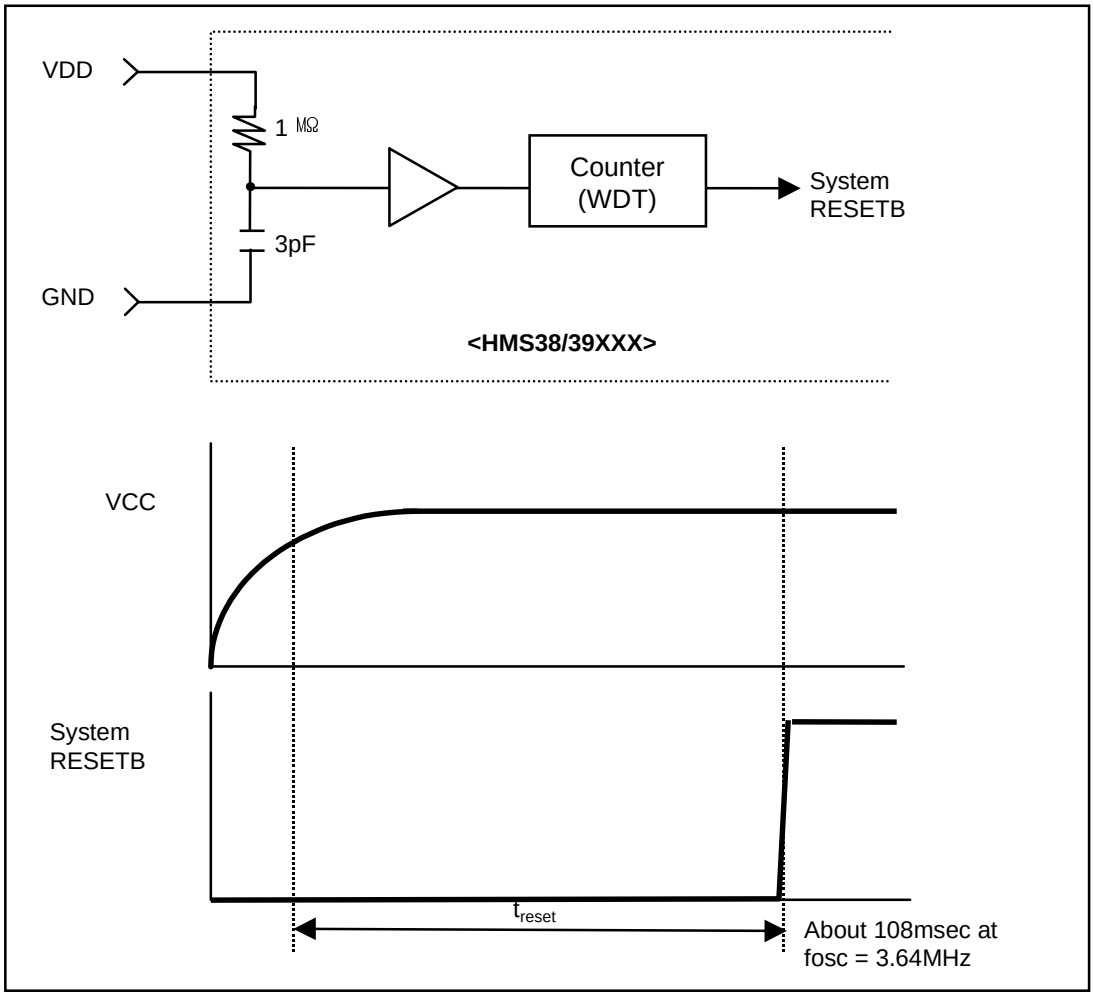


Fig. 3-4 Power-On Reset Circuit and Timing Chart

Built-in Low VDD Reset Circuit

HMS38112/39112 have a Low VDD detection circuit.
If VDD become Reset Voltage of Low VDD Detection circuit at a active status, system reset occur and WDT is cleared.
After VDD is increased upper Reset Voltage again, WDT is re-counted and if WDT is overflowed, system reset is released.

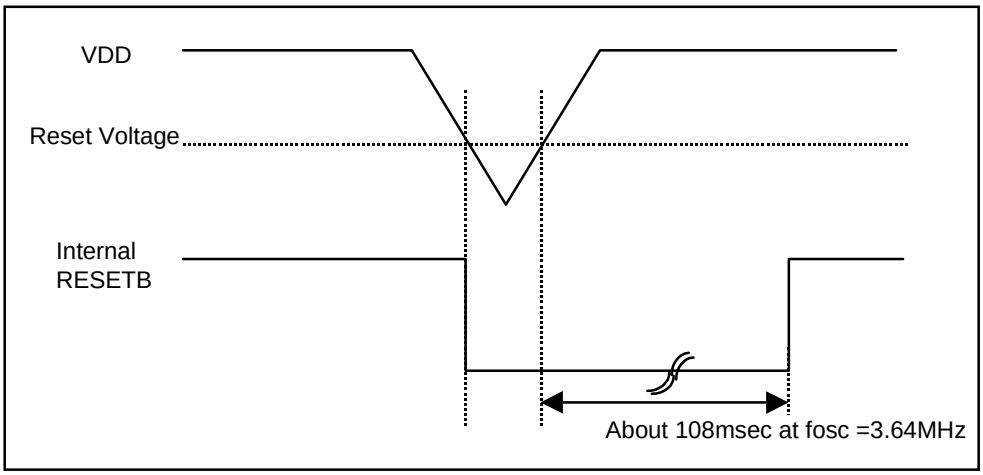


Fig. 3-5 Low Voltage Detection diagram

Watch Dog Timer (WDT)

Watch dog timer is organized binary of 14 steps. The signal of $f_{OSC}/48$ cycle comes in the first step of WDT after WDT reset. If this counter was overflowed, reset signal automatically come out so that internal circuit is initialized.
The overflow time is $8 \times 6 \times 2^{13}/f_{OSC}$ (108.026ms at f_{OSC} = 3.64MHz)
Normally, the binary counter must be reset before the overflow by using reset instruction (WDTR), Power-on reset pulse or Low VDD detection pulse.

* It is constantly reset in STOP mode. When STOP is released, counting is restarted. (Refer to STOP Operation>)

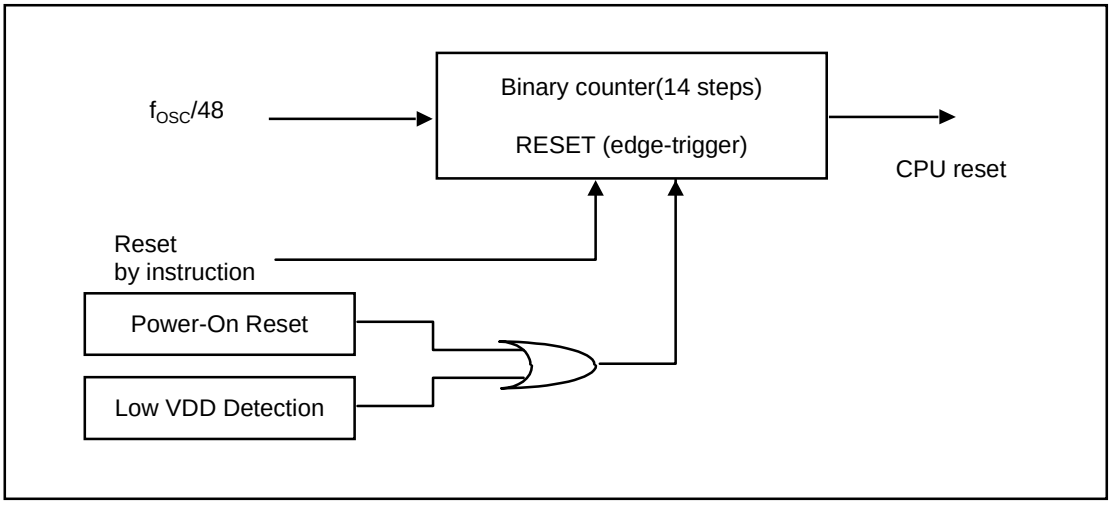


Fig 3-6 Block Diagram of Watch-dog Timer

STOP Operation

Stop mode can be achieved by STOP instructions.

In stop mode :

1. Oscillator is stopped, the operating current is low.
2. Watch dog timer is reset, D0~D3 output and REMOUT output are "L" .
3. Part other than WDT, D0~D3 output and REMOUT output have a value before come into stop mode.

Stop mode is released when one of K or R input is going to "L".

1. State of D0~D3 output and REMOUT output is return to state of before stop mode is achieved.
2. After 2^{10}×System clock time for stable oscillating, first instruction start to operate.
3. In return to normal operation, WDT is counted from zero again.

But, at executing stop instruction, if one of K or R input is chosen to "L", stop instruction is same to NOP instruction.

CHAPTER 4. Instruction

INSTRUCTION FORMAT

All of the 43 instruction in HMS38112/39112 is format in two fields of OP code and operand which consist of eight bits. The following formats are available with different types of operands.

*Format Ⅰ

All eight bits are for OP code without operand.

*Format Ⅱ

Two bits are for operand and six bits for OP code.
Two bits of operand are used for specifying bits of RAM and X-register (bit 1 and bit 7 are fixed at ″0″)

*Format Ⅲ

Four bits are for operand and the others are OP code.
Four bits of operand are used for specifying a constant loaded in RAM or Y-register, a comparison value of compare command, or page addressing in ROM.

*Format Ⅳ

Six bits are for operand and the others are OP code.
Six bits of operand are used for word addressing in the ROM.

INSTRUCTION TABLE

The HMS38112/39112 provides the following 43 basic instructions.

	Category	Mnemonic	Function	ST*1
1	Register to Register	LAY	A ← Y	S
2		LYA	Y ← A	S
3		LAZ	A ← 0	S
4	RAM to Register	LMA	M(X,Y) ← A	S
5		LMAIY	M(X,Y) ← A, Y ← Y+1	S
6		LYM	Y ← M(X,Y)	S
7		LAM	A ← M(X,Y)	S
8		XMA	A ↔ M(X,Y)	S
9	Immediate	LYI i	Y ← i	S
10		LMIIY i	M(X,Y) ← i, Y ← Y+1	S
11		LXI n	X ← n	S
12	RAM Bit Manipulation	SEM n	M(n) ← 1	S
13		REM n	M(n) ← 0	S
14		TM n	TEST M(n) = 1	E
15	ROM Address	BR a	if ST = 1 then Branch	S
16		CAL a	if ST = 1 then Subroutine call	S
17		RTN	Return from Subroutine	S
18		LPBI i	PB ← i	S
19	Arithmetic	AM	A ← A + M(X,Y)	C
20		SM	A ← M(X,Y) - A	B
21		IM	A ← M(X,Y) + 1	C
22		DM	A ← M(X,Y) - 1	B
23		IA	A ← A + 1	S
24		IY	Y ← Y + 1	C
25		DA	A ← A - 1	B

	Category	Mnemonic	Function	ST*1
26	Arithmetic	DY	Y ← Y - 1	B
27		EORM	A ← A ⊕ M (X,Y)	S
28		NEGA	A ← $\overline{A}$ + 1	Z
29	Comparison	ALEM	TEST A ≤ M(X,Y)	E
30		ALEI i	TEST A ≤ i	E
31		MNEZ	TEST M(X,Y) ≠ 0	N
32		YNEA	TEST Y ≠ A	N
33		YNEI i	TEST Y ≠ i	N
34		KNEZ	TEST K ≠ 0	N
35		RNEZ	TEST R ≠ 0	N
36	Input / Output	LAK	A ← K	S
37		LAR	A ← R	S
38		SO	Output(Y) ← 1 at HMS39112, 0 at HMS38112	S
39		RO	Output(Y) ← 0 at HMS39112, 1 at HMS39112	S
40	Control	WDTR	Watch Dog Timer Reset	S
41		STOP	Stop operation	S
42		LPY	PMR ← Y	S
43		NOP	No operation	S

Note) i = 0~f, n = 0~3, a = 6bit PC Address

*1 Column ST indicates conditions for changing status. Symbols have the following meanings

S : On executing an instruction, status is unconditionally set.
C : Status is only set when carry or borrow has occurred in operation.
B : Status is only set when borrow has not occurred in operation.
E : Status is only set when equality is found in comparison.
N : Status is only set when equality is not found in comparison.
Z : Status is only set when the result is zero.

Port Operation

Value of X-reg	Value of Y-reg	Operation
0 or 1	0 ~ 6	SO : D(Y) ← 1(High-Z) RO : D(Y) ← 0
0 or 1	8	REMOUT port repeats "H" and "L" in pulse frequency. (When PMR = 5, it is fixed at "H") SO : REMOUT(PMR) ← 1 at HMS39112, 0 at HMS38112 RO : REMOUT(PMR) ← 0 at HMS39112, 1 at HMS38112
0 or 1	9	SO : D0 ~ D6← 1 (High-Z) RO : D0 ~ D6← 0
0 or 1	C ~ D	SO : R(Y-Ah) ← 1 RO : R(Y-Ah) ← 0
0 or 1	E	SO : R2 ~ R3 ← 1 RO : R2 ~ R3 ← 0
0 or 1	F	SO : D0 ~ D6 ← 1(High-Z), R2 ~ R3 ← 1 RO : D0 ~ D6 ← 0, R2 ~ R3 ← 0

DETAILS OF INSTRUCTION SYSTEM

All 43 basic instructions of the HMS38112/39112 are one by one described in detail below.

Description Form

Each instruction is headlined with its mnemonic symbol according to the instructions table given earlier.
Then, for quick reference, it is described with basic items as shown below. After that, detailed comment follows.

• Items :

- Naming : Full spelling of mnemonic symbol
- Status : Check of status function
- Format : Categorized into Ⅰ to Ⅳ
- Operand : Omitted for Format Ⅰ
- Function

(1) LAY

Naming : Load Accumulator from Y-Register
Status : Set
Format : I
Function : A ← Y
<Comment> Data of four bits in the Y-register is unconditionally transferred to the accumulator. Data in the Y-register is left unchanged.

(2) LYA

Naming : Load Y-register from Accumulator
Status : Set
Format : I
Function : Y ← A
<Comment> Load Y-register from Accumulator

(3) LAZ

Naming : Clear Accumulator
Status : Set
Format : I
Function : A ← 0
<Comment> Data in the accumulator is unconditionally reset to zero.

(4) LMA

Naming : Load Memory from Accumulator
Status : Set
Format : I
Function : M(X,Y) ← A
<Comment> Data of four bits from the accumulator is stored in the RAM location addressed by the X-register and Y-register. Such data is left unchanged.

(5) LMAIY

Naming : Load Memory from Accumulator and Increment Y-Register
Status : Set
Format : I
Function : M(X,Y) ← A, Y ← Y+1
<Comment> Data of four bits from the accumulator is stored in the RAM location addressed by the X-register and Y-register. Such data is left unchanged.

(6) LYM

Naming : Load Y-Register form Memory
Status : Set
Format : I
Function : Y ← M(X,Y)
<Comment> Data from the RAM location addressed by the X-register and Y-register is loaded into the Y-register. Data in the memory is left unchanged.

(7) LAM

Naming : Load Accumulator from Memory
Status : Set
Format : I
Function : A ← M(X,Y)
<Comment> Data from the RAM location addressed by the X-register and Y-register is loaded into the Y-register. Data in the memory is left unchanged.

(8) XMA

Naming : Exchanged Memory and Accumulator
Status : Set
Format : I
Function : M(X,Y) ↔ A
<Comment> Data from the memory addressed by X-register and Y-register is exchanged with data from the accumulator. For example, this instruction is useful to fetch a memory word into the accumulator for operation and store current data from the accumulator into the RAM. The accumulator can be restored by another XMA instruction.

(9) LYI i

Naming : Load Y-Register from Immediate
Status : Set
Format : III
Operand : Constant $0 \leq i \leq 15$
Function : Y ← i
<Purpose> To load a constant in Y-register. It is typically used to specify Y-register in a particular RAM word address, to specify the address of a selected output line, to set Y-register for specifying a carrier signal outputted from OUT port, and to initialize Y-register for loop control. The accumulator can be restored by another XMA instruction.
<Comment> Data of four bits from operand of instruction is transferred to the Y-register.

(10) LMIIY i

Naming :	Load Memory from Immediate and Increment Y-Register
Status :	Set
Format :	III
Operand :	Constant $0 \leq i \leq 15$
Function :	$M(X,Y) \leftarrow i, \quad Y \leftarrow Y + 1$
<Comment>	Data of four bits from operand of instruction is stored into the RAM location addressed by the X-register and Y-register. Then data in the Y-register is incremented by one.

(11) LXI n

Naming :	Load X-Register from Immediate
Status :	Set
Format :	II
Operand :	X file address $0 \leq n \leq 3$
Function :	$X \leftarrow n$
<Comment>	A constant is loaded in X-register. It is used to set X-register in an index of desired RAM page. Operand of 1 bit of command is loaded in X-register.

(12) SEM n

Naming :	Set Memory Bit
Status :	Set
Format :	II
Operand :	Bit address $0 \leq n \leq 3$
Function :	$M(X,Y,n) \leftarrow 1$
<Comment>	Depending on the selection in operand of operand, one of four bits is set as logic 1 in the RAM memory addressed in accordance with the data of the X-register and Y-register.

(13) REM n

Naming :	Reset Memory Bit
Status :	Set
Format :	II
Operand :	Bit address $0 \leq n \leq 3$
Function :	$M(X,Y,n) \leftarrow 0$
<Comment>	Depending on the selection in operand of operand, one of four bits is set as logic 0 in the RAM memory addressed in accordance with the data of the X-register and Y-register.

(14) TM n

Naming : Test Memory Bit
Status : Comparison results to status
Format : II
Operand : Bit address $0 \leq n \leq 3$
Function : M(X,Y,n) ← 1?
ST ← 1 when M(X,Y,n)=1, ST ← 0 when M(X,Y,n)=0
<Purpose> A test is made to find if the selected memory bit is logic. 1 Status is set depending on the result.

(15) BR a

Naming : Branch on status 1
Status : Conditional depending on the status
Format : IV
Operand : Branch address a (Addr)
Function : When ST =1 , PA ← PB, PC ← a(Addr)
When ST = 0, PC ← PC + 1, ST ← 1
Note : PC indicates the next address in a fixed sequence that is actually pseudo-random count.
<Purpose> For some programs, normal sequential program execution can be change.
A branch is conditionally implemented depending on the status of results obtained by executing the previous instruction.
<Comment>
- Branch instruction is always conditional depending on the status.
  a. If the status is reset (logic 0), a branch instruction is not rightly executed but the next instruction of the sequence is executed.
  b. If the status is set (logic 1), a branch instruction is executed as follows.
- Branch is available in two types - short and long. The former is for addressing in the current page and the latter for addressing in the other page. Which type of branch to exeute is decided according to the PB register. To execute a long branch, data of the PB register should in advance be modified to a desired page address through the LPBI instruction.

(16) CAL a

Naming : Subroutine Call on status 1
Status : Conditional depending on the status
Format : Ⅳ
Operand : Subroutine code address a(Addr)
Function : When ST =1 , PC ← a(Addr) PA ← PB
SR1 ← PC + 1, PSR1 ← PA
SR2 ← SR1 PSR2 ← PSR1
SR3 ← SR2 PSR3 ← PSR2
When ST = 0 PC ← PC + 1 PB ← PS ST ← 1
Note : PC actually has pseudo-random count against the next instruction.

<Comment>

• In a program, control is allowed to be transferred to a mutual subroutine. Since a call instruction preserves the return address, it is possible to call the subroutine from different locations in a program, and the subroutine can return control accurately to the address that is preserved by the use of the call return instruction (RTN).
Such calling is always conditional depending on the status.

a. If the status is reset, call is not executed.
b. If the status is set, call is rightly executed.

The subroutine stack (SR) of three levels enables a subroutine to be manipulated on three levels. Besides, a long call (to call another page) can be executed on any level.

• For a long call, an LPBI instruction should be executed before the CAL. When LPBI is omitted (and when PA=PB), a short call (calling in the same page) is executed.

(17) RTN

Naming : Return from Subroutine
Status : Set
Format : |
Function :

PC ← SR1	PA, PB ← PSR1
SR1 ← SR2	PSR1 ← PSR2
SR2 ← SR3	PSR2 ← PSR3
SR3 ← SR3	PSR3 ← PSR2
	ST ← 1

<Purpose> Control is returned from the called subroutine to the calling program.
<Comment> Control is returned to its home routine by transferring to the PC the data of the return address that has been saved in the stack register (SR1).
At the same time, data of the page stack register (PSR1) is transferred to the PA and PB.

(18) LPBI i

Naming : Load Page Buffer Register from Immediate
Status : Set
Format : |||
Operand : ROM page address $0 \leq i \leq 15$
Function : PB ← i
<Purpose> A new ROM page address is loaded into the page buffer register (PB).
This loading is necessary for a long branch or call instruction.
<Comment> The PB register is loaded together with three bits from 4 bit operand.

(19) AM

Naming : Add Accumulator to Memory and Status 1 on Carry
Status : Carry to status
Format : |
Function : A ← M(X,Y)+A, ST ← 1(when total>15),
ST ← 0 (when total ≤15)
<Comment> Data in the memory location addressed by the X and Y-register is added to data of the accumulator. Results are stored in the accumulator. Carry data as results is transferred to status. When the total is more than 15, a carry is caused to put ″1″ in the status. Data in the memory is not changed.

(20) SM

Naming : Subtract Accumulator to Memory and Status 1 Not Borrow
Status : Carry to status
Format : |
Function : A ← M(X,Y) - A ST ← 1(when A ≤ M(X,Y))
ST ← 0(when A > M(X,Y))
<Comment> Data of the accumulator is, through a 2`s complemental addition, subtracted from the memory word addressed by the Y-register. Results are stored in the accumulator. If data of the accumulator is less than or equal to the memory word, the status is set to indicate that a borrow is not caused.
If more than the memory word, a borrow occurs to reset the status to ″0″.

(21) IM

Naming : Increment Memory and Status 1 on Carry
Status : Carry to status
Format : |
Function : A ← M(X,Y) + 1 ST ← 1(when M(X,Y) ≥ 15)
ST ← 0(when M(X,Y) < 15)
<Comment> Data of the memory addressed by the X and Y-register is fetched. Adding 1 to this word, results are stored in the accumulator. Carry data as results is transferred to the status. When the total is more than 15, the status is set. The memory is left unchanged.

(22) DM

Naming : Decrement Memory and Status 1 on Not Borrow
Status : Carry to status
Format : |
Function : A ← M(X,Y) - 1 ST ← 1(when M(X,Y) ≥1)
ST ← 0 (when M(X,Y) = 0)
<Comment> Data of the memory addressed by the X and Y-register is fetched, and one is subtracted from this word (addition of Fh)> Results are stored in the accumulator. Carry data as results is transferred to the status. If the data is more than or equal to one, the status is set to indicate that no borrow is caused. The memory is left unchanged.

(23) IA

Naming : Increment Accumulator
Status : Set
Format : |
Function : A ← A+1
<Comment> Data of the accumulator is incremented by one. Results are returned to the accumulator.
A carry is not allowed to have effect upon the status.

(24) IY

Naming : Increment Y-Register and Status 1 on Carry
Status : Carry to status
Format : |
Function : Y ← Y + 1 ST ← 1 (when Y = 15)
ST ← 0 (when Y < 15)
<Comment> Data of the Y-register is incremented by one and results are returned to the Y-register.
Carry data as results is transferred to the status. When the total is more than 15, the status is set.

(25) DA

Naming : Decrement Accumulator and Status 1 on Borrow
Status : Carry to status
Format : |
Function : A ← A - 1 ST ← 1(when A ≥1)
ST ← 0 (when A = 0)
<Comment> Data of the accumulator is decremented by one. As a result (by addition of Fh), if a borrow is caused, the status is reset to ″0″ by logic. If the data is more than one, no borrow occurs and thus the status is set to ″1″.

(26) DY

Naming : Decrement Y-Register and Status 1 on Not Borrow
Status : Carry to status
Format : |
Function : $Y \leftarrow Y - 1$ ST ← 1 (when $Y \geq 1$)
ST ← 0 (when Y = 0)
<Purpose> Data of the Y-register is decremented by one.
<Comment> Data of the Y-register is decremented by one by addition of minus 1 (Fh).
Carry data as results is transferred to the status. When the results is equal to 15, the status is set to indicate that no borrow has not occurred.

(27) EORM

Naming : Exclusive or Memory and Accumulator
Status : Set
Format : |
Function : $A \leftarrow M(X,Y) \oplus A$
<Comment> Data of the accumulator is, through a Exclusive OR, subtracted from the memory word addressed by X and Y-register. Results are stored into the accumulator.

(28) NEGA

Naming : Negate Accumulator and Status 1 on Zero
Status : Carry to status
Format : |
Function : $A \leftarrow \overline{A} + 1$ ST ← 1(when A = 0)
ST ← 0 (when A != 0)
<Purpose> The 2`s complement of a word in the accumulator is obtained.
<Comment> The 2`s complement in the accumulator is calculated by adding one to the 1`s complement in the accumulator. Results are stored into the accumulator. Carry data is transferred to the status. When data of the accumulator is zero, a carry is caused to set the status to ″1″.

(29) ALEM

Naming : Accumulator Less Equal Memory
Status : Carry to status
Format : |
Function : A ≤ M(X,Y) ST ← 1 (when A ≤ M(X,Y))
ST ← 0 (when A > M(X,Y))
<Comment> Data of the accumulator is, through a complemental addition, subtracted from data in the memory location addressed by the X and Y-register. Carry data obtained is transferred to the status. When the status is ″1″, it indicates that the data of the accumulator is less than or equal to the data of the memory word. Neither of those data is not changed.

(30) ALEI

Naming : Accumulator Less Equal Immediate
Status : Carry to status
Format : |||
Function : A ≤ i ST ← 1 (when A ≤ i)
ST ← 0 (when A > i)
<Purpose> Data of the accumulator and the constant are arithmetically compared.
<Comment> Data of the accumulator is, through a complemental addition, subtracted from the constant that exists in 4bit operand. Carry data obtained is transferred to the status. The status is set when the accumulator value is less than or equal to the constant. Data of the accumulator is left unchanged.

(31) MNEZ

Naming : Memory Not Equal Zero
Status : Comparison results to status
Format : |
Function : M(X,Y) ≠ 0 ST ← 1(when M(X,Y) ≠ 0)
ST ← 0 (when M(X,Y) = 0)
<Purpose> A memory word is compared with zero.
<Comment> Data in the memory addressed by the X and Y-register is logically compared with zero. Comparison data is thransferred to the status. Unless it is zero, the status is set.

(32) YNEA

Naming : Y-Register Not Equal Accumulator
Status : Comparison results to status
Format : |
Function : Y ≠ A ST ← 1 (when Y ≠ A)
ST ← 0 (when Y = A)
<Purpose> Data of Y-register and accumulator are compared to check if they are not equal.
<Comment> Data of the Y-register and accumulator are logically compared. Results are transferred to the status. Unless they are equal, the status is set.

(33) YNEI

Naming : Y-Register Not Equal Immediate
Status : Comparison results to status
Format : ||
Operand : Constant 0 ≤ i ≤ 15
Function : Y ≠ i ST ← 1 (when Y ≠ i)
ST ← 0 (when Y = i)
<Comment> The constant of the Y-register is logically compared with 4bit operand. Results are transferred to the status. Unless the operand is equal to the constant, the status is set.

(34) KNEZ

Naming : K Not Equal Zero
Status : The status is set only when not equal
Format : |
Function : When K ≠ 0, ST ← 1
<Purpose> A test is made to check if K is not zero.
<Comment> Data on K are compared with zero. Results are transferred to the status. For input data not equal to zero, the status is set.

(35) RNEZ

Naming : R Not Equal Zero
Status : The status is set only when not equal
Format : |
Function : When R ≠ 0, ST ← 1
<Purpose> A test is made to check if R is not zero.
<Comment> Data on R are compared with zero. Results are transferred to the status. For input data not equal to zero, the status is set.

(36) LAK

Naming : Load Accumulator from K
Status : Set
Format : |
Function : A ← K
<Comment> Data on K are transferred to the accumulator

(37) LAR

Naming : Load Accumulator from R
Status : Set
Format : |
Function : A ← R
<Comment> Data on R are transferred to the accumulator

(38) SO

Naming : Set Output Register Latch
Status : Set
Format : |
Function :

D(Y) ← 1	0 ≤ Y ≤ 7
REMOUT ← 1(PMR=5)	Y = 8
D0~D9 ← 1 (High-Z)	Y = 9
R(Y) ← 1	Ah ≤ Y ≤ Dh
R ← 1	Y = Eh
D0~D9, R ← 1	Y = Fh

<Purpose> A single D output line is set to logic 1, if data of Y-register is between 0 to 7.
Carrier frequency come out from REMOUT port, if data of Y-register is 8.
All D output line is set to logic 1, if data of Y-register is 9.
It is no operation, if data of Y-register between 10 to 15.
When Y is between Ah and Dh, one of R output lines is set at logic 1.
When Y is Eh, the output of R is set at logic 1.
When Y is Fh, the output D0~D9 and R are set at logic 1.

<Comment> Data of Y-register is between 0 to 7, selects appropriate D output.
Data of Y-register is 8, selects REMOUT port.
Data of Y-register is 9, selects all D port.
Data in Y-register, when between Ah and Dh, selects an appropriate R output (R0~R3).
Data in Y-register, when it is Eh, selects all of R0~R3.
Data in Y-register, when it is Fh, selects all of D0~D9 and R0~R3.

(39) RO

Naming : Reset Output Register Latch
Status : Set
Format : |
Function :

D(Y) ← 0	0 ≤ Y ≤ 7
REMOUT ← 0	Y = 8
D0~D9 ← 0	Y = 9
R(Y) ← 0	Ah ≤ Y ≤ Dh
R ← 0	Y = Eh
D0~D9, R ← 0	Y = Fh

<Purpose> A single D output line is set to logic 0, if data of Y-register is between 0 to 9.
REMOUT port is set to logic 0, if data of Y-register is 9.
All D output line is set to logic 0, if data of Y-register is 9.
When Y is between Ah and Dh, one of R output lines is set at logic 0.
When Y is Eh, the output of R is set at logic 0
When Y is Fh, the output D0~D9 and R are set at logic 1.

<Comment> Data of Y-register is between 0 to 7, selects appropriate D output.
Data of Y-register is 8, selects REMOUT port.
Data of Y-register is 9, selects D port.
Data in Y-register, when between Ah and Dh, selects an appropriate R output (R0~R3).
Data in Y-register, when it is Eh, selects all of R0~R3.
Data in Y-register, when it is Fh, selects all of D0~D9 and R0~R3.

(40) WDTR

Naming : Watch Dog Timer Reset
Status : Set
Format : |
Function : Reset Watch Dog Timer (WDT)
<Purpose> Normally, you should reset this counter before overflowed counter for dc watch dog timer. this instruction controls this reset signal.

(41) STOP

Naming : STOP
Status : Set
Format : |
Function : Operate the stop function
<Purpose> Stopped oscillator, and little current.
(See 1-12 page, STOP function.)

(42) LPY

Naming : Pulse Mode Set
Status : Set
Format : |
Function : PMR ← Y
<Comment> Selects a pulse signal outputted from REMOUT port.

(43) NOP

Naming : No Operation
Status : Set
Format : |
Function : No operation

Guideline for S/W

1. All rams need to be initialized to zero in reset address for proper design.

2. Make the output ports `H` after reset.

3. Do not use WDTR instruction in subroutine.

4. Before reading the input port the waiting time should be more than 200uS.

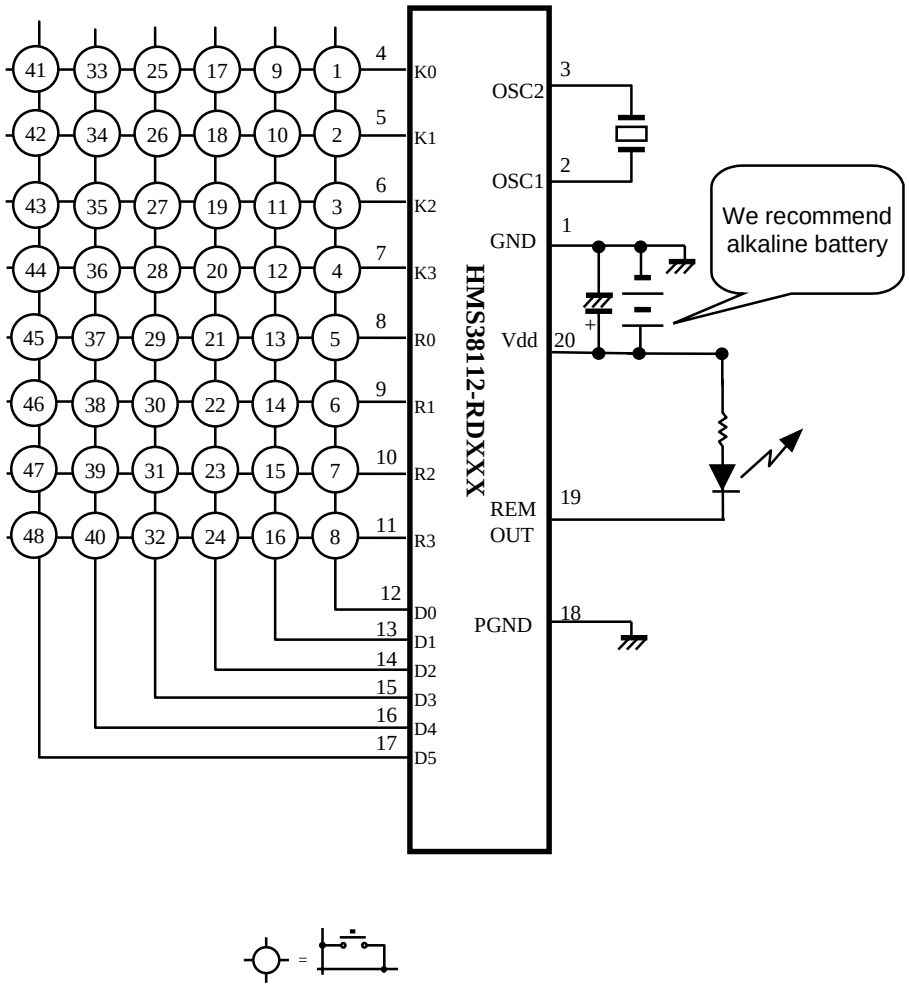
5. To decrease current consumption, make the output port as high in normal routine except for key scan strobe and STOP mode.

6. We recommend you do not use all 64 bytes in a page. You had better write ` BR $` in unused area. This will help you prevent unusual operation of MCU.

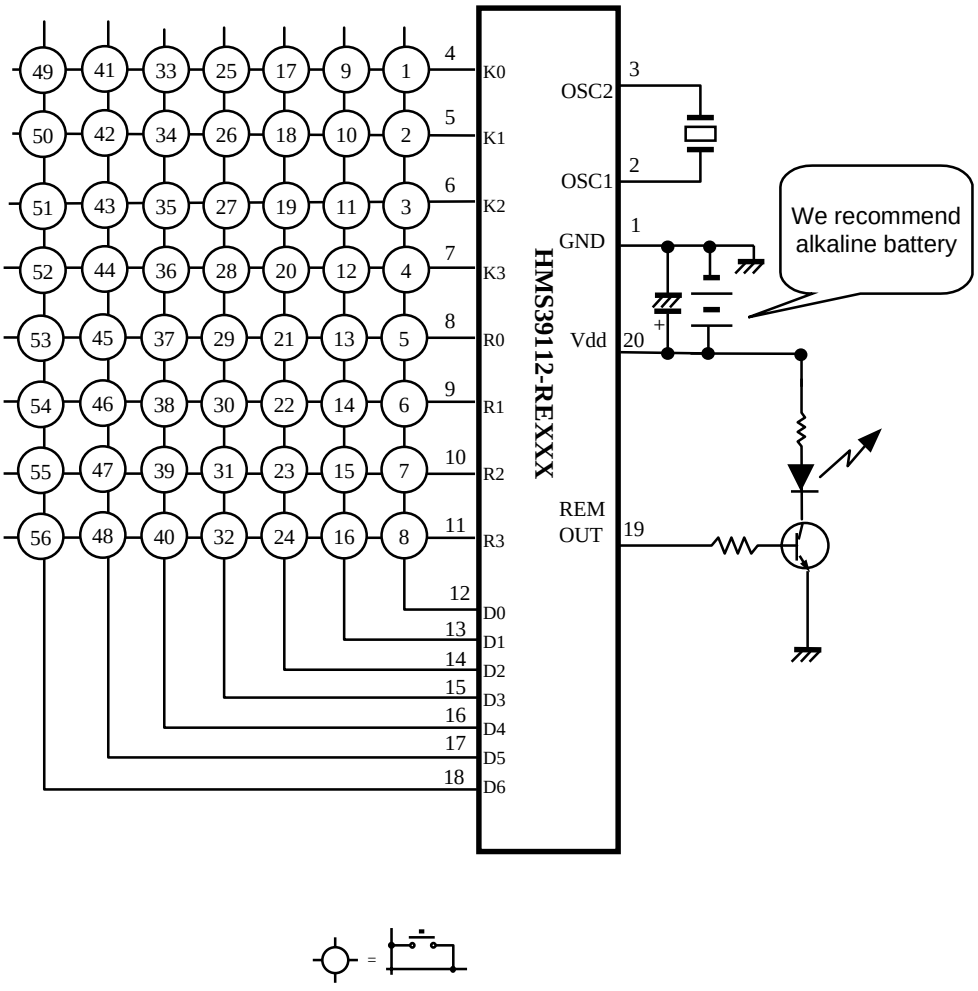
7. Be careful not to use long call or branch (CALL,BL) with arithmetic manipulation.
   If you want to use branch right after arithmetic manipulation, the long call or branch will be against your intention.

```
ex)   LAR        ; The value of R ports -> Accumulator
      ALEI  14   ;  A≤14 : S = 1,    A  >14 : S = 0
      BL   TRUE ; S is always 1  because BL is composed of LPBI and BR.
   ----------  Fail


      LAR        ; The value of R ports -> Accumulator
      ALEI  14   ;  A≤14 : S = 1,    A  >14 : S = 0
      BR   TRUE ; When S is 1 Branch will occur. Otherwise Branch will not occur and
      LAK        ; next instruction will be operated.
   ----------  Right
```

HMS38112 Circuit Diagram



HMS39112 Circuit Diagram



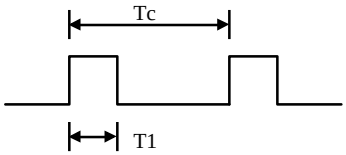
Truth Table for example program

CUSTOM:04H

KEY NO.	DATA(H)	KEY NO.	DATA(H)
K01	00	K29	1C
K02	01	K30	1D
K03	02	K31	1E
K04	03	K32	1F
K05	04	K33	20
K06	05	K34	21
K07	06	K35	22
K08	07	K36	23
K09	08	K37	24
K10	09	K38	25
K11	0A	K39	26
K12	0B	K40	27
K13	0C	K41	28
K14	0D	K42	29
K15	0E	K43	2A
K16	0F	K44	2B
K17	10	K45	2C
K18	11	K46	2D
K19	12	K47	2E
K20	13	K48	2F
K21	14	K49	30
K22	15	K50	31
K23	16	K51	32
K24	17	K52	33
K25	18	K53	34
K26	19	K54	35
K27	1A	K55	36
K28	1B	K56	37

Output waveform of uPD6121G

A single pulse, modulated with 37.917KHz signal at 3.64MHz



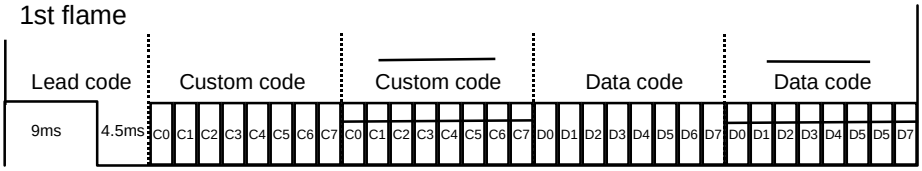
Carrier frequency

$f_{CAR} = 1/Tc = f_{OSC}/96$

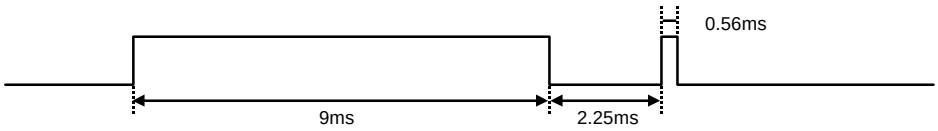
Duty ratio = T1/Tc = 1/3

- Configuration of Flame

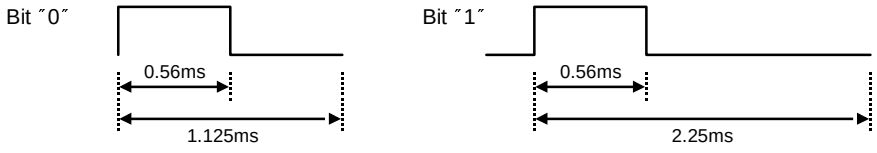
1st flame



- Repeat code

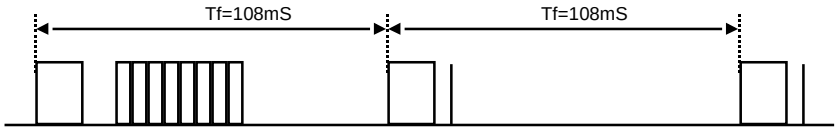


- Bit Description



- Flame Interval : Tf

The transmitted waveform as long as a key is depressed



Example program - uPD6121G

```
            INCLUDE GMS30K.LIB
;-------------------------------------------------------------------------------
;           99.9.8
;           This program is example program for GMS39112 BY Hee Jin RYU
;            The format is NEC format
;-------------------------------------------------------------------------------
;-------------------------------------------------------------------------------
;           RAM DEFINE
;           X=0
COUNT       EQU         00
NONE        EQU       00                ;BIT DEFINE
FIRST       EQU       01
REPEAT      EQU       02
INDAT       EQU         01
TOTLKY      EQU         02
POINT       EQU         03
STROBE      EQU         04
CC6L        EQU         06
CC6H        EQU         07
CC7L        EQU         08
CC7H        EQU         09
NEWDTL      EQU         10
NEWDTH      EQU         11
KEYDTL      EQU         12
KEYDTH      EQU         13
OLDL        EQU         14
OLDH        EQU         15
;-------------------------------------------------------------------------------
            PG          00
;-------------------------------------------------------------------------------
RST         LXI         0
            LYI         15              ;RAM CLEAR
CLA         LMIIY       0
            YNEI        15
            BR          CLA
            LYI          15
            SO
            LYI         6                ; MAKE STROBE PORT LOW BEFORE STOP MODE
TORO        RO
            DY
            BR          TORO
            CALL        TIM10            ; FOR STABLIZATION PORT
            STOP

MAIN        LXI         0
            LYI         15     ;ALL PORT HIGH FOR DECREASING CURRENT CONSUMPTION
            SO
            LYI         COUNT
            LMIIY        0
KEY         LYI          1
            LPY
            LYI         COUNT
            REM         FIRST
            REM         NONE
SCAN        LYI         INDAT
            LMIIY       15
CLR         LMIIY       0
            YNEI        KEYDTL
            BR          CLR
            CALL        SCAN1
            WDTR                        ; DON'T USE WDTR IN SUBROUTINE
            LYI         TOTLKY
            MNEZ
            BR          KEY11
            LYI         COUNT
            TM          NONE
            BR          RST
            SEM         NONE
            BR          SCAN
KEY11       LYM
            YNEI        1
            BR          MAIN
            BL           KEY12
```

```
DTCOM       CAL         COMPARE1
            ALEI        0
            BR          DTCOM1
            BL          TIM11
DTCOM1      DY
            CAL         COMPARE1
            ALEI        0
            BR          DATAC
            BR          RRTN
DATAC       LYI         0
            RTN
COMPARE1    LAM
            IY
            IY
            EORM
RRTN        RTN

            NOP
            BR          $               ; END ADDRESS
;-------------------------------------------------------------------------------
            PG          01
;-------------------------------------------------------------------------------
            BR          $               ;START ADDRESS
SCAN1       LYI         POINT
            LYM
            RO
            CALL        TIM30           ;DELAY FOR KEY SCAN
            LAK
            ALEI        14
            CAL         KSAVE
            LAR
            ALEI        14
            CAL         RSAVE
            LYI         15
            SO
            LYI         POINT
            IM
            LMA
            ALEI        6
            BR          SCAN1
            RTN

KSAVE       NOP
            BR          SAVE
RSAVE       LYI         NEWDTL
            SEM         2
SAVE        LYI         INDAT
            LMAIY
            IM
            LMAIY
            LAM
            LYI         STROBE
            LMA
            RTN

COUN        LYI         COUNT
            TM          FIRST
            BR          KEY25
            SEM         FIRST

KEY26       LYI         NEWDTL
            CALL        DTMOVE
            LYI         2
            CALL        DLY65M
            BL          SCAN

KEY25       LYI         NEWDTL
            CALL        DTCOM
            YNEI        0
            BR          KEY26
```

```
            LYI         KEYDTL
            CALL        DTCOM
            YNEI        0
            BR          KEY31

KEY32       LYI         KEYDTL
            CALL        DTMOVE
            BL          CUSREAD

KEY31       LYI         COUNT
            REM         REPEAT
            BR          KEY32

            NOP
            BR           $
;-------------------------------------------------------------------------------
            PG          02
;-------------------------------------------------------------------------------
            BR          $

KEY12       LYI         STROBE
            TM          0
            BR          LOOPA
            NOP
            BR          LOOPB
LOOPA       LYI         NEWDTL
            SEM         3
LOOPB       LYI         STROBE
            LAM
            LYI         NEWDTH

            ALEI        1
            BR          NT0
            ALEI        3
            BR          NT1
            ALEI        5
            BR          NT2
            LMIIY       3
             BR          CNVE

NT0         LMIIY       0
            CALL        TIM04
            BR          CNVE
NT1         LMIIY       1
            NOP
            NOP
            BR          CNVE
NT2         LMIIY       2
            NOP

CNVE        LYI         INDAT
            LAM
            LYI         0
            ALEI        6
            BR          DWKEY
            ALEI        7
            BR          CON4        ;3
            ALEI        10
            BR          DWKEY
            ALEI        11
            BR          CON3        ;2
            ALEI        12
            BR          DWKEY
            ALEI        13
            BR          CON2        ;1
            ALEI        14
            BR          CONV        ;0
DWKEY       BL          MAIN
CON4        IY
            CALL        TIM03
CON3        IY
            CALL        TIM03
```

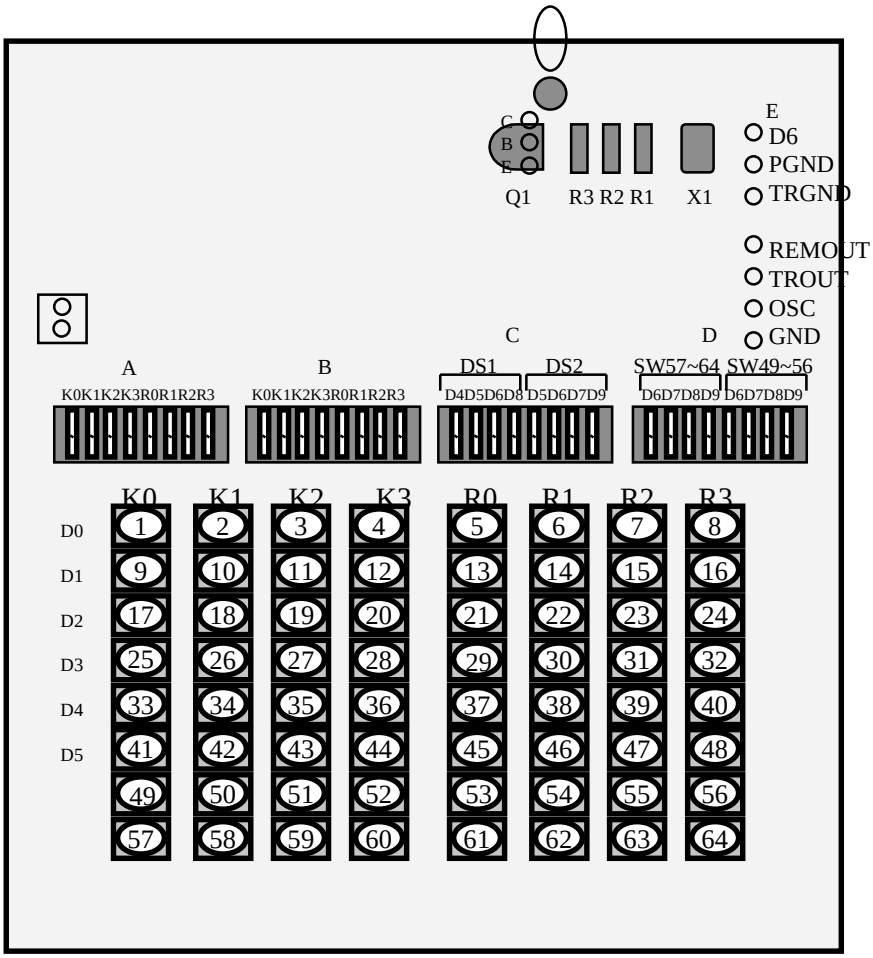
```
CON2        IY
            NOP
CONV        LAY
            LYI         NEWDTL
            AM
            LMA
            BL          COUN

             NOP
            BR          $
;-------------------------------------------------------------------------------
            PG          03
;-------------------------------------------------------------------------------
            BR          $
CUSREAD     LYI         CC6L
            LMIIY       4
            LMIIY       0
            LMIIY       11
            LMIIY       15
CUSCOM      LYI         NEWDTL
            CALL        BAR             ;Y=NEWDTL
            LYI         8
            SO                          ;HEAD
            LYI         9
            CALL        DLY65M
            CALL        TIM27
            LYI         8
            RO                          ;HEAD RO
            LYI         1
            CALL        DLY65M
            CALL        TIM29
            LYI         COUNT
            TM          REPEAT
            BR          HD1
FULCOD      LYI         1
            CALL        DLY65M

            CALL        TIM34
            LYI         POINT
            LMIIY       CC6L
            BL          TX

HD1         CALL        PULSE0
            LYI         10
            CAL         DLY65M
             CAL         DLY65M
            CAL         DLY65M
            WDTR
            CAL         DLY65M
            CAL         DLY65M
            CALL        TIM52
            BL          DDLY1

DLY65M      CALL        TIM63
DLY65M1     DY
            BR          DLY65M
            RTN

             IA                 ;UNUSED INSTRUCTION IS WRITTEN IN BLANK AREA
             DA
             LAY
             LYA
            LAZ
            XMA
            KNEZ
            RNEZ
            ALEM
            NOP

            BR          $
;-------------------------------------------------------------------------------
            PG          04
;-------------------------------------------------------------------------------
```

```
            BR          $
PULSE       CALL        TIM05
PULSE0      LYI         8
            SO
            CALL        TIM41
            RO
             LYI         POINT
            LYM
            BL          TIM31

HGHOUT      CALL        TIM60
            BL          TIM25

TX          CAL         PULSE0
            TM          0
            CAL         HGHOUT
            CAL         PULSE
            TM          1
            CAL         HGHOUT
            CAL         PULSE
            TM          2
            CAL         HGHOUT
            CAL         PULSE
            TM          3
            CAL         HGHOUT
            LYI         POINT
            IM
            LMA
            ALEI        13
            BR          TX

ENDTX       CAL         PULSE0
            WDTR
            LYI         COUNT
            SEM         REPEAT
            LYI         9
            CALL        DLY65M
            CALL        TIM33
DDLY1       LYI         0
            CALL        DLY65M
            CALL        DLY65M
            CALL        TIM54
            BL          KEY

bar         cal         bar1
bar1        im
            nega
COMPART     IY
            IY
            LMA
            DY
            RTN

DTMOVE      CAL         DTMOVE1
DTMOVE1     LAM
            BR          COMPART

            NOP
            BR          $
;-------------------------------------------------------------------------------
            PG          05
;-------------------------------------------------------------------------------
            BR          $
TIM65       NOP
TIM64       NOP
TIM63       NOP
TIM62       NOP
TIM61       NOP
TIM60       NOP
TIM59       NOP
TIM58       NOP
```

```
TIM57       NOP
TIM56       NOP
TIM55       NOP
TIM54       NOP
TIM53       NOP
TIM52       NOP
TIM51       NOP
TIM50       NOP
TIM49       NOP
TIM48       NOP
TIM47       NOP
TIM46       NOP
TIM45       NOP
TIM44       NOP
TIM43       NOP
TIM42       NOP
TIM41       NOP
TIM40       NOP
TIM39       NOP
TIM38       NOP
TIM37       NOP
TIM36       NOP
TIM35       NOP
TIM34       NOP
TIM33       NOP
TIM32       NOP
TIM31       NOP
TIM30       NOP
TIM29       NOP
TIM28       NOP
TIM27       NOP
TIM26       NOP
TIM25       NOP
TIM24       NOP
TIM23       NOP
TIM22       NOP
TIM21       NOP
TIM20       NOP
TIM19       NOP
TIM18       NOP
TIM17       NOP
TIM16       NOP
TIM15       NOP
TIM14       NOP
TIM13       NOP
TIM12       NOP
TIM11       NOP
TIM10       NOP
TIM09       NOP
TIM08       NOP
TIM07       NOP
TIM06       NOP
TIM05       NOP
TIM04       NOP
TIM03       RTN
```

HMS38112 TEST B/D Example

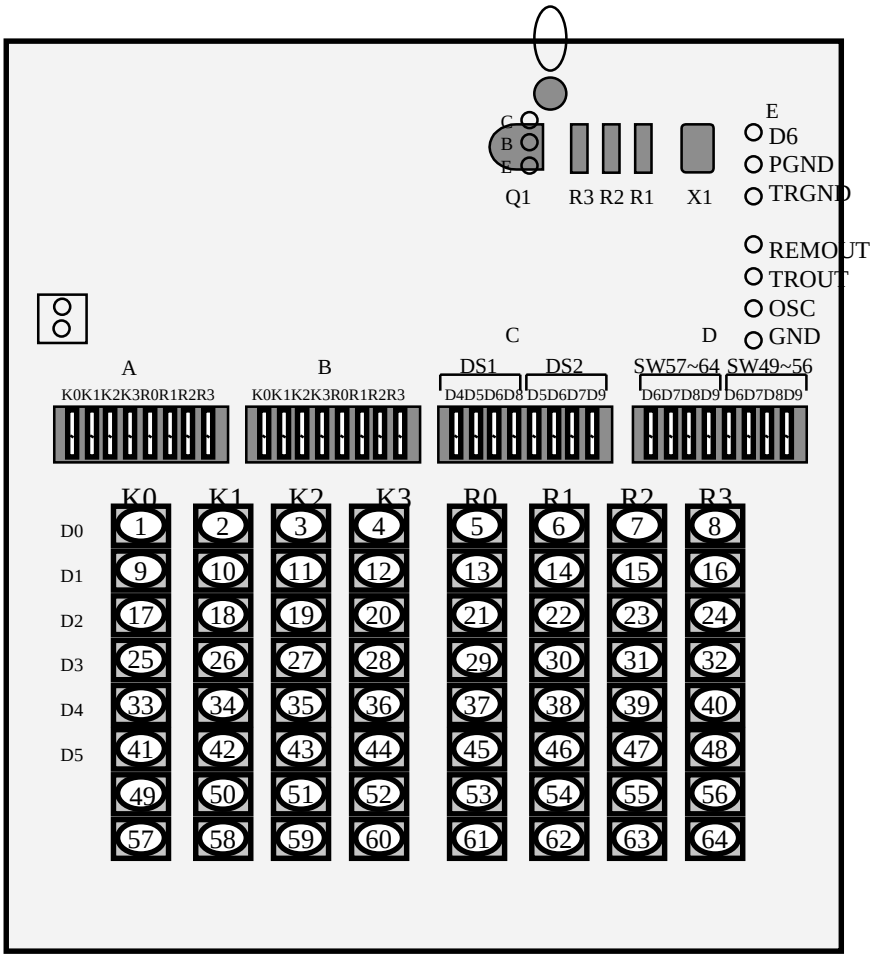
1. Attach resonator to X1
2. Connect base and collector at Q1
3. Connect PGND and TRGND with jumper at E



* DS1 is connected to A. If D6 switch is on among DS1 , A becomes D6 port.
* DS2 is connected to B. If D7 switch is on among DS2 , B becomes D7 port.
* If D6 switch among SW49~SW56 is on at D, the key 49~56 can be used as D6 port.
* If D7 switch among SW57~SW64 is on at D, the key 57~64 can be used as D7 port.
* note : the position of SW49~56 and SW57~64 in B/D is changed. The reference position is right.
* If you want to increase the remote controller valid distance, you try to disconnect R2 resistor and lessen R1 resistor.

HMS39112 TEST B/D Example

1. Attach resonator to X1
2. Attach 2222A transistor to Q1
3. Connect PGND and D6 with jumper at E
4. Attach about 150Ω to R3.



* DS1 is connected to A. If D6 switch is on among DS1 , A becomes D6 port.
* DS2 is connected to B. If D7 switch is on among DS2 , B becomes D7 port.
* If D6 switch among SW49~SW56 is on at D, the key 49~56 can be used as D6 port.
* If D7 switch among SW57~SW64 is on at D, the key 57~64 can be used as D7 port.
* note : the position of SW49~56 and SW57~64 in B/D is changed. The reference position is right.
* If you want to increase the remote controller valid distance, you try to disconnect R2 resistor and lessen R1 resistor.

MASK ORDER & VERIFICATION SHEET

HMS3☐112 -R☐☐☐☐ ☐

1. Customer Information

Company Name		Tel:	Fax:
Name & Signature		Order Date	

2. Device Information

Package	☐ 20 DIP ☐ 20 SOP ☐ 20 SSOP	Mask Data	E-Mail ( )	
			File Name	. RHX . DMP
			Check Sum	@27C256

3. Mask Option

Inclusion of Pull-up Register	Port	R2	R3	
	Y/N			

Release of Stop mode	Port	K0	K1	K2	K3	R0	R1	R2	R3
	Y/N								

Status of D port while Stop mode	Port	D4	D5	D6
	a/b			

1. Don't use WDTR instruction in subroutine.
2. Use Br $ at start (except 0 page) , end and unused address in every page.

3. a: State of " L" forcibly, b: Remain the state just before stop instruction. You must select "a" option when you use Dport as key application.
4. D6 port is available for HMS38112 but not available for HMS39112

4. Marking Specification

☐ Standard Marking

MagnaChip

R☐☐☐☐ YWW

○

☐ User Marking

☐☐☐☐☐☐☐☐☐☐ ← **User LOGO**

R☐☐☐☐ YWW

5. Delivery Schedule

	Date	Quantity	Confirmation
Mask Sample	. .	pcs	
Risk Order	. .	pcs	

6. ROM CODE Verification

MagnaChip Semiconductor Ltd. write in below

Verification Date :
Please confirm our verification data.
Check Sum : @27c256
TEL :82-270-4037 FAX :82-270-4075
Name & Signature ***MagnaChip Semiconductor Ltd. MCU APPLICATION TEAM***

Customer write in below

Approval Date : . .
I agree with your verification data and confirm you to make mask set.
TEL : FAX :
Company Name : Section Name : Signature :