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4-BIT SINGLE CHIP MICROCOMPUTERS

# **ADAM22X2X**

## **USER`S MANUAL**

- ADAM22C20
- ADAM22P20
- ADAM22C20S
- ADAM22P20S
- ADAM22C21
- ADAM22P21
- ADAM22C21S
- ADAM22P21S
- ADAM22C23
- ADAM22P23
- ADAM22C24
- ADMA22P24

## 1. OVERVIEW

The ADAM22XXX is remote control transmitter which uses CMOS technology.

The ADAM22XXX is suitable for remote control of TV, VCR, FANS, Air-conditioners, Audio Equipments, Toys, Games etc. The ADAM22CXX is MASK version and the ADAM22PXX is OTP version.

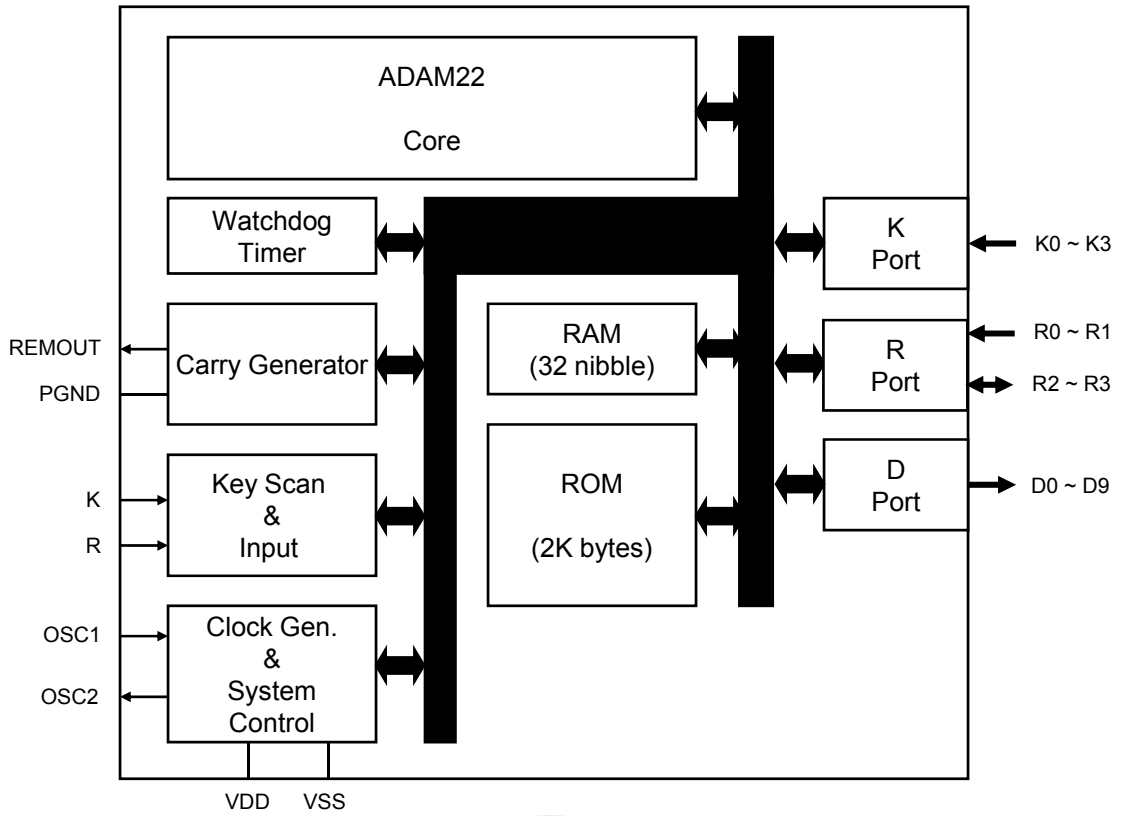
### 1.1. Features

- Program memory
  - 2,048 bytes (2,048 x 8bit)
- Data memory (RAM)
  - 32 nibble (32 x 4bit)
- 3 levels of subroutine nesting
- Operating frequency
  - 2.4MHz ~ 4MHz
- Instruction cycle
  - $f_{osc}/48$
- Stop mode
- Released stop mode by key input
- 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
  - 1.2 ~ 3.6V @ 4MHz
- 20/24 SOP Package.

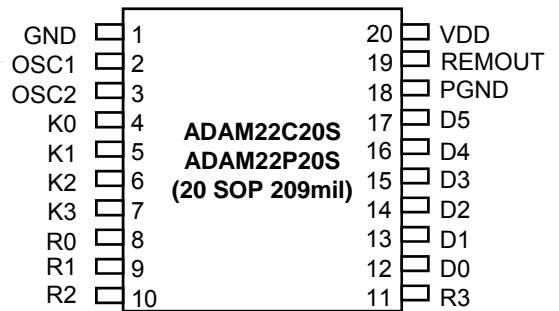
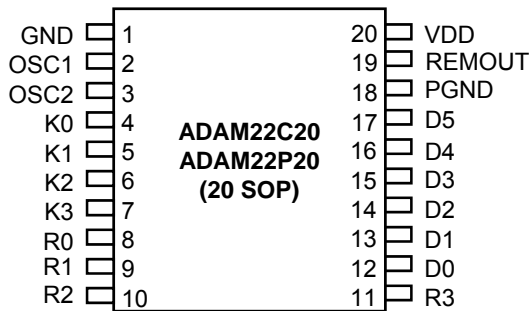
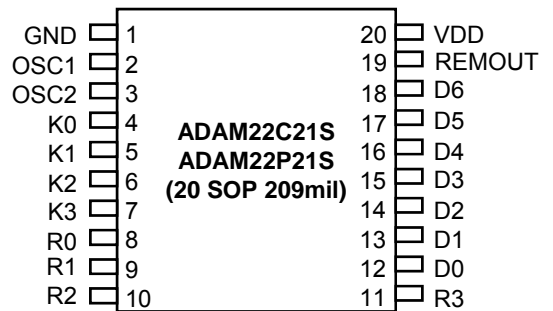
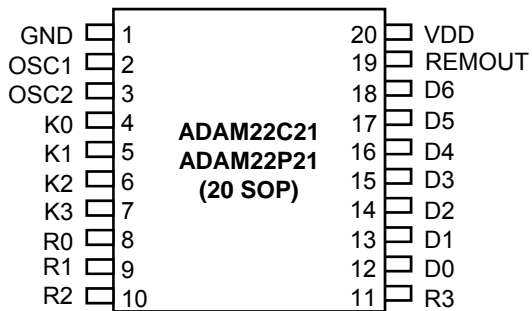
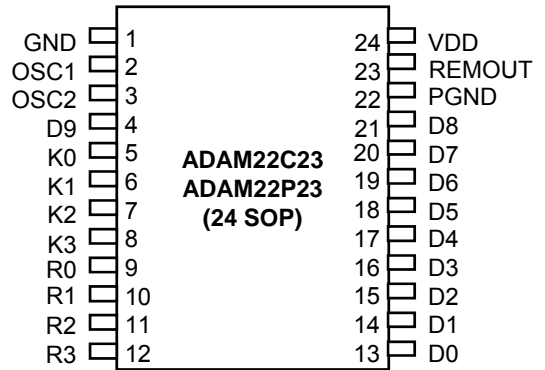
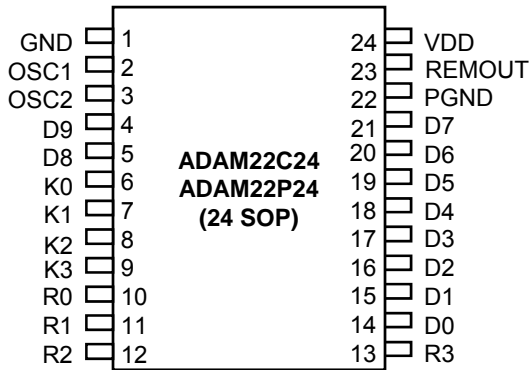
Series	ADAM22C24 ADAM22P24	ADAM22C23 ADAM22P23	ADAM22C21 ADAM22P21	ADAM22C21S ADAM22P21S	ADAM22C20 ADAM22P20	ADAM22C20S ADAM22P20S
Program memory	2,048	2,048	2,048	2,048	2,048	2,048
Data memory	32 x 4	32 x 4	32 x 4	32 x 4	32 x 4	32 x 4
Input ports	7	7	7	7	7	7
Output ports	12	12	9	9	8	8
I/O ports	2	2	2	2	2	2
Package	24SOP(300mil)	24SOP(300mil)	20SOP(300mil)	20SOP(209mil)	20SOP(300mil)	20SOP(209mil)

Table 1.1 ADAM22XXX series members

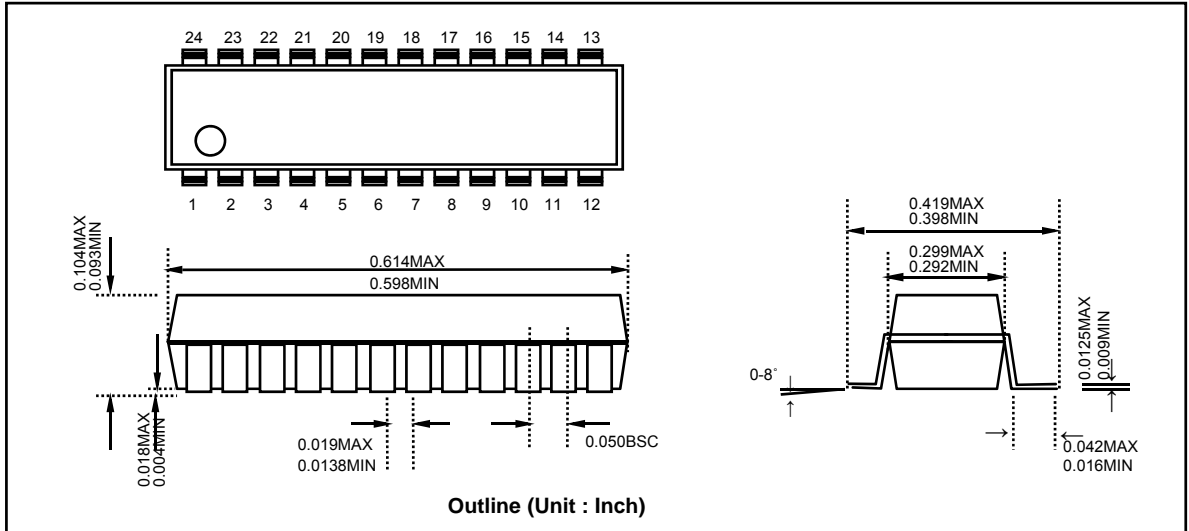
1.2. Block Diagram



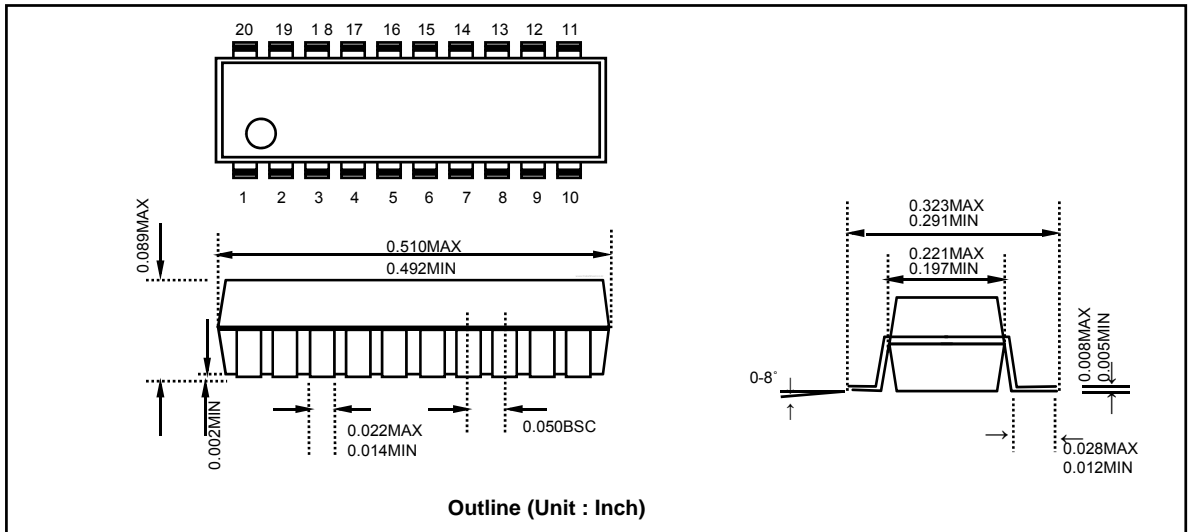
### 1.3. Pin Assignments ( top view )



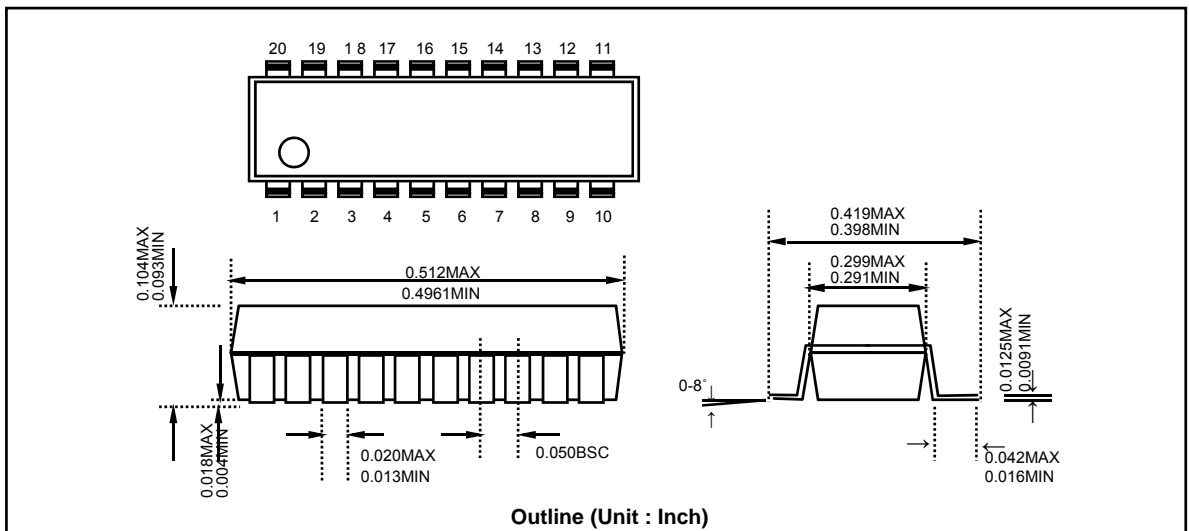
1.4. Package Dimension



24 SOP(300MIL) Pin Dimension (dimensions in inch)



20 SOP(209MIL) Pin Dimension (dimensions in inch)



20 SOP(300MIL) Pin Dimension (dimensions in inch)

### 1.5. Pin Function

PIN NAME	INPUT OUTPUT	FUNCTION	@RESET	@STOP
K R0~R1	Input	- 4-bit input Only Port. - CMOS input with pull-up resistor. - Each pin has STOP mode release function. (It is released by "L" input at STOP mode.)	Input (with Pull-up)	Input (with Pull-up)
R2~R3	I/O	-2-bit I/O Port. (Input mode is set only when each of them output "H") - Each pin has STOP mode release function. - Output mode is set when each of them Output is "L" - When used as "output", each pin can be set and reset independently	Input	-
D0 ~ D3	Output	- N-ch open drain output. - Each pin can be set and reset independently.	Low	Low
D4 ~ D9				Low or keep status before STOP *1
OSC1	Input	- Oscillator Input.	Oscillation	Low
OSC2	Output	- Oscillator Output.	Oscillation	High
REMOUT	Output	- High Current Pulse Output.	'Hi-Z' output	'Hi-Z' output
PGND	Power	-Ground pin for internal high current N-channel transistor. (connected to GND)	-	-
VDD	Power	- Positive power supply.	-	-
VSS	Power	- Ground	-	-

Note:

\*1. This Mask Option is not available in OTP version. In ADAM22PXX, D4~D9 output conditions at STOP Mode is fixed to "Keep status before STOP".

1.6. Pin Circuit

Pin Name	I/O	I/O circuit	Note
K R0~R1	I		- Built in MOS Tr. for pull-up.
R2~R3	I/O		- CMODS output. - "H" output at reset. - Built in MOS Tr. for pull-up.
D0 ~ D9	O		- Open drain output. - "L" output at reset. - D0~D3 Ports are "L" output at Stop Mode. - D4~D9 Ports are "L" output or Keep status before STOP at STOP Mode. (MASK OPTION) *1
REMOUT PGND	O		- Open drain output - Output Tr. Disable at reset and Stop Mode.
OSC1 OSC2	I O		- Built in feedback-resistor about 1MΩ.

Note:

\*1. This Mask Option is not available in OTP version. In ADAM22PXX, D4~D9 output conditions at STOP Mode is fixed to "Keep status before STOP".

## 1.7. Electrical Characteristics

### 1.7.1. Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Max. rating	Unit
Supply Voltage	VDD	-0.3 ~ 5.0	V
Power dissipation	Pd	700 *	mW
Input voltage	VIN	-0.3 ~ VDD+0.3	V
Output voltage	VOUT	-0.3 ~ VDD+0.3	V

\* Thermal derating above 25°C : 6mW per degree °C rise in temperature.

### 1.7.2. Recommended operating condition

Parameter		Symbol	Condition	Rating	Unit
Supply Voltage	ADAM22CXX	VDD	fosc = 2.4~ 4MHz	1.8 ~ 3.6	V
	ADAM22PXX			1.8 ~ 3.6	V
Operating temperature		Topr	-	-20 ~ +70	°C



## 1.7.3. DC Characteristics (Ta = 25 °C, VDD=3V)

Parameter	Symbol	Limits			Unit	Condition	
		Min.	Typ.	Max.			
Input H current	I <sub>IH</sub>	-	-	1	μA	V <sub>I</sub> =V <sub>DD</sub>	
Input Pull-up Resistance	R <sub>PU</sub>	70	120	300	kΩ	V <sub>I</sub> =GND	
OSC Feedback Resistance	R <sub>FD</sub>	0.3	1.0	3.0	MΩ	V <sub>OSC1</sub> =GND, V <sub>OSC2</sub> =V <sub>DD</sub>	
Input H voltage	V <sub>IH1</sub>	2.1	-	-	V	-	
Input L voltage	V <sub>IL1</sub>	-	-	0.9	V	-	
D output L voltage	V <sub>OL1</sub>	-	0.15	0.4	V	I <sub>OL</sub> =3mA	
OSC2 output L voltage	V <sub>OL2</sub>	-	0.4	0.9	V	I <sub>OL</sub> =150μA	
OSC2 output H voltage	V <sub>OH</sub>	2.1	2.5	-	V	I <sub>OH</sub> =-150μA	
REMOUT output L current	I <sub>OL</sub>	-	250	-	mA	V <sub>OL</sub> =0.3V	
REMOUT leakage current	I <sub>OLK1</sub>	-	-	1	μA	V <sub>OUT</sub> =V <sub>DD</sub> , Output off	
D output leakage current	I <sub>OLK2</sub>	-	-	1	μA	V <sub>OUT</sub> =V <sub>DD</sub> , Output off	
Current on STOP mode	I <sub>STP</sub>	-	-	1	μA	At STOP mode	
Operating supply current	I <sub>DD</sub>	-	0.7	1.5	mA	f <sub>osc</sub> = 4MHz	
System clock frequency	f <sub>osc</sub> /48	f <sub>osc</sub>	2.4	-	4	MHz	-

## 2. ARCHITECTURE

### 2.1. Program Memory

The ADAM22XXX can incorporate maximum 2,048 words (2 block × 16 pages × 64 words × 8bits) for program memory. Program counter PC (A0~A5), page address register PA(A6~A9) and Block address register BA(A10) 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.

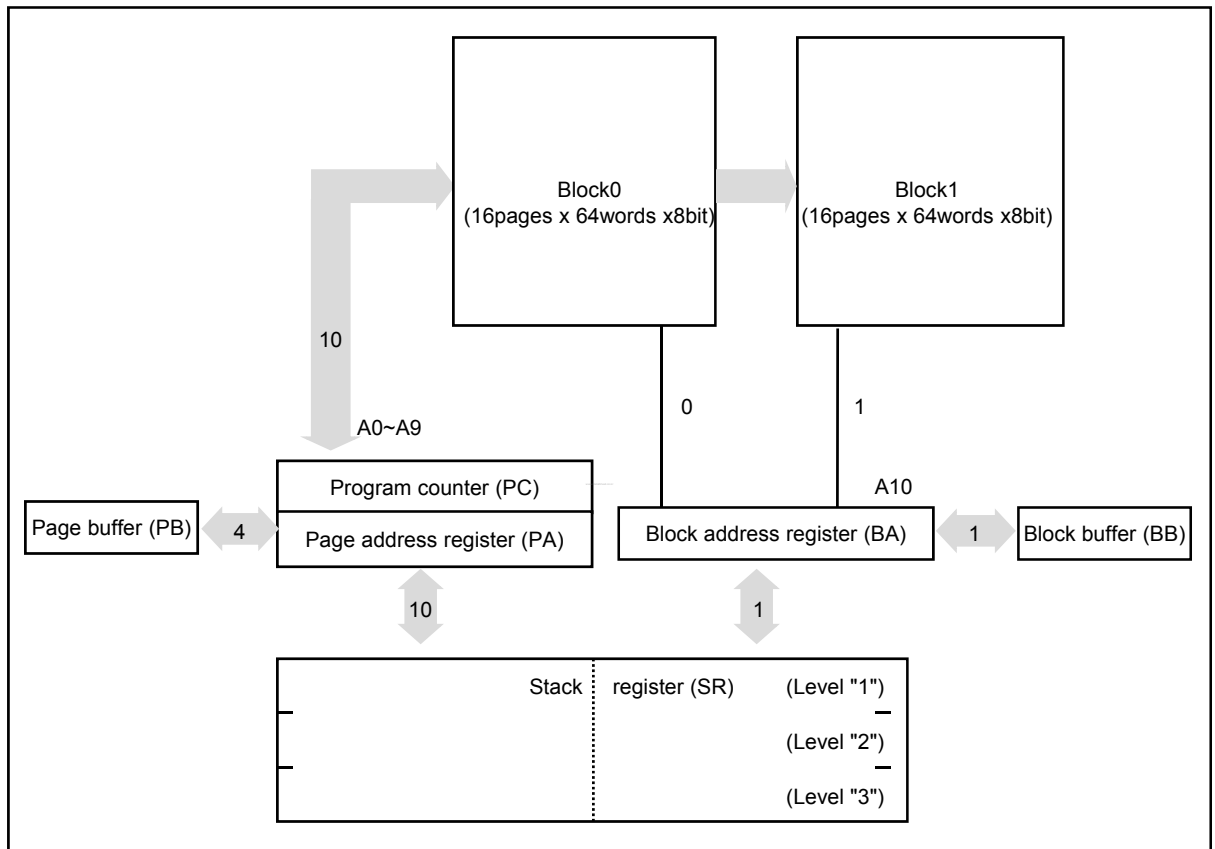


Fig 2-1 Configuration of Program Memory

## 2.2. Address Register

The following registers are used to address the ROM.

- Block address register (BA) :  
Holds ROM's Block number (0~1h) to be addressed.
- Block buffer register (BB) :  
Value of BB is loaded by an SEBB and REBB command when newly addressing a block.  
Then it is shifted into the BA when rightly executing a branch instruction (BR) and a subroutine call (CAL).
- 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.

### 2.2.1. Block address register and Block buffer register :

Address one of block #0 to #1 in the ROM by the 1-bit register.

Unlike the program counter, the block address register is not changed automatically.

To change the block address, take two steps such as

- (1) writing in the block buffer what block to jump (execution of SEBB or REBB) and
- (2) execution of BR or CAL, because instruction code is of eight bits so that block 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.

### 2.2.2. Page address register and page buffer register :

Address one of pages #0 to #15 in the ROM 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.

### 2.2.3. 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.

### 2.2.4. Stack register :

This stack register provides three stages each for the program counter (6bits), the page address register (4bits) and block address (1bit) so that subroutine nesting can be made on two levels.

### 2.3. 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 2-2 shows the configuration.

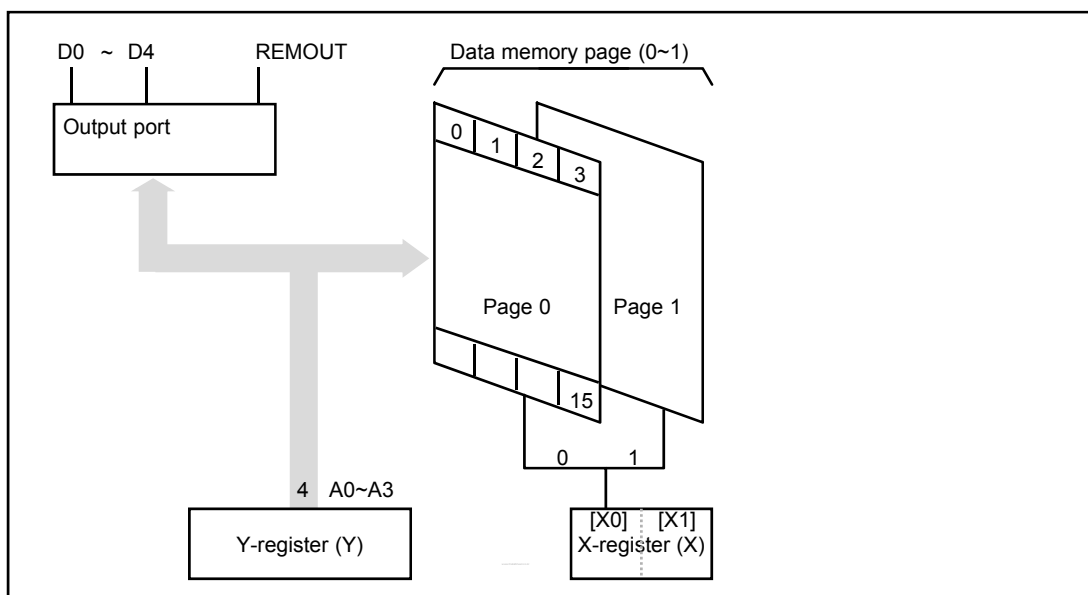


Fig 2-2 Composition of Data Memory

### 2.4. X-register (X)

X-register is consist of 2bit, X0 is a data pointer of page in the RAM, X1 is only used for selecting of D8 ~ D9 with value of Y-register

	X1 = 0	X1 = 1
Y = 0	D0	D8
Y = 1	D1	D9

Table2-1 Mapping table between X and Y register

### 2.5. 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<sub>0</sub>~A<sub>3</sub>) 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.

## 2.6. Accumulator ( $A_{CC}$ )

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

## 2.7. 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.)

### 2.7.1. 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  $A_{CC}$  ( $A_{CC}+1$ )

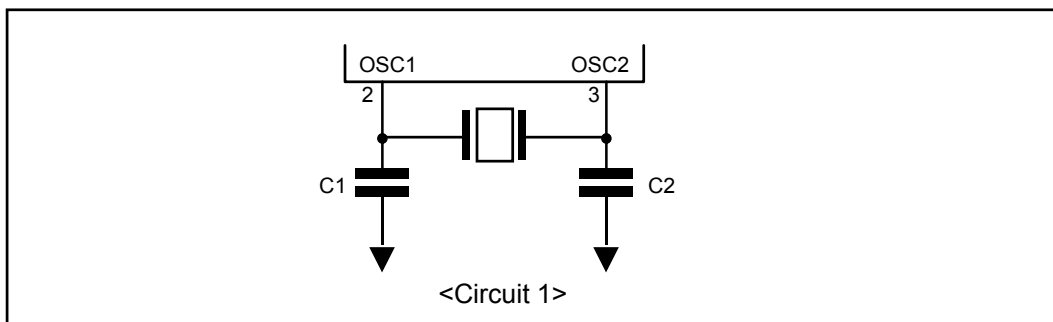
### 2.7.2. Status logic :

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.

### 2.8. Clock Generator

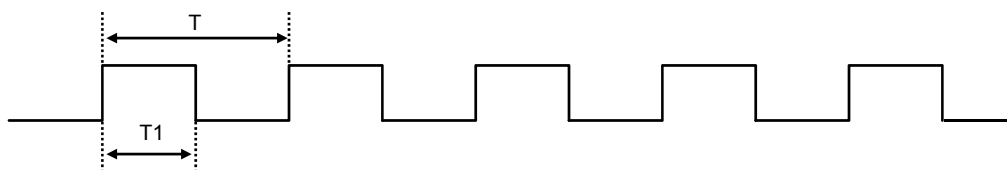
The ADAM22XXX has an internal clock oscillator. The oscillator circuit is designed to operate with an external ceramic resonator. Oscillator circuit is able to organize by connecting ceramic resonator to outside.

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



### 2.9. 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	Setting Prohibited

\* Default value is "0"

Table 2-2 PMR selection table

### 2.10. Reset Operation

ADAM22XXX has two reset sources. One is a built-in Low VDD Detection circuit, another is the overflow of Watch Dog Timer (WDT).

All reset operations are internal in the ADAM22XXX.

### 2.11. Built-in Low VDD Reset Circuit

ADAM22XXX has a Low VDD detection circuit.

If VDD becomes Reset Voltage of Low VDD detection circuit in a active status, system reset occur and WDT is cleared.

When VDD is increased over Reset Voltage again, WDT is re-counted until WDT overflow, system reset is released.

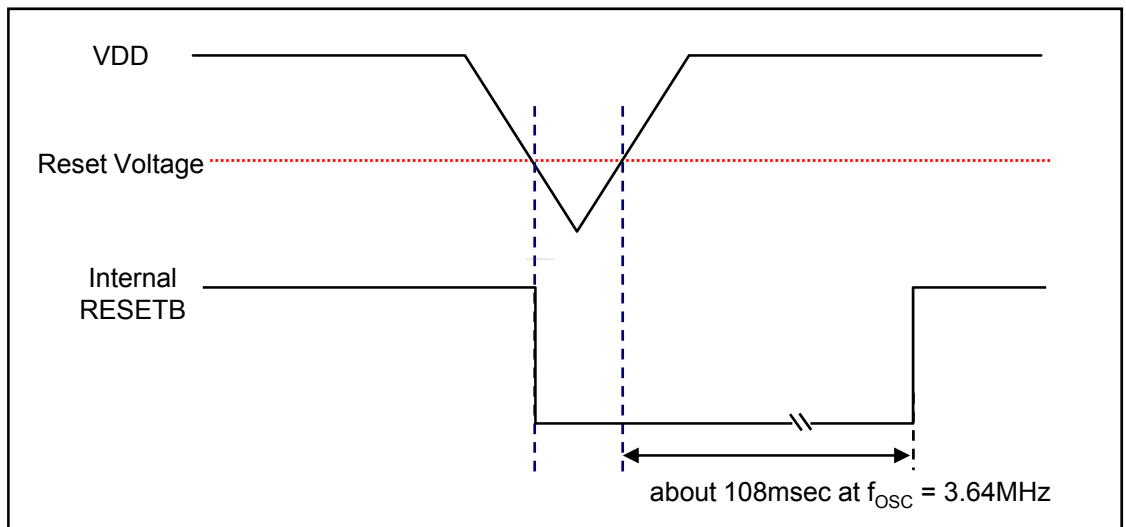


Fig 2-3 Low Voltage Detection Timing Chart.



### 2.12. 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 comes out so that internal circuit is initialized.

The overflow time is  $8 \times 6 \times 2^{13}/f_{OSC}$  (108.026ms at  $f_{OSC} = 3.64\text{MHz}$ )

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 2.14. STOP Operation)

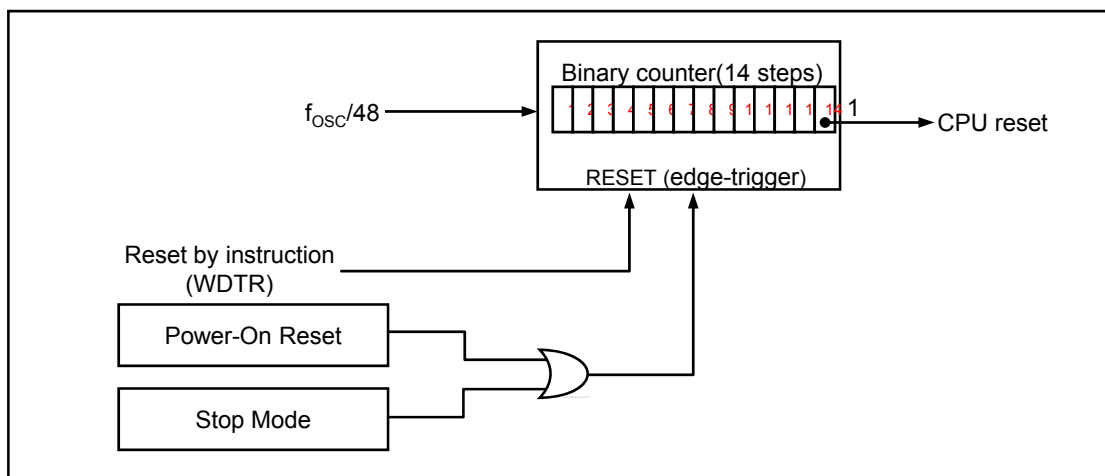


Fig 2-4 Block Diagram of Watch-dog Timer

### 2.13. 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 and REMOUT output is "High-Z" .
3. Part other than WDT and REMOUT output have a value before come into stop mode.
4. D0~D3 output are "Low" at STOP Mode.
5. D4~D9 output conditions at STOP Mode can be selectable by Mask Option.  
(“Low” or Keep status before STOP)

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

When stop mode released :

1. State of D4~D9 output and REMOUT output is return to state of before stop mode is achieved.
2. After  $8 \times 6 \times 2^{10}/f_{osc}$  time for stable oscillating, first instruction start to operate.
3. In return to normal operation, WDT is counted from zero.

When executing stop instruction, if any one of K,R input is "Low" state, stop instruction is same to NOP instruction.

### 2.14. Port Operation

Value of X - reg	Value of Y - reg	Operation
0 or 1	0 ~ 7	SO : D(Y) ← 1 (High-Z) RO : D(Y) ← 0
	8	REMOUT port repeats "H" and "L" in pulse frequency. (When PMR=5, it is fixed at "H" or "L") SO : REMOUT(PMR) ← 0 RO : REMOUT(PMR) ← 1 (High-Z)
	9 or F	SO : D0 ~ D9 ← 1 (High-Z) RO : D0 ~ D9 ← 0
	C~D	SO : R2(Y = C), R3(Y = D) ← 1 RO : R2(Y = C), R3(Y = D) ← 0
	E	SO : R2 ~ R3 ← 1 RO : R2 ~ R3 ← 0
	F	SO : D0 ~ D9 ← 1 (High-Z), R2~R3 ← 1 RO : D0 ~ D9 ← 0, R2~R3 ← 0
2 or 3	0	SO : D(8) ← 1 (High-Z) RO : D(8) ← 0
	1	SO : D(9) ← 1 (High-Z) RO : D(9) ← 0

**3. INSTRUCTION****3.1. INSTRUCTION FORMAT**

All of the 43 instruction in ADAM22XXX 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.

### 3.2. INSTRUCTION TABLE

The ADAM22XXX provides the following 43 basic instructions.

	Category	Mnemonic	Function	ST <sup>*1</sup>
1	Register to Register	LAY	$A \leftarrow Y$	S
2		LYA	$Y \leftarrow A$	S
3		LAZ	$A \leftarrow 0$	S
4	RAM to Register	LMA	$M(X,Y) \leftarrow A$	S
5		LMAIY	$M(X,Y) \leftarrow A, Y \leftarrow Y+1$	S
6		LYM	$Y \leftarrow M(X,Y)$	S
7		LAM	$A \leftarrow M(X,Y)$	S
8		XMA	$A \leftrightarrow M(X,Y)$	S
9	Immediate	LYI i	$Y \leftarrow i$	S
10		LMIIY i	$M(X,Y) \leftarrow i, Y \leftarrow Y+1$	S
11		LXI n	$X \leftarrow n$	S
12	RAM Bit Manipulation	SEM n	$M(n) \leftarrow 1$	S
13		REM n	$M(n) \leftarrow 0$	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	$PB \leftarrow i$	S
19		SEBB	$BB \leftarrow 1$	S
20		REBB	$BB \leftarrow 0$	S
21	Arithmetic	AM	$A \leftarrow M(X,Y) + A$	C
22		SM	$A \leftarrow M(X,Y) - A$	B
23		IM	$A \leftarrow M(X,Y) + 1$	C
24		DM	$A \leftarrow M(X,Y) - 1$	B
25		IA	$A \leftarrow A + 1$	S
26		IY	$Y \leftarrow Y + 1$	C
27		DA	$A \leftarrow A - 1$	B

	Category	Mnemonic	Function	ST <sup>*1</sup>
28	Arithmetic	DY	$Y \leftarrow Y - 1$	<b>B</b>
29		EORM	$A \leftarrow A \oplus M(X,Y)$	<b>S</b>
30		NEGA	$A \leftarrow \overline{A} + 1$	<b>Z</b>
31	Comparison	ALEM	TEST $A \leq M(X,Y)$	<b>E</b>
32		ALEI i	TEST $A \leq i$	<b>E</b>
33		MNEZ	TEST $M(X,Y) \neq 0$	<b>N</b>
34		YNEA	TEST $Y \neq A$	<b>N</b>
35		YNEI i	TEST $Y \neq i$	<b>N</b>
36	Input / Output	LAK	$A \leftarrow K$	<b>S</b>
37		LAR	$A \leftarrow R$	<b>S</b>
38		SO	Output(Y) $\leftarrow 1^{*2}$	<b>S</b>
39		RO	Output(Y) $\leftarrow 0^{*2}$	<b>S</b>
40	Control	WDTR	Watch Dog Timer Reset	<b>S</b>
41		STOP	Stop operation	<b>S</b>
42		LPY	$PMR \leftarrow Y$	<b>S</b>
43		NOP	No operation	<b>S</b>

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.

\*2 Refer to 2.14. Port Operation.

### 3.3. DETAILS OF INSTRUCTION SYSTEM

All 43 basic instructions of the ADAM22XXX 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 :  $A \leftarrow Y$   
<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 :  $Y \leftarrow A$   
<Comment> Load Y-register from Accumulator

**(3) LAZ**

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

**(4) LMA**

Naming : Load Memory from Accumulator  
Status : Set  
Format : I  
Function :  $M(X,Y) \leftarrow A$   
<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 :  $M(X,Y) \leftarrow A, Y \leftarrow Y+1$   
<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 :  $Y \leftarrow M(X,Y)$   
 <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 :  $A \leftarrow M(X,Y)$   
 <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 :  $M(X,Y) \leftrightarrow A$   
 <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 :  $Y \leftarrow i$   
 <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) LMIY i**

Naming : Load Memory from Immediate and Increment Y-Register  
 Status : Set  
 Format : III  
 Operand : Constant  $0 \leq i \leq 15$   
 Function :  $M(X,Y) \leftarrow i, Y \leftarrow Y + 1$   
 <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 :  $M(X,Y,n) \leftarrow 1?$   
 $ST \leftarrow 1$  when  $M(X,Y,n)=1$ ,  $ST \leftarrow 0$  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  $ST = 1$ ,  $PA \leftarrow PB$ ,  $PC \leftarrow a$  (Addr)  
 When  $ST = 0$ ,  $PC \leftarrow PC + 1$ ,  $ST \leftarrow 1$   
 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 execute 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.









**(28) DY**

Naming : Decrement Y-Register and Status 1 on Not Borrow  
 Status : Carry to status  
 Format : |  
 Function :  $Y \leftarrow Y - 1$   $ST \leftarrow 1$  (when  $Y \geq 1$ )  
 $ST \leftarrow 0$  (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.

**(29) 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.

**(30) NEGA**

Naming : Negate Accumulator and Status 1 on Zero  
 Status : Carry to status  
 Format : |  
 Function :  $A \leftarrow \overline{A} + 1$   $ST \leftarrow 1$  (when  $A = 0$ )  
 $ST \leftarrow 0$  (when  $A \neq 0$ )  
 <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".

**(31) ALEM**

Naming : Accumulator Less Equal Memory  
 Status : Carry to status  
 Format : |  
 Function :  $A \leq M(X,Y)$   $ST \leftarrow 1$  (when  $A \leq M(X,Y)$ )  
 $ST \leftarrow 0$  (when  $A > M(X,Y)$ )  
 <Comment> Data of the accumulator is, through a complement 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.

**(32) ALEI**

Naming : Accumulator Less Equal Immediate  
 Status : Carry to status  
 Format : III  
 Function :  $A \leq i$   $ST \leftarrow 1$  (when  $A \leq i$ )  
 $ST \leftarrow 0$  (when  $A > i$ )  
 <Purpose> Data of the accumulator and the constant are arithmetically compared.  
 <Comment> Data of the accumulator is, through a complement 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.

**(33) MNEZ**

Naming : Memory Not Equal Zero  
 Status : Comparison results to status  
 Format : |  
 Function :  $M(X,Y) \neq 0$   $ST \leftarrow 1$  (when  $M(X,Y) \neq 0$ )  
 $ST \leftarrow 0$  (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 transferred to the status. Unless it is zero, the status is set.



**(34) YNEA**

Naming : Y-Register Not Equal Accumulator  
 Status : Comparison results to status  
 Format : I  
 Function :  $Y \neq A$   $ST \leftarrow 1$  (when  $Y \neq A$ )  
 $ST \leftarrow 0$  (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.

**(35) YNEI**

Naming : Y-Register Not Equal Immediate  
 Status : Comparison results to status  
 Format : III  
 Operand : Constant  $0 \leq i \leq 15$   
 Function :  $Y \neq i$   $ST \leftarrow 1$  (when  $Y \neq i$ )  
 $ST \leftarrow 0$  (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.

**(36) LAK**

Naming : Load Accumulator from K  
 Status : Set  
 Format : I  
 Function :  $A \leftarrow K$   
 <Comment> Data on K are transferred to the accumulator

**(37) LAR**

Naming : Load Accumulator from R  
 Status : Set  
 Format : I  
 Function :  $A \leftarrow R$   
 <Comment> Data on R are transferred to the accumulator

**(38) SO**

Naming : Set Output Register Latch  
 Status : Set  
 Format : 1  
 Function :  $D(Y) \leftarrow 1$   $0 \leq Y \leq 5$   
 $REMOUT \leftarrow 1(PMR=5)$   $Y = 8$   
 $D0 \sim D4 \leftarrow 1$  (High-Z)  $Y = 9$  or F  
 $R(Y) \leftarrow 1$   $Ch \leq Y \leq Dh$   
 $R(Y) \leftarrow 1$   $Y = Eh$   
 $D0 \sim D9, R2 \sim R3 \leftarrow 1$   $Y = Fh$

<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 or F.  
 When Y is between Ch and Dh, one of R2 and R3 is set to logic 1.  
 When Y is Eh, R2 and R3 is set to logic 1.  
 When Y is Fh, All D output and R2 and R3 is set to 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 or F, selects all D port.  
 Data in Y-register, when between Ch and Dh, selects an appropriate R port.  
 Data in Y-register, when it is Eh, selects all of R2~R3.  
 Data in Y-register, when it is Fh, selects all of D0~D9 and R2~R3.

**(38) RO**

Naming : Set Output Register Latch  
 Status : Set  
 Format : 1  
 Function :  $D(Y) \leftarrow 0$   $0 \leq Y \leq 5$   
 $REMOUT \leftarrow 0(PMR=5)$   $Y = 8$   
 $D0 \sim D4 \leftarrow 0$   $Y = 9$  or F  
 $R(Y) \leftarrow 0$   $Ch \leq Y \leq Dh$   
 $R(Y) \leftarrow 0$   $Y = Eh$   
 $D0 \sim D9, R2 \sim R3 \leftarrow 0$   $Y = Fh$

<Purpose> A single D output line is set to logic 0, if data of Y-register is between 0 to 7.  
 REMOUT port is set to logic 0, if data of Y-register is 8.  
 All D output line is set to logic 0, if data of Y-register is 9 or F.  
 When Y is between Ch and Dh, one of R2 and R3 is set to logic 0.  
 When Y is Eh, R2 and R3 is set to logic 0.  
 When Y is Fh, All D output and R2 and R3 is set to logic 0.

<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 or F, selects all D port.  
 Data in Y-register, when between Ch and Dh, selects an appropriate R port.  
 Data in Y-register, when it is Eh, selects all of R2~R3.  
 Data in Y-register, when it is Fh, selects all of D0~D9 and R2~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.

**(42) LPY**

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

**(43) NOP**

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

**3.4. Guideline for S/W**

- (1) All rams need to be initialized to any value in reset address for proper design.
- (2) Make the output ports `High` after reset.
- (3) Do not use WDTR instruction in subroutine.
- (4) When you try to read input port changed from external condition, you must secure chattering time 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 ROM bytes in a page.  
It's recommend to add "BR \$" at first and last address of each page.  
Do not add "BR \$" at reset address which is first address of "00" page of "0" bank.