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# SH7000 Series

## Affine Transform

**Label:** AFIN

**Functions Used:** MAC.W Instruction
Post-Increment Register Indirect Addressing

## Contents

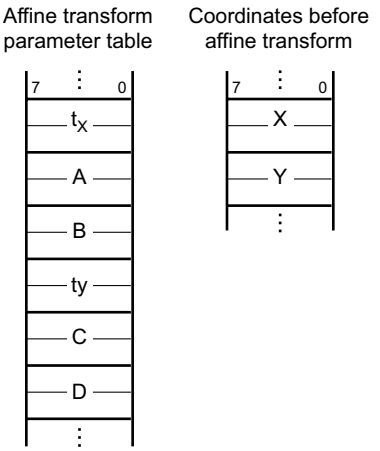
## 1. Function

Performs matrix operations of the affine transform. A the data table of the sort shown below must be prepared beforehand.

Affine transform matrix

$$\begin{bmatrix} A & B & t_X \\ C & D & ty \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix} = \begin{bmatrix} X' \\ Y' \\ 1 \end{bmatrix}$$

(X, Y) : Coordinate values before affine transform
(X', Y') : Coordinate values after affine transform
A, B, C, D : Affine transform parameters
$t_X$, ty : Amount of X/Y coordinate shift during affine transform




## 2. Arguments

| Description | | Storage Location | Data Length (Bytes) |
|---|---|---|---|
| Input | Start address of affine transform parameter table | R0 | 4 |
| | Storage address of coordinates before affine transform | R1 | 4 |
| | Storage address of coordinates after affine transform | R2 | 4 |

## 3. Internal Register Changes and Flag Changes

| | (Before Execution) → (After Execution) |
|---|---|
| R0 | Start address of affine transform parameter table → Undefined |
| R1 | Storage address of coordinates before affine transform → Undefined |
| R2 | Storage address of coordinates after affine transform → Undefined |
| R3 | Work |
| R4 | |
| R5 | |
| R6 | |
| R7 | |
| R8 | |
| R9 | |
| R10 | |
| R11 | |
| R12 | |
| R13 | |
| R14 | |
| R15 | (SP) |

T [—] — : No change
* : Change
0 : Fixed 0
1 : Fixed 1

## 4. Programming Specifications

| Program memory (bytes) |
|---|
| 34 |
| Data memory (bytes) |
| 0 |
| Stack (bytes) |
| 4 |
| Number of states |
| 22 |
| Reentrant |
| Yes |
| Relocation |
| Yes |
| Intermediate interrupt |
| Yes |

## 5. Description

### (1) Function

Details of the arguments are as follows.

R0: Set the affine transform parameter table start address as the input argument.
R1: Set the storage address of the coordinates before affine transform as the input argument.
R2: Set the storage address of the coordinates after affine transform as the input argument.

Figure 1 shows an execution example for the software AFIN instruction. In memory, affine transform parameters are allocated in advance from address H'1000 0000 through $t_x$, A, B, $t_y$, C, and D, in that order. Coordinates before affine transform are allocated from address H'1000 1000 in the order X, Y. The affine transform parameter table start address, storage address for coordinates before affine transform, and storage address for coordinates after affine transform are transferred to the software AFIN as the input argument. Transform matrix operations are performed in AFIN software and coordinates after affine transform are allocated as specified in the input argument from address H'1000 1100 in the order X', Y'.

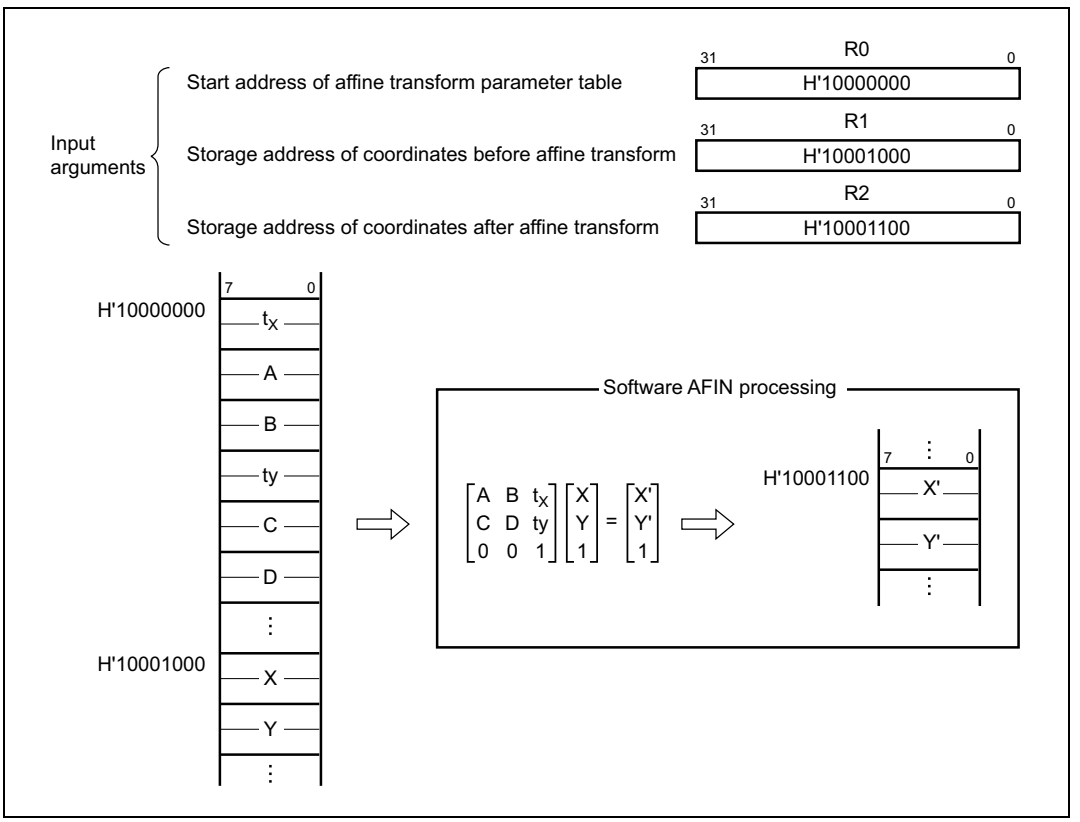



**Figure 1 Software AFIN Execution Example**

### (2) Usage Notes

Affine transform parameters and coordinates should be allocated before the affine transform, as shown in figure 1.

### (3) RAM Used

No RAM is used by the software AFIN instruction.

### (4) Usage Example

After the affine transform parameter table start address, the storage address for coordinates before affine transform, and the storage address for coordinates after affine transform are set in input arguments, the AFIN software instruction is called from a subroutine.

```
        MOV.L   DATA1,R0    ...Sets affine transform parameter table start address in input argument
        MOV.L   DATA2,R1    ...Sets the storage address for coordinates before affine transform in input
                                argument
        BSR     AFIN        ...Subroutine call to software instruction AFIN
        MOV.L   DATA3,R2    ...Sets storage address for coordinates after affine transform in input argument
                .
                .
                .
                .
        .align   4
DATA1   .data.l  H'10000000
DATA2   .data.l  H'10001000
DATA3   .data.l  H'10001100
```

### (5) Operating Principle

(a) Expanding the affine transform matrix produces the following formulas:

$X' = AX + BY + t_X$
$Y' = CX + DY = ty$

(b) As shown in figure 2, $AX + BY + t_x$ and $CX + DY + t_y$ are determined using the multiply and accumulate instruction (MAC).

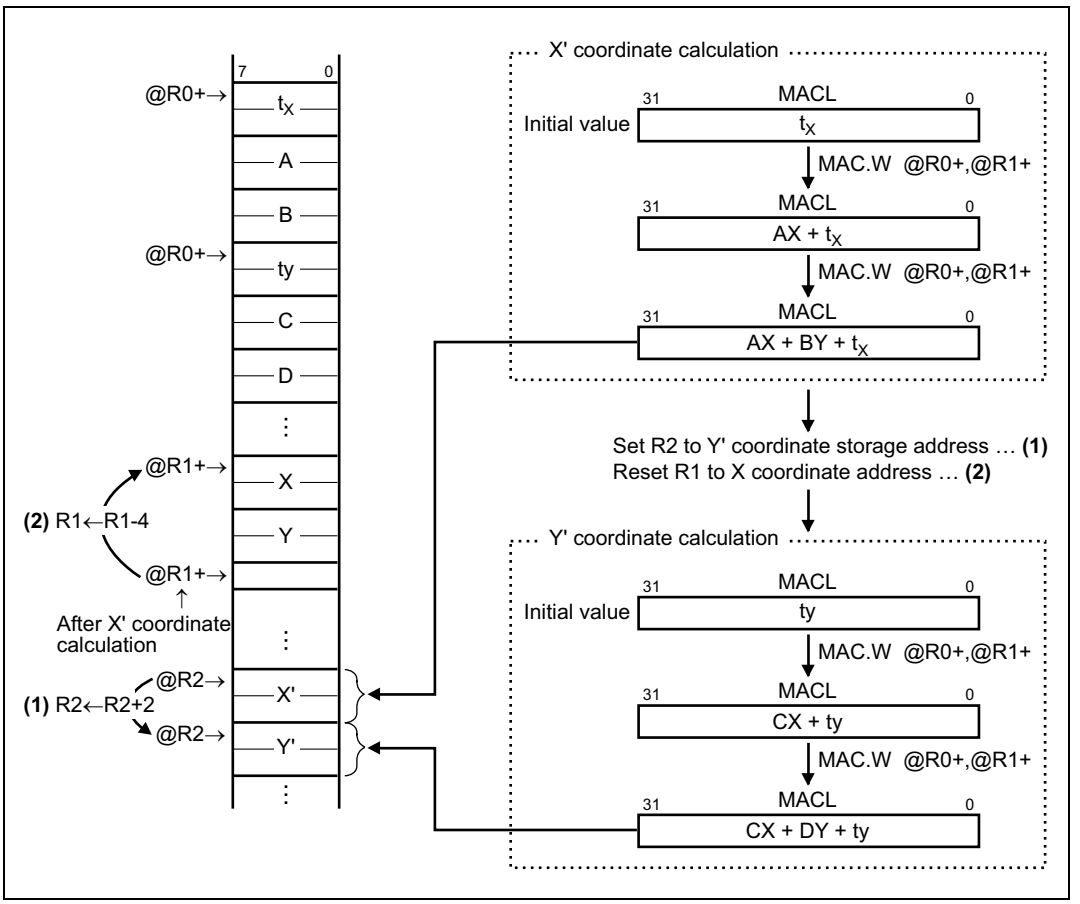
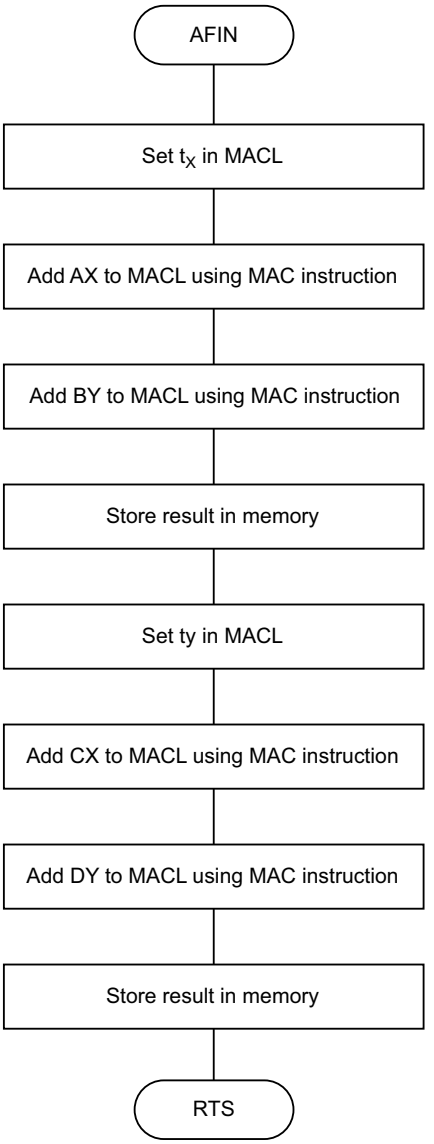



**Figure 2 Calculation of X' and Y' Coordinates**

## 6. Flowchart


AFIN
Set $t_X$ in MACL
Add AX to MACL using MAC instruction
Add BY to MACL using MAC instruction
Store result in memory
Set ty in MACL
Add CX to MACL using MAC instruction
Add DY to MACL using MAC instruction
Store result in memory
RTS

## 7. Program Listing

```
  1                       1   ;*************************************************************
  2                       2   ;*                                                           *
  3                       3   ;*      NAME ; AFIN CONVERSION (AFIN)                        *
  4                       4   ;*                                                           *
  5                       5   ;*************************************************************
  6                       6   ;*                                                           *
  7                       7   ;*      ENTRY : R0 (TOP ADDRESS OF PARAMETER)                *
  8                       8   ;*              R1 (STORED ADDRESS OF BEFORE AFIN CONVERSION) *
  9                       9   ;*              R2 (STOR ADDRESS OF AFTER AFIN CONVERSION)    *
 10                      10   ;*                                                           *
 11                      11   ;*************************************************************
 12 00001000             12           .SECTION A,CODE,LOCATE=H'1000
 13          00001000    13   AFIN    .EQU    $           ; Entry point
 14 00001000 2F36        14           MOV.L   R3,@-R15    ; Escape register
 15 00001002 6305        15           MOV.W   @R0+,R3     ; tx -> MACL
 16 00001004 431A        16           LDS     R3,MACL     ;
 17 00001006 410F        17           MAC.W   @R0+,@R1+   ; A=X+MACL -> MACL(=AX+Tx)
 18 00001008 410F        18           MAC.W   @R0+,@R1+   ; B=Y+MACL -> MACL(=AX+BY+Tx)
 19 0000100A 031A        19           STS     MACL,R3     ; MACL -> X'
 20 0000100C 2231        20           MOV.W   R3,@R2      ;
 21 0000100E 7202        21           ADD     #2,R2       ;
 22 00001010 6305        22           MOV.W   @R0+,R3     ; Ty -> MACL
 23 00001012 431A        23           LDS     R3,MACL     ;
 24 00001014 71FC        24           ADD     #-4,R1      ;
 25 00001016 410F        25           MAC.W   @R0+,@R1+   ; C=X+MACL -> MACL(=CX+Ty)
 26 00001018 410F        26           MAC.W   @R0+,@R1+   ; D=Y+MACL -> MACL(=CX+DY+Ty)
 27 0000101A 031A        27           STS     MACL,R3     ; MACL -> Y'
 28 0000101C 2231        28           MOV.W   R3,@R2      ;
 29 0000101E 000B        29           RTS                 ;
 30 00001020 63F6        30           MOV.L   @R15+,R3    ; Return register
 31                      31           .END
*****TOTAL ERRORS    0
*****TOTAL WARNINGS  0
```

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