MP FLOATING LOAD

DATE: February 1968

ID CODE: BPV

DRAWING: 391075

LABEL: FLD

AUTHOR: STVL

SOURCE: SYM I Assembly Language

OBJECT: Relocatable

PURPOSE

To load into the software registers MNT1, MNT2, MNT3, a mid-precision floating point number set in three consecutive words of memory.

USAGE

Calling Sequence

```
L-1     SMB     FLD
L       JSX     FLD
L+1     D       FARG
L+2     return
```

The routine will return to L+2 with the contents of MNT2 in the hardware accumulator.

Argument Description

FARG is the first of three consecutive words of memory containing a floating point number. The first will be an exponent; the remaining two will be a normalized two-word mantissa.

Storage Requirements

Four words of common storage: RET1, MNT1, MNT2, MNT3.

METHOD

Indexed loads and direct stores constitute the entire logic.

RESTRICTIONS

Entries

FLD

Other Routines

None.

External Constants

None.

Space Used

10 words

Timing

19 cycles.

APPENDIX A

ASSEMBLY LISTING

of

MP FLOATING LOAD

Drawing No.	ID Code
391075 (Revision B)	BPV

```
                                    2      'MP FLOATING LOAD DN391075 B'                                  BPV 0004
                                    3              BLK   MATH                                            BPV 0005
                                    4              LIBR  FLD                                             BPV 0006
   *    0 000 0  67FF  6 0 7FF      5      FLD     STX   RET1                                            BPV 0007
        0 001 0  9800  9 1 000      6              LDX * 0                                               BPV 0008
        0 002 0  8800  8 1 000      7              LDW * 0                                               BPV 0009
   *    0 003 0  77FF  7 0 7FF      8              STW   MNT0                                            BPV 0010
        0 004 0  8802  8 1 002      9              LDW * 2                                               BPV 0011
   *    0 005 0  77FF  7 0 7FF      10             STW   MNT3                                            BPV 0012
        0 006 0  8801  8 1 001      11             LDW * 1                                               BPV 0013
   *    0 007 0  77FF  7 0 7FF      12             STW   MNT2                                            BPV 0014
   *    0 008 0  9000  9 0 000      13             LDX   RET1                                            BPV 0015
        0 009 0  1801  1 1 001      14             JMP * 1                                               BPV 0016
                                    15     ********************************************************     BPV 0017
                                    16             NTRY  FLD                                             BPV 0018
        0 009 0*******9             17             END                                                   BPV 0019
```

X-REF

```
LIB 0 000 0  FLD
EXT 0003     MNT0       0 003 0
EXT 0007     MNT2       0 007 0
EXT 0005     MNT3       0 005 0
EXT 0008     RET1       0 000 0     0 008 0
```

NO ERRORS

CARDS	SHMBOLS	LITR	STACK
17	5 625	0	2

MP FLOATING STORE

DATE: February 1968

ID CODE: BPW

DRAWING: 391077 (Rev B)

LABEL: FST

AUTHOR: STVL

SOURCE: SYM I Assembly Language

OBJECT: Relocatable

PURPOSE

To store into three consecutive words of memory a mid precision floating point number set in the software registers MNT1, MNT2, MNT3.

USAGE

Calling Sequence

```
L-1    SMB    FST
L      JSX    FST
L+1    D      FARG
L+2    return
```

The routine will return to L+2 with the contents of MNT2 in the hardware accumulator.

Argument description

FARG is the first of three consecutive words of memory. The first will be an exponent; the remaining two will be a Double Precision Normalized word.

Storage Requirements

Four words of common storage: RET1, MNT1, MNT2, MNT3.

METHOD

Direct loads and indexed stores constitute the entire logic.

RESTRICTIONS

Entries

FST

Other Routines

None.

External Constants

None.

Space Used

10 words.

Timing

19 cycles.

APPENDIX A

ASSEMBLY LISTING

of

MP FLOATING STORE

Drawing No.

391077 (Revision B)

ID Code

BPW

```
                                        2      'MP FLOATING STORE DN391077 B'                                  BPW 0004
                                        3              BLK   MATH                                             BPW 0005
                                        4              LIBR  FST                                              BPW 0006
   *     0 000 0  67FF  6 0 7FF         5      FST     STX   RET1                                             BPW 0007
         0 001 0  9800  9 1 000         6              LDX * 0                                                BPW 0008
   *     0 002 0  87FF  8 0 7FF         7              LDW   MNT0                                             BPW 0009
         0 003 0  7800  7 1 000         8              STW * 0                                                BPW 0010
   *     0 004 0  87FF  8 0 7FF         9              LDW   MNT3                                             BPW 0011
         0 005 0  7802  7 1 002        10              STW * 2                                                BPW 0012
   *     0 006 0  87FF  8 0 7FF        11              LDW   MNT2                                             BPW 0013
         0 007 0  7801  7 1 001        12              STW * 1                                                BPW 0014
   *     0 008 0  9000  9 0 000        13              LDX   RET1                                             BPW 0015
         0 009 0  1801  1 1 001        14              JMP * 1                                                BPW 0016
                                       15      ***************************************************            BPW 0017
                                       16              NTRY  FST                                              BPW 0018
         0 009 0*******9               17              END                                                    BPW 0019
```

X-REF

```
LIB 0 000 0  FST
EXT 0002     MNT0      0 002 0
EXT 0006     MNT2      0 006 0
EXT 0004     MNT3      0 004 0
EXT 0008     RET1      0 000 0    0 008 0
```

NO ERRORS

CARDS	SYMBOLS	LITR	STACK
17	5	625	0	2

CONVERT FIXED POINT TO MP FLOAT

DATE: December 1968

ID CODE: BRF

DRAWING: 391094 (Rev C)

LABEL: FLT, FLT2

AUTHOR: JACQ

SOURCE: SYM I Assembly Language

OBJECT: Relocatable in Block "MATH"

PURPOSE

This subroutine converts data given in the single or double precision fixed point formats to a normalized mid precision floating point number. The result is stored in the software register MNT1, MNT2, MNT3.

USAGE

Scale Factor

The binary point in a fixed point number is normally considered to be between bits 0 and 1, i.e., immediately in front of the first magnitude bit. The use of an algebraic integer N as a scale factor permits to shift the point N bit positions from it normal location, either to the right if the factor is positive, or to the left if it is negative. That is equivalent to multiplying the fixed point number by 2^N prior to conversion, but without altering the number.

Calling Sequences

FLT refers to a single precision fixed point number. FLT2 refers to a double precision fixed point number. The calling sequence is as follows:

```
L-1    SMB      FLT (or FLT2)
L      JSX      FLT (or FLT2)
L+1    DATA     ARG
L+2    DATA     N + X'8000'
L+3    Return
```

Where ARG is the address of the fixed point number, and 2^N is the scale.

To convert from an unscaled integer, the scale factor N = 15 (FLT) or N = 30 (FLT2) need not be given:

```
L-1   SMB    FLT  (or FLT2)
      JSX    FLT  (or FLT2)
      DATA   ARG + X'8000'
```

Using the standard subroutine calls available with SYM I and SYM II is more convenient:

SYM I

```
      SMB    FLT (or FLT2)
      JSX    FLT (or FLT2), ARG,N
```

or:

```
      SMB    FLT (or FLT2)
      JSX    FLT (or FLT2),ARG
```

SYM II

```
      FLT (or FLT2)   ARG,N
```

or:

```
      FLT (or FLT2)   ARG
```

METHOD

The argument is normalized, i.e., shifted so that its most significant bit is brought into bit 1 of the higher word of the mantissa. In the process the exponent is decremented by 1 for each bit shifted, from an initial value equal to the scale factor plus the bias of the exponent. Exponent and mantissa are stored in the software registers MNT1, MNT2, MNT3.

A zero argument yields three zero words.

A negative argument with a magnitude equal to an integer power of two is given the unnormalized mantissa: X'C000', 0.

ACCURACY

Not applicable.

RESTRICTIONS

Scale Factor N

$-129 < N < 128$

Entries

FLT, FLT2

Loading

This subroutine locally references storage words and constants located in the "MATH POOL" module, and must therefore be loaded in the same 2k block as the pool.

Other Routines

FNRM

Space Used

29 words

Timing (in machine cycles)

	FLT	FLT2
Minimum	41	42
Maximum	161	180
Average	116	127

APPENDIX A

ASSEMBLY LISTING

of

CONVERT FIXED POINT TO MP FLOAT

Drawing No.	ID Code
391094	BRF

```
                    1 *CONVERT FIX PT TO MP FLOAT DN391094 C                        RF' C0000
                    2          BLK   MATH                                           RF' C0010
                    3          LIBR  FLT,FLT2                                       RF  C0020
                    4 ********************************************************      RF  00030
          0000      5 FLT      EQU   $                                              RF  00040
*   0000  67FF      6          STX   RET1                                           RF  00050
    0001  9800      7          LDX * 0                                              RF' C0060
    0002  8800      8          LDW * 0             FIRST WORD                       RF' C0070
*   0003  77FF      9          STW   MNT2                                           RF  00080
    0004  0100     10          CLR                 SECOND WORD = 0                  RF  00090
*   0005  77FF     11          STW   MNT3                                           RF) 10000
    0006  068F     12          LLB   143           BIAS + 15                        RF) 10010
    0007  100F     13          JMP   BOTH                                           RF) 10020
          0008     14 FLT2     EQU   $                                              RF) 10030
*   0008  6000     15          STX   RET1                                           RF) 10040
    0009  9800     16          LDX * 0                                              RF' 10050
    000A  8800     17          LDW * 0             FIRST WORD                       RF' 10060
*   000B  7003     18          STW   MNT2                                           RF' 10070
    000C  8801     19          LDW * 1             SECOND WORD                      RF) 10080
*   000D  7005     20          STW   MNT3                                           RF) 10090
    000E  801C     21          LDW   D158          BIAS + 30                        RF  20000
          000F     22 BOTH     EQU   $                                              RF  20010
    000F  0400     23          SXP                                                  RF  20020
    0010  1015     24          JMP   NOSC          NO SCALE, USE 15 OR 30           RF  20030
          0011     25 SCAL     EQU   $             SCALE IS GIVEN                   RF  20040
    0011  0680     26          LLB   128                                            RF  20050
*   0012  9008     27          LDX   RET1                                           RF  20060
    0013  A801     28          ADD * 1             BIAS + SCALE                     RF  20070
*   0014  E7FF     29          AND   D255                                           RF  20080
          0015     30 NOSC     EQU   $                                              RF  20090
*   0015  77FF     31          STW   MNT1          EXPONENT                         RF' 30000
*   0016  27FF     32          JSX   FNRM          NORMALIZE                        RF' 30010
*   0017  9012     33          LDX   RET1                                           RF' 30020
    0018  8800     34          LDW * 0             SCALE FLAG                       RF  30030
    0019  0810     35          SAP                                                  RF  30040
    001A  1801     36          JMP * 1             1 ARGUMENT                       RF' 30050
    001B  1802     37          JMP * 2             2 ARGUMENTS                      RF' 30060
    001C  009E     38 D158     D     158                                            RF' 30070
                   39          ENTRY FLT,FLT2                                       RF' 30080
                   40          END                                                  RF  30090


    0014  D255
    0016  FNRM
    0015  MNT1
    0008  MNT2
    0000  MNT3
    0017  RET1

NO ERRORS
```

BOTH	000F	D158	001C	D255	0014	FLT	0000
FLT2	0008	FNRM	0016	MATH	0000	MNT1	0015
MNT2	000E	MNT3	000D	NOSC	0015	RET1	0017
SCAL	0011						

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QUALITY SOFTWARE

700 PROGRAMMING SYSTEMS

CONVERT MP FLOAT TO DP FIX

DATE: December 1968

ID CODE: BYY

DRAWING: 392338

LABEL: FIX2

AUTHOR: JACQ

SOURCE: SYM I Assembly Language

OBJECT: Relocatable in Block "MATH"

PURPOSE

This subroutine converts data from the mid precision floating point format to the double precision fixed point format. The latter consists in two consecutive words in two's complement form, where in the first word bit 0 is reserved to the sign and bits 1 - 15 are the most significant half, while in the second word bit 0 is always zero and bits 1 - 15 are the least significant half.

The binary point is normally located between bits 0 and 1 of the most significant word. However, the use of a binary scale, extrinsic to the format, permits to consider the point to the left or right of its normal location.

A fixed point number can be considered as an integer by shifting the binary point to the right of the least significant bit.

USAGE

Scale Factor

The use of an algebraic integer N as a scale factor permits to shift the binary point, in the fixed point number, N bit positions from its normal location, either to the right if the factor is positive, or to the left if it is negative. That is equivalent to scaling the floating point number up or down by 2^N prior to the conversion, but without upsetting the given number.

Calling Sequences

The floating point number to convert is set in the software registers MNT1, MNT2, MNT3, before calling the subroutine FIX_2 as follows:

```
L-1     SMB     FIX2
L       JSX     FIX2
L+1     DATA    STORE
L+2     DATA    N + X'8000'
L+3     Return
```

Where STORE is the address of the converted number and 2^N is the scale.

To convert to an unscaled integer, N = 30 need not be given:

```
L-1     SMB     FIX2
L       JSX     FIX2
L+1     DATA    STORE + X'8000'
L+2     Return
```

Those sequences are coded more conveniently with the standard subroutine calls available in SYM I and SYM II:

SYM I

```
SMB     FIX2
JSX     FIX2,STORE,N
```

or:

```
SMB     FIX2
JSX     FIX2,STORE
```

SYM II

```
FIX2    STORE,N
```

or:

```
FIX2    STORE
```

The floating point number set in MNT1, MNT2, MNT3, is not upset by the subroutine FIX2.

METHOD

The mantissa Xm of the floating point number, $X = Xm \cdot 2^{xe}$, is shifted to the right by a number of bit positions S, if S is positive. The shift count S is the lesser of N-Xe or 30. A negative mantissa is converted to one's complement prior to the shift. The shifted mantissa is restored to two's complement and stored as the result.

A negative shift count S shows an overflow condition. The result is in this case replaced with $\pm (1-2^{-30})$.

ERROR CONDITIONS

An overflow conditions occurs, and the result is then set to $\pm (1-2^{-30})$, when the exponent of the floating point number is greater than the scale factor.

ACCURACY

Not applicable.

RESTRICTIONS

Scale Factor N

$-129 < N < 128$

Entry

FIX2

Loading

This subroutine locally references storage words and constants located in the "MATH POOL" module, and must therefore be loaded in the same 2k block as the pool.

Other Routines

FAD

Space Used

38 words

Timing (in machine cycles)

Minimum	33
Maximum	105
Average	98

APPENDIX A

ASSEMBLY LISTING

of

CONVERT MP FLOAT TO DP FIX

Drawing No.	ID Code
392338	BYY

```
                    1 *CONVERT MP FLOAT TO DP FIX DN392338 A                                YY C0000
                    2          BLK   MATH                                                   YY C0010
                    3          LIBR  FIX2                                                   YY C0020
                    4 ********************************************************             YY C0030
                    5 * NEXT 2 CARDS TO AGREE WITH FAD                                      YY C0040
      0013          6 FADS     EQU   X"13"          SHFT+1-FAD IN FAD                       YY C0050
      003A          7 FADX     EQU   X"3A"          CALL-FAD   IN FAD                       YY C0060
                    8 ********************************************************************* YY C0070
      0000          9 FIX2     EQU   $                                                      YY C0080
* 0000 67FF         10         STX   RET1                                                   YY C0090
  0001 8800         11         LDW * 0              RESULT STORAGE ADDRESS                  YY C0100
* 0002 77FF         12         STW   TMP4           TO BE USED BY *FAD*                     YY C0110
  0003 061E         13         LLB   30             30 IF NO SCALE GIVEN                    YY C0120
  0004 0820         14         SAM                                                          YY C0130
  0005 8801         15         LDW * 1                                                      YY C0140
* 0006 A7FF         16         ADD   D128           SCALE + BIAS                            YY C0150
* 0007 E7FF         17         AND   D255                                                   YY C0160
* 0008 B7FF         18         SUB   MNT1           SHIFT COUNT                             YY C0170
  0009 9800         19         LDX * 0                                                      YY C0180
  000A 0810         20         SAP                                                          YY C0190
  000B D017         21         JMP   OVER           EXPONENT TOO BIG                        YY C0200
* 000C 77FF         22         STW   TMP1                                                   YY C0210
* 000D 87FF         23         LDW   MNT2           MANTISSA                                YY C0220
  000E 7800         24         STW * 0              STORE IN RESULT CELLS                   YY C0230
* 000F 87FF         25         LDW   MNT3                                                   YY C0240
  0010 7801         26         STW * 1                                                      YY C0250
  0011 9025         27         LDX   FADC           FAD ADDRESS                             YY C0260
  0012 8016         28         LDW   BACK           SET RETURN INSTRUCTION                  YY C0270
  0013 783A         29         STW * FADX           IN LINE IN FAD                          YY C0280
* 0014 800C         30         LDW   TMP1           SHIFT COUNT                             YY C0290
  0015 1813         31         JMP * FADS           ENTER FAD AT *SHFT*+1                   YY C0300
  0016 1020         32 BACK    JMP   EXIT                                                   YY C0310
      0017          33 OVER    EQU   $              OVERFLOW                                YY C0320
* 0017 8000         34         LDW   MNT2                                                   YY C0330
  0018 08C0         35         SAZ                  EXCEPT FOR ZERO                         YY C0340
* 0019 C7FF         36         ORI   M15R           SET MAXIMUM                             YY C0350
  001A 0810         37         SAP                                                          YY C0360
* 001B D019         38         ORE   M15R           RESPECT SIGN                            YY C0370
  001C 7800         39         STW * 0                                                      YY C0380
  001D 0810         40         SAP                                                          YY C0390
  001E 0A51         41         SLC   1                                                      YY C0400
  001F 7801         42         STW * 1                                                      YY C0410
      0020          43 EXIT    EQU   $                                                      YY C0420
* 0020 9000         44         LDX   RET1                                                   YY C0430
  0021 88C0         45         LDW * 0              SCALE FLAG                              YY C0440
  0022 0810         46         SAP                                                          YY C0450
  0023 18C1         47         JMP * 1              1 ARGUMENT                              YY C0460
  0024 1802         48         JMP * 2              2 ARGUMENTS                             YY C0470
* 0025 37FF         49 FADC    D     FAD                                                    YY C0480
                    50         NTRY  FIX2                                                   YY C0490
                    51         END                                                          YY C0500


  0006  D128
  0007   D255
  0025   FAD
```

```
0018  MISF
0008  MNT1
0017  MNT2
008F  MNT3
0020  RET1
0014  TMP1
0002  TMP4

NO ERRORS
```

BACK	001E	D128	0006	D255	0007	EXIT	0020
FAD	0025	FADC	0025	FADS	0013	FADX	003A
FIX2	000C	M1SR	001B	MATH	0000	MNT1	0008
MNT2	0017	MNT3	000F	OVER	0017	RET1	0020
TMP1	0014	TMP4	0002				

CONVERT MP FLOAT TO SP FIX

DATE: December 1968

ID CODE: BYZ

DRAWING: 392339

LABEL: FIX

AUTHOR: JACQ

SOURCE: SYM I Assembly Language

OBJECT: Relocatable in Block "MATH"

PURPOSE

This subroutine converts data from the mid precision floating point format to the single precision fixed point format. A single precision fixed point number consists in one word in two's complement form, where bit 0 and bits 1 - 15 are reserved respectively to sign and magnitude.

The binary point is normally located between bits 0 and 1. However, the use of a binary scale, extrinsic to the format, permits to consider the point at any position to the left or right of its normal location.

A fixed point number can be considered as an integer by shifting the binary point to the right of the least magnitude bit.

USAGE

Scale Factor

The use of an algebraic integer N as a scale factor permits to shift the binary point, in the fixed point number, N bit positions from its normal location, either to the right if the factor is positive, or to the left if it is negative. That is equivalent to scaling the floating point number up or down by 2^N prior to the conversion, but without upsetting the given number.

Calling Sequences

The floating point number to convert is set in the software registers, MNT1, MNT2, MNT3, before calling the subroutine FIX as follows:

```
L-1     SMB     FIX
L       JSX     FIX
L+1     DATA    STORE
L+2     DATA    N + X'8000'
L+3     Return
```

Where STORE is the address of the converted number and 2N is the scale.

To convert to an unscaled integer, N = 15 need not be given:

```
L-1     SMB     FIX
L       JSX     FIX
L+1     DATA    STORE + X'8000'
L+2     Return
```

Those sequences are coded more conveniently with the standard subroutine calls available in SYM I and SYM II:

SYM I		SYM II	
SMB	FIX	FIX	STORE, N
JSX	FIX, STORE, N		
or:		or	
SMB	FIX	FIX	STORE
JSX	FIX, STORE		

The floating point number set in MNT1, MNT2, MNT3, is not upset by the subroutine FIX.

METHOD

The mantissa Xm of the floating point number, $X = Xm \cdot 2^{xe}$, is shifted to the right by a number of bit positions S, if S is positive. The shift count S is the lesser of N-Xe or 15. A negative mantissa is converted to one's complement prior to the shift. The most significant half of the shifted mantissa is restored to two's complement and stored as the result.

A negative shift count S shows an overflow condition. The result is in this case replaced with $\pm (1 - 2^{-15})$.

ERROR CONDITIONS

An overflow condition occurs, and the result is then set to $\pm (1 - 2^{-15})$, when the exponent of the floating point number is greater than the scale factor.

ACCURACY

Not applicable.

RESTRICTIONS

Scale Factor N

$-129 < N < 128$

Entry

FIX

Loading

This subroutine locally references storage words and constants located in the "MATH POOL" module, and must therefore be loaded in the same 2k block as the pool.

Other Routines

None

Space Used

39 words

Timing (in machine cycles)

Minimum	29
Maximum	51
Average	45

APPENDIX A

ASSEMBLY LISTING

of

CONVERT MP FLOAT TO SP FIX

Drawing No.	ID Code
392339	BY Z

```
                    1 *CONVERT MP FLOAT TO SP FIX DN392339 A                          YZ 00000
                    2          BLK   MATH                                            YZ 00010
                    3          LIBR  FIX                                             YZ 00020
                    4 **********************************************************     YZ 00030
          0000      5 FIX      EQU   $                                               YZ 00040
*   0000  67FF      6          STX   RET1                                            YZ 00050
    0001  8800      7          LDW * 0             FLAG FOR SCALE                    YZ 00060
    0002  060F      8          LLB   15            USE 15 IF NO SCALE                YZ 00070
    0003  0820      9          SAM                                                   YZ 00080
    0004  88C1     10          LDW * 1             GIVEN SCALE                       YZ 00090
*   0005  A7FF     11          ADD   D128                                            YZ 00100
*   0006  E7FF     12          AND   D255                                            YZ 00110
*   0007  B7FF     13          SUB   MNT1          SCALE - EXPONENT                  YZ 00120
    0008  0810     14          SAP                                                   YZ 00130
    0009  1020     15          JMP   OVER          EXPONENT TOO BIG                  YZ 00140
    000A  0130     16          CAX                                                   YZ 00150
    000B  050F     17          DXS   15                                             YZ 00160
    000C  060F     18          LLB   15            EXPONENT TOO SMALL                YZ 00170
    000D  E0CC     19          AND   $-1                                             YZ 00180
    000E  3028     20          STB   SHFT+1        SHIFT COUNT                       YZ 00190
*   000F  87FF     21          LDW   MNT2          MANTISSA                          YZ 00200
*   0010  97FF     22          LDX   MNT3                                            YZ 00210
    0011  0810     23          SAP                                                   YZ 00220
    0012  0501     24          DXS   1             CONVERT TO 1'S COMPL.             YZ 00230
    0013  1015     25          JMP   $+2                                             YZ 00240
*   0014  B7FF     26          SUB   D1            CARRY                             YZ 00250
    0015  0900     27 SHFT     SRA   0             **                                YZ 00260
    0016  0810     28          SAP                                                   YZ 00270
*   0017  A014     29          ADD   D1            BACK TO 2'S COMPLEMENT            YZ 00280
          0018     30 STOR     EQU   $                                               YZ 00290
*   0018  9000     31          LDX   RET1                                            YZ 00300
    0019  9800     32          LDX * 0                                               YZ 00310
    001A  7800     33          STW * 0             STORE RESULT                      YZ 00320
    001B  0140     34          CXA                                                   YZ 00330
*   001C  9018     35          LDX   RET1                                            YZ 00340
    001D  0810     36          SAP                 WAS SCALE GIVEN                   YZ 00350
    001E  1801     37          JMP * 1             NO                                YZ 00360
    001F  1802     38          JMP * 2             YES                               YZ 00370
          0020     39 OVER     EQU   $                                               YZ 00380
*   0020  800F     40          LDW   MNT2                                            YZ 00390
    0021  0800     41          SAZ                                                   YZ 00400
*   0022  C7FF     42          ORI   M15R                                            YZ 00410
    0023  0810     43          SAP                                                   YZ 00420
    0024  8026     44          LDW   NMAX                                            YZ 00430
    0025  1018     45          JMP   STOR                                            YZ 00440
    0026  8001     46 NMAX     D     -32767                                          YZ 00450
                   47          ENTRY FIX                                             YZ 00460
                   48          END                                                   YZ 00470


    0017  D1
    0005  D128
    0006  D255
    0022  M15R

    0007  MNT1
```

```
0020  MNT2
0010  MNT3
001C  RET1

NO ERRORS
```

D1	0017	D128	0005	D255	0006	FIX	0000
M15R	0022	MATH	0000	MNT1	0007	MNT2	0020
MNT3	001C	NMAX	0026	OVER	0020	RET1	001C
SHFT	0015	STOR	0018				

MP FLOATING ADD, SUBTRACT, NORM.

DATE: March 1968

ID CODE: BRD

DRAWING: 391090 (Rev D)

LABEL: FAD, FSB, FNRM

AUTHOR: FACQ

SOURCE: SYM I Assembly Language

OBJECT: Relocatable

PURPOSE

FAD, FSB: To add or subtract two mid-precision floating point numbers and leave the normalized mid-precision sum or difference in the software registers MNT1, MNT2, MNT3.

FNRM: To normalize a floating point number set in the software registers MNT1, MNT2, MNT3.

USAGE

Calling Sequence

FAD, FSB:

```
L-1   SMB     FAD (FSB)
L     JSX     FAD (FSB)
L+1   DATA    FARG
L+2   Return
```

FNRM

```
L-1   SMB     FNRM
L     JSX     FNRM
L+1   Return
```

Argument Description

All three routines use the Floating Point Register as one argument. FAD and FSB need a search argument, FARG.

Storage Requirements

External storage in RET3, TMP2, TMP3, TMP4, OVFL, and the Floating Register MNT1, MNT2, MNT3.

METHOD

The mantissa of the lesser argument is shifted to the right, by a number of bits equal to the difference of the two exponents, before algebraic summation or subtraction with the mantissa of the other argument. The exponent of the greater argument is given to the sum or difference. It is incremented or decremented upon normalization of the resulting mantissa on bit 1 as the first significant bit.

ERROR CONDITIONS

An overflow or an underflow gives an exponent off by ±256 and causes the flag word "OVFL" to be set to non-zero. No error message is given.

ACCURACY

30 bits
The shifted arguments is not rounded off before summation.

RESTRICTIONS

Entries

FAD, FSB, FNRM

Other Routines

DAD, DSUB,

External Constants

B0, B1, D0, D1, D255, M8R

Space Used

149 words

Timing (in cycles)	Average	Minimum	Maximum
FAD	120	107	208
FSB	120	107	208
FNRM	50	18	119

APPENDIX A

ASSEMBLY LISTING

of

MP FLOATING ADD, SUBTRACT, NORM.

Drawing No.

391090 (Revision C)

ID Code

BRD

```
                                        2      'MP FLOATING ADD, SUBTRACT, NORM, DN391090 C'                                BRD 0005
                                        3      *                                                                            BRD 0006
                                        4      *                                                                            BRD 0007
                                        5               BLK   MATH                                                          BRD 0008
                                        6               LIBR  FAD,FSB,FNRM                                                  BRD 0009
                                        7      * FLOATING MODE - ADD, SUBTRACT, NORMALIZE                                   BRD 0010
                                        8      ************************************************************                 BRD 0011
                                        9      * CONSTANTS                                                                 BRD 0012
*    0 000 0  27FF  2 0 7FF             10     FADC    JSX   DAD                                                           BRD 0013
*    0 001 0  27FF  2 0 7FF             11     FSBC    JSX   DSUB                                                          BRD 0014
                                       12     ************************************************************                 BRD 0015
                                       13     * FLOATING NORMALIZE - ENTRY                                               BRD 0016
              0002  0002                14     FNRM    EQU   $                                                             BRD 0017
     0 002 0  0501  05 01               15             DXS   1          DECREMENT RETURN ADDRESS                           BRD 0018
     0 003 0  1004  1 0 004             16             JMP   $+1        TO PERMIT EXIT WITH JMP *1                         BRD 0019
*    0 004 0  67FF  6 0 7FF             17             STX   RET3       SAVE RETURN                                        BRD 0020
*    0 005 0  87FF  8 0 7FF             18             LDW   MNT2                                                          BRD 0021
     0 006 0  1047  1 0 047             19             JMP   NRM                                                           BRD 0022
                                       20     ************************************************************                 BRD 0023
              0007  0007                21     FSB     EQU   $                                                             BRD 0024
     0 007 0  8001  8 0 001             22             LDW   FSBC       TO CALL DSUB                                       BRD 0025
     0 008 0  100A  1 0 00A             23             JMP   BOTH                                                          BRD 0026
                                       24     *                                                                           BRD 0027
              0009  0009                25     FAD     EQU   $                                                             BRD 0028
     0 009 0  8000  8 0 000             26             LDW   FADC       TO CALL DAD                                        BRD 0029
                                       27     *                                                                           BRD 0030
     0 00A 0  7043  7 0 043             28     BOTH    STW   CALL       SET CALL TO DOUBLE PRECISION                       BRD 0031
*    0 00B 0  6004  6 0 004             29             STX   RET3       SAVE RETURN                                        BRD 0032
     0 00C 0  9800  9 1 000             30             LDX * 0          GET SECOND TERM                                    BRD 0033
     0 00D 0  8801  8 1 001             31             LDW * 1                                                             BRD 0034
*    0 00E 0  77FF  7 0 7FF             32             STW   TMP1       SAVE MANTISSA                                      BRD 0035
     0 00F 0  8802  8 1 002             33             LDW * 2                                                             BRD 0036
*    0 010 0  77FF  7 0 7FF             34             STW   TMP2                                                          BRD 0037
*    0 011 0  87FF  8 0 7FF             35             LDW   MNT0       SEE WHICH TERM TO SHIFT                            BRD 0038
     0 012 0  B800  B 1 000             36             SUB * 0          FROM DIFFERENCE OF EXPONENTS                       BRD 0039
     0 013 0  0810  0810                37             SAP                                                                 BRD 0040
     0 014 0  1017  1 0 017             38             JMP   SFTA                                                          BRD 0041
     0 015 0  9044  9 0 044             39             LDX   CAL1       2ND TERM TO SHIFT                                  BRD 0042
     0 016 0  101B  1 0 01B             40             JMP   SHFT       KEEP 1ST EXP, FOR SUM                              BRD 0043
     0 017 0  9800  9 1 000             41     SFTA    LDX * 0          1ST TERM TO SHIFT                                  BRD 0044
*    0 018 0  6011  6 0 011             42             STX   MNT0       USE 2ND EXP, FOR SUM                               BRD 0045
     0 019 0  9066  9 0 066             43             LDX   P,A                                                           BRD 0046
     0 01A 0  0110  0110                44             CMP                                                                 BRD 0047
*    0 01B 0  67FF  6 0 7FF             45     SHFT    STX   TMP4       SAVE ADDR. OF TERM TO SHIFT                        BRD 0048
     0 01C 0  0130  0130                46             CAX              CHECK SHIFT COUNT                                  BRD 0049
     0 01D 0  0510  05 10               47             DXS   16                                                            BRD 0050
     0 01E 0  1021  1 0 021             48             JMP   SHF1                                                          BRD 0051
     0 01F 0  0620  06 20               49             LLB   X'20'      UNDER 16                                           BRD 0052
     0 020 0  1024  1 0 024             50             JMP   SHF2                                                          BRD 0053
     0 021 0  062F  06 2F               51     SHF1    LLB   X'2F'      OVER  15                                           BRD 0054
     0 022 0  050F  05 0F               52             DXS   15                                                            BRD 0055
     0 023 0  1025  1 0 025             53             JMP   SHF3       OVER  30                                           BRD 0056
     0 024 0  0430  04 30               54     SHF2    IXS   X'30'                                                        BRD 0057
```

```
                0 025 0  0130  0130          55     SHF3     CAX                                                  BRD 0058
                0 026 0  3067  3 0 033 1     56              STB   SFT1+1                                        BRD 0059
                0 027 0  0140  0140          57              CXA                                                  BRD 0060
                0 028 0  3069  3 0 034 1     58              STB   SFT2+1                                        BRD 0061
              * 0 029 0  9018  9 0 018       59              LDX   TMP4                                           BRD 0062
                0 02A 0  8800  8 1 000       60              LDW * 0                                              BRD 0063
                0 02B 0  9801  9 1 001       61              LDX * 1                                              BRD 0064
                0 02C 0  0810  0810          62              SAP                 NEGATIVE TERM TO BE SHIFTED      BRD 0065
                0 02D 0  0501  05 01         63              DXS   1             IN 1'S COMPLEMENT                BRD 0066
                0 02E 0  1030  1 0 030       64              JMP   $+2                                            BRD 0067
              * 0 02F 0  87FF  8 0 7FF       65              SUB   D1                                             BRD 0068
              * 0 030 0  77FF  7 0 7FF       66              STW   TMP3                                           BRD 0069
                0 031 0  0A31  0A3 1         67              SLL D 1                                              BRD 0070
              * 0 032 0  8030  8 0 030       68              LDW   TMP3                                           BRD 0071
                0 033 0  0920  092 0         69     SFT1     SRA D 0             **COUNT SET ABOVE                BRD 0072
                0 034 0  0920  092 0         70     SFT2     SRA D 0             **                               BRD 0073
                0 035 0  0810  0810          71              SAP                   NEGATIVE SHIFTED TERM TO BE    BRD 0074
                0 036 0  0402  04 02         72              IXS   2               RESTORED TO 2'S COMPLEMENT     BRD 0075
                0 037 0  103D  1 0 03D       73              JMP   SFTX                                           BRD 0076
              * 0 038 0  6032  6 0 032       74              STX   TMP3                                           BRD 0077
                0 039 0  0502  05 02         75              DXS   2                                              BRD 0078
                0 03A 0  103E  1 0 03E       76              JMP   SFTN                                           BRD 0079
              * 0 03B 0  A02F  A 0 02F       77              ADD   D1                                             BRD 0080
                0 03C 0  103E  1 0 03E       78              JMP   SFTN                                           BRD 0081
              * 0 03D 0  6038  6 0 038       79     SFTX     STX   TMP3                                           BRD 0082
              * 0 03E 0  9029  9 0 029       80     SFTN     LDX   TMP4            STORE BACK SHIFTED TERM        BRD 0083
                0 03F 0  7600  7 1 000       81              STW * 0                                              BRD 0084
              * 0 040 0  803D  8 0 03D       82              LDW   TMP3                                           BRD 0085
                0 041 0  0A01  0A0 1         83              SRL   1                                              BRD 0086
                0 042 0  7801  7 1 001       84              STW * 1                                              BRD 0087
                0 043 0  2000  2 0 000       85     CALL     JSX   0               ADDR. OF DAD OR DSUB           BRD 0088
              * 0 044 0  300E  300E          86     CAL1     D     TMP1            ARGUMENT ADDRESS               BRD 0089
                0 045 0  08A0  08A0          87              SNO                   ANY OVERFLOW                   BRD 0090
                0 046 0  107D  1 0 07D       88              JMP   FIXO            YES - CAN BE FIXED             BRD 0091
                               89     ************************************************                          BRD 0092
                               90     * NORMALIZE                                    *                          BRD 0093
                               91     ************************************************                          BRD 0094
                0 047 0  0820  0820          92     NRM      SAM                                                  BRD 0095
                0 048 0  104F  1 0 04F       93              JMP   NRM1                                           BRD 0096
              * 0 049 0  97FF  9 0 7FF       94              LDX   MNT3            GET ABSOLUTE VALUE             BRD 0097
                0 04A 0  0501  05 01         95              DXS   1               TO CHECK FOR ZERO IN HIGH WORD BRD 0098
              * 0 04B 0  A03B  A 0 03B       96              ADD   D1              AND FOR NEGATIVE 2**15         BRD 0099
                0 04C 0  0110  0110          97              CMP                                                  BRD 0100
                0 04D 0  08A0  08A0          98              SNO                                                  BRD 0101
                0 04E 0  1092  1 0 092       99              JMP   N230                                           BRD 0102
                0 04F 0  0800  0800          100    NRM1     SAZ                   IS FIRST WORD ZERO             BRD 0103
                0 050 0  105A  1 0 05A       101             JMP   NRM2            NO                             BRD 0104
              * 0 051 0  8005  8 0 005       102             LDW   MNT2            YES - MOVE UP 2ND WORD         BRD 0105
              * 0 052 0  E7FF  E 0 7FF       103             AND   B0                                             BRD 0106
              * 0 053 0  C049  C 0 049       104             ORI   MNT3                                           BRD 0107
              * 0 054 0  97FF  9 0 7FF       105             LDX   D0                                             BRD 0108
              * 0 055 0  6053  6 0 053       106             STX   MNT3                                           BRD 0109
              * 0 056 0  7051  7 0 051       107             STW   MNT2                                           BRD 0110
```

```
                0 057 0  0800  0800        108            SAZ                IS SECOND WORD ZERO                  BRD 0111
                0 058 0  105F  1 0 05F     109            JMP   NRM3         NO                                   BRD 0112
                0 059 0  108D  1 0 08D     110            JMP   SETZ         ALL ZERO - EXPONENT TO RESET         BRD 0113
                0 05A 0  0A11  0A1 1       111  NRM2      SLL   1            CHECK FIRST BIT                      BRD 0114
                0 05B 0  0810  0810        112            SAP                                                     BRD 0115
                0 05C 0  107B  1 0 07B     113            JMP   EXIT         ALL SET                              BRD 0116
              * 0 05D 0  9018  9 0 018     114            LDX   MNT0         TO NORMALIZE                         BRD 0117
                0 05E 0  106B  1 0 06B     115            JMP   NRMC                                              BRD 0118
                0 05F 0  0810  0810        116  NRM3      SAP                                                     BRD 0119
                0 060 0  0110  0110        117            CMP                                                     BRD 0120
              * 0 061 0  905D  9 0 05D     118            LDX   MNT0                                             BRD 0121
                0 062 0  050F  05 0F       119            DXS   15                                               BRD 0122
                0 063 0  1067  1 0 067     120            JMP   NRM4                                             BRD 0123
              * 0 064 0  27FF  2 0 7FF     121  UNDR      JSX   M,ZE         UNDERFLOW - GIVE ZERO                BRD 0124
                0 065 0  107B  1 0 07B     122            JMP   EXIT                                             BRD 0125
              * 0 066 0  3056  3056        123  P,A       D     MNT2                                             BRD 0126
              * 0 067 0  6061  6 0 061     124  NRM4      STX   MNT0                                             BRD 0127
                0 068 0  0A11  0A1 1       125  NRM5      SLL   1            SHIFT HIGHER WORD                    BRD 0128
                0 069 0  0810  0810        126            SAP                DONE                                 BRD 0129
                0 06A 0  106E  1 0 06E     127            JMP   NRMX         YES                                  BRD 0130
                0 06B 0  0501  05 01       128  NRMC      DXS   1            NO - DECREMENT EXPONENT              BRD 0131
                0 06C 0  1068  1 0 068     129            JMP   NRM5         KEEP SHIFTING                        BRD 0132
                0 06D 0  1064  1 0 064     130            JMP   UNDR         UNDERFLOW                            BRD 0133
                0 06E 0  0630  06 30       131  NRMX      LLB   X'30'                                            BRD 0134
              * 0 06F 0  A067  A 0 067     132            ADD   MNT0                                             BRD 0135
              * 0 070 0  606F  6 0 06F     133            STX   MNT0                                             BRD 0136
              * 0 071 0  B070  B 0 070     134            SUB   MNT0                                             BRD 0137
                0 072 0  30ED  3 0 076 1   135            STB   NRMS+1                                           BRD 0138
              * 0 073 0  9055  9 0 055     136            LDX   MNT3         MANTISSA TO SHIFT                    BRD 0139
                0 074 0  0A31  0A3 1       137            SLL D 1                                                BRD 0140
              * 0 075 0  8066  8 0 066     138            LDW   MNT2                                             BRD 0141
                0 076 0  0930  093 0       139  NRMS      SLA D 0          **COUNT SET ABOVE                     BRD 0142
              * 0 077 0  7075  7 0 075     140            STW   MNT2                                             BRD 0143
                0 078 0  0140  0140        141            CXA                                                    BRD 0144
                0 079 0  0A01  0A0 1       142            SRL   1                                                BRD 0145
              * 0 07A 0  7073  7 0 073     143            STW   MNT3                                             BRD 0146
              * 0 07B 0  9008  9 0 008     144  EXIT      LDX   RET3         BACK TO CALLER                       BRD 0147
                0 07C 0  1801  1 1 001     145            JMP * 1                                                BRD 0148
                                           146  ********************************************************      BRD 0149
                                           147  * OVERFLOW IN SUM OF MANTISSAE - SHIFT 1 RIGHT                 BRD 0150
              * 0 07D 0  907A  9 0 07A     148  FIXO      LDX   MNT3                                             BRD 0151
                0 07E 0  0810  0810        149            SAP                                                    BRD 0152
                0 07F 0  1084  1 0 084     150            JMP   FIXP                                             BRD 0153
                0 080 0  0401  04 01       151            IXS   1                KEEP TWO'S COMPLEMENT          BRD 0154
              * 0 081 0  A048  A 0 048     152            ADD   D1           CARRY                               BRD 0155
                0 082 0  0400  0400        153            SXP                                                    BRD 0156
              * 0 083 0  9054  9 0 054     154            LDX   D0                                               BRD 0157
                       0084  0084          155  FIXP      EQU   $                                                BRD 0158
                0 084 0  0921  092 1       156            SRA D 1            GET MOST SIGNIFICANT BIT            BRD 0159
              * 0 085 0  D052  D 0 052     157            ORE   B0           OUT OF SIGN, RESTORE SIGN           BRD 0160
              * 0 086 0  7077  7 0 077     158            STW   MNT2                                             BRD 0161
                0 087 0  0140  0140        159            CXA                                                    BRD 0162
                0 088 0  0810  0810        160            SAP                                                    BRD 0163
```

```
*     0 089 0  B7FF   B 0 7FF     161            SUB   B1                                  BRD 0164
*     0 08A 0  707D   7 0 07D     162            STW   MNT3                                BRD 0165
                                  163    * INCREMENT EXPONENT BY ONE                     BRD 0166
*     0 08B 0  8071   8 0 071     164    FIXE    LDW   MNT0                               BRD 0167
*     0 08C 0  A081   A 0 081     165            ADD   D1                                  BRD 0168
*     0 08D 0  708B   7 0 08B     166    SETE    STW   MNT0                               BRD 0169
      0 08E 0  0600   06 00       167            LLB   0                                   BRD 0170
      0 08F 0  0800   0800        168            SAE             CHECK OVERFLOW          BRD 0171
*     0 090 0  27FF   2 0 7FF     169            JSX   M,OV                                BRD 0172
      0 091 0  107B   1 0 07B     170            JMP   EXIT                                BRD 0173
                                  171    * NEGATIVE 2**30 - SHIFT 1 TO THE RIGHT         BRD 0174
      0 092 0  0901   090 1      172    N230    SRA   1                                   BRD 0175
*     0 093 0  7086   7 0 086     173            STW   MNT2                                BRD 0176
      0 094 0  108B   1 0 08B     174            JMP   FIXE                                BRD 0177
                                  175    ********************************************** BRD 0178
                                  176            ENTRY FAD,FSB,FNRM                      BRD 0179
      0 094 0*******148           177            END                                     BRD 0180
```

X-REF

```
    0 00A 0  BOTH      0 008 0
EXT 0085     B0        0 052 0    0 085 0
EXT 0089     B1        0 089 0
    0 043 0  CALL      0 00A 0
    0 044 0  CAL1      0 015 0
EXT 0000     DAD       0 000 0
EXT 0001     DSUB      0 001 0
EXT 0083     D0        0 054 0    0 083 0
EXT 008C     D1        0 02F 0    0 038 0    0 048 0    0 081 0    0 08C 0
    0 07B 0  EXIT      0 05C 0    0 065 0    0 091 0
LIB 0 009 0  FAD       0 009 0
    0 000 0  FADC      0 009 0
    0 08B 0  FIXE      0 094 0
    0 07D 0  FIXO      0 046 0
    0 084 0  FIXP      0 07F 0    0 084 0
LIB 0 002 0  FNRM      0 002 0
LIB 0 007 0  FSB       0 007 0
    0 001 0  FSBC      0 007 0
EXT 0090     M,OV      0 090 0
EXT 0064     M,ZE      0 064 0
EXT 008D     MNT0      0 011 0    0 018 0    0 05D 0    0 061 0    0 067 0    0 06F 0    0 070 0    0 071 0
                       0 08B 0    0 08D 0
EXT 0093     MNT2      0 005 0    0 051 0    0 056 0    0 066 0    0 075 0    0 077 0    0 086 0    0 093 0
EXT 008A     MNT3      0 049 0    0 053 0    0 055 0    0 073 0    0 07A 0    0 07D 0    0 08A 0
    0 047 0  NRM       0 006 0
    0 06B 0  NRMC      0 05E 0
    0 076 0  NRMS      0 072 0
    0 06E 0  NRMX      0 06A 0
    0 04F 0  NRM1      0 048 0
    0 05A 0  NRM2      0 050 0
    0 05F 0  NRM3      0 058 0
    0 067 0  NRM4      0 063 0
    0 068 0  NRM5      0 06C 0
```

```
     0 092 0  N2S0        0 04E 0
     0 066 0  P,A         0 019 0
EXT  007B     RET3        0 004 0    0 00B 0    0 07B 0
     0 08D 0  SETZ        0 059 0
     0 017 0  SFTA        0 014 0
     0 03E 0  SFTN        0 03A 0    0 03C 0
     0 03D 0  SFTX        0 037 0
     0 033 0  SFT1        0 026 0
     0 034 0  SFT2        0 028 0
     0 01B 0  SHFT        0 016 0
     0 021 0  SHF1        0 01E 0
     0 024 0  SHF2        0 020 0
     0 025 0  SHF3        0 023 0
EXT  0044     TMP1        0 00E 0    0 044 0
EXT  0010     TMP2        0 010 0
EXT  0040     TMP3        0 030 0    0 032 0    0 038 0    0 03D 0    0 040 0
EXT  003E     TMP4        0 018 0    0 029 0    0 03E 0
     0 064 0  UNDR        0 06D 0
```

NO ERRORS

CARDS	SYMBOLS	LITR	STACK
177	50	614	0	6