

QUALITY SOFTWARE

DATE: July 1969
ID CODE: CAL
DRAWING: 392325 (Rev B)
LABEL: N/A
AUTHOR: GENE
SOURCE: N/A
OBJECT: N/A

The following pages will assist you in your use of the Raytheon 700 Series Math Library. Please note the following:

Page

2	Table of Contents by Sections
3	Actual sequence of programs on the Math Library tapes
4-6	Math Library data format
7-10	Math Subroutines Timing Summary

TABLE OF CONTENTS

MATH SUBROUTINES

Section I

Math Subroutine Storage Pool	391098	BRH
SP Multiply	390663	BLG
SP Divide	390665	BLH
SP Cumulative Multiply	391101	BRJ

Section II

DP Fixed Point Load	391079	BPX
DP Fixed Point Store	391081	BPY
DP Fixed Point Add, Subtract	391083	BPZ
DP Fixed Point Two's Complement	390664	BLJ
Double Shift Arithmetic	391085	BRA
MP Floating Underflow	390014	BSP
MP Floating Overflow	390015	BSR
MP Floating, DP Fixed MPY and DIV	391096	BRB
MP Floating, DP Fixed Compare	391088	BRC

Section III

MP Floating Load	391075	BPV
MP Floating Store	391077	BPW
Math Convert FXD PT to MP Float	391094	BRF
Convert MP Float to DP Fix	392338	BYY
Convert MP Float to SP Fix	392339	BYZ
MP Floating Add, Subtract, Norm	391090	BRD

MATH FUNCTIONS

Section I

Square Root - MP Floating Point	390006	BSH
Sin and Cos - MP Floating Point	390007	BSJ
Arc Tangent - MP Floating Point	390010	BSM
Exponential - MP Floating Point	390009	BSL
Natural Logarithm - MP Floating Point	390008	BSK
Polynomial - MP Floating Point	390016	BSS
Double Shift Magnitude	390017	BST
MP Hyperbolic Tangent	392279	BYB

The following is the actual sequence of programs on the Math Library tapes:

MATH LIBRARY FUNCTIONS

BSH	Square Root - MP Floating Point	390006
BSJ	Sin and Cos - MP Floating Point	390007
BSM	Arc Tangent - MP Floating Point	390010
BYB	MP Hyperbolic Tangent	392279
BSL	Exponential - MP Floating Point	390009
BSK	Natural Logarithm - MP Floating Point	390008
BSS	Polynomial - MP Floating Point	390016
BST	Double Shift Magnitude	390017

MATH LIBRARY SUBROUTINES

BPV	MP Floating Load	391075
BPW	MP Floating Store	391077
BRF	Math Convert FXD PT to MP Float	391094
BYY	Convert MP Float to DP Fix	392338
BYZ	Convert MP Float to SP Fix	392339
BRD	MP Floating Add, Subtract, Norm	391090
BRC	MP Floating, DP Fixed Compare	391088
BRB	MP Floating, DP Fixed MPY and DIV	391096
BSR	MP Floating Overflow	390015
BSP	MP Floating Underflow	390014
BPX	DP Fixed Point Load	391079
BPY	DP Fixed Point Store	391081
BPZ	DP Fixed Point Add, Subtract	391083
BLJ	DP Fixed Point Two's Complement	390664
BRA	Double Shift Arithmetic	391085
BRJ	SP Cumulative Multiply	391101
BLG	SP Multiply	390663
BLH	SP Divide	390665
BRH	Math Subroutine Storage Pool	391098

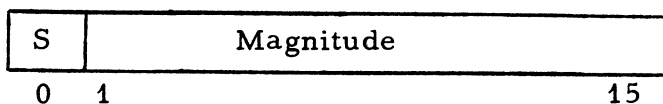
1. INTRODUCTION

The Math Library is a comprehensive set of mathematical functions and subroutines. Operations for floating point and single and double precision fixed point formats are provided. Negative integers and mantissas are represented in two's complement notation. Floating point exponents are in excess 80_{16} . The numerical data formats utilized are illustrated below.

2. FIXED POINT SINGLE PRECISION

A Fixed Point Single Precision integer is a signed number from one to five decimal digits long. Its maximum absolute value is 2^{15} or 32,767.

Fixed Point Single Precision



The DATA statement may be used in both the SYM I and SYM II assemblers to define fixed point single precision constants.

Example:

<u>Label</u>	<u>Operation</u>	<u>Operand</u>
TWFV	DATA	25

would assemble as: 19_{16}

<u>Label</u>	<u>Operation</u>	<u>Operand</u>
NHUN	DATA	-100

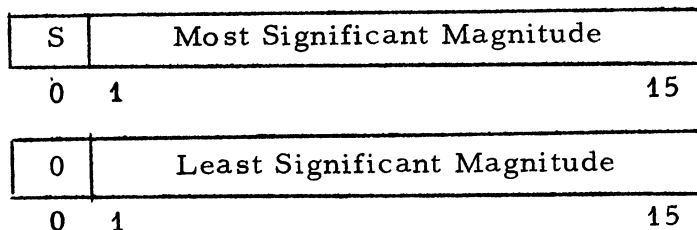
would assemble as: $FF9C_{16}$

3.

FIXED POINT DOUBLE PRECISION

A Fixed Point Double Precision number is a signed number from one to ten decimal digits long. Its maximum absolute value is 2^{30-1} or 1,073,741,823. The sign bit (bit 0) of word one signifies the algebraic sign of the number.

Fixed Point Double Precision



The DPI statement may be used in the SYM II assembler to define fixed point double precision constants.

Example:

<u>Label</u>	<u>Operation</u>	<u>Operand</u>
ME	DPI	-123456789

would assemble as: $F148_{16}, 32EB_{16}$

4.

FLOATING POINT (MID-PRECISION)

A mid-precision floating point number is a signed number of one to nine decimal digits with the approximate limits of $+10^{38}$ to -10^{38} . Actual precision is limited to 30 bits.

would assemble as: 0074_{16} , $BF45_{16}$, 7483_{16} .

EPRL 2.4E8

would assemble as: $009C_{16}$, $42C1_{16}$, $6C00_{16}$

5. PSEUDO CALLS

Both the SYM I and SYM II assemblers will allow the entry name of any math subroutine to be placed in the operations field of the input statement.

The statement:

MSQR ARG

would assemble as:

SMB MSQR

JSX MSQR

DATA ARG

Floating Point (Mid-Precision)

Zeros				Exponent			
0	1	7	8				15

S	Most Significant Mantissa					
0	1					15

0	Least Significant Mantissa					
0	1					15

Excess 80₁₆ means that the exponent of the number 1.0, for example would be represented as:

0000	0000	1000	0001
------	------	------	------

0	100	0000	0000	0000
---	-----	------	------	------

0	000	0000	0000	0000
---	-----	------	------	------

and -1.0 would be represented as:

0000	0000	1000	0001
------	------	------	------

1	111	1111	1111	1111
---	-----	------	------	------

0	111	1111	1111	1111
---	-----	------	------	------

The EPRL statement may be used in the SYM II assembler to define a mid-precision floating point constant.

Example:

<u>Label</u>	<u>Operation</u>	<u>Operand</u>
MY	EPRL	-123456.709E-9

MATH SUBROUTINES TIMING SUMMARY

Entry Names	Cycles-with Software Multiply/Divide			Cycles-with Hardware Multiply/Divide			Storage Required (Words)	Accuracy
	Min	Max	Avg	Min	Max	Avg		
SP Multiply	65	105	84			20	71/8 *	
SP Divide	149	193	171	25	30	30	73/16*	
SP Cum. Multiply						24	6/12 *	
DP Fixed Point Load			15				8	
DP Fixed Point Store			15				8	
DP Fixed Point Add			24				19	
DP Fixed Point Sub			23				15	
DP Fixed Point Two's Comp			14				13	
Double Shift Arithmetic Left	55	71	63				40	
Double Shift Arithmetic Right	54	70	62				E	
MP Floating Underflow			8				5	
MP Floating Overflow			21				11	
MP Floating Multiply			370			203	209	29 bits
MP Floating Divide			584			247	A	29 bits

Entry Names	Cycles-with Software Multiply/Divide			Cycles-with Hardware Multiply/Divide			Storage Required (Words)	Accuracy	
	Min	Max	Avg	Min	Max	Avg			
DP Fixed Multiply			332			165	A	29 bits	
DP Fixed Divide			578			241	A	29 bits	
MP Floating Compare			26				28		
DP Floating Compare			15				B		
MP Floating Load			19				10		
MP Floating Store			19				10		
Convert SP Fixed Point to MP Floating		41	161	116			29		
Convert DP Fixed Point to MP Floating		42	180	127			F		
Convert MP Floating to SP Fixed Point		29	51	45			39		
Convert MP Floating to DP Fixed Point		33	105	98			38		
MP Floating Add		107	208	120			149	30 bits	
MP Floating Sub		107	208	120			C	30 bits	
MP Floating Normalize		18	119	50			C	30 bits	
MP Floating Point Square Root		31	730	676	31	232	215	82	29 bits
MP Floating Point Sine		2980	3800	3110	1940	2350	2110	119	29 to 16 bits
MP Floating Point Cosine		2730	3800	3110	1010	2350	2110	D	29 to 16 bits

	<u>Entry Name</u>	<u>Cycle-with Software Multiply/Divide</u>			<u>Cycle-with Hardware Multiply/Divide</u>			<u>Storage Required (Words)</u>	<u>Accuracy</u>
		<u>Min</u>	<u>Max</u>	<u>Avg</u>	<u>Min</u>	<u>Max</u>	<u>Avg</u>		
MP Floating Point Arc Tangent	MATN	2700	4800	4120	2000	2900	2690	128	29 bits
MP Floating Point If (Tan < 1)				3820			2470		
MP Floating Point Exponential	MEXP	42	4750	3950	42	2760	2530	138	29 bits
MP Floating Point Natural Log	MLOG	4000	4600	4230	2700	2850	2740	83	29 bits
MP Hyperbolic Tangent	MTNH	35	4800	4550	35	3100	2450	91	28 bits
703 cycle time is 1.75 μ seconds									
706 cycle time is 900 nanoseconds									
* Software/Hardware									
A Contained in MP Floating Multiple									
B Contained in MP Floating Compare									
C Contained in MP Floating Add									
D Contained in Sine									
E Contained in Double Shift Arithmetic, Left									
F Contained in FLT									