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MM      MM      TTTTTTTTTT  HH      HH      DDDDDDDDD  CCCCCCCCC  000000  SSSSSSSSS  HH      HH
MM      MM      TTTTTTTTTT  HH      HH      DDDDDDDDD  CCCCCCCCC  000000  SSSSSSSSS  HH      HH
MMM     MMM     TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MMM     MMM     TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HHHHHHHHHHHH DD      DD  CC      CC      00      00  SSSSSSS  HHHHHHHHHHHH
MM      MM      TT          HHHHHHHHHHHH DD      DD  CC      CC      00      00  SSSSSSS  HHHHHHHHHHHH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DD      DD  CC      CC      00      00  SS      SS      HH      HH
MM      MM      TT          HH      HH      DDDDDDDDD  CCCCCCCCC  000000  SSSSSSSSS  HH      HH
MM      MM      TT          HH      HH      DDDDDDDDD  CCCCCCCCC  000000  SSSSSSSSS  HH      HH
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LL      IIIIIII  SSSSSSSS
LL      IIIIIII  SSSSSSSS
LL      II      SS
LL      II      SS
LL      II      SS
LL      II      SS
LL      II      SSSSSS
LL      II      SSSSSS
LL      II      SS
LL      II      SS
LL      II      SS
LL      II      SS
LLLLLLLLLLLL IIIIIII  SSSSSSSS
LLLLLLLLLLLL IIIIIII  SSSSSSSS
```


(2) 50
(3) 86
(4) 148

HISTORY ; Detailed Current Edit History
DECLARATIONS ; Declarative Part of Module
MTH\$DCOSH - Standard Double Precision Floating DCOSH

```
0000 1      .TITLE  MTH$DCOSH      ; Double Floating Hyperbolic Cosine routine
0000 2      ; (DCOSH)
0000 3      .IDENT /1-008/        ; File: MTHDCOSH.MAR  Edit: RNH1008
0000 4
0000 5      ;*****
0000 6      ;
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0000 24     ;
0000 25     ;
0000 26     ;*****
0000 27
0000 28
0000 29     FACILITY: MATH LIBRARY
0000 30     ++
0000 31     ABSTRACT:
0000 32
0000 33     MTH$DCOSH is a function which returns the double floating hyperbolic cosine
0000 34     of its double precision floating point argument. The call is standard
0000 35     call-by-reference.
0000 36
0000 37     --
0000 38
0000 39     VERSION: 01
0000 40
0000 41     HISTORY:
0000 42     AUTHOR:
0000 43         Peter Yuo, 29-Jun-77: Version 01
0000 44
0000 45     MODIFIED BY:
0000 46
0000 47
0000 48
```



```
0000 50      .SBTTL HISTORY ; Detailed Current Edit History
0000 51
0000 52
0000 53 : ALGORITHMIC DIFFERENCES FROM FP-11/C ROUTINE: none
0000 54 :
0000 55 : Edit History for Version 01 of MTH$DCOSH
0000 56 :
0000 57 : 0-2 MTH$ERROR changed to MTH$SIGNAL.
0000 58 : MTH$... changed to MTH$...
0000 59 : Changed error handling mechanism. Put error result in R0:R1 before
0000 60 : calling MTH$SIGNAL in order to allow user modify error result.
0000 61 :
0000 62 : 0-3 Seven term Taylor series, in powers of argument, replaced
0000 63 : by six term Chebyshev series, in powers of ARG**2,
0000 64 : with overhang, to improve accuracy. 18-May-1978; Mary Payne
0000 65 : 0-4 Fix LOG(2) constant. TNH 16-June-78
0000 66 : 1-001 - Update version number and copyright notice. JBS 16-NOV-78
0000 67 : 1-002 - Change MTH_FLOOVEMAT to MTH$K_FLOOVEMAT. JBS 07-DEC-78
0000 68 : 1-003 - Removed $SRMDEF - not needed. JBS 16-DEC-78
0000 69 : 1-004 - Add " " to the PSECT directive. JBS 22-DEC-78
0000 70 : 1-005 - Declare externals. SBL 17-May-1979
0000 71 : 1-006 - Use MTH$DEXP_R6. SBL 27-Sept-1979
0000 72 : 1-007 - Changed lower limit for Chebyshev approximation from 2**-27 to
0000 73 : 2**-28.
0000 74 : - Eliminated second call to EXP for input values between .25 and
0000 75 : 28.5*ln2 by computing COSH(x) = (Z + 1/Z)/2, with Z = EXP(ixi).
0000 76 : - Eliminated second call to EXP for input values between 28.5*ln2
0000 77 : and 127*ln2.
0000 78 : - Changed all final floating point divisions by 2 to interger
0000 79 : subtracts of 1 from the exponent field.
0000 80 : - Changed entry mask to excluded R7 - no longer needed.
0000 81 : - Extended maximum range from 87.69 to 128*ln2=88.72.
0000 82 : - Changed logic for computing EXP(ixi-ln2) to reduce error.
0000 83 : - RNH 10-FEB-81
0000 84 : 1-003 - Changed W^ to G^ on call to MTH$SIGNAL RNH 09-Sept-1981
```

```
0000 86      .SBTTL  DECLARATIONS      ; Declarative Part of Module
0000 87
0000 88      ;
0000 89      ; INCLUDE FILES:
0000 90      ;
0000 91      ;
0000 92      ;
0000 93      ; EXTERNAL SYMBOLS:
0000 94      ;
0000 95      .DSABL  GBL
0000 96      .EXTRN  MTH$DEXP_R6
0000 97      .EXTRN  MTH$K_FLOOVEMAT
0000 98      .EXTRN  MTH$$SIGNAL
0000 99
0000 100     ;
0000 101     ; EQUATED SYMBOLS:
0000 102
0000 103     SD_1.0 = ^F1.0              ; 1.0
0000 104     value = 4                  ; value.rd.r
0000 105
0000 106     ;
0000 107     ; MACROS:      none
0000 108     ;
0000 109     ;
0000 110     ; PSECT DECLARATIONS:
0000 111
0000 112     .PSECT  _MTH$CODE          PIC,SHR,LONG,EXE,NOWRT
0000 113     ; program section for math routines
0000 114     ;
0000 115     ; OWN STORAGE:  none
0000 116     ;
0000 117     ;
0000 118     ; CONSTANTS:
0000 119     ;
0000 120
0000 121     D_127_LOG_2:
0000 122     .QUAD  ^X2BDAC7E20F3343B0      ; 127*ln2
0008 123     D_128_LOG_2:
0008 124     .QUAD  ^XCF79F7D1721743B1      ; 128*ln2
0010 125     D_2_POWER_28.5:
0010 126     .QUAD  ^XDE6433F904F34EB5      ; 2**28.5
0018 127     D_LOG_2_HI:
0018 128     .QUAD  ^XCF80F7D172174031      ; (high 49 bits of ln2) + 2**-49
0020 129     D_LOG_2_LO:
0020 130     .QUAD  ^XFF81898C86C3A5CA      ; ln2 - D_LOG_2_HI
0028 131
0028 132     DCOSHTAB:
2853 3594 0028 133     .WORD  ^0032624,^0024123
DBD2 3EEC 002C 134     .WORD  ^0037354,^0155722      ; DECIMAL: 0.2759648863787355D-06
OCF1 38D0 0030 135     .WORD  ^0034320,^0006361
CA4F AB28 0034 136     .WORD  ^0125450,^0145117      ; DECIMAL: 0.2480155975461668D-04
0B60 3BB6 0038 137     .WORD  ^0035666,^0005540
FE08 B801 003C 138     .WORD  ^0134001,^0177010      ; DECIMAL: 0.1388888889781712D-02
AAAA 3E2A 0040 139     .WORD  ^0037052,^0125252
6FC4 AAAA 0044 140     .WORD  ^0125252,^0067704      ; DECIMAL: 0.4166666666665359D-01
0000 4000 0048 141     .WORD  ^0040000,0
0005 0000 004C 142     .WORD  0,^0000005      ; DECIMAL: 0.5000000000000000D0
```

MTHSDCOSH
1-008

; Double Floating Hyperbolic Cosine rout 16-SEP-1984 01:15:53 VAX/VMS Macro V04-00
DECLARATIONS ; Declarative Part of Modul 6-SEP-1984 11:21:57 [MTHRTL.SRC]MTHDCOSH.MAR;1

Page 4
(3)

0000 4080	0050	143	.WORD	^0040200,0	
0000 0000	0054	144	.WORD	0,0	
00000006	0058	145	DCOSHLN	= '- DCOSHTAB/8	; DECIMAL: 0.1000000000000000D+01
	0058	146			


```
0058 148 .SBTTL MTH$DCOSH - Standard Double Precision Floating DCOSH
0058 149
0058 150
0058 151 :++
0058 152 : FUNCTIONAL DESCRIPTION:
0058 153 :
0058 154 : DCOSH - double precision floating point function
0058 155 :
0058 156 : DCOSH(X) is computed as:
0058 157 :
0058 158 : If |X| < 2**-28, DCOSH(X) = 1.
0058 159 : If 2**-28 <= |X| < 0.25, DCOSH(X) = Chebyshev series
0058 160 : If 0.25 <= |X| <= 28.5*ln2, set Z = DEXP(|X|) and compute
0058 161 : DCOSH(X) = (Z + 1/Z)/2.
0058 162 : If 28.5*ln2 < |X| <= 127*ln2, COSH(X) = EXP(|X|)/2
0058 163 : If 127*ln2 < |X| <= 128*ln2 then DCOSH(X) = DEXP(|X|-LOG(2)).
0058 164 : If 128*ln2 < |X| then overflow.
0058 165 :
0058 166 : CALLING SEQUENCE:
0058 167 :
0058 168 : DCOSH.wd.v = MTH$DCOSH(x.rd.r)
0058 169 :
0058 170 : INPUT PARAMETERS:
0058 171 :
00000004 0058 172 : LONG = 4 ; define longword multiplier
00000004 0058 173 : x = 1 * LONG ; Contents of x is the argument
0058 174 :
0058 175 : IMPLICIT INPUTS: none
0058 176 :
0058 177 : OUTPUT PARAMETERS:
0058 178 :
0058 179 : VALUE: double precision floating hyperbolic cosine of the argument
0058 180 :
0058 181 : IMPLICIT OUTPUTS: none
0058 182 :
0058 183 : COMPLETION CODES: none
0058 184 :
0058 185 : SIDE EFFECTS:
0058 186 :
0058 187 : Signal: MTH$ FLOOVEMAT if 128*ln2 < |X| with reserved operand in R0/R1
0058 188 : (copied to the signal mechanism vector CHF$MCH_R0/R1 by LIB$SIGNAL).
0058 189 : Associated message is: 'FLOATING OVERFLOW IN MATH LIBRARY'. Result is reserved
0058 190 : operand -0.0 unless a user supplied (or any) error handler changes CHF$MCH_R0/R1
0058 191 :
0058 192 : NOTE: This procedure disables floating point underflow, enables integer
0058 193 : overflow.
0058 194 :
0058 195 : ---
0058 196 :
0058 197 :
0058 198 : .ENTRY MTH$DCOSH, ^M<IV, R2, R3, R4, R5, R6 >
005A 199 : ; standard call-by-reference entry
005A 200 : ; disable DV (and FU), enable IV
005A 201 : MTH$FLAG_JACKET ; flag that this is a jacket procedure in
005A
6D 00000000'GF 9E 005A MOVAB G^MTH$$JACKET_HND, (FP)
0061 ; set handler address to jacket
```



```

0061 ; handler
0061 ; case of an error in routine
0061 202 ; If an error, convert signal to user PC
0061 203 ; and resignal
0061 204 ; R0/R1 = |X| = @value(AP)
50 04 BC 70 0061 205 MOVD @value(AP), R0
50 8000 8F AA 0065 206 BICW2 #^X8000, R0
3F80 8F 50 B1 006A 207 CMPW R0, #^X3F80
14 18 006F 208 BGEQ GEQ_TO_0.25
0071 209
0071 210 ;
0071 211 ; |X| < 0.25
0071 212 ;
0071 213 ;
3280 8F 50 B1 0071 214 CMPW R0, #^X3280 ; compare |X| with 2**-28
04 18 0076 215 BGEQ GEQ_TO_2M28 ; branch if |X| >= 2**-28
0078 216
0078 217 ;
0078 218 ; |X| < 2**-28
0078 219 ;
0078 220 ;
50 08 70 0078 221 MOVD S^#SD_1.0, R0 ; R0/R1 = 1.0
04 04 007B 222 RET ; return with result = 1.0
007C 223
007C 224 ;
007C 225 ; 2**-28 <= |X| < 0.25
007C 226 ;
007C 227 ;
007C 228 GEQ_TO_2M28:
A4 AF 50 50 64 007C 229 MULD R0, R0 ; Get ARG**2 for POLYD.
05 50 75 007F 230 POLYD R0, #DCOSHLN-1, DCOSHTAB
0084 231
0084 232 RET ; R0/R1 = SUM(Ci*X**i)
0085 233 ; return with result in R0
0085 234 ;
0085 235 ; 0.25 <= |X|
0085 236 ;
0085 237 ;
FF76 CF 50 71 0085 238 GEQ_TO_0.25:
1A 14 008A 239 CMPD R0, D 127 LOG 2 ; compare |X| with 127*ln2
008C 240 BGTR GTR_TRAN_127_LOG_2 ; branch if |X| > 127*ln2
008C 241
008C 242 ;
008C 243 ; 0.25 <= |X| <= 127*ln2
008C 244 ;
008C 245 ;
00000000 EF 16 008C 246 JSB MTH$DEXP R6 ; R0/R1 = DEXP(X)
FF79 CF 50 71 0092 247 CMPD R0, D 2 POWER_28.5 ; See if the DEXP(-|X|) is significant
07 14 0097 248 BGTR ONE_TERM_ONLY ; if not skip computation
52 08 50 67 0099 249 DIVD3 R0, S^#SD_1.0, R2 ; R2/R3 = DEXP(-|X|)
50 50 52 60 009D 250 ADDD R2, R0 ; R0/R1 = DEXP(X) + DEXP(-X)
00A0 251 ONE_TERM_ONLY:
50 0080 8F A2 00A0 252 SUBW #^X0080, R0 ; R0/R1 = (DEXP(X) + DEXP(-X))/2
04 00A5 253 RET ; return with result in R0/R1
00A6 254
00A6 255 ;
00A6 256 ; 127*ln2 < |X|

```

```
00A6 257 ;
00A6 258
00A6 259 GTR_THAN 127_LOG_2:
00A6 260      CMPD    R0, D_128_LOG_2      ; Check for possible overflow
00AB 261      BGTR   ERROR
00AD 262      SUBD   D_LOG_2_HI, R0
00B2 263      JSB    MTH$DEXP_R6
00B8 264      MULDS D_LOG_2_CO, R0, R2
00BE 265      SUBD   R2, R0
00C1 266      RET
00C2 267      ; 128*Ln2 < !X!
00C2 268      ;
00C2 269      ;
00C2 270
00C2 271 ERROR: MOVZBL #MTH$K_FLOOVEMAT, -(SP) ; condition value
00C6 272      ASHQ    #15, #T, R0           ; R0 = result = reserved operand -0.0
00CA 273      ; goes to signal mechanism vector
00CA 274      ; (CHF$MCH_R0/R1) so error handler
00CA 275      ; can modify the result.
00CA 276      CALLS   #1, G^MTH$$SIGNAL    ; signal error and use real user's PC
00D1 277      RET                          ; independent of CALL vs JSB
00D1 278      ; return - R0/R1 restored from CHF$MCH_R0/
00D2 279
00D2 280
00D2 281
00D2 282      .END
```

FF5D CF 50 71
50 FF67 CF 14
00000000'EF 62
52 50 FF64 CF 16
50 52 65
7E 00'8F 9A
50 01 0F 79
00000000'GF 01 FB
04

MTH\$DCOSH
Symbol table

K 3
; Double Floating Hyperbolic Cosine rout 16-SEP-1984 01:15:53 VAX/VMS Macro V04-00
6-SEP-1984 11:21:57 [MTHRTL.SRC]MTHDCOSH.MAR;1

Page 8
(4)

DCOSHLEN = 00000006
DCOSHTAB = 00000028 R 01
D_127_LOG_2 = 00000000 R 01
D_128_LOG_2 = 00000008 R 01
D_2_POWER_28.5 = 00000010 R 01
D_LOG_2_HI = 00000018 R 01
D_LOG_2_LO = 00000020 R 01
ERROR = 000000C2 R 01
GEQ_TO_0.25 = 00000085 R 01
GEQ_TO_2M28 = 0000007C R 01
GTR_THAN_127_LOG_2 = 000000A6 R 01
LONG = 00000004
MTH\$\$JACKET_HND ***** X 01
MTH\$\$SIGNAL ***** X 00
MTH\$DCOSH 00000058 RG 01
MTH\$DEXP_R6 ***** X 00
MTH\$K_FLOOVEMAT ***** X 00
ONE_TERM_ONLY 000000A0 R 01
SD_T.0 = 00004080
VALUE = 00000004

+-----+
! Psect synopsis !
+-----+

PSECT name	Allocation	PSECT No.	Attributes														
ABS	00000000 (0.)	00 (0.)	NOPIC	USR	CON	ABS	LCL	NOSHR	NOEXE	NORD	NOWRT	NOVEC	BYTE				
_MTH\$CODE	000000D2 (210.)	01 (1.)	PIC	USR	CON	REL	LCL	SHR	EXE	RD	NOWRT	NOVEC	LONG				

+-----+
! Performance indicators !
+-----+

Phase	Page faults	CPU Time	Elapsed Time
Initialization	32	00:00:00.10	00:00:00.72
Command processing	119	00:00:00.66	00:00:04.63
Pass 1	92	00:00:00.90	00:00:04.19
Symbol table sort	0	00:00:00.01	00:00:00.00
Pass 2	65	00:00:00.70	00:00:02.47
Symbol table output	3	00:00:00.03	00:00:00.08
Psect synopsis output	3	00:00:00.02	00:00:00.02
Cross-reference output	0	00:00:00.00	00:00:00.00
Assembler run totals	316	00:00:02.42	00:00:12.12

The working set limit was 750 pages.
4120 bytes (9 pages) of virtual memory were used to buffer the intermediate code.
There were 10 pages of symbol table space allocated to hold 21 non-local and 0 local symbols.
342 source lines were read in Pass 1, producing 11 object records in Pass 2.
1 page of virtual memory was used to define 1 macro.

```

+-----+
! Macro library statistics !
+-----+

```

Macro Library name

Macros defined

_\$255\$DUA28:[SYSLIB]STARLET.MLB;2

0

0 GETS were required to define 0 macros.

There were no errors, warnings or information messages.

MACRO/ENABLE=SUPPRESSION/DISABLE=(GLOBAL,TRACEBACK)/LIS=LIS\$:MTHDCOSH/OBJ=OBJ\$:MTHDCOSH MSRCS:MTHJACKET/UPDATE=(ENHS:MTHJACKET)+MSRC

MTH
Sym

ACM
APP
DXP
DXP
DXP
DXP
D_1
D_L
D_L
EVA
EXC
LON
MTH
MTH
MTH
MTH
MTH
MTH
MTH
MTH
OVE
SFS
SMT
TAB
TAB
UND
X
X_2

PSE

SAB
MT

Pha

Ini
Com
Pas
Sym
Pas
Sym
Pse
Cro
Ass

**The
860**

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 VAX/VMS V4.0

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