ELLIOTT

900

Volume 2: PROGRAMMING INFORMATION

Part 2: PROGRAM DESCRIPTION

Section 14: QFMATH (FLOATING POINT MATHEMATICAL FUNCTIONS)

Contents

Printed in England by
Engineering Unit, English Electric Computers Ltd.

Chapter 1: DESCRIPTION

1.1 INTRODUCTION

1.1.1 Purpose.

To compute certain mathematical functions of floating-point numbers held in the floating-point accumulator (FPA). The functions are performed by sub-routines entered via the floating-point package (QF).

1.1.2 Summary.

The functions provided are square-root, sine, cosine, arctangent, natural logarithm, exponential.

1.1.3 Accuracy.

The maximum error is 8×10^{-8}.

1.1.4 Form of Distribution.

The routines are distributed as a single SIR mnemonic tape. This must be assembled immediately after the floating-point package (QF).

1.1.5 Method of Use.

The routines are assembled as part of the block QF and are entered as floating-point subroutines. They may be run at any program-level and in any store-module.

1.2 FUNCTIONS

1.2.1 Entry and Exit.

Entry to all functions is made by a standard sub-routine entry which is interpreted by QF. On entry the argument is in the FPA which also contains the result on exit. (This result may be the effect of recovery after an error).

The available functions and their entry-points are listed below:

Function	Entry	Comments
square-root	11 SQRT 8 SQRT+1	entry with negative argument is an error
sine	11 SIN 8 SIN+1	argument is in radians
cosine	11 CØS 8 CØS+1	argument is in radians
arctangent	11 ARCTAN 8 ARCTAN+1	result is in radians and lies in the range $-\frac{\Pi}{2}$ to $+\frac{\Pi}{2}$
natural logarithm	11 LN 8 LN+1	entry with zero or negative argument is an error
exponential	11 EXP 8 EXP+1	the user should note that this operation may give an answer which cannot be held in packed format. This will be detected by QF

1.2.2 Example.

To calculate the function

$$y = \exp(x^2)^{\frac{1}{2}}$$

using packed format for the users workspace.

```
.
.
.
11    QF        (ENTER QF IF NECESSARY)
8     QF+1      (ASSUME PACKED FORMAT ON ENTRY)
4     X
12    X         (FORM X↑2)
11    EXP
8     EXP+1     (FORM EXP [X↑2])
11    SQRT
8     SQRT+1    (FORM {EXP [X↑2]}↑½)
5     Y
.
.
```

1.2.3 Global Identifiers.

The following labels are declared as global identifiers on the library tape and must be declared at the head of all blocks of the user's program which refer to them.

QF
SQRT
SIN
CØS
ARCTAN
LN
EXP

1.3 ERROR INDICATIONS

If a routine is entered with an impossible operand then an error is displayed. Recovery may be made by re-entry at 9. The detected errors are listed below.

Function	Error Message	Cause (x is the argument of the function)	Effect of Re-entry at 9.
logarithm	LN!	$x \leq 0$	result taken as +0
square root	SQ!	$x<0$	result taken as $\sqrt{\lvert x \rvert}$
exponential	EX!	$x>2$	result taken as x

1.4 METHOD USED

The method used for all routines is the same as in the 903 Algol procedures. In this package the functions use QF to perform basic arithmetic functions using unpacked format for the calculations.

All the functions except SQRT are calculated by a polynomial approximation in the form of a Chebyshev ecónomised power series. The polynomial is calculated by the subroutine SERIES.

On entry to square root, the argument, x, is adjusted so that the exponent is even. The square root of y is found,

where $\frac{1}{4} \leq y < 1$

and $x = y \times 2^{2n}$

This part of the calculation uses an iterative method. The final result is formed by halving the adjusted exponent and combining this with the result of the iteration.

1.5 STORE USED

SQRT	approx.	90 locations
SERIES	approx.	20 locations
SIN COS	approx.	80 locations
ARCTAN	approx.	120 locations
LN	approx.	110 locations
EXP	approx.	80 locations
		500

1.6 TIMES

Typical times are:

SQRT	5.3 millisec.
SIN	15.5 millisec.
COS	15.5 millisec.
ARCTAN	24.0 millisec.
LN	22.0 millisec.
EXP	13.0 millisec.