

# NAG Library Routine Document

## S18CTF

**Note:** before using this routine, please read the Users' Note for your implementation to check the interpretation of *bold italicised* terms and other implementation-dependent details.

### 1 Purpose

S18CTF returns an array of values of the scaled modified Bessel function  $e^{-|x|}I_1(x)$ .

### 2 Specification

```
SUBROUTINE S18CTF (N, X, F, IFAIL)
  INTEGER                N, IFAIL
  REAL (KIND=nag_wp) X(N), F(N)
```

### 3 Description

S18CTF evaluates an approximation to  $e^{-|x_i|}I_1(x_i)$ , where  $I_1$  is a modified Bessel function of the first kind for an array of arguments  $x_i$ , for  $i = 1, 2, \dots, n$ . The scaling factor  $e^{-|x|}$  removes most of the variation in  $I_1(x)$ .

The routine uses the same Chebyshev expansions as S18ATF, which returns an array of the unscaled values of  $I_1(x)$ .

### 4 References

Abramowitz M and Stegun I A (1972) *Handbook of Mathematical Functions* (3rd Edition) Dover Publications

### 5 Arguments

- |    |   |                     |
|----|---|---------------------|
| 1: | N – INTEGER   | <i>Input</i>        |
|    | <i>On entry:</i> $n$ , the number of points.  |                     |
|    | <i>Constraint:</i> $N \geq 0$ .   |                     |
| 2: | X(N) – REAL (KIND=nag_wp) array   | <i>Input</i>        |
|    | <i>On entry:</i> the argument $x_i$ of the function, for $i = 1, 2, \dots, N$ .   |                     |
| 3: | F(N) – REAL (KIND=nag_wp) array   | <i>Output</i>       |
|    | <i>On exit:</i> $e^{- x_i }I_1(x_i)$ , the function values.   |                     |
| 4: | IFAIL – INTEGER   | <i>Input/Output</i> |
|    | <i>On entry:</i> IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this argument you should refer to Section 3.4 in How to Use the NAG Library and its Documentation for details.   |                     |
|    | For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this argument, the recommended value is 0. <b>When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.</b> |                     |
|    | <i>On exit:</i> IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).  |                     |

## 6 Error Indicators and Warnings

If on entry  $IFAIL = 0$  or  $-1$ , explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

$IFAIL = 1$

On entry,  $N = \langle value \rangle$ .  
Constraint:  $N \geq 0$ .

$IFAIL = -99$

An unexpected error has been triggered by this routine. Please contact NAG.

See Section 3.9 in How to Use the NAG Library and its Documentation for further information.

$IFAIL = -399$

Your licence key may have expired or may not have been installed correctly.

See Section 3.8 in How to Use the NAG Library and its Documentation for further information.

$IFAIL = -999$

Dynamic memory allocation failed.

See Section 3.7 in How to Use the NAG Library and its Documentation for further information.

## 7 Accuracy

Relative errors in the argument are attenuated when propagated into the function value. When the accuracy of the argument is essentially limited by the *machine precision*, the accuracy of the function value will be similarly limited by at most a small multiple of the *machine precision*.

## 8 Parallelism and Performance

S18CTF is not threaded in any implementation.

## 9 Further Comments

None.

## 10 Example

This example reads values of  $X$  from a file, evaluates the function at each value of  $x_i$  and prints the results.

### 10.1 Program Text

```

Program s18ctfe

!      S18CTF Example Program Text

!      Mark 26 Release. NAG Copyright 2016.

!      .. Use Statements ..
      Use nag_library, Only: nag_wp, s18ctf
!      .. Implicit None Statement ..
      Implicit None
!      .. Parameters ..
      Integer, Parameter          :: nin = 5, nout = 6
!      .. Local Scalars ..

```

```

      Integer                                :: i, ifail, n
!      .. Local Arrays ..
      Real (Kind=nag_wp), Allocatable :: f(:), x(:)
!      .. Executable Statements ..
      Write (nout,*) 'S18CTF Example Program Results'

!      Skip heading in data file
      Read (nin,*)

      Write (nout,*)
      Write (nout,*) '      X      F'
      Write (nout,*)

      Read (nin,*) n

      Allocate (x(n),f(n))

      Read (nin,*) x(1:n)

      ifail = 0
      Call s18ctf(n,x,f,ifail)

      Do i = 1, n
         Write (nout,99999) x(i), f(i)
      End Do

99999 Format (1X,1P,2E12.3,I5)
      End Program s18ctfe

```

## 10.2 Program Data

S18CTF Example Program Data

8

0.0 0.5 1.0 3.0 6.0 10.0 1000.0 -1.0

## 10.3 Program Results

S18CTF Example Program Results

X	F
0.000E+00	0.000E+00
5.000E-01	1.564E-01
1.000E+00	2.079E-01
3.000E+00	1.968E-01
6.000E+00	1.521E-01
1.000E+01	1.213E-01
1.000E+03	1.261E-02
-1.000E+00	-2.079E-01

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