

NAG C Library Function Document

nag_zspmv (f16tcc)

1 Purpose

nag_zspmv (f16tcc) performs matrix-vector multiplication for a complex symmetric matrix stored in packed form.

2 Specification

```
#include <nag.h>
#include <nagf16.h>
```

```
void nag_zspmv (Nag_OrderType order, Nag_UploType uplo, Integer n, Complex alpha,
               const Complex ap[], const Complex x[], Integer incx, Complex beta,
               Complex y[], Integer incy, NagError *fail)
```

3 Description

nag_zspmv (f16tcc) performs the matrix-vector operation

$$y \leftarrow \alpha Ax + \beta y$$

where A is an n by n complex symmetric matrix stored in packed form, x and y are n element complex vectors, and α and β are complex scalars.

4 References

The BLAS Technical Forum Standard (2001) www.netlib.org/blas/blast-forum

5 Arguments

- 1: **order** – Nag_OrderType *Input*
On entry: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order = Nag_RowMajor**. See Section 2.2.1.4 of the Essential Introduction for a more detailed explanation of the use of this argument.
Constraint: **order = Nag_RowMajor** or **Nag_ColMajor**.
- 2: **uplo** – Nag_UploType *Input*
On entry: specifies whether the upper or lower triangular part of A is stored.
uplo = Nag_Upper
The upper triangular part of A is stored.
uplo = Nag_Lower
The lower triangular part of A is stored.
Constraint: **uplo = Nag_Upper** or **Nag_Lower**.
- 3: **n** – Integer *Input*
On entry: n , the order of the matrix A .
Constraint: $n \geq 0$.

- 4: **alpha** – Complex *Input*
On entry: the scalar α .
- 5: **ap**[*dim*] – const Complex *Input*
Note: the dimension, *dim*, of the array **ap** must be at least $\max(1, \mathbf{n} \times (\mathbf{n} + 1)/2)$.
On entry: the n by n symmetric matrix A , packed by rows or columns. The storage of elements a_{ij} depends on the **order** and **uplo** arguments as follows:
- if **order** = **Nag_ColMajor** and **uplo** = **Nag_Upper**,
 a_{ij} is stored in **ap**[($j - 1$) \times $j/2 + i - 1$], for $i \leq j$;
 - if **order** = **Nag_ColMajor** and **uplo** = **Nag_Lower**,
 a_{ij} is stored in **ap**[($2n - j$) \times ($j - 1$)/2 + $i - 1$], for $i \geq j$;
 - if **order** = **Nag_RowMajor** and **uplo** = **Nag_Upper**,
 a_{ij} is stored in **ap**[($2n - i$) \times ($i - 1$)/2 + $j - 1$], for $i \leq j$;
 - if **order** = **Nag_RowMajor** and **uplo** = **Nag_Lower**,
 a_{ij} is stored in **ap**[($i - 1$) \times $i/2 + j - 1$], for $i \geq j$.
- 6: **x**[*dim*] – const Complex *Input*
Note: the dimension, *dim*, of the array **x** must be at least $\max(1, 1 + (\mathbf{n} - 1)|\mathbf{incx}|)$.
On entry: the vector x .
- 7: **incx** – Integer *Input*
On entry: the increment in the subscripts of **x** between successive elements of x .
Constraint: **incx** $\neq 0$.
- 8: **beta** – Complex *Input*
On entry: the scalar β .
- 9: **y**[*dim*] – Complex *Input/Output*
Note: the dimension, *dim*, of the array **y** must be at least $\max(1, 1 + (\mathbf{n} - 1)|\mathbf{incy}|)$.
On entry: the vector y .
 If **beta** = 0, **y** need not be set.
On exit: the updated vector y .
- 10: **incy** – Integer *Input*
On entry: the increment in the subscripts of **y** between successive elements of y .
Constraint: **incy** $\neq 0$.
- 11: **fail** – NagError * *Input/Output*
 The NAG error argument (see Section 2.6 of the Essential Introduction).

6 Error Indicators and Warnings

NE_BAD_PARAM

On entry, argument $\langle value \rangle$ had an illegal value.

NE_INT

On entry, **incx** = $\langle value \rangle$.
Constraint: **incx** $\neq 0$.

On entry, **incy** = $\langle value \rangle$.

Constraint: **incy** $\neq 0$.

On entry, **n** = $\langle value \rangle$.

Constraint: **n** ≥ 0 .

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of The BLAS Technical Forum Standard (2001)).

8 Further Comments

None.

9 Example

To compute the matrix-vector product

$$y = \alpha Ax + \beta y$$

where

$$A = \begin{pmatrix} 1.0 + 1.0i & 2.0 + 1.0i & 3.0 + 1.0i & 4.0 + 1.0i \\ 2.0 + 1.0i & 2.0 + 2.0i & 3.0 + 2.0i & 4.0 + 2.0i \\ 3.0 + 1.0i & 3.0 + 2.0i & 3.0 + 3.0i & 4.0 + 3.0i \\ 4.0 + 1.0i & 4.0 + 2.0i & 4.0 + 3.0i & 4.0 + 4.0i \end{pmatrix},$$

$$x = \begin{pmatrix} 1.0 + 0.0i \\ 0.0 - 1.0i \\ -1.0 + 0.0i \\ 0.0 + 1.0i \end{pmatrix},$$

$$y = \begin{pmatrix} 10.0 + 4.0i \\ 10.0 + 8.0i \\ 10.0 + 16.0i \\ 14.0 + 24.0i \end{pmatrix},$$

$$\alpha = 1.0 + 1.0i \quad \text{and} \quad \beta = 0.5 + 0.0i.$$

9.1 Program Text

```
/* nag_zspmv (f16tcc) Example Program.
 *
 * Copyright 2005 Numerical Algorithms Group.
 *
 * Mark 8, 2005.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf16.h>
#include <nagx04.h>

int main(void)
{
    /* Scalars */
    Complex alpha, beta;
    Integer aplen, exit_status, i, incx, incy, j, n, xlen, ylen;

    /* Arrays */
```

```

Complex *ap=0, *x=0, *y=0;
char nag_enum_arg[40];

/* Nag Types */
NagError fail;
Nag_OrderType order;
Nag_UploType uplo;

#ifdef NAG_COLUMN_MAJOR
#define A_UPPER(I,J) ap[J*(J-1)/2 + I - 1]
#define A_LOWER(I,J) ap[(2*n-J)*(J-1)/2 + I - 1]
order = Nag_ColMajor;
#else
#define A_LOWER(I,J) ap[I*(I-1)/2 + J - 1]
#define A_UPPER(I,J) ap[(2*n-I)*(I-1)/2 + J - 1]
order = Nag_RowMajor;
#endif

exit_status = 0;
INIT_FAIL(fail);
Vprintf( "nag_zspmv (f16tcc) Example Program Results\n\n");

/* Skip heading in data file */
Vscanf("%*[\n] ");
/* Read the problem dimension */
Vscanf("%ld%*[\n] ", &n);
/* Read uplo */
Vscanf("%s%*[\n] ", nag_enum_arg);
/* nag_enum_name_to_value(x04nac).
 * Converts NAG enum member name to value
 */
uplo = nag_enum_name_to_value(nag_enum_arg);
/* Read scalar parameters */
Vscanf(" ( %lf , %lf ) ( %lf , %lf )%*[\n] ",
        &alpha.re, &alpha.im, &beta.re, &beta.im);
/* Read increment parameters */
Vscanf("%ld%ld%*[\n] ", &incx, &incy);

aplen = n*(n+1)/2;
xlen = MAX(1, 1 + (n - 1)*ABS(incx));
ylen = MAX(1, 1 + (n - 1)*ABS(incy));

if (n > 0)
{
    /* Allocate memory */
    if ( !(ap = NAG_ALLOC(aplen, Complex)) ||
        !(x = NAG_ALLOC(xlen, Complex)) ||
        !(y = NAG_ALLOC(ylen, Complex)) )
    {
        Vprintf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }
}
else
{
    Vprintf("Invalid n\n");
    exit_status = 1;
    return exit_status;
}

/* Read A from data file */
if (uplo == Nag_Upper)
{
    for (i = 1; i <= n; ++i)
    {
        for (j = i; j <= n; ++j)
            Vscanf(" ( %lf , %lf )",
                    &A_UPPER(i,j).re, &A_UPPER(i,j).im);
    }
}

```

```

        Vscanf("%*[^\\n] ");
    }
else
    {
        for (i = 1; i <= n; ++i)
            {
                for (j = 1; j <= i; ++j)
                    Vscanf(" ( %lf , %lf )%*[^\\n] ",
                        &A_LOWER(i,j).re, &A_LOWER(i,j).im);
            }
        Vscanf("%*[^\\n] ");
    }

/* Input vectors x and y */
for (i = 1; i <= xlen; ++i)
    Vscanf(" ( %lf , %lf )%*[^\\n] ", &x[i - 1].re, &x[i - 1].im);
for (i = 1; i <= ylen; ++i)
    Vscanf(" ( %lf , %lf )%*[^\\n] ", &y[i - 1].re, &y[i - 1].im);

/* nag_zspmv(f16tcc).
 * Complex symmetric packed storage matrix-vector multiply.
 */
nag_zspmv(order, uplo, n, alpha, ap, x, incx, beta, y,
          incy, &fail);
if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from nag_zspmv.\\n%s\\n", fail.message);
        exit_status = 1;
        goto END;
    }

/* Print output vector y */
Vprintf("%s\\n", " y");
for (i = 1; i <= ylen; ++i)
    Vprintf("( %11f,%11f)\\n", y[i-1].re, y[i-1].im);

END:
    if (ap) NAG_FREE(ap);
    if (x) NAG_FREE(x);
    if (y) NAG_FREE(y);

    return exit_status;
}

```

9.2 Program Data

```

nag_zspmv (f16tcc) Example Program Data
4                               :Value of n
Nag_Lower                       :Value of uplo
( 1.0, 1.0) ( 0.5, 0.0)         :Values of alpha, beta
1 1                               :Values of incx, incy
( 1.0, 1.0)
( 2.0, 1.0) ( 2.0, 2.0)
( 3.0, 1.0) ( 3.0, 2.0) ( 3.0, 3.0)
( 4.0, 1.0) ( 4.0, 2.0) ( 4.0, 3.0) ( 4.0, 4.0) :End of matrix A
( 1.0, 0.0)
( 0.0,-1.0)
(-1.0, 0.0)
( 0.0, 1.0)                       :End of vector x
(10.0, 4.0)
(10.0, 8.0)
(10.0,16.0)
(14.0,24.0)                       : the end of vector y

```

9.3 Program Results

nag_zspmv (f16tcc) Example Program Results

```
      y
(  1.000000,  2.000000)
(  3.000000,  4.000000)
(  5.000000,  6.000000)
(  7.000000,  8.000000)
```
