

NAG Library Function Document

nag_zhpmv (f16sec)

1 Purpose

nag_zhpmv (f16sec) performs matrix-vector multiplication for a complex Hermitian matrix stored in packed form.

2 Specification

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

void nag_zhpmv (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_zhpmv (f16sec) performs the matrix-vector operation

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

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

4 References

Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001) *Basic Linear Algebra Subprograms Technical (BLAST) Forum Standard* University of Tennessee, Knoxville, Tennessee <http://www.netlib.org/blas/blast-forum/blas-report.pdf>

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 2.3.1.3 in How to Use the NAG Library and its Documentation 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** ≥ 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 Hermitian 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 n -element vector x .
If **incx** > 0, x_i must be stored in **x**[($i - 1$) \times **incx**], for $i = 1, 2, \dots, \mathbf{n}$.
If **incx** < 0, x_i must be stored in **x**[($\mathbf{n} - i$) \times **incx**], for $i = 1, 2, \dots, \mathbf{n}$.
Intermediate elements of **x** are not referenced. If **n** = 0, **x** is not referenced and may be **NULL**.
- 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 . See **x** for details of storage.
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 2.7 in How to Use the NAG Library and its Documentation).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.

See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

NE_BAD_PARAM

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

NE_INT

On entry, $\mathbf{incx} = \langle value \rangle$.

Constraint: $\mathbf{incx} \neq 0$.

On entry, $\mathbf{incy} = \langle value \rangle$.

Constraint: $\mathbf{incy} \neq 0$.

On entry, $\mathbf{n} = \langle value \rangle$.

Constraint: $\mathbf{n} \geq 0$.

NE_INTERNAL_ERROR

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

See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

NE_NO_LICENCE

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

See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001)).

8 Parallelism and Performance

nag_zhpmv (f16sec) is not threaded in any implementation.

9 Further Comments

None.

10 Example

This example computes the matrix-vector product

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

where

$$A = \begin{pmatrix} 1.0 + 0.0i & 2.0 - 1.0i & 3.0 - 1.0i & 4.0 - 1.0i \\ 2.0 + 1.0i & 2.0 + 0.0i & 3.0 - 2.0i & 4.0 - 2.0i \\ 3.0 + 1.0i & 3.0 + 2.0i & 3.0 + 0.0i & 4.0 - 3.0i \\ 4.0 + 1.0i & 4.0 + 1.0i & 4.0 + 3.0i & 4.0 + 0.0i \end{pmatrix},$$

$$x = \begin{pmatrix} -1.0 + 1.0i \\ 2.0 - 3.0i \\ -3.0 + 2.0i \\ 1.0 - 1.0i \end{pmatrix},$$

$$y = \begin{pmatrix} 2.5 + 2.5i \\ 2.5 + 1.5i \\ 2.5 + 5.0i \\ 6.0 + 9.0i \end{pmatrix},$$

$$\alpha = 1.0 + 0.0i \quad \text{and} \quad \beta = 2.0 + 0.0i.$$

10.1 Program Text

```

/* nag_zhpmv (f16sec) Example Program.
*
* NAGPRODCODE Version.
*
* Copyright 2016 Numerical Algorithms Group.
*
* Mark 26, 2016.
*/

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf16.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);

    printf("nag_zhpmv (f16sec) Example Program Results\n\n");

    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%s[^\n] ");
#else
    scanf("%s[^\n] ");
#endif
    /* Read the problem dimension */
#ifdef _WIN32

```

```

    scanf_s("%" NAG_IFMT "%*[\n] ", &n);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &n);
#endif
    /* Read uplo */
#ifdef _WIN32
    scanf_s("%39s%*[\n] ", nag_enum_arg, (unsigned)_countof(nag_enum_arg));
#else
    scanf("%39s%*[\n] ", nag_enum_arg);
#endif
    /* nag_enum_name_to_value (x04nac).
     * Converts NAG enum member name to value
     */
    uplo = (Nag_UploType) nag_enum_name_to_value(nag_enum_arg);
    /* Read scalar parameters */
#ifdef _WIN32
    scanf_s(" ( %lf , %lf ) ( %lf , %lf )%*[\n] ",
            &alpha.re, &alpha.im, &beta.re, &beta.im);
#else
    scanf(" ( %lf , %lf ) ( %lf , %lf )%*[\n] ",
            &alpha.re, &alpha.im, &beta.re, &beta.im);
#endif
    /* Read increment parameters */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%" NAG_IFMT "%*[\n] ", &incx, &incy);
#else
    scanf("%" NAG_IFMT "%" NAG_IFMT "%*[\n] ", &incx, &incy);
#endif

    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)))
        {
            printf("Allocation failure\n");
            exit_status = -1;
            goto END;
        }
    }
    else {
        printf("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)
#ifdef _WIN32
                scanf_s(" ( %lf , %lf )", &A_UPPER(i, j).re, &A_UPPER(i, j).im);
#else
                scanf(" ( %lf , %lf )", &A_UPPER(i, j).re, &A_UPPER(i, j).im);
#endif
        }
    }
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else
    scanf("%*[\n] ");
#endif
    }
    else {
        for (i = 1; i <= n; ++i) {
            for (j = 1; j <= i; ++j)
#ifdef _WIN32
                scanf_s(" ( %lf , %lf )", &A_LOWER(i, j).re, &A_LOWER(i, j).im);
#else

```

```

        scanf(" ( %lf , %lf )", &A_LOWER(i, j).re, &A_LOWER(i, j).im);
#endif
    }
#ifdef _WIN32
    scanf_s("%*[^\\n] ");
#else
    scanf("%*[^\\n] ");
#endif
}

/* Input vectors x and y */
for (i = 1; i <= xlen; ++i)
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[^\\n] ", &x[i - 1].re, &x[i - 1].im);
#else
    scanf(" ( %lf , %lf )%*[^\\n] ", &x[i - 1].re, &x[i - 1].im);
#endif
for (i = 1; i <= ylen; ++i)
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[^\\n] ", &y[i - 1].re, &y[i - 1].im);
#else
    scanf(" ( %lf , %lf )%*[^\\n] ", &y[i - 1].re, &y[i - 1].im);
#endif

/* nag_zhpmv (f16sec).
 * Hermitian packed storage matrix-vector multiply.
 *
 */
nag_zhpmv(order, uplo, n, alpha, ap, x, incx, beta, y, incy, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_zhpmv.\\n%s\\n", fail.message);
    exit_status = 1;
    goto END;
}

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

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

    return exit_status;
}

```

10.2 Program Data

```

nag_zhpmv (f16sec) Example Program Data
4                               :Value of n
Nag_Upper                     :Value of uplo
( 1.0, 0.0) ( 2.0, 0.0)       :Values of alpha, beta
1 1                             :Values of incx, incy
(1.0, 0.0) (2.0,-1.0) (3.0,-1.0) (4.0,-1.0)
(2.0, 0.0) (2.0, 0.0) (3.0,-2.0) (4.0,-2.0)
(3.0, 0.0) (4.0,-3.0)
(4.0, 0.0) :End of matrix A

(-1.0, 1.0)
( 2.0,-3.0)
(-3.0, 2.0)
( 1.0,-1.0)                   : the end of vector x
( 2.5, 2.5)
( 2.5, 1.5)
( 2.5, 5.0)
( 6.0, 9.0)                   : the end of vector y

```

10.3 Program Results

nag_zhpmv (f16sec) Example Program Results

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