

NAG Library Function Document

nag_ztpmv (f16shc)

1 Purpose

nag_ztpmv (f16shc) performs matrix-vector multiplication for a complex triangular matrix stored in packed form.

2 Specification

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

void nag_ztpmv (Nag_OrderType order, Nag_UploType uplo, Nag_TransType trans,
               Nag_DiagType diag, Integer n, Complex alpha, const Complex ap[],
               Complex x[], Integer incx, NagError *fail)
```

3 Description

nag_ztpmv (f16shc) performs one of the matrix-vector operations

$$x \leftarrow \alpha Ax, \quad x \leftarrow \alpha A^T x \quad \text{or} \quad x \leftarrow \alpha A^H x,$$

where A is an n by n complex triangular matrix, stored in packed form, x is an n -element complex vector and α is a complex scalar.

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 A is upper or lower triangular.
uplo = Nag_Upper
 A is upper triangular.
uplo = Nag_Lower
 A is lower triangular.
Constraint: **uplo** = Nag_Upper or Nag_Lower.

- 3: **trans** – Nag_TransType *Input*
On entry: specifies the operation to be performed.
trans = Nag_NoTrans
 $x \leftarrow \alpha Ax.$
trans = Nag_Trans
 $x \leftarrow \alpha A^T x.$
trans = Nag_ConjTrans
 $x \leftarrow \alpha A^H x.$
Constraint: **trans** = Nag_NoTrans, Nag_Trans or Nag_ConjTrans.
- 4: **diag** – Nag_DiagType *Input*
On entry: specifies whether A has nonunit or unit diagonal elements.
diag = Nag_NonUnitDiag
The diagonal elements are stored explicitly.
diag = Nag_UnitDiag
The diagonal elements are assumed to be 1 and are not referenced.
Constraint: **diag** = Nag_NonUnitDiag or Nag_UnitDiag.
- 5: **n** – Integer *Input*
On entry: n , the order of the matrix A .
Constraint: $n \geq 0$.
- 6: **alpha** – Complex *Input*
On entry: the scalar α .
- 7: **ap**[*dim*] – const Complex *Input*
Note: the dimension, *dim*, of the array **ap** must be at least $\max(1, n \times (n + 1)/2)$.
On entry: the n by n triangular 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 $i \geq j$.
If **diag** = Nag_UnitDiag, the diagonal elements of AP are assumed to be 1, and are not referenced; the same storage scheme is used whether **diag** = Nag_NonUnitDiag or **diag** = Nag_UnitDiag.
- 8: **x**[*dim*] – Complex *Input/Output*
Note: the dimension, *dim*, of the array **x** must be at least $\max(1, 1 + (n - 1)|\mathbf{incx}|)$.
On entry: the right-hand side vector b .
On exit: the solution vector x .

- 9: **incx** – Integer *Input*
On entry: the increment in the subscripts of **x** between successive elements of *x*.
Constraint: **incx** \neq 0.
- 10: **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 3.2.1.2 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, **incx** = $\langle value \rangle$.
Constraint: **incx** \neq 0.

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

NE_INTERNAL_ERROR

An unexpected error has been triggered by this function. Please contact NAG.
See Section 3.6.6 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 3.6.5 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_ztpmv (f16shc) is not threaded in any implementation.

9 Further Comments

None.

10 Example

This example computes the matrix-vector product

$$y = \alpha Ax$$

where

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

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

and

$$\alpha = 1.0 + 0.0i.$$

10.1 Program Text

```

/* nag_ztpmv (f16shc) 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;
    Integer aplen, exit_status, i, incx, j, n, xlen;

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

    /* Nag Types */
    NagError fail;
    Nag_DiagType diag;
    Nag_OrderType order;
    Nag_TransType trans;
    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_ztpmv (f16shc) Example Program Results\n\n");

    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else

```

```

    scanf("%*[\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 trans */
#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
 */
trans = (Nag_TransType) nag_enum_name_to_value(nag_enum_arg);
/* Read diag */
#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
 */
diag = (Nag_DiagType) nag_enum_name_to_value(nag_enum_arg);
/* Read scalar parameters */
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[\n] ", &alpha.re, &alpha.im);
#else
    scanf(" ( %lf , %lf )%*[\n] ", &alpha.re, &alpha.im);
#endif
/* Read increment parameters */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%*[\n] ", &incx);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &incx);
#endif

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

if (n > 0) {
    /* Allocate memory */
    if (!(ap = NAG_ALLOC(aplen, Complex)) || !(x = NAG_ALLOC(xlen, 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 vector x */
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

/* nag_ztpmv (f16shc).
 * Complex triangular packed storage matrix-vector multiply.
 */
nag_ztpmv(order, uplo, trans, diag, n, alpha, ap, x, incx, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_ztpmv (f16shc).\n%s\n", fail.message);
    exit_status = 1;
    goto END;
}

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

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

    return exit_status;
}

```

10.2 Program Data

nag_ztpmv (f16shc) Example Program Data

4	:Values of n
Nag_Lower	:Value of uplo
Nag_NoTrans	:Value of trans
Nag_NonUnitDiag	:Value of diag
(1.0, 0.0)	:Value of alpha
1	:Value of incx

```
( 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
```

10.3 Program Results

nag_ztpmv (f16shc) Example Program Results

```
  x
(  1.000000,  1.000000)
(  4.000000, -1.000000)
(  2.000000, -5.000000)
( -2.000000, -2.000000)
```
