

NAG Library Function Document

nag_zher (f16spc)

1 Purpose

nag_zher (f16spc) performs a Hermitian rank-1 update on a complex Hermitian matrix.

2 Specification

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

void nag_zher (Nag_OrderType order, Nag_UploType uplo, Integer n,
               double alpha, const Complex x[], Integer incx, double beta, Complex a[],
               Integer pda, NagError *fail)
```

3 Description

nag_zher (f16spc) performs the Hermitian rank-1 update operation

$$A \leftarrow \alpha x x^H + \beta A,$$

where A is an n by n complex Hermitian matrix, x is an n -element complex vector, while α and β are real 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** – double *Input*
On entry: the scalar α .
- 5: **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) × **incx**], for $i = 1, 2, \dots, \mathbf{n}$.
 If **incx** < 0, x_i must be stored in **x**[(**n** − *i*) × |**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**.
- 6: **incx** – Integer *Input*
On entry: the increment in the subscripts of **x** between successive elements of *x*.
Constraint: **incx** ≠ 0.
- 7: **beta** – double *Input*
On entry: the scalar β .
- 8: **a**[*dim*] – Complex *Input/Output*
Note: the dimension, *dim*, of the array **a** must be at least $\max(1, \mathbf{pda} \times \mathbf{n})$.
On entry: the *n* by *n* Hermitian matrix *A*.
 If **order** = Nag_ColMajor, A_{ij} is stored in **a**[(*j* − 1) × **pda** + *i* − 1].
 If **order** = Nag_RowMajor, A_{ij} is stored in **a**[(*i* − 1) × **pda** + *j* − 1].
 If **uplo** = Nag_Upper, the upper triangular part of *A* must be stored and the elements of the array below the diagonal are not referenced.
 If **uplo** = Nag_Lower, the lower triangular part of *A* must be stored and the elements of the array above the diagonal are not referenced.
On exit: the updated matrix *A*. The imaginary parts of the diagonal elements are set to zero.
- 9: **pda** – Integer *Input*
On entry: the stride separating row or column elements (depending on the value of **order**) of the matrix *A* in the array **a**.
Constraint: **pda** ≥ max(1, **n**).
- 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 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

NE_BAD_PARAM

On entry, argument *⟨value⟩* had an illegal value.

NE_INT

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

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

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

Constraint: **n** ≥ 0 .

NE_INT_2

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

Constraint: **pda** $\geq \max(1, \mathbf{n})$.

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_zher (f16sps) is not threaded in any implementation.

9 Further Comments

None.

10 Example

Perform rank-1 update of complex Hermitian matrix A using vector x :

$$A \leftarrow A - xx^H,$$

where A is the 4 by 4 Hermitian matrix given by

$$A = \begin{pmatrix} 4.0 + 0.0i & 7.0 - 4.0i & -0.6 + 2.2i & -4.0 + 3.0i \\ 7.0 + 4.0i & 14.0 + 0.0i & 0.3 + 1.2i & -4.7 + 2.1i \\ -0.6 - 2.2i & 0.3 - 1.2i & 2.04 + 0.0i & -5.9 - 0.1i \\ -4.0 - 3.0i & -4.7 + 2.1i & -5.9 + 0.1i & 6.0 + 0.0i \end{pmatrix}$$

and

$$x = \begin{pmatrix} 2.0 + 1.0i \\ 2.0 + 3.0i \\ 0.2 - 1.0i \\ -1.0 - 2.0i \end{pmatrix}.$$

10.1 Program Text

```

/* nag_zher (f16spc) 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>
#include <nagx04.h>

int main(void)
{
    /* Scalars */
    double alpha, beta;
    Integer exit_status, i, incx, j, n, pda, xlen;

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

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

#ifdef NAG_COLUMN_MAJOR
#define A(I, J) a[(J-1)*pda + I - 1]
    order = Nag_ColMajor;
#else
#define A(I, J) a[(I-1)*pda + J - 1]
    order = Nag_RowMajor;
#endif

    exit_status = 0;
    INIT_FAIL(fail);

    printf("nag_zher (f16spc) 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 the uplo storage parameter */
#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%*[\n] ", &alpha, &beta);
#else
    scanf("%lf%lf%*[\n] ", &alpha, &beta);
#endif
/* Read increment parameter */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%*[\n] ", &incx);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &incx);
#endif

pda = n;

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

if (n > 0) {
    /* Allocate memory */
    if (!(a = NAG_ALLOC(pda * n, 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;
}

/* Input matrix A and vector x */

if (uplo == Nag_Upper) {
    for (i = 1; i <= n; ++i) {
        for (j = i; j <= n; ++j)
#ifdef _WIN32
            scanf_s(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
#else
            scanf(" ( %lf , %lf )", &A(i, j).re, &A(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(i, j).re, &A(i, j).im);
#else
            scanf(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
#endif
    }
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else
    scanf("%*[\n] ");
#endif
}
for (i = 0; i < xlen; ++i)
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[\n] ", &x[i].re, &x[i].im);
#else
    scanf(" ( %lf , %lf )%*[\n] ", &x[i].re, &x[i].im);
#endif

```

```

/* nag_zher (f16spc).
 * Rank one update of complex Hermitian matrix.
 *
 */
nag_zher(order, uplo, n, alpha, x, incx, beta, a, pda, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_zher.\n%s\n", fail.message);
    exit_status = 1;
    goto END;
}

if (uplo == Nag_Upper) {
    matrix = Nag_UpperMatrix;
}
else {
    matrix = Nag_LowerMatrix;
}
/* Print updated matrix A */
/* nag_gen_complx_mat_print_comp (x04dbc).
 * Print complex general matrix (comprehensive)
 */
fflush(stdout);
nag_gen_complx_mat_print_comp(order, matrix, Nag_NonUnitDiag, n, n, a,
                              pda, Nag_BracketForm, "%7.4f",
                              "Updated Matrix A", Nag_IntegerLabels,
                              0, Nag_IntegerLabels, 0, 80, 0, 0, &fail);

if (fail.code != NE_NOERROR) {
    printf("Error from nag_gen_complx_mat_print_comp (x04dbc).\n%s"
           "\n", fail.message);
    exit_status = 1;
    goto END;
}

END:
    NAG_FREE(a);
    NAG_FREE(x);

    return exit_status;
}

```

10.2 Program Data

nag_zher (f16spc) Example Program Data

4	:Value of n
Nag_Lower	:Storage of A
-1.0 1.0	:Values of alpha and beta
1	:Value of incx
(4.0, 0.0)	
(7.0, 4.0) (14.0, 0.0)	
(-0.6,-2.2) (0.3,-1.2) (2.04,0.0)	
(-4.0,-3.0) (-4.7, 2.1) (-5.9, 0.1) (6.0, 0.0)	:End of matrix A
(2.0, 1.0)	
(2.0, 3.0)	
(0.2,-1.0)	
(-1.0,-2.0)	:End of vector x

10.3 Program Results

nag_zher (f16spc) Example Program Results

Updated Matrix A	1	2	3	4
1	(-1.0000, 0.0000)			
2	(0.0000, 0.0000)	(1.0000, 0.0000)		
3	(0.0000, 0.0000)	(2.9000, 1.4000)	(1.0000, 0.0000)	
4	(0.0000, 0.0000)	(3.3000, 3.1000)	(-7.7000, 1.5000)	(1.0000, 0.0000)
