NAG Library Function Document

nag_zher2 (f16src)

1 Purpose

nag_zher2 (f16src) performs a Hermitian rank-2 update on a complex Hermitian matrix.

2 Specification

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

```
void nag_zher2 (Nag_OrderType order, Nag_UploType uplo, Integer n,
     Complex alpha, const Complex x[], Integer incx, const Complex y[],
     Integer incy, double beta, Complex a[], Integer pda, NagError *fail)
```

3 Description

nag_zher2 (f16src) performs the Hermitian rank-2 update operation

$$A \leftarrow \alpha xy^{\mathrm{H}} + \bar{\alpha} yx^{\mathrm{H}} + \beta A$$

where A is an n by n complex Hermitian matrix, x and y are n-element complex vectors, α is a complex scalar and β is a real 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 3.2.1.3 in 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** ≥ 0.

4: **alpha** – Complex *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 vector x.

6: **incx** – Integer *Input*

On entry: the increment in the subscripts of **x** between successive elements of x.

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

7: **y**[dim] – const Complex *Input*

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.

8: **incy** – Integer *Input*

On entry: the increment in the subscripts of **y** between successive elements of y.

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

9: **beta** – double *Input*

On entry: the scalar β.

10: **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 $\mathbf{a}[(j - 1) \times \mathbf{pda} + i - 1]$.

If **order** = Nag_RowMajor, A_{ij} is stored in $\mathbf{a}[(i - 1) \times \mathbf{pda} + j - 1]$.

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.

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

12: **fail** – NagError * *Input/Output*

The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.
See Section 3.2.1.2 in the Essential Introduction 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, **incy** $= \langle value \rangle$.
Constraint: **incy** $\neq 0$.

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 3.6.6 in the Essential Introduction 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 the Essential Introduction 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

Not applicable.

9 Further Comments

None.

10 Example

Perform rank-2 update of complex Hermitian matrix A using vectors x and y:

$$A \leftarrow A - xy^{\mathrm{H}} - yx^{\mathrm{H}},$$

where A is the 4 by 4 matrix given by

$$A = \begin{pmatrix} 23.0 + 0.0i & 10.0 - 17.0i & 13.0 + 14.2i & -19.0 + 8.0i \\ 10.0 + 17.0i & 1.0 + 0.0i & 0.3 + 1.2i & -4.7 + 2.1i \\ 13.0 - 14.2i & 0.3 - 1.2i & 1.0 + 0.0i & -5.9 + 0.1i \\ -19.0 - 8.0i & -4.7 + 2.1i & -5.9 + 0.1i & 1.0 + 0.0i \end{pmatrix},$$

and where

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

and

$$y = \begin{pmatrix} 5.0 + 1.0i \\ -2.0 + 1.0i \\ 7.0 - 1.0i \\ -5.0 - 2.0i \end{pmatrix}.$$

The vector y is stored in every second element of array **y** (**incy** $= 2$).

10.1 Program Text

```
/* nag_zher2 (f16src) Example Program.
 *
 * Copyright 2014 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;
  double         beta;
  Integer        exit_status, i, incx, incy, j, n, pda, xlen, ylen;

  /* Arrays */
  Complex        *a = 0, *x = 0, *y = 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_zher2 (f16src) 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, _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.re, &alpha.im);
#else
  scanf(" ( %lf , %lf )%*[^\n] ", &alpha.re, &alpha.im);
#endif
#ifdef _WIN32
  scanf_s("%lf%*[^\n] ", &beta);
#else
  scanf("%lf%*[^\n] ", &beta);
#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

  pda = n;

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

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

  /* 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
  for (i = 0; i < ylen; ++i)
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[^\n] ", &y[i].re, &y[i].im);
#else
    scanf(" ( %lf , %lf )%*[^\n] ", &y[i].re, &y[i].im);
#endif

  /* nag_zher2 (f16src).
   * Rank two update of complex Hermitian matrix.
   *
   */
  nag_zher2(order, uplo, n, alpha, x, incx, y, incy, beta, a, pda,
            &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_zher2 (f16src).\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, "%5.1f",
                                "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);
```

```
  NAG_FREE(y);

  return exit_status;
}
```

10.2 Program Data

```
nag_zher2 (f16src) Example Program Data
  4                             :Value of n
  Nag_Lower                     :Storage of A
 (-1.0, 0.0)                    :Value of alpha
  1.0                           :Value of beta
  1  2                          :Values of incx and incy
 ( 23.0,  0.0)
 ( 10.0, 17.0) ( 1.0, 0.0)
 ( 13.0,-14.2) ( 0.3,-1.2) ( 1.0, 0.0)
 (-19.0, -8.0) (-4.7, 2.1) (-5.9, 0.1) ( 1.0, 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
 ( 5.0, 1.0)
 ( 0.0, 0.0)
 (-2.0, 1.0)
 ( 0.0, 0.0)
 ( 7.0,-1.0)
 ( 0.0, 0.0)
 (-5.0,-2.0)                                       :End of vector y
```

10.3 Program Results

```
nag_zher2 (f16src) Example Program Results

 Updated Matrix A
               1               2               3               4
 1  (   1.0,   0.0)
 2  (   0.0,   0.0)  (   3.0,   0.0)
 3  (   0.0,   0.0)  (  -9.3,  20.0)  (  -3.8,   0.0)
 4  (   0.0,   0.0)  (  11.3, -13.9)  (  -1.9,  20.5)  ( -17.0,   0.0)
```