

NAG Library Function Document

nag_zsyr2k (f16zwc)

1 Purpose

nag_zsyr2k (f16zwc) performs a rank- $2k$ update on a complex symmetric matrix.

2 Specification

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

void nag_zsyr2k (Nag_OrderType order, Nag_UploType uplo,
                 Nag_TransType trans, Integer n, Integer k, Complex alpha,
                 const Complex a[], Integer pda, const Complex b[], Integer pdb,
                 Complex beta, Complex c[], Integer pdc, NagError *fail)
```

3 Description

nag_zsyr2k (f16zwc) performs one of the symmetric rank- $2k$ update operations

$$C \leftarrow \alpha AB^T + \alpha BA^T + \beta C \quad \text{or} \quad C \leftarrow \alpha A^T B + \alpha B^T A + \beta C,$$

where A and B are complex matrices, C is an n by n complex symmetric matrix, 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 C is stored.
uplo = Nag_Upper
The upper triangular part of C is stored.
uplo = Nag_Lower
The lower triangular part of C is stored.
Constraint: **uplo** = Nag_Upper or Nag_Lower.

- 3: **trans** – Nag_TransType *Input*
On entry: specifies the operation to be performed.
trans = Nag_NoTrans

$$C \leftarrow \alpha AB^T + \alpha BA^T + \beta C.$$
trans = Nag_Trans

$$C \leftarrow \alpha A^T B + \alpha B^T A + \beta C.$$
Constraint: **trans** = Nag_NoTrans or Nag_Trans.
- 4: **n** – Integer *Input*
On entry: n , the order of the matrix C ; the number of rows of A and B if **trans** = Nag_NoTrans, or the number of columns of A and B otherwise.
Constraint: **n** ≥ 0 .
- 5: **k** – Integer *Input*
On entry: k , the number of columns of A and B if **trans** = Nag_NoTrans, or the number of rows of A and B otherwise.
Constraint: **k** ≥ 0 .
- 6: **alpha** – Complex *Input*
On entry: the scalar α .
- 7: **a**[*dim*] – const Complex *Input*
Note: the dimension, *dim*, of the array **a** must be at least
 $\max(1, \mathbf{pda} \times \mathbf{k})$ when **trans** = Nag_NoTrans and **order** = Nag_ColMajor;
 $\max(1, \mathbf{n} \times \mathbf{pda})$ when **trans** = Nag_NoTrans and **order** = Nag_RowMajor;
 $\max(1, \mathbf{pda} \times \mathbf{n})$ when **trans** = Nag_Trans and **order** = Nag_ColMajor;
 $\max(1, \mathbf{k} \times \mathbf{pda})$ when **trans** = Nag_Trans and **order** = Nag_RowMajor.
If **order** = Nag_ColMajor, A_{ij} is stored in **a**[($j - 1$) \times **pda** + $i - 1$].
If **order** = Nag_RowMajor, A_{ij} is stored in **a**[($i - 1$) \times **pda** + $j - 1$].
On entry: the matrix A ; A is n by k if **trans** = Nag_NoTrans, or k by n otherwise.
- 8: **pda** – Integer *Input*
On entry: the stride separating row or column elements (depending on the value of **order**) in the array **a**.
Constraints:
if **order** = Nag_ColMajor,
 if **trans** = Nag_NoTrans, **pda** $\geq \max(1, \mathbf{n})$;
 if **trans** = Nag_Trans, **pda** $\geq \max(1, \mathbf{k})$.;
if **order** = Nag_RowMajor,
 if **trans** = Nag_NoTrans, **pda** $\geq \max(1, \mathbf{k})$;
 if **trans** = Nag_Trans, **pda** $\geq \max(1, \mathbf{n})$.
- 9: **b**[*dim*] – const Complex *Input*
Note: the dimension, *dim*, of the array **b** must be at least
 $\max(1, \mathbf{pda} \times \mathbf{k})$ when **trans** = Nag_NoTrans and **order** = Nag_ColMajor;
 $\max(1, \mathbf{n} \times \mathbf{pda})$ when **trans** = Nag_NoTrans and **order** = Nag_RowMajor;
 $\max(1, \mathbf{pda} \times \mathbf{n})$ when **trans** = Nag_Trans and **order** = Nag_ColMajor;

$\max(1, \mathbf{k} \times \mathbf{pdb})$ when **trans** = Nag_Trans and **order** = Nag_RowMajor.

If **order** = Nag_ColMajor, B_{ij} is stored in $\mathbf{b}[(j-1) \times \mathbf{pdb} + i - 1]$.

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

On entry: the matrix B ; B is n by k if **trans** = Nag_NoTrans, or k by n otherwise.

10: **pdb** – Integer

Input

On entry: the stride separating row or column elements (depending on the value of **order**) in the array **b**.

Constraints:

if **order** = Nag_ColMajor,

if **trans** = Nag_NoTrans, $\mathbf{pdb} \geq \max(1, \mathbf{n})$;

if **trans** = Nag_Trans, $\mathbf{pdb} \geq \max(1, \mathbf{k})$;

if **order** = Nag_RowMajor,

if **trans** = Nag_NoTrans, $\mathbf{pdb} \geq \max(1, \mathbf{k})$;

if **trans** = Nag_Trans, $\mathbf{pdb} \geq \max(1, \mathbf{n})$.

11: **beta** – Complex

Input

On entry: the scalar β .

12: **c**[*dim*] – Complex

Input/Output

Note: the dimension, *dim*, of the array **c** must be at least $\max(1, \mathbf{pdc} \times \mathbf{n})$.

On entry: the n by n symmetric matrix C .

If **order** = Nag_ColMajor, C_{ij} is stored in $\mathbf{c}[(j-1) \times \mathbf{pdc} + i - 1]$.

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

If **uplo** = Nag_Upper, the upper triangular part of C must be stored and the elements of the array below the diagonal are not referenced.

If **uplo** = Nag_Lower, the lower triangular part of C must be stored and the elements of the array above the diagonal are not referenced.

On exit: the updated matrix C .

13: **pdc** – Integer

Input

On entry: the stride separating row or column elements (depending on the value of **order**) of the matrix C in the array **c**.

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

14: **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_ENUM_INT_2

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

Constraint: if **trans** = Nag_NoTrans, **pda** $\geq \max(1, \mathbf{k})$.

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

Constraint: if **trans** = Nag_Trans, **pda** $\geq \max(1, \mathbf{k})$.

On entry, **trans** = $\langle value \rangle$, **k** = $\langle value \rangle$, **pdb** = $\langle value \rangle$.

Constraint: if **trans** = Nag_NoTrans, **pdb** $\geq \max(1, \mathbf{k})$.

On entry, **trans** = $\langle value \rangle$, **k** = $\langle value \rangle$, **pdb** = $\langle value \rangle$.

Constraint: if **trans** = Nag_Trans, **pdb** $\geq \max(1, \mathbf{k})$.

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

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

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

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

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

Constraint: if **trans** = Nag_NoTrans, **pdb** $\geq \max(1, \mathbf{n})$.

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

Constraint: if **trans** = Nag_Trans, **pdb** $\geq \max(1, \mathbf{n})$.

NE_INT

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

Constraint: **k** ≥ 0 .

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

Constraint: **n** ≥ 0 .

NE_INT_2

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

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

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

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_zsyr2k (f16zwc) is threaded by NAG for parallel execution in multithreaded implementations of the NAG Library.

nag_zsyr2k (f16zwc) makes calls to BLAS and/or LAPACK routines, which may be threaded within the vendor library used by this implementation. Consult the documentation for the vendor library for further information.

Please consult the x06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users' Note for your implementation for any additional implementation-specific information.

9 Further Comments

None.

10 Example

Perform rank- $2k$ update of complex symmetric 4 by 4 matrix C using 4 by 2 matrices A and B , $C = C + (-0.5 + 0.5i)AB^T + (-0.5 - 0.5i)BA^T$, where

$$C = \begin{pmatrix} 4.78 + 0.00i & 2.00 - 0.30i & 2.89 - 1.34i & -1.89 + 1.15i \\ 2.00 - 0.30i & -4.11 + 0.00i & 2.36 - 4.25i & 0.04 - 3.69i \\ 2.89 - 1.34i & 2.36 - 4.25i & 4.15 + 0.00i & -0.02 + 0.46i \\ -1.89 + 1.15i & 0.04 - 3.69i & -0.02 + 0.46i & 0.33 + 0.00i \end{pmatrix},$$

$$A = \begin{pmatrix} 1.7 - 2.3i & -1.8 + 2.4i \\ 2.9 - 2.1i & 1.2 + 1.4i \\ -2.9 + 1.0i & 0.6 + 0.8i \\ 1.5 + 0.9i & -1.4 - 1.7i \end{pmatrix}$$

and

$$B = \begin{pmatrix} -0.3 - 1.9i & 2.1 - 1.1i \\ -2.4 + 1.4i & 0.6 - 2.9i \\ -0.2 - 2.9i & -1.5 + 0.1i \\ 3.5 + 0.8i & 2.2 + 3.7i \end{pmatrix}.$$

10.1 Program Text

```
/* nag_zsyr2k (f16zwc) 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 */
    Complex alpha, beta;
    Integer adim1, adim2, exit_status, i, j, k, n, pda, pdb, pdc;

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

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

```

    Nag_TransType trans;
    Nag_MatrixType matrix;

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

    exit_status = 0;
    INIT_FAIL(fail);

    printf("nag_zsyr2k (f16zwc) Example Program Results\n\n");

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

    /* Read the problem dimensions */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%" NAG_IFMT "%*[\n] ", &n, &k);
#else
    scanf("%" NAG_IFMT "%" NAG_IFMT "%*[\n] ", &n, &k);
#endif

    /* Read the uplo 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 the transpose 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), see above. */
    trans = (Nag_TransType) 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 , %lf )%*[\n] ", &beta.re, &beta.im);
#else
    scanf(" ( %lf , %lf )%*[\n] ", &beta.re, &beta.im);
#endif

    if (trans == Nag_NoTrans) {
        adim1 = n;
        adim2 = k;
    }
    else {
        adim1 = k;
        adim2 = n;
    }

```

```

    }

#ifdef NAG_COLUMN_MAJOR
    pda = adim1;
#else
    pda = adim2;
#endif
    pdb = pda;
    pdc = n;
    if (k > 0 && n > 0) {
        /* Allocate memory */
        if (!(a = NAG_ALLOC(k * n, Complex)) ||
            !(b = NAG_ALLOC(k * n, Complex)) || !(c = NAG_ALLOC(n * n, Complex)))
        {
            printf("Allocation failure\n");
            exit_status = -1;
            goto END;
        }
    }
    else {
        printf("Invalid k or n\n");
        exit_status = 1;
        return exit_status;
    }

    /* Input matrix A. */
    for (i = 1; i <= adim1; ++i) {
        for (j = 1; j <= adim2; ++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
    }
    /* Input matrix A. */
    for (i = 1; i <= adim1; ++i) {
        for (j = 1; j <= adim2; ++j)
#ifdef _WIN32
            scanf_s(" ( %lf , %lf )", &B(i, j).re, &B(i, j).im);
#else
            scanf(" ( %lf , %lf )", &B(i, j).re, &B(i, j).im);
#endif
#ifdef _WIN32
            scanf_s("%*[\n] ");
#else
            scanf("%*[\n] ");
#endif
    }
    /* Input matrix C. */
    if (uplo == Nag_Upper) {
        for (i = 1; i <= n; ++i) {
            for (j = i; j <= n; ++j)
#ifdef _WIN32
                scanf_s(" ( %lf , %lf )", &C(i, j).re, &C(i, j).im);
#else
                scanf(" ( %lf , %lf )", &C(i, j).re, &C(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 )", &C(i, j).re, &C(i, j).im);
#else
            scanf(" ( %lf , %lf )", &C(i, j).re, &C(i, j).im);
#endif
        }
#ifdef _WIN32
        scanf_s("%*[^\\n] ");
#else
        scanf("%*[^\\n] ");
#endif
    }

    /* nag_zsyr2k (f16zwc).
     * Rank 2k update of complex symmetric matrix.
     */
    nag_zsyr2k(order, uplo, trans, n, k, alpha, a, pda, b, pdb, beta,
               c, pdc, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_zsyr2k.\\n%s\\n", fail.message);
        exit_status = 1;
        goto END;
    }
    if (uplo == Nag_Upper) {
        matrix = Nag_UpperMatrix;
    }
    else {
        matrix = Nag_LowerMatrix;
    }
    /* Print updated matrix C */
    /* 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, c,
                                   pdc, Nag_BracketForm, "%7.3f",
                                   "Updated Matrix C", 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(b);
    NAG_FREE(c);

    return exit_status;
}

```

10.2 Program Data

```

nag_zsyr2k (f16zwc) Example Program Data
  4  2                               :Values of n and k
  Nag_Lower                          :Value of uplo
  Nag_NoTrans                        :Value of trans
  ( -0.5, 0.5)                       :Value of alpha
  (  1.0, 0.0)                       :Value of beta
  (  1.7, -2.3) ( -1.8,  2.4)
  (  2.9, -2.1) (  1.2,  1.4)
  ( -2.9,  1.0) (  0.6,  0.8)
  (  1.5,  0.9) ( -1.4, -1.7)
  ( -0.3, -1.9) (  2.1, -1.1)
  ( -2.4,  1.4) (  0.6, -2.9)
  ( -0.2, -2.9) ( -1.5,  0.1)
                                           :End of matrix A

```



```
( 3.5, 0.8) ( 2.2, 3.7) :End of matrix B
( 4.78, 0.00)
( 2.00,-0.30) (-4.11, 0.00)
( 2.89,-1.34) ( 2.36,-4.25) ( 4.15, 0.00)
(-1.89, 1.15) ( 0.04,-3.69) (-0.02, 0.46) ( 0.33, 0.00) :End of matrix C
```

10.3 Program Results

nag_zsyr2k (f16zwc) Example Program Results

```
Updated Matrix C
1 2 3 4
1 ( 6.320,-10.500)
2 ( -5.760, -3.840) (-11.330, -5.700)
3 ( 3.720, -0.150) ( 11.390, 4.410) ( -5.420, -4.570)
4 ( 9.020, 3.460) ( -2.025, -7.095) ( 2.465, -5.065) ( -2.840, 12.310)
```
