

NAG Library Function Document

nag_ztrsv (f16sjc)

1 Purpose

nag_ztrsv (f16sjc) solves a system of equations given as a complex triangular matrix.

2 Specification

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

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

3 Description

nag_ztrsv (f16sjc) performs one of the matrix-vector operations

$$x \leftarrow \alpha A^{-1}x, \quad x \leftarrow \alpha A^{-T}x \quad \text{or} \quad x \leftarrow A^{-H}x,$$

where A is an n by n complex triangular matrix, x is an n -element complex vector and α is a complex scalar. A^{-T} denotes A^{-T} or equivalently A^{-T} ; A^{-H} denotes $(A^H)^{-1}$ or equivalently $(A^{-1})^H$.

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
 $x \leftarrow A^{-1}x$.
trans = Nag_Trans
 $x \leftarrow A^{-T}x$.
trans = Nag_ConjTrans
 $x \leftarrow A^{-H}x$.
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: **a**[dim] – const Complex *Input*
Note: the dimension, dim , of the array **a** must be at least $\max(1, pda \times n)$.
On entry: the n by n triangular matrix A .
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** + $j - 1$].
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.
If **diag** = Nag_UnitDiag, the diagonal elements of A are assumed to be 1, and are not referenced.
- 8: **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** $\geq \max(1, n)$.
- 9: **x**[dim] – Complex *Input/Output*
Note: the dimension, dim , of the array **x** must be at least $\max(1, 1 + (n - 1)|incx|)$.
On entry: the vector x .
On exit: the solution vector x .

- 10: **incx** – Integer *Input*
On entry: the increment in the subscripts of **x** between successive elements of *x*.
Constraint: **incx** $\neq 0$.
- 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, **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_ztrsv (f16sjc) is not threaded in any implementation.

9 Further Comments

No test for singularity or near-singularity of *A* is included in nag_ztrsv (f16sjc). Such tests must be performed before calling this function.

10 Example

Solves complex triangular system of linear equations, $Ax = y$, where A is a complex triangular 4 by 4 matrix given by

$$A = \begin{pmatrix} 4.78 + 4.56i & & & \\ 2.00 - 0.30i & -4.11 + 1.25i & & \\ 2.89 - 1.34i & 2.36 - 4.25i & 4.15 + 0.80i & \\ -1.89 + 1.15i & 0.04 - 3.69i & -0.02 + 0.46i & 0.33 - 0.26i \end{pmatrix},$$

and

$$y = \begin{pmatrix} -14.78 - 32.36i \\ 2.98 - 2.14i \\ -20.96 + 17.06i \\ 9.54 + 9.91i \end{pmatrix}.$$

10.1 Program Text

```
/* nag_ztrsv (f16sjc) 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 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_TransType trans;
    Nag_UploType uplo;
    Nag_DiagType diag;

#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_ztrsv (f16sjc) Example Program Results\n\n");

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

```

#endif

/* Read the problem dimensions */
#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 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 the unit-diagonal 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. */
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 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) {

```

```

        if (diag == Nag_NonUnitDiag)
#ifdef _WIN32
            scanf_s(" ( %lf , %lf )", &A(i, i).re, &A(i, i).im);
#else
            scanf(" ( %lf , %lf )", &A(i, i).re, &A(i, i).im);
#endif
        for (j = i + 1; 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
            if (diag == Nag_NonUnitDiag)
#ifdef _WIN32
                scanf_s(" ( %lf , %lf )", &A(i, i).re, &A(i, i).im);
#else
                scanf(" ( %lf , %lf )", &A(i, i).re, &A(i, i).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_ztrsv (f16sjc).
     * Solution of complex triangular system of linear equations.
     */
    nag_ztrsv(order, uplo, trans, diag, n, alpha, a, pda, x, incx, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_ztrsv (f16sjc).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    /* Print output vector x */
    printf("%s\n", " Solution x:");
    for (i = 0; i < xlen; ++i) {
        printf("( %11f , %11f )\n", x[i].re, x[i].im);
    }

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

    return exit_status;
}

```

10.2 Program Data

```
nag_ztrsv (f16sjc) Example Program Data
  4                               :Value of n
  Nag_Lower                      :Storage of A
  Nag_NoTrans                    :Transpose A?
  Nag_NonUnitDiag               :Unit diagonal elements?
  ( 1.0, 0.0)                   :Value of alpha
  1                               :Value of incx
  ( 4.78, 4.56)
  ( 2.00,-0.30) (-4.11, 1.25)
  ( 2.89,-1.34) ( 2.36,-4.25) ( 4.15, 0.80)
  (-1.89, 1.15) ( 0.04,-3.69) (-0.02, 0.46) ( 0.33,-0.26) :End of matrix A
  (-14.78,-32.36)
  ( 2.98, -2.14)
  (-20.96, 17.06)
  ( 9.54, 9.91)                               :End of vector x
```

10.3 Program Results

nag_ztrsv (f16sjc) Example Program Results

```
Solution x:
( -5.000000 , -2.000000 )
( -3.000000 , -1.000000 )
( 2.000000 , 1.000000 )
( 4.000000 , 3.000000 )
```
