

# NAG Library Function Document

## nag\_ztrtri (f07twc)

### 1 Purpose

nag\_ztrtri (f07twc) computes the inverse of a complex triangular matrix.

### 2 Specification

```
#include <nag.h>
#include <nagf07.h>

void nag_ztrtri (Nag_OrderType order, Nag_UploType uplo, Nag_DiagType diag,
                Integer n, Complex a[], Integer pda, NagError *fail)
```

### 3 Description

nag\_ztrtri (f07twc) forms the inverse of a complex triangular matrix  $A$ . Note that the inverse of an upper (lower) triangular matrix is also upper (lower) triangular.

### 4 References

Du Croz J J and Higham N J (1992) Stability of methods for matrix inversion *IMA J. Numer. Anal.* **12** 1–19

### 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: **diag** – Nag\_DiagType *Input*
- On entry:* indicates whether  $A$  is a nonunit or unit triangular matrix.
- diag** = Nag\_NonUnitDiag  
 $A$  is a nonunit triangular matrix.
- diag** = Nag\_UnitDiag  
 $A$  is a unit triangular matrix; the diagonal elements are not referenced and are assumed to be 1.
- Constraint:* **diag** = Nag\_NonUnitDiag or Nag\_UnitDiag.

- 4: **n** – Integer *Input*  
*On entry:*  $n$ , the order of the matrix  $A$ .  
*Constraint:*  $\mathbf{n} \geq 0$ .
- 5: **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  $n$  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.  
*On exit:*  $A$  is overwritten by  $A^{-1}$ , using the same storage format as described above.
- 6: **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:*  $\mathbf{pda} \geq \max(1, \mathbf{n})$ .
- 7: **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, **n** = *<value>*.

Constraint:  $\mathbf{n} \geq 0$ .

On entry, **pda** = *<value>*.

Constraint:  $\mathbf{pda} > 0$ .

### NE\_INT\_2

On entry, **pda** = *<value>* and **n** = *<value>*.

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

### 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.

### NE\_SINGULAR

Element  $\langle value \rangle$  of the diagonal is exactly zero.  $A$  is singular its inverse cannot be computed.

## 7 Accuracy

The computed inverse  $X$  satisfies

$$|XA - I| \leq c(n)\epsilon|X||A|,$$

where  $c(n)$  is a modest linear function of  $n$ , and  $\epsilon$  is the *machine precision*.

Note that a similar bound for  $|AX - I|$  cannot be guaranteed, although it is almost always satisfied.

The computed inverse satisfies the forward error bound

$$|X - A^{-1}| \leq c(n)\epsilon|A^{-1}||A||X|.$$

See Du Croz and Higham (1992).

## 8 Parallelism and Performance

nag\_ztrtri (f07twc) 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

The total number of real floating-point operations is approximately  $\frac{4}{3}n^3$ .

The real analogue of this function is nag\_dtrtri (f07tjc).

## 10 Example

This example computes the inverse of the matrix  $A$ , where

$$A = \begin{pmatrix} 4.78 + 4.56i & 0.00 + 0.00i & 0.00 + 0.00i & 0.00 + 0.00i \\ 2.00 - 0.30i & -4.11 + 1.25i & 0.00 + 0.00i & 0.00 + 0.00i \\ 2.89 - 1.34i & 2.36 - 4.25i & 4.15 + 0.80i & 0.00 + 0.00i \\ -1.89 + 1.15i & 0.04 - 3.69i & -0.02 + 0.46i & 0.33 - 0.26i \end{pmatrix}.$$

### 10.1 Program Text

```
/* nag_ztrtri (f07twc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */
```

```

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf07.h>
#include <nagx04.h>

int main(void)
{
    /* Scalars */
    Integer i, j, n, pda;
    Integer exit_status = 0;
    Nag_UploType uplo;
    Nag_MatrixType matrix;
    NagError fail;
    Nag_OrderType order;
    /* Arrays */
    char nag_enum_arg[40];
    Complex *a = 0;

#ifdef NAG_LOAD_FP
    /* The following line is needed to force the Microsoft linker
       to load floating point support */
    float force_loading_of_ms_float_support = 0;
#endif /* NAG_LOAD_FP */

#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

    INIT_FAIL(fail);

    printf("nag_ztrtri (f07twc) Example Program Results\n\n");

    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else
    scanf("%*[\n] ");
#endif
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%*[\n] ", &n);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &n);
#endif
#ifdef NAG_COLUMN_MAJOR
    pda = n;
#else
    pda = n;
#endif

    /* Allocate memory */
    if (!(a = NAG_ALLOC(n * n, Complex)))
    {
        printf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }

    /* Read A from data file */
#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);

    if (uplo == Nag_Upper) {
        matrix = Nag_UpperMatrix;
        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 {
        matrix = Nag_LowerMatrix;
        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
    }

    /* Compute inverse of A */
    /* nag_ztrtri (f07twc).
     * Inverse of complex triangular matrix
     */
    nag_ztrtri(order, uplo, Nag_NonUnitDiag, n, a, pda, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_ztrtri (f07twc).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    /* Print inverse */
    /* 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", "Inverse",
                                   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);

    return exit_status;
}

```

## 10.2 Program Data

```
nag_ztrtri (f07twc) Example Program Data
  4                                     :Value of n
  Nag_Lower                           :Value of uplo
  ( 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
```

## 10.3 Program Results

```
nag_ztrtri (f07twc) Example Program Results

Inverse
      1          2          3          4
1 ( 0.1095,-0.1045)
2 ( 0.0582,-0.0411) (-0.2227,-0.0677)
3 ( 0.0032, 0.1905) ( 0.1538,-0.2192) ( 0.2323,-0.0448)
4 ( 0.7602, 0.2814) ( 1.6184,-1.4346) ( 0.1289,-0.2250) ( 1.8697, 1.4731)
```

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