

# NAG Library Function Document

## nag\_zgetri (f07awc)

### 1 Purpose

nag\_zgetri (f07awc) computes the inverse of a complex matrix  $A$ , where  $A$  has been factorized by nag\_zgetrf (f07arc).

### 2 Specification

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

```
void nag_zgetri (Nag_OrderType order, Integer n, Complex a[], Integer pda,
                 const Integer ipiv[], NagError *fail)
```

### 3 Description

nag\_zgetri (f07awc) is used to compute the inverse of a complex matrix  $A$ , the function must be preceded by a call to nag\_zgetrf (f07arc), which computes the  $LU$  factorization of  $A$  as  $A = PLU$ . The inverse of  $A$  is computed by forming  $U^{-1}$  and then solving the equation  $XPL = U^{-1}$  for  $X$ .

### 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: **n** – Integer *Input*  
*On entry:*  $n$ , the order of the matrix  $A$ .  
*Constraint:*  $n \geq 0$ .
- 3: **a**[ $dim$ ] – Complex *Input/Output*  
**Note:** the dimension,  $dim$ , of the array **a** must be at least  $\max(1, pda \times n)$ .  
The  $(i, j)$ th element of the matrix  $A$  is stored in  

$$\begin{aligned} &\mathbf{a}[(j-1) \times pda + i - 1] \text{ when } \mathbf{order} = \text{Nag\_ColMajor}; \\ &\mathbf{a}[(i-1) \times pda + j - 1] \text{ when } \mathbf{order} = \text{Nag\_RowMajor}. \end{aligned}$$
*On entry:* the  $LU$  factorization of  $A$ , as returned by nag\_zgetrf (f07arc).  
*On exit:* the factorization is overwritten by the  $n$  by  $n$  matrix  $A^{-1}$ .

- 4: **pda** – Integer *Input*  
*On entry:* the stride separating row or column elements (depending on the value of **order**) in the array **a**.  
*Constraint:* **pda**  $\geq \max(1, \mathbf{n})$ .
- 5: **ipiv**[*dim*] – const Integer *Input*  
**Note:** the dimension, *dim*, of the array **ipiv** must be at least  $\max(1, \mathbf{n})$ .  
*On entry:* the pivot indices, as returned by nag\_zgetrf (f07arc).
- 6: **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, **n** =  $\langle value \rangle$ .

Constraint: **n**  $\geq 0$ .

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

Constraint: **pda**  $> 0$ .

### NE\_INT\_2

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

Constraint: **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 zero. *U* is singular, and the inverse of *A* cannot be computed.

## 7 Accuracy

The computed inverse  $X$  satisfies a bound of the form:

$$|XA - I| \leq c(n)\epsilon|X|P|L||U|,$$

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. See Du Croz and Higham (1992).

## 8 Parallelism and Performance

nag\_zgetri (f07awc) 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  $\frac{16}{3}n^3$ .

The real analogue of this function is nag\_dgetri (f07ajc).

## 10 Example

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

$$A = \begin{pmatrix} -1.34 + 2.55i & 0.28 + 3.17i & -6.39 - 2.20i & 0.72 - 0.92i \\ -0.17 - 1.41i & 3.31 - 0.15i & -0.15 + 1.34i & 1.29 + 1.38i \\ -3.29 - 2.39i & -1.91 + 4.42i & -0.14 - 1.35i & 1.72 + 1.35i \\ 2.41 + 0.39i & -0.56 + 1.47i & -0.83 - 0.69i & -1.96 + 0.67i \end{pmatrix}.$$

Here  $A$  is nonsymmetric and must first be factorized by nag\_zgetrf (f07arc).

### 10.1 Program Text

```
/* nag_zgetri (f07awc) 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, ipiv_len, j, n, pda;
    Integer exit_status = 0;
    NagError fail;
    Nag_OrderType order;
    /* Arrays */
    Complex *a = 0;
    Integer *ipiv = 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_zgetri (f07awc) 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
    ipiv_len = n;

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

    /* Read A from data file */
    for (i = 1; i <= n; ++i) {
        for (j = 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

    /* Factorize A */
    /* nag_zgetrf (f07arc).
     * LU factorization of complex m by n matrix
     */
    nag_zgetrf(order, n, n, a, pda, ipiv, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_zgetrf (f07arc).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    /* Compute inverse of A */

```

```

/* nag_zgetri (f07awc).
 * Inverse of complex matrix, matrix already factorized by
 * nag_zgetrf (f07arc)
 */
nag_zgetri(order, n, a, pda, ipiv, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_zgetri (f07awc).\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, Nag_GeneralMatrix, 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);
    NAG_FREE(ipiv);
    return exit_status;
}

```

## 10.2 Program Data

```

nag_zgetri (f07awc) Example Program Data
4
(-1.34, 2.55) ( 0.28, 3.17) (-6.39,-2.20) ( 0.72,-0.92) :Value of N
(-0.17,-1.41) ( 3.31,-0.15) (-0.15, 1.34) ( 1.29, 1.38)
(-3.29,-2.39) (-1.91, 4.42) (-0.14,-1.35) ( 1.72, 1.35)
( 2.41, 0.39) (-0.56, 1.47) (-0.83,-0.69) (-1.96, 0.67) :End of matrix A

```

## 10.3 Program Results

nag\_zgetri (f07awc) Example Program Results

Inverse	1	2	3	4
1	( 0.0757,-0.4324)	( 1.6512,-3.1342)	( 1.2663, 0.0418)	( 3.8181, 1.1195)
2	(-0.1942, 0.0798)	(-1.1900,-0.1426)	(-0.2401,-0.5889)	(-0.0101,-1.4969)
3	(-0.0957,-0.0491)	( 0.7371,-0.4290)	( 0.3224, 0.0776)	( 0.6887, 0.7891)
4	( 0.3702,-0.5040)	( 3.7253,-3.1813)	( 1.7014, 0.7267)	( 3.9367, 3.3255)

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