

# NAG Library Routine Document

## F07AWF (ZGETRI)

**Note:** before using this routine, please read the Users' Note for your implementation to check the interpretation of *bold italicised* terms and other implementation-dependent details.

### 1 Purpose

F07AWF (ZGETRI) computes the inverse of a complex matrix  $A$ , where  $A$  has been factorized by F07ARF (ZGETRF).

### 2 Specification

```
SUBROUTINE F07AWF(N, A, LDA, IPIV, WORK, LWORK, INFO)
INTEGER          N, LDA, IPIV(*), LWORK, INFO
complex*16     A(LDA,*), WORK(max(1,LWORK))
```

The routine may be called by its LAPACK name *zgetri*.

### 3 Description

F07AWF (ZGETRI) is used to compute the inverse of a complex matrix  $A$ , the routine must be preceded by a call to F07ARF (ZGETRF), 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 Parameters

- 1: N – INTEGER *Input*  
*On entry:*  $n$ , the order of the matrix  $A$ .  
*Constraint:*  $N \geq 0$ .
- 2: A(LDA,\*) – **complex\*16** array *Input/Output*  
**Note:** the second dimension of the array  $A$  must be at least  $\max(1, N)$ .  
*On entry:* the  $LU$  factorization of  $A$ , as returned by F07ARF (ZGETRF).  
*On exit:* the factorization is overwritten by the  $n$  by  $n$  matrix  $A^{-1}$ .
- 3: LDA – INTEGER *Input*  
*On entry:* the first dimension of the array  $A$  as declared in the (sub)program from which F07AWF (ZGETRI) is called.  
*Constraint:*  $LDA \geq \max(1, N)$ .
- 4: IPIV(\*) – INTEGER array *Input*  
**Note:** the dimension of the array IPIV must be at least  $\max(1, N)$ .  
*On entry:* the pivot indices, as returned by F07ARF (ZGETRF).

- 5: WORK(max(1,LWORK)) – **complex\*16** array *Workspace*  
*On exit:* if INFO = 0, WORK(1) contains the minimum value of LWORK required for optimum performance.
- 6: LWORK – INTEGER *Input*  
*On entry:* the dimension of the array WORK as declared in the (sub)program from which F07AWF (ZGETRI) is called, unless LWORK = -1, in which case a workspace query is assumed and the routine only calculates the optimal dimension of WORK (using the formula given below).  
*Suggested value:* for optimum performance LWORK should be at least  $N \times nb$ , where  $nb$  is the **blocksize**.  
*Constraint:* LWORK  $\geq \max(1, N)$  or LWORK = -1.
- 7: INFO – INTEGER *Output*  
*On exit:* INFO = 0 unless the routine detects an error (see Section 6).

## 6 Error Indicators and Warnings

Errors or warnings detected by the routine:

INFO < 0

If INFO = - $i$ , the  $i$ th parameter had an illegal value. An explanatory message is output, and execution of the program is terminated.

INFO > 0

If INFO =  $i$ , the  $i$ th diagonal element of the factor  $U$  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 Further Comments

The total number of real floating-point operations is approximately  $\frac{16}{3}n^3$ .

The real analogue of this routine is F07AJF (DGETRI).

## 9 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 F07ARF (ZGETRF).

## 9.1 Program Text

```

*      F07AWF Example Program Text
*      Mark 15 Release. NAG Copyright 1991.
*      .. Parameters ..
INTEGER          NIN, NOUT
PARAMETER       (NIN=5,NOUT=6)
INTEGER          NMAX, LDA, LWORK
PARAMETER       (NMAX=8,LDA=NMAX,LWORK=64*NMAX)
*      .. Local Scalars ..
INTEGER          I, IFAIL, INFO, J, N
*      .. Local Arrays ..
COMPLEX *16     A(LDA,NMAX), WORK(LWORK)
INTEGER          IPIV(NMAX)
CHARACTER       CLABS(1), RLABS(1)
*      .. External Subroutines ..
EXTERNAL        X04DBF, ZGETRF, ZGETRI
*      .. Executable Statements ..
WRITE (NOUT,*) 'F07AWF Example Program Results'
*      Skip heading in data file
READ (NIN,*)
READ (NIN,*) N
IF (N.LE.NMAX) THEN
*
*      Read A from data file
*
      READ (NIN,*) ((A(I,J),J=1,N),I=1,N)
*
*      Factorize A
*
      CALL ZGETRF(N,N,A,LDA,IPIV,INFO)
*
      WRITE (NOUT,*)
      IF (INFO.EQ.0) THEN
*
*      Compute inverse of A
*
      CALL ZGETRI(N,A,LDA,IPIV,WORK,LWORK,INFO)
*
*      Print inverse
*
      IFAIL = 0
      CALL X04DBF('General',' ',N,N,A,LDA,'Bracketed','F7.4',
+              'Inverse','Integer',RLABS,'Integer',CLABS,80,0,
+              IFAIL)
      ELSE
      WRITE (NOUT,*) 'The factor U is singular'
      END IF
    END IF
*
    END

```

## 9.2 Program Data

```

F07AWF Example Program Data
4                                     :Value of N
(-1.34, 2.55) ( 0.28, 3.17) (-6.39,-2.20) ( 0.72,-0.92)
(-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

```

### 9.3 Program Results

F07AWF 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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