NAG Library Routine Document

F07WXF (ZTFTRI)

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

F07WXF (ZTFTRI) computes the inverse of a complex triangular matrix stored in Rectangular Full Packed (RFP) format.

2   Specification

```
SUBROUTINE F07WXF (TRANSR, UPLO, DIAG, N, AR, INFO)

INTEGER              N, INFO
COMPLEX (KIND=nag_wp) AR(N*(N+1)/2)
CHARACTER(1)         TRANSR, UPLO, DIAG
```

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

3   Description

F07WXF (ZTFTRI) forms the inverse of a complex triangular matrix A, stored using RFP format. The RFP storage format is described in Section 3.3.3 in the F07 Chapter Introduction. 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

Gustavson F G, Waśniewski J, Dongarra J J and Langou J (2010) Rectangular full packed format for Cholesky's algorithm: factorization, solution, and inversion *ACM Trans. Math. Software* **37, 2**

5   Parameters

1:    TRANSR – CHARACTER(1)   *Input*

On entry: specifies whether the normal RFP representation of A or its conjugate transpose is stored.

TRANSR = 'N'
    The matrix A is stored in normal RFP format.

TRANSR = 'C'
    The conjugate transpose of the RFP representation of the matrix A is stored.

Constraint: TRANSR = 'N' or 'C'.

2:    UPLO – CHARACTER(1)   *Input*

On entry: specifies whether A is upper or lower triangular.

UPLO = 'U'
    A is upper triangular.

UPLO = 'L'
    A is lower triangular.

Constraint: UPLO = 'U' or 'L'.

3:    DIAG – CHARACTER(1)   *Input*

On entry: indicates whether A is a nonunit or unit triangular matrix.

DIAG = 'N'
       A is a nonunit triangular matrix.

DIAG = 'U'
       A is a unit triangular matrix; the diagonal elements are not referenced and are assumed to
       be 1.

Constraint: DIAG = 'N' or 'U'.

4:    N – INTEGER   *Input*

On entry: n, the order of the matrix A.

Constraint: $N \geq 0$.

5:    AR$(N \times (N + 1)/2)$ – COMPLEX (KIND=nag_wp) array   *Input/Output*

On entry: the upper or lower triangular part (as specified by UPLO) of the n by n Hermitian
matrix A, in either normal or transposed RFP format (as specified by TRANSR). The storage
format is described in detail in Section 3.3.3 in the F07 Chapter Introduction.

On exit: A is overwritten by A^{-1}, in the same storage format as A.

6:    INFO – INTEGER   *Output*

On exit: INFO = 0 unless the routine detects an error (see Section 6).

6   Error Indicators and Warnings

INFO < 0

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

INFO > 0

       Diagonal element $\langle value \rangle$ of A 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 ϵ 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

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

See Du Croz and Higham (1992).

8   Parallelism and Performance

F07WXF (ZTFTRI) is not threaded by NAG in any implementation.

F07WXF (ZTFTRI) 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 routine. 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 routine is F07WKF (DTFTRI).

10 Example

This example computes the inverse of the matrix A, where

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

and is stored using RFP format.

10.1 Program Text

```
      Program f07wxfe

!     F07WXF Example Program Text

!     Mark 25 Release. NAG Copyright 2014.

!     .. Use Statements ..
      Use nag_library, Only: nag_wp, x04dbf, ztftri, ztfttr
!     .. Implicit None Statement ..
      Implicit None
!     .. Parameters ..
      Integer, Parameter                 :: nin = 5, nout = 6
!     .. Local Scalars ..
      Integer                            :: i, ifail, info, k, lar1, lda, lenar, &
                                            n, q
      Character (1)                      :: diag, transr, uplo
!     .. Local Arrays ..
      Complex (Kind=nag_wp), Allocatable :: a(:,:), ar(:)
      Character (1)                      :: clabs(1), rlabs(1)
!     .. Executable Statements ..
      Write (nout,*) 'F07WXF Example Program Results'
!     Skip heading in data file
      Read (nin,*)
      Read (nin,*) n, uplo, transr, diag

      lenar = n*(n+1)/2
      lda = n
      Allocate (ar(1:lenar),a(lda,n))

!     Setup notional dimensions of RFP matrix AR
      k = n/2
      q = n - k
      If (transr=='N' .Or. transr=='n') Then
        lar1 = 2*k + 1
      Else
        lar1 = q
      End If

!     Read an RFP matrix into array AR
      Do i = 1, lar1
        Read (nin,*) ar(i:lenar:lar1)
      End Do

!     Compute inverse of A
```

```
!      The NAG name equivalent of ztftri is f07wxf
       Call ztftri(transr,uplo,diag,n,ar,info)

       Write (nout,*)
       Flush (nout)
       If (info==0) Then

!        Convert and print inverse
!        The NAG name equivalent of ztfttr is f01vhf
         Call ztfttr(transr,uplo,n,ar,a,lda,info)
         ifail = 0

         Call x04dbf(uplo,'Nonunit',n,n,a,lda,'Bracketed','F7.4','Inverse', &
           'Integer',rlabs,'Integer',clabs,80,0,ifail)
       Else
         Write (nout,*) 'A is singular'
       End If

     End Program f07wxfe
```

10.2 Program Data

```
F07WXF Example Program Data
   4      'L'      'N'      'N'   : n, uplo, transr, diag
 ( 4.15,-0.80)  (-0.02,-0.46)
 ( 4.78, 4.56)  ( 0.33, 0.26)
 ( 2.00,-0.30)  (-4.11, 1.25)
 ( 2.89,-1.34)  ( 2.36,-4.25)
 (-1.89, 1.15)  ( 0.04,-3.69) : AR
```

10.3 Program Results

```
 F07WXF 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)
```