NAG Library Routine Document

F07QWF (ZSPTRI)

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

F07QWF (ZSPTRI) computes the inverse of a complex symmetric matrix A, where A has been factorized by F07QRF (ZSPTRF), using packed storage.

2 Specification

```
SUBROUTINE F07QWF (UPLO, N, AP, IPIV, WORK, INFO)

INTEGER                 N, IPIV(*), INFO
COMPLEX (KIND=nag_wp) AP(*), WORK(N)
CHARACTER(1)            UPLO
```

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

3 Description

F07QWF (ZSPTRI) is used to compute the inverse of a complex symmetric matrix A, the routine must be preceded by a call to F07QRF (ZSPTRF), which computes the Bunch–Kaufman factorization of A, using packed storage.

If UPLO = 'U', $A = PUDU^{\mathrm{T}}P^{\mathrm{T}}$ and A^{-1} is computed by solving $U^{\mathrm{T}}P^{\mathrm{T}}XPU = D^{-1}$.

If UPLO = 'L', $A = PLDL^{\mathrm{T}}P^{\mathrm{T}}$ and A^{-1} is computed by solving $L^{\mathrm{T}}P^{\mathrm{T}}XPL = D^{-1}$.

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: UPLO – CHARACTER(1) *Input*

On entry: specifies how A has been factorized.

UPLO = 'U'
$A = PUDU^{\mathrm{T}}P^{\mathrm{T}}$, where U is upper triangular.

UPLO = 'L'
$A = PLDL^{\mathrm{T}}P^{\mathrm{T}}$, where L is lower triangular.

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

2: N – INTEGER *Input*

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

Constraint: N ≥ 0.

3: AP($*$) – COMPLEX (KIND=nag_wp) array *Input/Output*

Note: the dimension of the array AP must be at least $\max(1, \mathrm{N} \times (\mathrm{N}+1)/2)$.

On entry: the factorization of A stored in packed form, as returned by F07QRF (ZSPTRF).

On exit: the factorization is overwritten by the n by n matrix A^{-1}.

More precisely,

if UPLO = 'U', the upper triangle of A^{-1} must be stored with element A_{ij} in $\mathrm{AP}(i+j(j-1)/2)$ for $i \leq j$;

if UPLO = 'L', the lower triangle of A^{-1} must be stored with element A_{ij} in $\mathrm{AP}(i+(2n-j)(j-1)/2)$ for $i \geq j$.

4: IPIV($*$) – INTEGER array *Input*

Note: the dimension of the array IPIV must be at least $\max(1, \mathrm{N})$.

On entry: details of the interchanges and the block structure of D, as returned by F07QRF (ZSPTRF).

5: WORK(N) – COMPLEX (KIND=nag_wp) array *Workspace*

6: 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 ith parameter had an illegal value. An explanatory message is output, and execution of the program is terminated.

INFO > 0

If INFO $= i$, $d(i,i)$ is exactly zero; D is singular and the inverse of A cannot be computed.

7 Accuracy

The computed inverse X satisfies a bound of the form

if UPLO = 'U', $\left|DU^{\mathrm{T}}P^{\mathrm{T}}XPU - I\right| \leq c(n)\epsilon\left(|D|\left|U^{\mathrm{T}}\right|P^{\mathrm{T}}|X|P|U| + |D|\left|D^{-1}\right|\right)$;

if UPLO = 'L', $\left|DL^{\mathrm{T}}P^{\mathrm{T}}XPL - I\right| \leq c(n)\epsilon\left(|D|\left|L^{\mathrm{T}}\right|P^{\mathrm{T}}|X|P|L| + |D|\left|D^{-1}\right|\right)$,

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

8 Further Comments

The total number of real floating point operations is approximately $\frac{8}{3}n^3$.

The real analogue of this routine is F07PJF (DSPTRI).

9 Example

This example computes the inverse of the matrix A, where

$$A = \begin{pmatrix} -0.39 - 0.71i & 5.14 - 0.64i & -7.86 - 2.96i & 3.80 + 0.92i \\ 5.14 - 0.64i & 8.86 + 1.81i & -3.52 + 0.58i & 5.32 - 1.59i \\ -7.86 - 2.96i & -3.52 + 0.58i & -2.83 - 0.03i & -1.54 - 2.86i \\ 3.80 + 0.92i & 5.32 - 1.59i & -1.54 - 2.86i & -0.56 + 0.12i \end{pmatrix}.$$

Here A is symmetric, stored in packed form, and must first be factorized by F07QRF (ZSPTRF).

9.1 Program Text

```
    Program f07qwfe

!     F07QWF Example Program Text

!     Mark 24 Release. NAG Copyright 2012.

!     .. Use Statements ..
      Use nag_library, Only: nag_wp, x04ddf, zsptrf, zsptri
!     .. Implicit None Statement ..
      Implicit None
!     .. Parameters ..
      Integer, Parameter               :: nin = 5, nout = 6
!     .. Local Scalars ..
      Integer                          :: i, ifail, info, j, n
      Character (1)                    :: uplo
!     .. Local Arrays ..
      Complex (Kind=nag_wp), Allocatable :: ap(:), work(:)
      Integer, Allocatable             :: ipiv(:)
      Character (1)                    :: clabs(1), rlabs(1)
!     .. Executable Statements ..
      Write (nout,*) 'F07QWF Example Program Results'
!     Skip heading in data file
      Read (nin,*)
      Read (nin,*) n

      Allocate (ap(n*(n+1)/2),work(n),ipiv(n))

!     Read A from data file

      Read (nin,*) uplo
      If (uplo=='U') Then
        Read (nin,*)((ap(i+j*(j-1)/2),j=i,n),i=1,n)
      Else If (uplo=='L') Then
        Read (nin,*)((ap(i+(2*n-j)*(j-1)/2),j=1,i),i=1,n)
      End If

!     Factorize A
!     The NAG name equivalent of zsptrf is f07qrf
      Call zsptrf(uplo,n,ap,ipiv,info)

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

!       Compute inverse of A
!       The NAG name equivalent of zsptri is f07qwf
        Call zsptri(uplo,n,ap,ipiv,work,info)

!       Print inverse

!       ifail: behaviour on error exit
!              =0 for hard exit, =1 for quiet-soft, =-1 for noisy-soft
        ifail = 0
        Call x04ddf(uplo,'Nonunit',n,ap,'Bracketed','F7.4','Inverse', &
          'Integer',rlabs,'Integer',clabs,80,0,ifail)
```

```
      Else
        Write (nout,*) 'The factor D is singular'
      End If

    End Program f07qwfe
```

9.2 Program Data

```
F07QWF Example Program Data
  4                                                          :Value of N
  'L'                                                        :Value of UPLO
 (-0.39,-0.71)
 ( 5.14,-0.64) ( 8.86, 1.81)
 (-7.86,-2.96) (-3.52, 0.58) (-2.83,-0.03)
 ( 3.80, 0.92) ( 5.32,-1.59) (-1.54,-2.86) (-0.56, 0.12)  :End of matrix A
```

9.3 Program Results

```
 F07QWF Example Program Results

 Inverse
                     1                 2                 3                 4
 1  (-0.1562,-0.1014)
 2  ( 0.0400, 0.1527) ( 0.0946,-0.1475)
 3  ( 0.0550, 0.0845) (-0.0326,-0.1370) (-0.1320,-0.0102)
 4  ( 0.2162,-0.0742) (-0.0995,-0.0461) (-0.1793, 0.1183) (-0.2269, 0.2383)
```