# NAG Toolbox for MATLAB

# f07qw

## 1 Purpose

f07qw computes the inverse of a complex symmetric matrix $A$, where $A$ has been factorized by f07qr, using packed storage.

## 2 Syntax

```
[ap, info] = f07qw(uplo, ap, ipiv, 'n', n)
```

## 3 Description

f07qw is used to compute the inverse of a complex symmetric matrix $A$, the function must be preceded by a call to f07qr, 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

### 5.1 Compulsory Input Parameters

1: **uplo – string**

Indicates 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: **ap**$(*)$ **– complex array**

**Note**: the dimension of the array **ap** must be at least $\max(1, \mathbf{n} \times (\mathbf{n}+1)/2)$.

The factorization of $A$ stored in packed form, as returned by f07qr.

3: **ipiv**$(*)$ **– int32 array**

**Note**: the dimension of the array **ipiv** must be at least $\max(1, \mathbf{n})$.

Details of the interchanges and the block structure of $D$, as returned by f07qr.

### 5.2 Optional Input Parameters

1: **n – int32 scalar**

*Default*: The dimension of the array **ipiv**.

$n$, the order of the matrix $A$.

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

### 5.3 Input Parameters Omitted from the MATLAB Interface

work

### 5.4 Output Parameters

1: **ap**$(*)$ **– complex array**

**Note**: the dimension of the array **ap** must be at least $\max(1, \mathbf{n} \times (\mathbf{n}+1)/2)$.

The factorization contains the $n$ by $n$ matrix $A^{-1}$.

More precisely,

if **uplo** = 'U', the upper triangle of {\it A}$^{-1}$ must be stored with element $A_{ij}$ in **ap**$(i+j(j-1)/2)$ for $i \leq j$;
if **uplo** = 'L', the lower triangle of {\it A}$^{-1}$ must be stored with element $A_{ij}$ in **ap**$(i+(2n-j)(j-1)/2)$ for $i \geq j$.

2: **info – int32 scalar**

**info** $= 0$ unless the function detects an error (see Section 6).

## 6 Error Indicators and Warnings

Errors or warnings detected by the function:

**info** $= -i$

If **info** $= -i$, parameter $i$ had an illegal value on entry. The parameters are numbered as follows:

1: **uplo**, 2: **n**, 3: **ap**, 4: **ipiv**, 5: **work**, 6: **info**.

It is possible that **info** refers to a parameter that is omitted from the MATLAB interface. This usually indicates that an error in one of the other input parameters has caused an incorrect value to be inferred.

**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 $\epsilon$ 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 function is f07pj.

# 9 Example

```
uplo = 'L';
ap = [complex(-0.39, -0.71);
     complex(-7.86, -2.96);
     complex(0.5278724801640799, -0.3714660014825906);
     complex(0.442558238872675, +0.1936483698297402);
     complex(-2.83, -0.03);
     complex(-0.6078391056683192, +0.281079647893122);
     complex(-0.4822822975185383, +0.01498936219105284);
     complex(4.407906236731014, +5.399120676796941);
     complex(-0.1070821880092683, -0.3156780862488454);
     complex(-2.095414887840057, -2.201139281440786)];
ipiv = [int32(-3);
     int32(-3);
     int32(3);
     int32(4)];
[apOut, info] = f07qw(uplo, ap, ipiv)
```

```
apOut =
  -0.1562 - 0.1014i
   0.0400 + 0.1527i
   0.0550 + 0.0845i
   0.2162 - 0.0742i
   0.0946 - 0.1475i
  -0.0326 - 0.1370i
  -0.0995 - 0.0461i
  -0.1320 - 0.0102i
  -0.1793 + 0.1183i
  -0.2269 + 0.2383i
info =
           0
```