

NAG Library Routine Document

F01LHF

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

F01LHF factorizes a real almost block diagonal matrix.

2 Specification

```
SUBROUTINE F01LHF(N, NBLOKS, BLKSTR, A, LENA, PIVOT, TOL, KPIVOT, IFAIL)
  INTEGER          N, NBLOKS, BLKSTR(3,NBLOKS), LENA, PIVOT(N), KPIVOT,
1 IFAIL
  double precision  A(LENA), TOL
```

3 Description

F01LHF factorizes a real almost block diagonal matrix, A , by row elimination with alternate row and column pivoting such that no 'fill-in' is produced. The code, which is derived from ARCECO described in Diaz *et al.* (1983), uses Level 1 and Level 2 BLAS. No three successive diagonal blocks may have columns in common and therefore the almost block diagonal matrix must have the form shown in the following diagram:

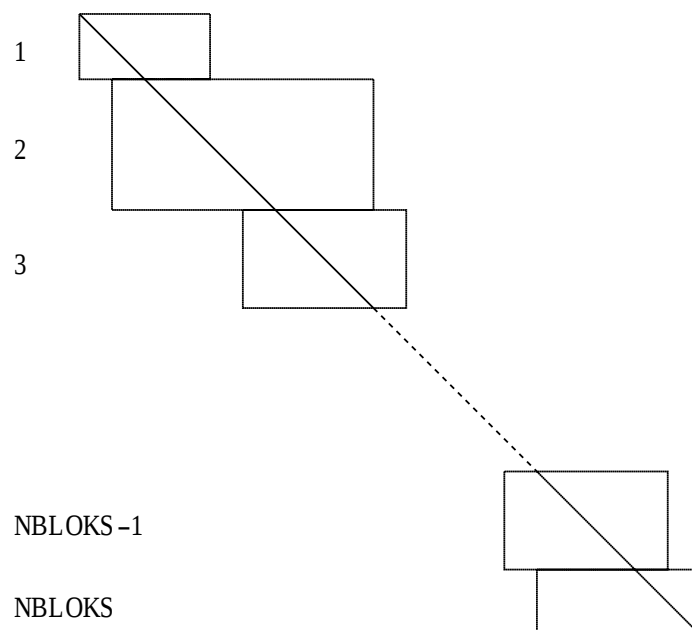


Figure 1

This routine may be followed by F04LHF, which is designed to solve sets of linear equations $AX = B$ or $A^T X = B$.

4 References

Diaz J C, Fairweather G and Keast P (1983) Fortran packages for solving certain almost block diagonal linear systems by modified alternate row and column elimination *ACM Trans. Math. Software* **9** 358–375

5 Parameters

1: N – INTEGER *Input*

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

Constraint: $N > 0$.

2: NBLOKS – INTEGER *Input*

On entry: n , the total number of blocks of the matrix A .

Constraint: $0 < \text{NBLOKS} \leq N$.

3: BLKSTR(3,NBLOKS) – INTEGER array *Input*

On entry: information which describes the block structure of A as follows:

BLKSTR(1, k) must contain the number of rows in the k th block, $k = 1, 2, \dots, \text{NBLOKS}$;

BLKSTR(2, k) must contain the number of columns in the k th block, $k = 1, 2, \dots, \text{NBLOKS}$;

BLKSTR(3, k) must contain the number of columns of overlap between the k th and $(k + 1)$ th blocks, $k = 1, 2, \dots, \text{NBLOKS} - 1$. BLKSTR(3, NBLOKS) need not be set.

The following conditions delimit the structure of A :

$\text{BLKSTR}(1, k), \text{BLKSTR}(2, k) > 0, \quad k = 1, 2, \dots, \text{NBLOKS},$

$\text{BLKSTR}(3, k) \geq 0, \quad k = 1, 2, \dots, \text{NBLOKS} - 1,$

(there must be at least one column and one row in each block and a non-negative number of columns of overlap);

$\text{BLKSTR}(3, k - 1) + \text{BLKSTR}(3, k) \leq \text{BLKSTR}(2, k), \quad k = 2, 3, \dots, \text{NBLOKS} - 1,$

(the total number of columns in overlaps in each block must not exceed the number of columns in that block);

$\text{BLKSTR}(2, 1) \geq \text{BLKSTR}(1, 1),$

$$\text{BLKSTR}(2, 1) + \sum_{k=2}^j [\text{BLKSTR}(2, k) - \text{BLKSTR}(3, k - 1)] \geq \sum_{k=1}^j \text{BLKSTR}(1, k),$$

$j = 2, 3, \dots, \text{NBLOKS} - 1,$

$$\sum_{k=1}^j [\text{BLKSTR}(2, k) - \text{BLKSTR}(3, k)] \leq \sum_{k=1}^j \text{BLKSTR}(1, k), \quad j = 1, 2, \dots, \text{NBLOKS} - 1,$$

(the index of the first column of the overlap between the j th and $(j + 1)$ th blocks must be $\leq$ the index of the last row of the j th block, and the index of the last column of overlap must be $\geq$ the index of the last row of the j th block);

$$\sum_{k=1}^{\text{NBLOKS}} \text{BLKSTR}(1, k) = n,$$

$$\text{BLKSTR}(2, 1) + \sum_{k=2}^{\text{NBLOKS}} [\text{BLKSTR}(2, k) - \text{BLKSTR}(3, k - 1)] = nk,$$

(both the number of rows and the number of columns of A must equal n).

4: A(LENA) – **double precision** array

Input/Output

On entry: the elements of the almost block diagonal matrix stored block by block, with each block stored column by column. The sizes of the blocks and the overlaps are defined by the parameter BLKSTR.

If a_{rs} is the first element in the k th block, then an arbitrary element a_{ij} in the k th block must be stored in the array element:

$$A(p_k + (j - r)m_k + (i - s) + 1)$$

where

$$p_k = \sum_{l=1}^{k-1} \text{BLKSTR}(1, l) \times \text{BLKSTR}(2, l)$$

is the base address of the k th block, and

$$m_k = \text{BLKSTR}(1, k)$$

is the number of rows of the k th block.

See Section 8 for comments on scaling.

On exit: the factorized form of the matrix.

5: LENA – INTEGER

Input

On entry: the dimension of the array A as declared in the (sub)program from which F01LHF is called.

$$\text{Constraint: } \text{LENA} \geq \sum_{k=1}^{\text{NBLOKS}} [\text{BLKSTR}(1, k) \times \text{BLKSTR}(2, k)].$$

6: PIVOT(N) – INTEGER array

Output

On exit: details of the interchanges.

7: TOL – **double precision**

Input/Output

On entry: a relative tolerance to be used to indicate whether or not the matrix is singular. For a discussion on how TOL is used see Section 8. If TOL is nonpositive, then TOL is reset to 10ϵ , where ϵ is the **machine precision**.

On exit: unchanged unless $\text{TOL} \leq 0.0$ on entry, in which case it is set to 10ϵ .

8: KPIVOT – INTEGER

Output

On exit: if IFAIL = 2, KPIVOT contains the value k , where k is the first position on the diagonal of the matrix A where too small a pivot was detected. Otherwise KPIVOT is set to 0.

9: IFAIL – INTEGER

Input/Output

On entry: IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.

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

For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

The exact solution is

$$x = (1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1)^T.$$

9.1 Program Text

```

*      F01LHF Example Program Text
*      Mark 14 Revised. NAG Copyright 1989.
*      .. Parameters ..
      INTEGER          NIN, NOUT
      PARAMETER        (NIN=5,NOUT=6)
      INTEGER          NBLMAX, NMAX, IRLMAX, LENA, LDB
      PARAMETER        (NBLMAX=10,NMAX=20,IRLMAX=5,LENA=200,LDB=NMAX)
*      .. Local Scalars ..
      DOUBLE PRECISION TOL
      INTEGER          I, IFAIL, IR, J, K, KPIVOT, N, NBASEK, NBLOKS
*      .. Local Arrays ..
      DOUBLE PRECISION A(LENA), B(LDB,IRLMAX)
      INTEGER          BLKSTR(3,NBLMAX), PIVOT(NMAX)
*      .. External Subroutines ..
      EXTERNAL         F01LHF, F04LHF
*      .. Executable Statements ..
      WRITE (NOUT,*) 'F01LHF Example Program Results'
*      Skip heading in data file
      READ (NIN,*)
      READ (NIN,*) NBLOKS
      WRITE (NOUT,*)
      IF (NBLOKS.LE.NBLMAX) THEN
        NBASEK = 0
        N = 0
        DO 40 I = 1, NBLOKS
          READ (NIN,*) (BLKSTR(J,I),J=1,3)
          DO 20 K = 1, BLKSTR(1,I)
            IF (NBASEK+BLKSTR(2,I)*BLKSTR(1,I).GT.LENA) THEN
              WRITE (NOUT,*)
+              ' Array A is too small for this problem'
              GO TO 80
            ELSE
              READ (NIN,*) (A(NBASEK+(J-1)*BLKSTR(1,I)+K),J=1,
+              BLKSTR(2,I))
            END IF
          CONTINUE
          NBASEK = NBASEK + BLKSTR(2,I)*BLKSTR(1,I)
          N = N + BLKSTR(1,I)
        40  CONTINUE
        IF (N.GT.NMAX) THEN
          WRITE (NOUT,*) ' N is too large'
          GO TO 80
        END IF
        TOL = 0.0D0
        IFAIL = 1
*
        CALL F01LHF(N,NBLOKS,BLKSTR,A,LENA,PIVOT,TOL,KPIVOT,IFAIL)
*
        IF (IFAIL.EQ.0) THEN
          READ (NIN,*) IR
          IF (IR.LE.IRLMAX) THEN
            READ (NIN,*) ((B(I,J),I=1,N),J=1,IR)
            IFAIL = -1
*
            CALL F04LHF('N',N,NBLOKS,BLKSTR,A,LENA,PIVOT,B,LDB,IR,
+            IFAIL)
*
            IF (IFAIL.EQ.0) THEN
              WRITE (NOUT,*) 'Component Solution'
              WRITE (NOUT,*)
              DO 60 I = 1, N
                WRITE (NOUT,99999) I, (B(I,J),J=1,IR)
              60  CONTINUE
            END IF
          ELSE

```

```

        WRITE (NOUT,*) ' Too many right hand sides specified'
      END IF
    ELSE
      WRITE (NOUT,99998) IFAIL
    END IF
  ELSE
    WRITE (NOUT,*) ' NBLOKS is invalid'
  END IF
80 CONTINUE
*
99999 FORMAT (1X,I5,6X,5F6.4)
99998 FORMAT (1X,/1X,' ** F01LHF returned with IFAIL = ',I5)
END

```

9.2 Program Data

F01LHF Example Program Data

```

5      : Number of blocks
2 4 3 : Number of rows, columns and column overlap, block 1
-1.00 -0.98 -0.79 -0.15
-1.00 0.25 -0.87 0.35 : End block 1
4 7 4 : Number of rows, columns and column overlap, block 2
0.78 0.31 -0.85 0.89 -0.69 -0.98 -0.76
-0.82 0.12 -0.01 0.75 0.32 -1.00 -0.53
-0.83 -0.98 -0.58 0.04 0.87 0.38 -1.00
-0.21 -0.93 -0.84 0.37 -0.94 -0.96 -1.00 : End block 2
5 8 2 : Number of rows, columns and column overlap, block 3
-0.99 -0.91 -0.28 0.90 0.78 -0.93 -0.76 0.48
-0.87 -0.14 -1.00 -0.59 -0.99 0.21 -0.73 -0.48
-0.93 -0.91 0.10 -0.89 -0.68 -0.09 -0.58 -0.21
0.85 -0.39 0.79 -0.71 0.39 -0.99 -0.12 -0.75
0.17 -1.37 1.29 -1.59 1.10 -1.63 -1.01 -0.27 : End block 3
3 6 3 : Number of rows, columns and column overlap, block 4
0.08 0.61 0.54 -0.41 0.16 -0.46
-0.67 0.56 -0.99 0.16 -0.16 0.98
-0.24 -0.41 0.40 -0.93 0.70 0.43 : End block 4
4 5 0 : Number of rows, columns and column overlap, block 5
0.71 -0.97 -0.60 -0.30 0.18
-0.47 -0.98 -0.73 0.07 0.04
-0.25 -0.92 -0.52 -0.46 -0.58
0.89 -0.94 -0.54 -1.00 -0.36 : End block 5
1      : Number of right hand sides
-2.92 -1.27 -1.30 -1.17 -2.10 -4.51 -1.71 -4.59
-4.19 -0.93 -3.31 0.52 -0.12 -0.05 -0.98 -2.07
-2.73 -1.95 : End right hand side 1

```

9.3 Program Results

F01LHF Example Program Results

Component Solution

1	1.0000
2	1.0000
3	1.0000
4	1.0000
5	1.0000
6	1.0000
7	1.0000
8	1.0000
9	1.0000
10	1.0000
11	1.0000
12	1.0000
13	1.0000

14	1.0000
15	1.0000
16	1.0000
17	1.0000
18	1.0000
