

# NAG Fortran Library Routine Document

## F08WWF (CGGBAK/ZGGBAK)

**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

F08WWF (CGGBAK/ZGGBAK) forms the right or left eigenvectors of the real generalized eigenvalue problem  $Ax = \lambda Bx$ , by backward transformation on the computed eigenvectors given by F08YXF (CTGEVC/ZTGEVC). It is necessary to call this routine only if the optional balancing routine F08WVF (CGGBAL/ZGGBAL) was previously called to balance the matrix pair  $(A, B)$ .

### 2 Specification

```

SUBROUTINE F08WWF (JOB, SIDE, N, ILO, IHI, LSCALE, RSCALE, M, V, LDV,
1                INFO)
ENTRY          cggbak (JOB, SIDE, N, ILO, IHI, LSCALE, RSCALE, M, V, LDV,
1                INFO)
INTEGER       N, ILO, IHI, M, LDV, INFO
real        LSCALE(*), RSCALE(*)
complex    V(LDV,*)
CHARACTER*1   JOB, SIDE

```

The ENTRY statement enables the routine to be called by its LAPACK name.

### 3 Description

If the matrix pair has been previously balanced using the routine F08WVF (CGGBAL/ZGGBAL) then F08WWF (CGGBAK/ZGGBAK) backtransforms the eigenvector solution given by F08YXF (CTGEVC/ZTGEVC). This is usually the sixth and last step in the solution of the generalized eigenvalue problem.

For a description of balancing, see the document for F08WVF (CGGBAL/ZGGBAL).

### 4 References

Ward R C (1981) Balancing the generalized eigenvalue problem *SIAM J. Sci. Stat. Comp.* **2** 141–152

### 5 Parameters

1: JOB – CHARACTER\*1 *Input*

*On entry:* specifies the backtransformation step required:

if JOB = 'N', no transformations are done;

if JOB = 'P', only do backward transformations based on permutations;

if JOB = 'S', only do backward transformations based on scaling;

if JOB = 'B', do backward transformations for both permutations and scaling.

**Note:** this must be identical to the parameter JOB as supplied to F08WVF (CGGBAL/ZGGBAL).

*Constraint:* JOB = 'N', 'P', 'S' or 'B'.

- 2: SIDE – CHARACTER\*1 *Input*  
*On entry:* indicates whether left or right eigenvectors are to be transformed, as follows:  
 if SIDE = 'L', left eigenvectors are transformed;  
 if SIDE = 'R', right eigenvectors are transformed.  
*Constraint:* SIDE = 'L' or 'R'.
- 3: N – INTEGER *Input*  
*On entry:*  $n$ , the order of the matrices  $A$  and  $B$  of the generalized eigenvalue problem.  
*Constraint:*  $N \geq 0$ .
- 4: ILO – INTEGER *Input*  
 5: IHI – INTEGER *Input*  
*On entry:*  $i_{lo}$  and  $i_{hi}$  as determined by a previous call to F08WWF (CGGBAL/ZGGBAL).  
*Constraints:*  
 $1 \leq ILO \leq IHI \leq N$  if  $N > 0$ ;  
 $ILO = 1$  and  $IHI = 0$  if  $N = 0$ .
- 6: LSCALE(\*) – *real* array *Input*  
**Note:** the dimension of the array LSCALE must be at least  $\max(1, N)$ .  
*On entry:* details of the permutations and scaling factors applied to the left side of the matrices  $A$  and  $B$ , as returned by a previous call to F08WWF (CGGBAL/ZGGBAL).
- 7: RSCALE(\*) – *real* array *Input*  
**Note:** the dimension of the array RSCALE must be at least  $\max(1, N)$ .  
*On entry:* details of the permutations and scaling factors applied to the right side of the matrices  $A$  and  $B$ , as returned by a previous call to F08WWF (CGGBAL/ZGGBAL).
- 8: M – INTEGER *Input*  
*On entry:*  $m$ , the required number of left or right eigenvectors.  
*Constraint:*  $0 \leq M \leq N$ .
- 9: V(LDV,\*) – *complex* array *Input/Output*  
**Note:** the second dimension of the array V must be at least  $\max(1, M)$ .  
*On entry:* the matrix of right or left eigenvectors, as returned by F08WWF (CGGBAL/ZGGBAL).  
*On exit:* the transformed right or left eigenvectors.
- 10: LDV – INTEGER *Input*  
*On entry:* the first dimension of the array V as declared in the (sub)program from which F08WWF (CGGBAK/ZGGBAK) is called.  
*Constraint:*  $LDV \geq \max(1, N)$ .
- 11: 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.

## **7 Accuracy**

The errors are negligible, compared with the previous computations.

## **8 Further Comments**

The number of operations is proportional to  $n^2$ .

The real analogue of this routine is F08WJF (SGGBAK/DGGBAK).

## **9 Example**

See Section 9 of the documents for F08XSF (CHGEQZ/ZHGEQZ) and F08YXF (CTGEVC/ZTGEVC).

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