

# NAG Library Routine Document

## C09EDF

**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

C09EDF computes the inverse two-dimensional multi-level discrete wavelet transform (DWT). This routine reconstructs data from (possibly filtered or otherwise manipulated) wavelet transform coefficients calculated by C09ECF from an original input matrix. The initialization routine C09ABF must be called first to set up the DWT options.

### 2 Specification

```
SUBROUTINE C09EDF (NWLINV, LENC, C, M, N, B, LDB, ICOMM, IFAIL)
  INTEGER          NWLINV, LENC, M, N, LDB, ICOMM(180), IFAIL
  REAL (KIND=nag_wp) C(LENC), B(LDB,N)
```

### 3 Description

C09EDF performs the inverse operation of C09ECF. That is, given a set of wavelet coefficients, computed up to level  $n_{\text{fwd}}$  by C09ECF using a DWT as set up by the initialization routine C09ABF, on a real matrix,  $A$ , C09EDF will reconstruct  $A$ . The reconstructed matrix is referred to as  $B$  in the following since it will not be identical to  $A$  when the DWT coefficients have been filtered or otherwise manipulated prior to reconstruction. If the original input matrix is level 0, then it is possible to terminate reconstruction at a higher level by specifying fewer than the number of levels used in the call to C09ECF. This results in a partial reconstruction.

### 4 References

None.

### 5 Arguments

- 1: NWLINV – INTEGER *Input*  
*On entry:* the number of levels to be used in the inverse multi-level transform. The number of levels must be less than or equal to  $n_{\text{fwd}}$ , which has the value of argument NWL as used in the computation of the wavelet coefficients using C09ECF. The data will be reconstructed to level  $(\text{NWL} - \text{NWLINV})$ , where level 0 is the original input dataset provided to C09ECF.  
*Constraint:*  $1 \leq \text{NWLINV} \leq \text{NWL}$ , where NWL is the value used in a preceding call to C09ECF.
- 2: LENC – INTEGER *Input*  
*On entry:* the dimension of the array C as declared in the (sub)program from which C09EDF is called.  
*Constraint:*  $\text{LENC} \geq n_{\text{ct}}$ , where  $n_{\text{ct}}$  is the total number of coefficients that correspond to a transform with NWLINV levels and is unchanged from the preceding call to C09ECF.
- 3: C(LENC) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* the coefficients of a multi-level wavelet transform of the original matrix,  $A$ , which may have been filtered or otherwise manipulated.

Let  $q(i)$  be the number of coefficients (of each type) at level  $i$ , for  $i = n_{\text{fwd}}, n_{\text{fwd}} - 1, \dots, 1$ . Then, setting  $k_1 = q(n_{\text{fwd}})$  and  $k_{j+1} = k_j + q(n_{\text{fwd}} - \lceil j/3 \rceil + 1)$ , for  $j = 1, 2, \dots, 3n_{\text{fwd}}$ , the coefficients are stored in C as follows:

C( $i$ ), for  $i = 1, 2, \dots, k_1$

Contains the level  $n_{\text{fwd}}$  approximation coefficients,  $a_{n_{\text{fwd}}}$ .

C( $i$ ), for  $i = k_j + 1, \dots, k_{j+1}$

Contains the level  $n_{\text{fwd}} - \lceil j/3 \rceil + 1$  vertical, horizontal and diagonal coefficients. These are:

vertical coefficients if  $j \bmod 3 = 1$ ;

horizontal coefficients if  $j \bmod 3 = 2$ ;

diagonal coefficients if  $j \bmod 3 = 0$ ,

for  $j = 1, \dots, 3n_{\text{fwd}}$ .

Note that the coefficients in C may be extracted according to level and type into two-dimensional arrays using C09EYF, and inserted using C09EZF.

4: M – INTEGER

*Input*

*On entry:* the number of elements,  $m$ , in the first dimension of the reconstructed matrix  $B$ . For a full reconstruction of NWL levels, where NWL is as supplied to C09ECF, this must be the same as argument M used in the call to C09ECF. For a partial reconstruction of  $\text{NWLINV} < \text{NWL}$  levels, this must be equal to  $\text{DWTLVM}(\text{NWLINV} + 1)$ , as returned from C09ECF.

5: N – INTEGER

*Input*

*On entry:* the number of elements,  $n$ , in the second dimension of the reconstructed matrix  $B$ . For a full reconstruction of NWL levels, where NWL is as supplied to C09FCF, this must be the same as argument N used in the call to C09ECF. For a partial reconstruction of  $\text{NWLINV} < \text{NWL}$ , this must be equal to  $\text{DWTLVN}(\text{NWLINV} + 1)$ , as returned from C09ECF.

6: B(LDB, N) – REAL (KIND=nag\_wp) array

*Output*

*On exit:* the  $m$  by  $n$  reconstructed matrix,  $B$ , based on the input multi-level wavelet transform coefficients and the transform options supplied to the initialization routine C09ABF.

7: LDB – INTEGER

*Input*

*On entry:* the first dimension of the array B as declared in the (sub)program from which C09EDF is called.

*Constraint:*  $\text{LDB} \geq \text{M}$ .

8: ICOMM(180) – INTEGER array

*Communication Array*

*On entry:* contains details of the discrete wavelet transform and the problem dimension as setup in the call to the initialization routine C09ABF.

9: IFAIL – INTEGER

*Input/Output*

*On entry:* IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this argument you should refer to Section 3.4 in How to Use the NAG Library and its Documentation for details.

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 argument, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

*On exit:* IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

## 6 Error Indicators and Warnings

If on entry  $IFAIL = 0$  or  $-1$ , explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

$IFAIL = 1$

On entry,  $NWLINV = \langle value \rangle$ .

Constraint:  $NWLINV \geq 1$ .

On entry,  $NWLINV = \langle value \rangle$  and  $n_{\text{fwd}} = \langle value \rangle$ .

Constraint:  $NWLINV \leq n_{\text{fwd}}$ .

$IFAIL = 2$

On entry,  $LDB = \langle value \rangle$  and  $M = \langle value \rangle$ .

Constraint:  $LDB \geq M$ .

$IFAIL = 3$

On entry,  $LENC = \langle value \rangle$ .

Constraint:  $LENC \geq \langle value \rangle$ , the total number of coefficients generated by the preceding call to C09ECF.

$IFAIL = 4$

On entry,  $M = \langle value \rangle$ .

Constraint:  $M \geq \langle value \rangle$ , the number of coefficients in the first dimension at the required level of reconstruction.

On entry,  $N = \langle value \rangle$ .

Constraint:  $N \geq \langle value \rangle$ , the number of coefficients in the second dimension at the required level of reconstruction.

$IFAIL = 6$

Either the initialization routine has not been called first or ICOMM has been corrupted.

Either the initialization routine was called with  $WTRANS = 'S'$  or ICOMM has been corrupted.

$IFAIL = -99$

An unexpected error has been triggered by this routine. Please contact NAG.

See Section 3.9 in How to Use the NAG Library and its Documentation for further information.

$IFAIL = -399$

Your licence key may have expired or may not have been installed correctly.

See Section 3.8 in How to Use the NAG Library and its Documentation for further information.

$IFAIL = -999$

Dynamic memory allocation failed.

See Section 3.7 in How to Use the NAG Library and its Documentation for further information.

## 7 Accuracy

The accuracy of the wavelet transform depends only on the floating-point operations used in the convolution and downsampling and should thus be close to *machine precision*.

## 8 Parallelism and Performance

C09EDF is not threaded in any implementation.

## 9 Further Comments

None.

## 10 Example

See Section 10 in C09ECF.

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