NAG Toolbox for MATLAB

c06pc

1 Purpose

c06pc calculates the discrete Fourier transform of a sequence of n complex data values (using complex data type).

2 Syntax

```
[x, ifail] = c06pc(direct, x, 'n', n)
```

3 Description

Given a sequence of n complex data values z_j, for $j = 0, 1, \ldots, n-1$, c06pc calculates their (**forward** or **backward**) discrete Fourier transform defined by

$$\hat{z}_k = \frac{1}{\sqrt{n}} \sum_{j=0}^{n-1} z_j \times \exp\left(\pm i \frac{2\pi jk}{n}\right), \qquad k = 0, 1, \ldots, n-1.$$

(Note the scale factor of $\frac{1}{\sqrt{n}}$ in this definition.) The minus sign is taken in the argument of the exponential within the summation when the forward transform is required, and the plus sign is taken when the backward transform is required.

A call of c06pc with **direct** = 'F' followed by a call with **direct** = 'B' will restore the original data.

c06pc uses a variant of the fast Fourier transform (FFT) algorithm (see Brigham 1974) known as the Stockham self-sorting algorithm, which is described in Temperton 1983b.

4 References

Brigham E O 1974 *The Fast Fourier Transform* Prentice–Hall

Temperton C 1983b Self-sorting mixed-radix fast Fourier transforms *J. Comput. Phys.* **52** 1–23

5 Parameters

5.1 Compulsory Input Parameters

1: **direct – string**

If the **F**orward transform as defined in Section 3 is to be computed, then **direct** must be set equal to 'F'.

If the **B**ackward transform is to be computed then **direct** must be set equal to 'B'.

Constraint: **direct** = 'F' or 'B'.

2: **x(n) – complex array**

If **x** is declared with bounds $(0 : \mathbf{n} - 1)$ in the (sub)program from which c06pc is called, then $\mathbf{x}(j)$ must contain z_j, for $j = 0, 1, \ldots, n-1$.

5.2 Optional Input Parameters

1: **n – int32 scalar**

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

n, the number of data values. The total number of prime factors of **n**, counting repetitions, must not exceed 30.

Constraint: $\mathbf{n} \geq 1$.

5.3 Input Parameters Omitted from the MATLAB Interface

work

5.4 Output Parameters

1: **x(n) – complex array**

The components of the discrete Fourier transform. If **x** is declared with bounds $(0 : \mathbf{n} - 1)$ in the (sub)program from which c06pc is called, then for $0 \leq k \leq n - 1$, $\hat{z}_k$ is contained in $\mathbf{x}(k)$.

2: **ifail – int32 scalar**

0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail $= 1$

On entry, $\mathbf{n} < 1$.

ifail $= 2$

On entry, **direct** $\neq$ 'F' or 'B'.

ifail $= 3$

On entry, **n** has more than 30 prime factors.

ifail $= 4$

An unexpected error has occurred in an internal call. Check all (sub)program calls and array dimensions. Seek expert help.

7 Accuracy

Some indication of accuracy can be obtained by performing a subsequent inverse transform and comparing the results with the original sequence (in exact arithmetic they would be identical).

8 Further Comments

The time taken is approximately proportional to $n \times \log n$, but also depends on the factorization of n. c06pc is faster if the only prime factors of n are 2, 3 or 5; and fastest of all if n is a power of 2.

9 Example

```
direct = 'F';
x = [complex(0.34907, -0.37168);
     complex(0.5489000000000001, -0.35669);
     complex(0.74776, -0.31175);
     complex(0.94459, -0.23702);
     complex(1.1385, -0.13274);
     complex(1.3285, +0.00074);
```

```
     complex(1.5137, +0.16298)];
[xOut, ifail] = c06pc(direct, x)
```

```
xOut =
   2.4836 - 0.4710i
  -0.5518 + 0.4968i
  -0.3671 + 0.0976i
  -0.2877 - 0.0586i
  -0.2251 - 0.1748i
  -0.1483 - 0.3084i
   0.0198 - 0.5650i
ifail =
           0
```