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FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
IN NASTRAN

by

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS3-22533

NASA Lewis Research Center
Cleveland, Ohio 44135

December 1981
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NASTRAN Manuals

A new capability has been added to the general purpose finite element program NASTRAN Level 17.7 to conduct forced vibration analysis of tuned cyclic structures rotating about their axis of symmetry. The effects of Coriolis and centripetal accelerations together with those due to linear acceleration of the axis of rotation have been included.

This report presents the Theoretical, User's, Programmer's and Demonstration manuals for this new capability. The work was conducted under Contract NAS3-22533 from NASA Lewis Research Center, Cleveland, Ohio, with Mr. Richard E. Morris as the Technical Monitor.

Forc e Vibrations, Rotating Cyclic Structures, NASTRAN, Finite Elements, Turbomachines, Propellers, Base Excitation

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1.1 Introduction

A new capability has been developed and implemented in NASTRAN Level 17.7 to perform forced vibration analysis of cyclic structures rotating about their axis of symmetry. Fans, propellers, and bi-axial shrouded discs of turbomachines are some examples of such structures. The capability includes the effects of Coriolis and centripetal accelerations on the rotating structure which can be loaded with:

1) directly applied loads moving with the structure and
2) inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

One rotationally cyclic sector of the N-sectored structure is modelled and analyzed. Steady-state sinusoidal or general periodic loads are specified to represent:

1) the physical loads on various segments of the complete structure, or
2) the circumferential harmonic components of the loads in (1).

The sinusoidal loads are specified as functions of frequency and the general periodic loads are specified as functions of time.

The translational acceleration of the axis of rotation may be specified as a function of frequency in an inertial coordinate system.

The details of the User's, Programmer's and Demonstration manuals are presented in Sections 2, 3 and 4, respectively. The following sections present the salient points in the theoretical development.

1.2 Theory

The theoretical development of Reference 1 to conduct forced vibration analysis of rotating cyclic structures in conjunction with the theory of rotational cyclic symmetry as presented in Section 4.5.1 of the NASTRAN Theoretical Manual (Reference 2) is summarized in this section.

1.2.1 Equations of Motion

The complete structure consists of N identical sectors. The displacement at any grid point in any sector can be expressed in any body-fixed coordinate system as a combination of:

1) the steady displacement due to the steady rotation of the structure, and
2) the vibratory displacement (superposed on the steady displacement) due to the vibratory excitation provided by the directly applied loads and base acceleration.
The vibratory response of rotating cyclic structures may be determined by this new capability. As shown in Reference 1, the equations of forced response can be written as

\[ M^n_{\text{u}} \ddot{u}^n + D^n_{\text{u}} \dot{u}^n + K^n_{\text{u}} u^n = P^n - M^n_{\text{i}} , \quad n = 1, 2, ..., N. \]  

(1)

For the \( n \)th cyclic sector, \( u^n \) represents the vibratory degrees of freedom; \( M^n, B^n \) and \( K^n \) represent its mass, damping and stiffness matrices respectively; \( P^n \) represents the directly applied loads on \( u^n \), and \( -M^n_{\text{i}} \) represents the inertial loads on \( u^n \) due to base acceleration \( \ddot{R} \). The damping matrix \( B^n \) consists of the viscous and structural damping, and the contribution due to the Coriolis acceleration, i.e.,

\[ B^n = B^n_{\text{viscous}} + 2\Omega B^n_{\text{Coriolis}}, \]

(2)

structural

with \( \Omega \) as the (constant) rotational speed. The stiffness matrix \( K^n \) consists of elastic and differential stiffness together with the contribution due to the centripetal acceleration, i.e.,

\[ K^n = K^n_{\text{elastic}} + K^n_{\text{differential}} - \Omega^2 M^n_{\text{centripetal}}. \]  

(3)

The derivation of the coefficient matrices \( B^n_{\text{Coriolis}}, M^n_{\text{centripetal}} \) and \( M^n_{\text{i}} \) is given in Reference 1.

Equations (1) supplemented by the inter-segment boundary compatibility conditions (Section 4.5.1, Reference 2),

\[ u^{n+1}_{\text{side 1}} = u^n_{\text{side 2}}, \quad n = 1, 2, ..., N, \]  

(4)

completely describe the vibratory forced motion of the rotating cyclic structure.

1.2.2 Method of Solution

The method of solution of equations (1) consists of four principal steps:

1) Transformation of applied loads to frequency-dependent circumferential harmonic components.

2) Application of circumferential harmonic-dependent inter-segment compatibility constraints.

3) Solution of frequency-dependent circumferential harmonic components of displacements.
4) Recovery of frequency-dependent response (displacements, stresses, loads, etc.) in various segments of the total structure.

An overall flowchart outlining the solution algorithm is shown in Figure 1.

1. Transformation of Applied Loads

The transformation to frequency-dependent circumferential harmonic components depends on the form in which the excitation is specified by the user. The following options are made available in the present capability to specify the form of excitation due to the directly applied loads and base acceleration loads:

Directly applied loads specified as:
- periodic functions of time on various segments
- periodic functions of time for various circumferential harmonic indices
- functions of frequency on various segments
- functions of frequency for various circumferential harmonic indices.

Base acceleration specified as:
- function of frequency for circumferential harmonic indices 0 (axial) and 1 (lateral).

Details of each of the above five loading conditions are as follows.

Directly applied loads (segment-dependent and periodic in time)

If \( P^n \) represents a general periodic load on sector \( n \) specified as a function of time at \( M \) equally spaced instances of time per period (Figure 2), the load at \( m\)th time instant can be written as

\[
p^n = P^n + \sum_{\ell=1}^{\ell_L} \left[ P^n \cos(m-T_{2b}) + P^n \sin(m-T_{2b}) \right] + (-1)^{m-L} P^n ,
\]

where \( b = 2\pi/N, \ell_L = (M-1)/2 \) for odd \( M \), \( \ell_L = (M-2)/2 \) for even \( M \). The last term in equation (5) exists only when \( M \) is even. The coefficients \( P^n \) ("\( \ell \) = 0; \( \ell = 1, 2, \ldots, \ell_L; M/2 \)) in equation (5) are independent of time, and are defined by the relations

\[
p^n = \frac{M}{M} \sum_{m=1}^{m=1} P^n , \quad (\ell = 0) \quad \text{part of (6)}
\]
Each of the coefficient vectors \( \mathbf{p}^n \) on the left hand sides of equations (6) can further be expanded in a circumferential (truncated) Fourier series

\[
\mathbf{p}^n = \mathbf{p}^0 + \sum_{k=1}^{k_L} \left[ \mathbf{p}^k \cos(k \omega a) + \mathbf{p}^{k*} \sin(k \omega a) \right] + (-1)^{n-1} \mathbf{p}^{N/2},
\]

where \( n = 1, 2, \ldots, N \),
"\( \omega \)" = 0; kc, ks, \( \zeta = 1, 2, \ldots, k_L; M/2 \)
\( a = 2\pi/N \)
\( k_L = (N-1)/2 \) for \( N \) odd
\( k_L = (N-2)/2 \) for \( N \) even.

The last term in equation (7) exists only when \( N \) is even. The Fourier coefficients \( \mathbf{p}^k \) ("\( k \)" = 0; kc, ks, \( k = 1, 2, \ldots, k_L; N/2 \)) in equation (7) do not vary from sector to sector, and are defined by

\[
\begin{align*}
\mathbf{p}^0 &= \frac{1}{N} \sum_{n=1}^{N} \mathbf{p}^n \quad (k = 0) \\
\mathbf{p}^{k_c} &= \frac{2}{N} \sum_{n=1}^{N} \mathbf{p}^n \cos(n \omega a) \\
\mathbf{p}^{k_s} &= \frac{2}{N} \sum_{n=1}^{N} \mathbf{p}^n \sin(n \omega a), \quad (k = 1, 2, \ldots, k_L) \\
\mathbf{p}^{N/2} &= \frac{1}{N} \sum_{n=1}^{N} (-1)^{n-1} \mathbf{p}^n \quad (N \text{ even only}) \quad (k = N/2). 
\end{align*}
\]
The terms $p^n_k$ ($k = 0; kc, ks, k = 1, 2, \ldots, k_L; N/2$ and $k = 0; kc, ks, k = 1, 2, \ldots, k_L; N/2$) are the transformed frequency-dependent circumferential harmonic components of the directly applied loads $p^n$ ($m = 1, 2, \ldots, M$ and $n = 1, 2, \ldots, N$).

Directly applied loads (Circumferential harmonic-dependent and periodic in time).

Such loads can be represented as

$$\tilde{p}^n_k = p^n_k + \sum_{l=1}^{k_L} \left[ \frac{-\tilde{p}^n_{kc} \cos((\bar{m}-l)c) + \tilde{p}^n_{ks} \sin((\bar{m}-l)c)}{\bar{m}} \right] + (-1)^{\bar{m}} \tilde{p}^{n/2}_k, \quad (10)$$

where $m = 1, 2, \ldots, M$ represent the time instances at which harmonic components $k = 0; kc, ks, k = 1, 2, \ldots, k_L; N/2$ of directly applied loads are specified.

The coefficients $\tilde{p}^n_k$ on the right hand side of equation (10) are obtained using equations (6) with sector number $n$ replaced by harmonic number $k$.

Directly applied loads (frequency-and segment-dependent).

This type of loads can be represented as

$$\tilde{p}^n = p^n + \sum_{k=1}^{k_L} \left[ \frac{-\tilde{p}^n_{kc} \cos((\bar{n}-l)c) + \tilde{p}^n_{ks} \sin((\bar{n}-l)c)}{\bar{n}} \right] + (-1)^{\bar{n}} \tilde{p}^{n/2}, \quad (11)$$

where $\bar{n}$ ($=1, 2, \ldots, F$) now represents the frequencies at which excitation is specified. The transformed frequency-dependent circumferential harmonic components $\tilde{p}^n_k$ ($k = 0; kc, ks, k = 1, 2, \ldots, k_L; N/2$) are obtained using equations (9) with $\bar{n}$ as defined above.

Directly applied loads (frequency-and circumferential harmonic-dependent).

These loads are the transformed frequency-dependent circumferential harmonic components $\tilde{p}^n_k$ ($k = 0; kc, ks, k = 1, 2, \ldots, k_L; N/2$) with $\bar{n}$ ($=1, 2, \ldots, F$) representing the various frequencies at which the directly applied loads are specified.

Base acceleration (frequency- and circumferential harmonic-dependent).

In Reference 1, it is shown that the components of the translational base acceleration contribute to inertial loads on the rotating structure in the following manner:
1. Axial component contributes to \( \vec{P}^{'2} \) where \( \vec{P}^{'2} \) represents the specified excitation frequencies.

2. Lateral components contribute to \( \vec{P}^{'2} \) where \( \vec{P}^{'2} \) represents the effective excitation frequencies which are shifted from the specified frequencies by \( 2 \omega \), the rotational frequency.

The user specifies the components of the base acceleration vector \( \vec{R} \) as functions of frequency. The program computes the inertial loads \(-M_2 \vec{R}\) and transforms them to appropriate frequency-dependent circumferential harmonic components.

2. Application of Inter-Segment Compatibility Constraints

As shown in Section 4.5.1 of Reference 2, equations (4) are used to derive the compatibility conditions relating the circumferential harmonic component degrees of freedom on the two sides of a rotationally cyclic sector:

\[
\begin{align*}
\vec{u}_2^0 &= \vec{u}_1^0 & (k = 0) \\
\vec{u}_2^{kc} &= \vec{u}_1^{kc} \cos(k\alpha) + \vec{u}_1^{ks} \sin(k\alpha) & (k = 1, 2, \ldots, k_L) \\
\vec{u}_2^{ks} &= -\vec{u}_1^{kc} \sin(k\alpha) + \vec{u}_1^{ks} \cos(k\alpha) \\
\text{and} \quad \vec{u}_2^{N/2} &= -\vec{u}_1^{N/2} & (k = N/2)
\end{align*}
\]

In order to apply these constraint relationships for any given harmonic \( k \), an independent set \( \vec{u}^K \) consisting of the circumferential harmonic component (cosine and sine) degrees of freedom from the interior and side 1 of the cyclic sector is defined. \( \vec{u}^K \) is selected from the 'analysis' set degrees of freedom, and is defined as

\[
\begin{align*}
\vec{u}^{kc} &= G_{ck}(k) \vec{u}^K, \quad \text{and} \\
\vec{u}^{ks} &= G_{sk}(k) \vec{u}^K
\end{align*}
\]

\( \vec{u}^{kc} \) and \( \vec{u}^{ks} \) each contain all (and only) the 'analysis' set degrees of freedom from the interior and both sides of the cyclic sector. Equations (12) are used to define some of the elements of the transformation matrices \( G_{ck} \) and \( G_{sk} \). For \( k = 0 \) and \( N/2 \), the matrix \( G_{sk} \) is null.
3. Solution of Frequency-Dependent Harmonic Displacements

For a given harmonic k, the introduction of \( \bar{u}^k \) in the equations of motion, (1), results in the transformed equations of motion (Reference 3)

\[
\begin{align*}
[\bar{M}^{kk} + \bar{B}^{k} + \bar{K}^{k}]\bar{u}^{k} &= \bar{p}^{k} , \\
\end{align*}
\]

(14)

where

\[
\begin{align*}
\bar{M}^{k} &= \bar{G}_{ck}^{T} M^{n} \bar{G}_{ck}^{*} + G_{sk}^{T} M^{n} G_{sk} , \\
\bar{B}^{k} &= \bar{G}_{ck}^{T} B^{n} \bar{G}_{ck}^{*} + G_{sk}^{T} B^{n} G_{sk} , \\
\bar{K}^{k} &= \bar{G}_{ck}^{T} K^{n} \bar{G}_{ck}^{*} + G_{sk}^{T} K^{n} G_{sk} , \text{ and} \\
\bar{p}^{k} &= \bar{G}_{ck}^{T} \bar{p}_{k}^{c} + G_{sk}^{T} \bar{p}_{k}^{s} .
\end{align*}
\]

(15)

As discussed in subsection 1 of Section 1.2.2, \( \bar{p}_{k}^{c} \) and \( \bar{p}_{k}^{s} \) are the transformed frequency-dependent circumferential harmonic components of the directly applied and base acceleration loads.

At any excitation frequency \( \omega \), let

\[
\begin{align*}
\bar{p}^{k} &= p_{k} e^{i\omega t} \quad \text{and accordingly,} \\
\bar{u}^{k} &= u_{k} e^{i\omega t} ,
\end{align*}
\]

(16)

where \( \bar{p}^{k} \) and \( \bar{u}^{k} \) are complex quantities. Equation (14) can be rewritten as

\[
[-\omega^2 \bar{M}^{k} + i\omega \bar{B}^{k} + \bar{K}^{k}]\bar{u}^{k} = \bar{p}^{k} .
\]

(17)

The excitation frequency \( \omega \) is given by

\[
\begin{align*}
\omega &= \omega \text{ for all directly applied and axial true acceleration loads, and} \\
&= \omega \text{ for lateral base acceleration loads.}
\end{align*}
\]

(18)

Equation (17) is solved for \( \bar{u}^{k} \) for all excitation frequencies and all harmonics as specified by the user. The cosine and sine harmonic components of displacements are recovered using equations (13).

4. Recovery of Frequency-Dependent Displacements in Various Segments

This step is carried out only when the applied loads are specified on the various segments of the complete structure.
For loads specified as functions of time, equation (7) is used to obtain the displacements $u_n^k$ in various segments with $\xi = 0; \xi, \xi_s, \xi = 1, 2, \ldots, \xi_{max}$. The circumferential harmonic $k$ is varied from $k_{min}$ to $k_{max}$. The user specifies $k_{max}, k_{min}$ and $k_{max}$.

For loads specified as functions of frequency, equation (11) is used to obtain the displacements $u_n$ in various segments with $\gamma$ representing the excitation frequencies. The circumferential harmonic is varied from user specified $k_{min}$ to $k_{max}$.

The recovery of other responses such as stresses, internal forces, etc., is identical to that currently existent in NASTRAN.
1.3 References


FIGURE 1: Overall Flowchart of Forced Vibration Analysis of Rotating Cyclic Structures
Application of inter-segment compatibility constraints to stiffness, mass, damping and load matrices

Solution of independent harmonic displacements

Increment k by 1.

Recovery of segment-dependent independent displacements (Inverse Phase 2, if necessary)

Recovery of dependent displacements

Output requests for displacements, stresses, loads, plots, etc.

Exit

FIGURE 1. (Concluded)
Figure 2: Directly Applied Periodic Loads Specified as Functions of Time
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.1 Introduction

Forced vibration analysis of cyclic structures rotating about their axis of symmetry can be conducted using this capability. An extensive package of ALTERs including new Functional Modules and PARAMETERS has been developed and used to modify the existing Displacement Approach Rigid Format 8 (Direct Frequency and Random Response), Series R, in NASTRAN Level 17.7. Example 2 of the Demonstration Manual (Section 4) illustrates the use of this ALTER package. The Theoretical and Programmer's Manuals are described in Sections 1 and 3, respectively.

2.2 NASTRAN Model

The user models one rotationally cyclic sector (segment) of the entire structure as shown by the 12-bladed disc example in Figure 1. All NASTRAN coordinate systems (basic, location and displacement) are considered fixed to the rotating structure. The only additional requirement is that the X-axis of the basic coordinate system be coincident with the axis of rotation. A positive value of the rotational speed (PARAM RPS) indicates a clockwise sense of rotation when the structure is viewed at in the positive basic X direction.

Except for the special features discussed in this section, the general rules of modelling rotationally cyclic structures in NASTRAN (e.g. CYJOIN, NSEGS, etc.) have been maintained.

The rotating structure can be loaded with steady-state sinusoidal or general periodic loads classified as:

1. directly applied loads moving with the structure, and
2. inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

The sinusoidal loads are specified as functions of frequency using the RLOADi bulk data cards. The general periodic loads are specified as functions of time using the TLOADi bulk data cards.

The following notes apply when using TLOADi bulk data cards:

1. Time delay τ must be set to zero.
2. In conjunction with the TSTEP bulk data card, TLOADi information is used to discretely define P(t) at M time instances as $P_m$ or $P_m^W$ ($m = 1, 2, ..., M$), as discussed in Section 1.2.2 of the Theoretical


1. \( N(1) \) of TSTEP bulk data card = \( M-2 \)
2. \( DT(1) \) of TSTEP bulk data card = \( (T2 - T1)/M \)

3. \( P(t) \) is defined in the interval \([T1, T2]\) with \((T2 - T1)\) as the period.
4. Only one physical TSTEP bulk data card is allowed, i.e. continuation of the TSTEP card is not permitted.

The following options are provided to specify the form of excitation:

- Directly applied loads specified as:
  - periodic functions of time on various segments (PARAM CYCIO = +1)
  - periodic functions of time for various circumferential harmonic indices (PARAM CYCIO = -1)
  - functions of frequency on various segments (PARAM CYCIO = +1)
  - functions of frequency for various circumferential harmonic indices (PARAM CYCIO = -1)

Base acceleration specified as:

- function of frequency for circumferential harmonic indices 0 (axial) and 1 (lateral) (PARAM CYCIO = -1)

The base acceleration refers to the translational acceleration of the axis of rotation, and is specified in an inertial coordinate system. The user defines a rectangular inertial coordinate system with its X-axis parallel to and in the direction of the basic X axis, as shown in Figure 1. The definition of this inertial system, otherwise, is arbitrary. The user specifies the X, Y, Z components (magnitude and phase) of the base acceleration vector as functions of frequency on TABLEDi bulk data cards. The use of these tables is activated by the PARAMs BXTID, BXPTID, BYTID, BYPTID, BZTID and BZPTID.

The user is provided with two options to include damping by specifying the form of the matrices \( K_{dd} \), \( B_{dd} \) and \( H_{dd} \) in the Functional module GKAD as per equations 16 through 21, pages 9.3-7 and 9.3-8, Section 9.3.3 of the NASTRAN Level 17.7 Theoretical Manual. The PARAMeters GKAD and LGKAD have been defined for this purpose.

Section 2.4.4 of this manual describes all the PARAMeters applicable with this new capability.
2.3 Subcase Definitions

The parameters CYCIO (±1) and KMAX (≥0 ≤ NSEGS/2 for even NSEGS, ≤ (NSEGS-1)/2 for odd NSEGS) determine the number, order and meaning of subcases as follows:

**CYCIO=+1**

The number of subcases is equal to NSEGS, independent of KMAX.

- **SUBCASE 1 (SEGMENT NO. 1)**
- **SUBCASE 2 (SEGMENT NO. 2)**
- ...
- **SUBCASE NSEGS (SEGMENT NO. NSEGS)**

**CYCIO=-1**

The number of subcases is equal to FKMAX, where

\[
FKMAX = \begin{cases} 
1, & \text{if } KMAX = 0, \\
1 + 2 \cdot KMAX, & \text{if } 0 < KMAX \leq (NSEGS-1)/2, \text{ NSEGS odd}, \\
1 + 2 \cdot KMAX, & \text{if } 0 < KMAX \leq (NSEGS-2)/2, \text{ NSEGS even, and} \\
NSEGS, & \text{if } KMAX \leq NSEGS/2, \text{ NSEGS even.}
\end{cases}
\]

- **SUBCASE 1 ('k' = 0)**
- **SUBCASE 2 ('k' = 1c)**
- **SUBCASE 3 ('k' = 1s)**
- **SUBCASE 4 ('k' = 2c)**
- **SUBCASE 5 ('k' = 2s)**
- ...
- **SUBCASE FKMAX ('k' = KMAX)**

In the event that NSEGS is even and KMAX = NSEGS/2, subcase FKMAX will represent 'k' = KMAX/2 as KMAX/2 does not exist.

Directly applied loads on various segments (CYCIO=+1) or their circumferential harmonic components (CYCIO=-1) are specified under the appropriate subcases. With RLOADi bulk data cards, null loads need not be specified by the user. With TLOADi bulk data cards, the user is required to provide information to generate null loads where applicable.
Base acceleration is included only when CYCIO=-1. Based on the activating parameters BXTID etc., the corresponding inertial loads are internally calculated and assigned to 'k' = 0, 1c and 1s as applicable.
Figure 1: NASTRAN Model of the 12-Bladed Disc
2.4 Rigid Format Description

2.4.1 Rigid Format Alters to Displacement SOL 8

EXECUTIVE DECK INPUT -

1. SOL 8
2. R.F. ALTERS

CASE CONTROL DECK INPUT -

1. ALL SPC AND MPC CONSTRAINTS MUST BE ABOVE THE SUBCASE LEVEL.
2. EITHER FREQUENCY OR TSTEP MUST BE SELECTED AND MUST BE ABOVE
   THE SUBCASE LEVEL.
3. IF SELECTED, FREQUENCY MUST BE USED TO SELECT ONE AND ONLY
   ONE FREQ, FTREL OR FREQ2 CARD FROM THE BULK DATA DECK AND
   MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
4. IF SELECTED, TSTEP MUST BE USED TO SELECT THE TIME-STEPS TO BE
   USED FOR LOCAL DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE
   LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. OFREQUENCY MUST NOT BE USUED.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEFINED FOR EACH SYMMETRIC
   SEGMENT.
8. ULOAD MUST BE USED TO DEFINE A FREQUENCY OR TIME-DEPENDENT
   LOADING CONDITION FOR EACH SUBCASE.
   FOR FREQUENCY-DEPENDENT LOADS, SUBCASES WITHOUT LOADS NEED NOT
   REFER TO A ULOAD CARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO
   A ULOAD CARD THAT GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF
   SUBCASES FOR EACH HARMONIC INDEX. K. THE PARAMETER CYCIC IS
   INCLUDED AND THE LOAD COMPONENTS FOR EACH INDX ARE DEFINED
   DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

BULK DATA DECK INPUT -
1. SUPORT BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPOINT BULK DATA CARDS ARE NOT ALLOWED.
4. CYJOIN BULK DATA CARDS ARE REQUIRED.
5. IF A TSTEP CARD IS USED THEN IT MUST NOT BE CONTINUED SINCE ONLY ONE UNIFORM TIME STEP INTERVAL MUST BE SPECIFIED.
6. THE SKIP FACTOR FOR OUTPUT, NG, OR THE TSTEP CARD MUST BE 1.
7. PARAMETERS USED ARE -

A. NSEGS - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF IDENTICAL SEGMENTS IN THE STRUCTURAL MODEL.
B. CYCLO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA. A VALUE OF 01 IS USED TO SPECIFY PHYSICAL SEGMENT REPRESENTATION. A VALUE OF -1 IS USED TO SPECIFY CYCLIC TRANSFORMATION REPRESENTATION. THERE IS NO DEFAULT, A VALUE MUST BE INPUT.
C. CYCSEU - FIXED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE PROCEDURE FOR SEQUENCING THE EQUATIONS IN THE SOLUTION SET. THE VALUE OF THIS PARAMETER HAS BEEN SET TO -1 TO SPECIFY ALTERNATING COSINE AND SINE TERMS.
D. CTYPF - FIXED - THE BCD VALUE OF THIS PARAMETER DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE OF THIS PARAMETER HAS BEEN SET TO -1 - FOR ROTATIONAL SYMMETRY.
E. KMAX - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MAXIMUM VALUE OF THE HARMONIC INDEX. THERE IS NO DEFAULT FOR THIS PARAMETER. THE MAXIMUM VALUE THAT CAN BE SPECIFIED IS NSEGS/2.
F. KMIN - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MINIMUM VALUE OF THE HARMONIC INDEX TO BE USED IN THE SOLUTION LOOP. KMIN CAN BE QUAL KMAX. THE DEFAULT VALUE IS 0.
G. LMAX - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MAXIMUM TIME HARMONIC INDEX. THE DEFAULT VALUE IS NSTEPS/2. WHERE NSTEPS EQUALS \( N \) FROM TSTEP CARD PLUS 2.
H. NLOAD - FIXED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF LOADING CONDITIONS. THE VALUE OF THIS PARAMETER IS INTERNALLY CALCULATED.
J. dXTIIU BYTID - OPTIONAL - THE POSITIVE INTEGER VALUES OF THESE PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS.
BZTID - THE TABLED BULK DATA CARDS WHICH DEFINE THE COMPONENTS OF THE BASE ACCELERATION VECTOR. THE
BYP1D  TABLES REFERRED TO BY BXTI0, BYTID AND B12TID
B2PT10  DEFINE MAGNITUDE (LT-2) AND THE TABLES REFERRED TO
BY BXTI0, BYTID AND B12TID DEFINE PHASE (DEGREE).
THE DEFAULT VALUES ARE -1 WHICH MEANS THAT THE
RESPECTIVE TERMS ARE IGNORED.
K. NOKPRT -  AN INTEGER VALUE OF 61 FOR THIS
PARAMETER WILL CAUSE THE CURRENT HARMONIC INDEX:
KINDA, TO BE PRINTED AT THE TOP OF THE HARMONIC
LOOP. THE DEFAULT VALUE IS 61.
L. GRUPN1 -  OPTIONAL - A POSTIVE INTEGER VALUE OF THIS
PARAMETER WILL CAUSE THE GRID POINT WEIGHT
GENERATOR TO BE EXECUTED AND THE RESULTING WEIGHT
BALANCE INFORMATION TO BE PRINTED. DEFAULT IS -1.
M. WMASS -  OPTIONAL - THE TERMS OF THE STRUCTURAL MASS
MATRIX ARE MULTIPLIED BY THE REAL VALUE OF THIS
PARAMETER WHEN THEY ARE GENERATED IN EMG. THE
DEFAULT IS 1.0.
N. GUJPMAS5 -  FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.
G. GRAD -  OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS
USED TO TELL THE GRAD MODULE THE DESIRED FORM OF
MATRICES KOU, BUD AND MOU. THE BCD VALUE CAN BE
FREKESP OR TRANKESP. THE DEFAULT IS TRANKESP.
SEE SECTION 9.3.3 (DIRECT DYNAMIC MATRIX ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE
NASTRAN THEORETICAL HANnAL.
P. LGKAD -  OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
IS USED IN CONJUNCTION WITH PARAMETER GRAD. IF
GRAD=GRANDESP THEN SET LGKAD=1. IF GRAD=TRANKESP
THEN SET LGKAD=-1. THE DEFAULT VALUE IS -1.
Q. G -  OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A UNIFORM STRUCTURAL DAMPING COEFFICIENT
IN THE DIRECT FORMULATION OF DYNAMICS PROBLEMS.
R. W3 -  OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR UNIFORM STRUCTURAL
DAMPING IF PARAMETER GRAD=TRANKESP. IN THIS CASE
W3 IS REQUIRED IF UNIFORM STRUCTURAL DAMPING IS
DESIRED. THE DEFAULT VALUE IS 0.0.
S. W4 -  OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR ELEMENT STRUCTURAL
DAMPING IF PARAMETER GRAD=TRANKESP. IN THIS CASE
W4 IS REQUIRED IF STRUCTURAL DAMPING IS DESIRED FOR
ANY OF THE STRUCTURAL ELEMENTS. DEFAULT IS 0.0.

REMARKS:
1. THE ANALYSIS WILL LOOP THRU A RANGE OF THE CYCLIC INDEX,
   KINDA = KMIN TO KMAX.
ORIGINAL PAGE IS OF POOR QUALITY

NASTRAN EXECUTIVE CONTROL DECK ECH

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PARAM  //C,N,NUT /V,N,FRETIME $  
PARAM  //C,N,LE /V,N,NOFREV /V,N,FRESET /C,N,0 $  
PARAM  //C,N,LE /V,N,NUTIME /V,N,TIMESET /C,N,0 $  
COND   ERRORCN+TERNL $ BOTH FREQ AND TSTEP IN CASE CONTROL DECK.  
$ EPONT BULK DATA NOT ALLOWED  
PARAM  //C,N,NUT /V,N,EXTRAPTS /V,N,NOQUE $  
COND   ERRORCN+EXTRAPTS $  
$ GENERATE DATA FOR CYICT2 MODULE.  
GPCYC  GSEM4,EUQTYN,USETDY /CYCDU /V,N,CTYPE=RGT /S=N,NOMGG $  
LCNG  ERRORCN+NOGC $  
CHKPT  CYCDU $  
ALTR  32 $  
$ PRE-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED  
PARAM  //C,N,UR /V,N,NOBM1 /V,N,NOMGG /V,N,NUKPS $  
PURGL  B1GG,M1GG /NOMGG $  
PURGL  M2GG,M2BASEG $ /NOMGG $  
ALTR  35 $  
$ CLINEKATE DATA BLOCKS FRRLX, B1GG, M1GG, M2GG AND BASLAX.  
$ GENERATE PARAMETERS FKMAX AND NBASEX.  
LUPMOD1 CASLM4,SDPML,CLTH,DSW,FRL,X,NOMAX, /FRLX,B1GG,M1GG,  
M2GG,4ASLG,PDZERG, /V,N,NUMGG/V,Y,LYGIC/V,Y,INSEG/  
V,Y,PKMAX/S,Y,PKMAX/V,Y,BXTID=-1/V,Y,BXTID=-1/  
V,Y,SYTID=-1/V,Y,SYTID=-1/V,Y,BXTID=-1/  
V,Y,OZTID=-1/S,N,NBASEX/V,N,NUFREV/V,N,OMEGA $  
PARAM  FRLX //C,N,PRESLEN //V,N,NCFRRLX $  
COND   LBLFRXL,NCFRRLX $  
EQUIV  FRLX,FRL $  
LABEL  LBLFRXL $  
CHKPT  FRLX,B1GG,M1GG,M2GG,DASEXG $  
ALTR  42 $  
PARAM  //C,N,ADDU /V,N,NUGDG /V,N,NOBMI /C,N,0 $ RESET NUGDG.  
ALTR  52 $  
$ HLE51 IN BGG AND KGG.  
COND   LBL11A,NOBMI $  
PARAM  //C,N,COMPLEX /V,N,OMEGA2 /C,N,0,0 / V,N,CMPLX1 $  
PARAM  //C,N,SBG /V,N,MCHLGASQ /C,N,0,0 / V,N,OMEGASOR $  
PARAM  //C,N,COMPLEX /V,N,SHOMEGASQ /C,N,0,0 / V,N,CMPLX2 $  
ALC  BGG,B1GG / BGG / C,N,(1.0,0.0) / V,N,CMPLX1 $  
EQUIV  BGG1,BGG $  
PADD  KGG1,M1GG / KGG1 / C,N,(1.0,0.0) / V,N,CMPLX2 $  
EQUIV  KGG1,KGG $  
CHKPT  BGG,KGG $  
LABEL  LBL11A $  
ALTR  53,55 $ GT+ HAS BEEN MOVED-UP.  
ALTR  89,98 $ LDU HAS BEEN MOVED-UP.  
ALTR  114 $ PARAM AND EQUIV LOGIC DEPENDING ON LKRAO FOR FREQ OR TRAN.  
PARAM  //C,N,ANDU/V,N,KEKA/V,N,NOQUE/V,N,NOK2PP $  
COND   LKRAO,LKRAO $ BRANCH IN NT FREDSP.  
ALTR  115 $ SEE ALTR 114 COMMENT.  
JUMP  LKRAO2 $
LABEL  LOKAD4 $   
LQUIV  H2PP,M2DD/NGA/b2PP,K200/NGA/K2PP,K2DO/NGA/MAA,MHD,MDEK/ 
       KAA,KDD/KDEKA & 
CHKPTN  K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MDD $ 
LABEL  LOKAD2 $ 
ALTER  117,117 $ ADU PARAMETERS GKAAD, H3 AND H6 TC GKAAD. 
GKAAD  USEXO:GN,GO,KAA,JAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDO,MDD,MHD, 
       GDD,K2DD,H2DD,B2DD/C,Y,GKAAD=TRANESP/C,N,DIRECT/ 
       C,Y,G=0.0/C,Y,N=0.0/C,Y,.4=0.0/V,N,NUK2PP/V,N,NUM2PP/V,N,NUB2PP/V,N,NMPF1/V,N,SINGLE/V,N,OHIT/V,N,NGUE/V,N,NUK4GG/ 
       V,N,NUBGO/V,N,KDEK2/C,N,-1 $ 
ALTER  118 $ SEE ALTER 114 COMMENT. 
ALCD  LOKAD3,LOKAD $ BRANCH IF NOT FREQESP. 
ALTER  119 $ SEE ALTER 114 COMMENT. 
JUMP  LOKAD4 $ 
LABEL  LOKAD3 $   
LQUIV  D2DC,BDD/NUGPT/K2DD,MDD/NOSIMP/K2DD,KDD/KDEK2 $ 
LABEL  LOKAD4 $   
ALTER  120,123 $   
   * NEW SOLUTION LOGIC   \$  
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL. 
CCDC  LALIKL1,NOTIME $   
$ ALCD  TVH ALL SUBCASES FOR TIME-DEPENDENT LOADS. 
PARAM //C,N,MPY /V,N,REPEATT /C,N,-1 /C,N,-1 $   
PARAM //C,N,AUD /V,N,APPFLG /C,N,1 /C,N,0 $   
   * INITIALIZE FOR SOL1. 
JUMP  TRLGLOOP $   
LABEL  TRLGLOOP $   
CASE  CASLCA/CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NOLUCCI $   
CHKPTN  CASLBY $   
PARAM //C,N,MPY /V,N,NCLL /C,N,0 /C,N,1 $   
TRLG  CASLBY,USET1,ULT,SLT,UGPOT,SIL,CSTM,TRL,UIT,GMJ,GUO,EST,HGG/ 
       *PLT1,PD1,TCL/V,N,NGSLT/S,N,PDPBDU/V,N,NCLL $   
SURF  TRL,POD1,............ / PD1V /V,N,APFLLG/C,N,DYNAMICS $   
SURF  TRL,PO1,............ / PD1 /V,N,APPFLG/C,N,DYNAMICS $   
PARAM //C,N,AUD /V,N,APPFLG /V,N,APPFLG /C,N,1 $   
   * APPFLG=APPFLG1. 
CCCD  TRLGLONE,REPEATT $   
KEPL  TRLGLOCP,10C $   
JUMP  LRRCK3 $   
LABEL  TRLGOUNL $   
CHKPTN  PLT,PD,TDL $   
LQUIV  PC,PO/TPLBDU $   
CHKPTN  PCT $   
GUMOD2  TCL,............ / FRLZ,TLGZ,RENDZ,KLCRUERZ $   
       V,Y,NSESE,V,Y,YCYC10/S,Y,NMAX=-1/V,N,FKMAX/ 
       S,N,FLMAX/S,N,NSTEPS/S,N,KGRC1/S,N,KGRC2 $   
LQUIV  FRLZ,FRL // FULZ,FCL $   
CHKPTN  FRL,FCL,KEURER1,KEURERZ $   
JUMP  LHRFLZL2 $   
LABEL  LULTRL1 $   
   * GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC. 
2.11
NASTRAN EXECUTIVE CONTROL DECK ECHO

EQUIV PXF2, PXF1 $ 
CHKPT PXF1 $ 
JUMP LBLTRL3 $ 
LABEL LBLTRL2 $ 
$ CYC IC = 61 
MPYAD PDX1/KEORDER1 / PDX2 / C,N,0 $ 
CYC1 PDX2 / PXTR2, NCGYCF4 / V,N,CTYPE/C,N,FORE/V,N,NSEGS/V,Y,LMAX/ 
V,Y,NSEGS/S,N,NGGC $ 
COND ERRUGA1,NGGC $ 
CHKPT PXTR2 $ 
EQUIV PXTR2, PXTR2/NURD2 $ 
COND LBLR02, NURD2 $ 
MPYAD PXTR2 /KEORDER2 / PXTR2 / C,N,0 $ 
LABEL LBLR02 $ 
CYC1 PXTR2 / PXF2, NCGYCF4 / V,N,CTYPE/C,N,FORE/V,Y,NSEGS/V,Y,KMAX/ 
V,Y,FLMAX/S,N,NGGC $ 
COND ERRUGA1,NGGC $ 
EQUIV PXF2, PXF1 $ 
CHKPT PXF1 $ 
LABEL LBLTRL3 $ 
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND 
$ TO FREQUENCY DEPENDENT LOADS. ALSO SUR2 EXPECTS LOADS TO BE COMPLEX 
$ IN FREQUENCY TYPE PROBLEMS. 
$ CDFN1 NLOAD FCG CYC2. 
PARAM //C,N,AUD / V,N,NSLAD / V,N,FLMAX / C,H,0 $ NLCMD = FLMAX 
LABEL LBLPDMONE $ 
PARAM //C,N,AUD / V,N,KNDEX / V,Y,KMIN=0 / C,N,0 > INITIALIZE KNDEX. 
$ INITIALIZE UXVF IF KMIN IS NOT ZERO. 
$ PARAM //C,N,AUD / V,N,KMINL / V,Y,KMIN / C,N,1 $ 
COND NUKMINL,KMINL > 
PARAM //C,N,AUD / V,N,KMINV / C,N,0 / C,N,0 $ 
JUMP KMINLUP $ 
LABEL KMINLUP $ 
CYC2 CYCUD, PFX2, / PFX2, / C,N,FORE/V,Y,NSEGS/ 
V,N,KMINV/V,N,CGYCF2/V,N,NLCMD/S,N,NGGC $ 
COND ERRUGA1,NGGC $ 
ASC PKF2 / UXVFZ / C,H,(0.0,0.0,0) $ 
CYC2 CYCUD, UVFZ, / UXVFZ, / C,N,BACK/V,Y,NSEGS/ 
V,N,KMINV/V,N,CGYCF2/V,N,NLCMD/S,N,NGGC $ 
COND ERRUGA1,NGGC $ 
PARAM //C,N,AUD / V,N,KMINV / V,N,KMIN / C,N,1 $ 
KEPT KMINLUP,KMINL $ 
LABEL NUKMINL $ 
$ JUMP TCPCYC $ 
LABEL TCPCYC $ LOOP CN KNDEX
NASTRAN EXECUTIVE CONTROL DECK ECHO

CCND  NDKPRT,NDKPRT $  
PRTPARM  //C,N=0 /C,N=INDEX $  
LABEL  NDKPRT $  
CYCT2  CYCDU,KDU,MDU... /KKKF,HKKF... /C,N,FOKE/V,Y,NSEG $  
         V,N,INDEX/V,N,CYCEQ=-1/V,N,LOAD/S,N,NGC $  
COND  ERKRL1,NGC $  
CHAMPNT  KKRF,MMKF $  
PARAM  //C,N,SYST //C,N,56 /C,N,2 $  METHOD 3T IN CYCT2 PRODUCES  
        UNDERFLOW FOR PXF, USE METHOD 2.  
        CYCT2  LYCDU,DDU,PXF... /BKF,PKF... /C,FUKE/V,Y,NSEG $  
         V,N,INDEX/V,N,CYSEQ/V,N,LOAD/S,N,NGC $  
PARAM  //C,N,SYST //C,N,58 /C,N,0 $  RESET MPYAD METHOD CONTROL.  
         CYCT2  LERKRL1,NGC $  
CHAMPNT  BKF,PKF $  
$ SOLUTION  FRKU2  KKKF,BKKF,MMKF...PRF...FOL /UKVF /C,N=0 /C,N=0 /C,N=-1.0 $  
CHAMPNT  UKVF $  
        CYCT2  LYCDU,DDU,PXF... /UKVF... /C,N,BACK/V,Y,NSEG $  
         V,N,CYCEQ/V,N,LOAD/S,N,NGC $  
COND  LERKRL1,NGC $  
CHAMPNT  UKVF $  
PARAM  //C,N,AUX /V,N,INDEX/V,N,INDEX/C,N,1 $  INDEX = INDEX + 1  
        CYCT2  LCY2,DONE...IF INDEX GT KMAX THEN EXIT  
        CYCT2  LCY2,DONE...IF INDEX GT KMAX THEN EXIT  
KEPT  TLPLCYL,1CC $  
JUMP  ERR0R3 $  
LABEL  LCY2 $  
EQUIV  UXVF,UDVF / CYCL $  
CHAMPNT  UDVF $  
COND  LCY3,LCYU $  IF CYCL GE 0 THEN TRANSFORM TO PHYSICAL.  
        CYC1  UXVF / UDVF / UCYL / V,N,CTYPE/C,N,BACK/V,Y,NSEG/V,Y,KMAX/$  
         V,F,LOAD $  
CHAMPNT  UDVF $  
LABEL  LCY3 $  
COND  LCY3,LCY4,NUTIME $  
EQUIV  PXF,PXF / CYC1 $  
COND  LCY4,LCYU $  IF CYC1 GE 0 THEN TRANSFORM TO PHYSICAL.  
        CYC1  PXF / PPF2/UCYL / V,N,CTYPE/C,N,BACK/V,Y,NSEG/V,Y,KMAX/$  
         V,F,LOAD $  
LABEL  LCY4 $  
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF.  
$SDF  USEP...PFZ... /PPFZ... /C,N,DYNAMICS $  
$SCE  USEP...JN,J.../SPLU...PPFZ.../PCDE,PSF,PLDU $  
EQUIV  PPFZ,PPF // PSFZ,PSF $  
CHAMPNT  PPF,PSF $  
LABEL  LCY4 $  
ALTER  124,126 $ USE FOL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  
VOR  CASLX,E=0,YUS,USEP...UDVF,FOL/UCYL /V,DYCEQ /C,N,FREQUENCIES/C,N,  
         DIRECT/S,N,NGCR/2/S,N,NGP/C,N,0 $  
ALTER  140,140 $ USE FOL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.
NASTRAN EXECUTIVE CONTROL DECK ECHO

SUR2 CASEXX,CSTH,MPT,JOIT,EDYNY,SILD,EPDP,FLL,UPC,UPVC,EST,XYCOB,PPF/UPPCI,UPPCI,UPVCI,USC,UPFCI,UPVCI,CN,FREORSP/
S,N,NOSUR,2$

ALTER 160 $ ADD LABEL FOR ERROR3$
LABEL ERROR3$
ALTER 103,166 $ REMOVE ERROR1 AND ERROR2$
ALTER 168 $ FORCED VIBRATION ERRORS
LABEL ERROR1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
PKTPARM /C,J,-7 /C,J,CYCLSTATICS$
LABEL ERROR2 $ COUPLED MASS NOT ALLOWED
PKTPARM /C,J,0 /C,J,COUPMASS$
JUMP FINIS$
LABEL ERROR3 $ SUPPORT BULK DATA NOT ALLOWED.
PKTPARM /C,J,-6 /C,J,CYCLSTATICS$
LABEL ERROR4 $ EPOINT BULK DATA NOT ALLOWED.
PKTPARM /C,J,0 /C,J,NEGUE$
JUMP FINIS$
LABEL ERROR5 $ NEITHER FREU OR TSTEP WERE IN BULK DATA DECK.
PKTPARM /C,J,0 /C,J,NEGUE$
PKTPARM /C,J,0 /C,J,NUTRL$
JUMP FINIS$
LABEL ERROR6 $ BOTH FREU AND TSTEP WERE SELECTED IN CASE CONTROL.
PKTPARM /C,J,0 /C,J,NOFREU$
PKTPARM /C,J,0 /C,J,NOTIM$
JUMP FINIS$
LNLALTER
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.4.2 DMAP Sequence for Forced Vibration Analysis of Rotating Cyclic Structures

OPTIONS IN EFFECT GO ERR=2 NOLIST NODECK NOREF NOOSCAR
1 BEGIN NO.8 FORCED VIBRATIONS OF ROTATING CYCLIC STRUCTURES - SERIES R
2 PKLCHK ALL $
3 FILE KGGX=TAPE/KGG=TAPE/CUD=SMD=SAVE/GMD=SAVE/MDD=SAVE/BDD=SAVE $
4 FILE UXVF=APPEND/PDT=APPEND/PD=APPEND $
5 CUNQ ERRRC1,NSEGS IF USER HAS NOT SPECIFIED NSEGS.
6 CUNQ ERRRC1,KMAX IF USER HAS NOT SPECIFIED KMAX.
7 PARAM //C,N,E2 /V,N,CYCIERR /V,Y,CYCI=0 /C,N,0 $
8 CUNQ ERRRC1,CYCIERR IF USER HAS NOT SPECIFIED CYCI.
9 PARAM //C,N,DIV /V,N,NSEG2 /V,Y,NSEGS /C,N,2 $ NSEG2 = NSEGS/2
10 PARAM //C,N,SUB /V,N,KMAXERR /V,N,NSEG2 /V,Y,KMAX $
11 CUNQ ERRRC1,KMAXERR IF KMAX GT NSEGS/2
12 PARAM //C,N,NUP /V,Y,NOKPRT=11 /V,Y,LGKAD=-L $
13 PARAMR //C,N,MPY /V,N,OMEIII /V,Y,RPS=C.0 /C,N,6.283185 $
14 PARAMR //C,N,MPY /V,N,OMEII2 /C,N,2.0 /V,N,OMEII $
15 PARAMR //C,N,MPY /V,N,OMEIISUP /V,N,OMEII /V,N,OMEII $
16 PARAMR //C,N,EQ //V,Y,RPS /C,N,0,0 ///V,N,NURPS. $
17 PARAMR //C,N,NUT /V,N,NOLUMP /V,Y,COUPMASS=-1 $
18 CUNQ ERRRC2,NOLUMP $
19 PARAM //NMPY/*/CARDNO/0/C $
20 GPL GEOM1,GECM2,GPL,EQEXIN,GPDT,CLSTP,BGPDTSIL/S,N,LUSET/ S,N, NUGPDTS $
21 PLTTRAN BGPDTSIL/HPDPSIL/LUSET/S,N,LUSEP $
22 PURGE USETS,GM,GO,KAA,RAA,AAL,KAAA,KF5,PSF,QPC,EST,ECT,PLTSETX,PLTPAR, GPSETS,ELSETS/NUGPDTS $

2.16
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

23 COND LBL5,NOGPDT $
24 GP2 GEOM2,EQEXIN/ECT $
25 PARAM PCDB/*PRESC///NOPCDB $
26 PURGE PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
27 COND P1,NOPCDB $
28 PLTSET PCDB,GEOM2,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/ S,N, JUMPPLOT=1 $
29 PRTMSG PLTSETX// $
30 PARAM /*MPY*/PLTFLG/L/1 $
31 PARAM /*MPY*/PFILE/0/0 $
32 COND P1,JUMPPLOT $
33 PLT PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLTXX1/ NSIL/LUSE/S,N,JUMPPLOT/S,N,PLTFLG/S,N,PFILE $
34 PRTMSG PLTXX1/$
35 LABEL P1 $
36 GP3 GEOM3,EQEXIN,GEOM2 / SLT,GPTT / V,N,NOGRAV $
37 CHKPTT SLT,GPTT $
38 1A1 ECT,GPTT,BGPDT,SIL,GPTT,CEM/EST,GEI,GPECT,,/LUSE/S,N,NGSIMP= -1/L/S,N,NGENEL=-1/S,N,GENEL $
39 PURGE KG6,GPST,DPST,SG,BOO,MG,BOO,K4NN,K4FF,K4AA,1NA,MFF,MAA,BNN,BFF,BAA, KGEX/NSIMP/CPST/GENEL $
40 PARAM /*C,N,MPY /V,N,NSKP /C,N,0 /C,N,0 $
42 PURGE G4,GM,GM/MPF1/GO,GO,OMIT/KFS,PSF,QPC*/SINGLE $
43 CHKPTT GM,GM,GM,GO,GO,GO,GM,PSF,QPC/USET,YS $
LEVEL 2.0 NASTRAN DL/PS COMPILER - SOURCE LISTING

44 PARAM //C,N,NOT /V,N,REALDATA /V,N,REACT $

45 COND ERRORC3,REALDATA $

46 UPD DYNAMICS,S/GPL,S/LSET /GPD,S/LSETU,TFPGD,L,OLT,PSDL,FRL,,
TRL,B,EQDYQ /V,N,LUSET/S,N,LSETU/V,N,NUF/R/S,N,NDLTX/S,
S,N,NGPSDL/S,N,NCFRL/V,N,NOMFT/S,N,NOTRL/V,N,NOED/C,N,/
S,N,NOUE $

47 PARAM //C,N,ANG /V,N,FTERR /V,N,NCFRL /V,N,NOTRL $

48 COND ERRORC9,FTERR $ NC FREQ OR TSTEP BULK DATA.


51 PARAM //C,N,MIPY /V,N,FREETIME /V,N,FREQSET /V,N,TIMESET $

52 PARAM //C,N,NOT /V,N,FTERRL /V,N,FREETIME $

53 PARAM //C,N,LE /V,N,NUMRQ /V,N,FREQSET /C,N,0 $ 54 PARAM //C,N,LE /V,N,NOMTIME /V,N,TIMESET /C,N,0 $

55 COND ERRORC6,FTERRL $ BOTH FREQ AND TSTEP IN CASF CONTROL DECK.

56 PARAM //C,N,NOT /V,N,EXTRAPTS /V,N,NCUE $ 57 COND ERRORC4,EXTRAPTS $ 58 GPCYC GEW4,EQDYQ,USETU /CYCDO /V,N,CTYPE=ROT /S,N,NOG $ 59 COND ERRORC1,NOG $ 60 CHKPT CYCDO $

61 COND LBL1,NLNSIMP $ 62 PARAM //ADD*/NUGG/1/0 $ 63 PARAM //ADD*/NUGG/1/0 $ 64 PARAM //ADD*/NUGG=1/1/0 $ 65 PARAM //ADD*/NUGG/1/0 $ 66 EM4 EST,CS,T*M,P,F,DIT,GEW4, /KLM,KUICT,HEL,H,MDICT,DELMT,DDLMT/ S,
N,N2KGX/S,N,NOG /S,N,NOG/NET/S,N,NETNKN/CP,CP,CPMASS/C,Y,
CPBAR/C,Y,CPBRD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIAL/C,Y,

2.18
LEVEL 2.0 NASTRAN DMAP COMPILERT - SOURCE LISTING

67 COND LBLKGGX,NOKGGX $ 
68 EMA GPECT,KDICT,KELM/KGGX,GPST $ 
69 LABEL LBLKGGX $ 
70 PARAM ///C,N,OF ///V,N,NOMBML ///V,N,NOMGG ///V,N,NOKPS $ 
71 PURGE M2GG,M2BASEXG /NOMGG $ 
73 COND LBLMGG,NOMGG $ 
74 EMA GPECT,MUDICT,MELM/MGG,-1/C,Y,NTM=1.0 $ 
75 LABEL LBLMGG $ 
77 PARAM FRLX ///C,N,PRES/ ///V,N,NDFRLX $ 
78 COND LBLFRXLX,NDFRLX $ 
79 EQUIV FRLX,FRL $ 
80 LABEL LBLFRXLX $ 
81 CHKPT FRL,B1G,G,M1G,G,M2GG,BASEXG $ 
82 COND LBLBGG,NOBCCG $ 
83 EMA GPECT,KDICT,BELM/RGG, $ 
84 LABEL LBLBGG $ 
85 COND LBLK4GG,NOK4GG $ 
86 EMA GPECT,KDICT,KELM/K4GG,NOK4GG $ 
87 LABEL LBLK4GG $ 
88 PURGE MNN,MFF,MAA/NOMGG $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

99 PARAM //C,N,ADD //V,N,NOBGG //V,N,NODIM1 /C,N,U $  \hspace{1cm} \text{RESET NOBGG.}
90   \text{PURGE} \hspace{0.5cm} \text{BNN,OFF,BAA,NOBGG $}
91   \text{COND} \hspace{1cm} \text{LBL1,GRDPNT $}
92   \text{COND} \hspace{1cm} \text{ERROR4,NOBGG $}
93   \text{GPW}G \hspace{1cm} \text{BGP,DP,CSTH,EQEXIN,NOG/CMPGN/V,Y,GRDPNT=-1/C,Y,NTMASS $}
94   \text{DFF} \hspace{1cm} \text{OPWG,++,//S,N,CARDNO $}
95   \text{LABEL} \hspace{1cm} \text{LBL1 $}
96   \text{EQUIV} \hspace{1cm} \text{KGGX,KGG/NOGENL $}
97   \text{COND} \hspace{1cm} \text{LBL11,NOGENL $}
98   \text{SAM}3 \hspace{1cm} \text{GEI,KGGX/KGG/LUSET/NOGENL/NOSIMP $}
99   \text{LABEL} \hspace{1cm} \text{LBL11 $}
100  \text{COND} \hspace{1cm} \text{LBL1IA,NORM1 $}
101  \text{PARAM} \hspace{1cm} //C,N,COMPLXX //V,N,OMEAGA2 /C,N,0.0 / V,N,CMPLX1 $
102  \text{PARAM} \hspace{1cm} //C,N,SUB / V,N,OMEGASQ / C,N,0.0 / V,N,CMPEGASQK $
103  \text{PARAM} \hspace{1cm} //C,N,COMPLEX // V,N,OMEGASQ / C,N,0.0 / V,N,CMPLX2 $
104  \text{ADD} \hspace{1cm} \text{BGG,BLGG / BGG1 / C,N,(1.0,0.0) / V,N,CMPLX1 $}
105  \text{EQUIV} \hspace{1cm} \text{BGG1,BGG $}
106  \text{ADD} \hspace{1cm} \text{KGG,M1GG / KGG1 / C,N,(1.0,0.0) / V,N,CMPLX2 $}
107  \text{EQUIV} \hspace{1cm} \text{KGG1,KGG $}
108  \text{CHKPNT} \hspace{1cm} \text{BGG,KGG $}
109   \text{LABEL} \hspace{1cm} \text{LBL1IA $}
110   \text{COND} \hspace{1cm} \text{LBL4,GENEL $}
111   \text{COND} \hspace{1cm} \text{LBL4,NOSIMP $}
112  \text{PARAM} \hspace{1cm} //*EQ*/GPSPFLG/AUTOSPC/O $
113  \text{COND} \hspace{1cm} \text{LBL4,GPSPFLG $}

2.20
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

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2.21
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

139 COND     LBL5,NOK4BG $     4  
140 SYS2      USET,GO,K4FL/24AA $  
141 LABEL     LBL5 $            4  
142 EQJ IV    GO,GOD/NOQUE/GM,GMD/NCLE $  
143 PARAM     //=ADD*/NEVER/1/O $  
144 PARAM     //=MPY*/REPEATF/-1/I $  
145 BHG       MATPOOL,BGPD*T,EQEXIN,CSTM/8DPCLC/S,N,NCKHFL/S,N,NOABFL/ S,N, MFACT S  
146 PARAM     //=AND*/NOFL/NOABFL/NOKFL $  
147 PURGE     KBFL/NOKFL/ ABFL/NOABFL $  
148 COND     LBLFL3,NCFL $  
149 MTRXIN   ,HPOOL,EQDYN,,/ABFL,KRFL,/LUSETO/S,N,NOABFL/S,N,NOKBFL/0 $  
150 LABEL     LBL13 $  
151 JUMP     LBL13 $  
152 LABEL     LBL13 $  
153 PURGE     OUDVC1,ULOVC2,XYPLTFA,UPPC1,GQPC1,GUPVC1,CESC1,GECF1,UPPC*, DQPC2,0UPVC2,DES2,CESC2,GECF2,XYPLTF,PSDF,AUTG,XYPLTR, K2PP,M2PP, BZPP,K2PP,D2PP,B2PP/NEVER $  
154 CASE      CASECC,PSDL/CASEXX/FREQ*/S,N,REPEATF/S,N,NOLODPP $  
155 MTRXIN   CASEXX,MAUTPOOL,EQDYN,,TFPCOL/K2OPP,M2OPP,B2PP/LUSETO/S,N, NOK2DPP/S,N,NOK2DPP/S,N,NCB2PP $  
156 PARAM     //=AND*/NOK2PP/NOABFL/NCB2DPP $  
157 PARAM     //=AND*/NOK2PP/NOFL /NCK2DPP $  
158 EQJ IV    M2DPP,K2PP/NOABFL S   4  
159 ADDS ABFL,KBFL,K2DPP,,/K2PP/(1-1,0,0) $  
160 COND     LBLFL2,NCABFL $  
161 TRN5P     ABFL/AUFLL $  

2.22
LEVEL 2.0 NASTRAN MAP COMPILER - SOURCE LISTING

162 ADD ABFLT, M22PP/NO2PP/IMPACT $  
163 LABEL LBLFL2 $  
164 PARAM //AND*/BDEBA/NOQUE/KGB2PP $  
165 PARAM //AND*/KDEK2/NOGENL/NOSIMP $  
166 PARAM //AND*/MDEMA/NOQUE/NCN2PP $  
167 PURGE K2DD/NOK2PP/M2DD/NOK2PP/B2DD/NOB2PP $  
168 PARAM //C, N, AND/V, N, KDEKA/V, N, NOQUE/V, N, NCK2PP $  
169 COVD LGKAD1, LGKAD2 $ BRANCH IN NOT FREQRESP.  
171 JUMP LGKAD2 $  
172 LABEL LGKAD1 $  
174 CHK PNT K2PP, M2PP, B2PP, K2DD, M2DD, B2DD, KDD, MDD $  
175 LABEL LGKAD2 $  
176 COVD LBL18, NOGPD $  
177 G K A D USETO, CM, GO, KAA, BAA, KAA, K44A, K2PP, M2PP, B2PP/KDD, BDD, MDD, GMD, 
178 LABEL LBL18 $  
179 COVD LGKAD3, LGKAD4 $ BRANCH IF NOT FREQRESP.  
180 EQUIV B2DD, BDD/NO8GG/ M2DD, MDD/NOSIMP/ K2DD, KDD/KDEK2 $  
181 JUMP LGKAD4 $  
182 LABEL LGKAD3 $  
183 EQUIV B2DD, BDD/NO8PD/M2DD, MDD/NOSIMP/K2DD, KDD/KDEK2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

184 LABEL LOCKAD4 $  
185 COND LBLTRL1,NOTIME $  
186 PARAM //C,N,MPY /V,N,REPEATT /C,N,1 /C,N,-1 $  
187 PARAM //C,N,AUD /V,N,APPFLG /C,N,1 /C,N,0 $ INITIALIZE FOR SDRI.  
188 JUMP TRLGLCOP $  
189 LABEL TRLGLCOP $  
190 CASE CASECC,CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NCCLLGPL1 $  
191 CHKPTN CASEYY $  
192 PARAM //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1 $  
193 TRLG CASEYY,USETD,DLT,SLT,BGPD1T,SIL,CSTM,TRL,DIT,GMD,GOO,EST,MGG/,,PDT1,PDL1,TOL/ V,N,NGSET/S,N,PDEPDC/V,N,NCOL $  
194 SDRI TRL,PDT1,.........,/PDT1,/V,N,APPFLG/C,N,DYNAMICS $  
195 SDRI TRL,PDL1,.........,/PDL1,/V,N,APPFLG/C,N,DYNAMICS $  
197 COND TRLGDONE,REPEATT $  
198 REPT TRLGDONE,100 $  
199 JUMP ERROR3 $  
200 LABEL TRLGDONE $  
201 CHKPTN PDT,PDL,TOL $  
202 LQIV PD,PDT,PDEPDC $  
203 CHKPTN PDT $  
204 DUMMY2 TDL,.........,/FKLZ,FGLZ,REORDER1,REORDER2,.........,/ V,Y,NSELGS/V,Y,CYCIC/S,Y,LMAX=-1/V,N,FKMAX/ S,N,FLMAX/S,N,NTSTEPS/S,N,NGROI/S,N,NGRO2 $  
205 LQIV FKLZ,FRL //FOLZ,FCL $  
206 CHKPTN FRL,FOL,REORDER1,REORDER2 $  
207 JUMP LULFRL2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

208 LABEL LBLTRL1 $
209 FRLG CASEXX,USETD,DLT,FRL,GMD,GCD,DIT, / PPF,PSF,PDF,FOL,PHDUM / C,N,DIRECT/V,N,FREQ/C,N,FREQ$
210 CUND LBLFRLX1,NOFLRX $ ZER0 DLT LOAD COLUMNS IF FRLX HAS GENERATED $
211 MPYAD PPF,PDZERO, / PPFX /C,N,O $
212 EQUIV PPFX,PPF $
213 LABEL LBLFRLX1 $
214 CUND LBLFRL1,NOBASEX $
215 MPYAD M2GG,BASEXG, / M2BASEXG /C,N,O $
216 ADD PPF,M2BASEXG / PPF1 /C,N,(1.0,0.0) /C,N,(-1.0,0.0) $
217 EQUIV PPF1,PPF $
218 CUND LBLBASE1,NOSET $
219 SSG2 USETD,GMD,YS,KFS,GCD,PPF / PPDFUM,PSFL,PDF1 $
220 EQUIV PSFL,PSF // PDF1,PDF $
221 LABEL LBLBASE1 $
222 LABEL LBLFRL1 $
223 EQUIV PPF,PDF/NOSET $
224 CHKNT PPF,PSF,PDF,FOL $
225 PARAML PDF //C,N,TRAILER /C,N,1 /V,N,PDFCGLS $
226 PARAM //C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,N,FKMAX $ NLOAD = NF/FKMAX $
227 EQUIV PDF,PIXF/CYCLIC $
228 CUND LBLDUNECYCLO $
229 PARAM //C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,Y,NSEG $ NLOAD = NF/SEG $
230 CYCT1 PDF / PXF,GCYC1 /V,N,CATYPE /C,N,FCRE /V,Y,NSEG=-1 / V,Y,KMAX=-1 / V,N,KNLAD /S,N,NOGG $
231 CUND ERRORC1,NOGG $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

232 CHKPNT PXF $
233 JUMP LBLPDONE $
234 LABEL LBLTRL2 $
235 PARAM /*C,N,KUT /V,N,NOTCYCIO /V,Y,CYCIO $
236 COND LBLTRL2,NOTCYCIO $
237 EQUIV POT,PDIRZ2/NCR01 $
238 COND LBLRO1A,NOR01 $
239 MPYAD POT,KEORDER1, / PDTRZ1 / C,N,0 $
240 LABEL LBLRO1A $
241 CYC1 PDTRZ1 / PXTRZ1,GCYCF2 /V,N,CTYPE/C,N,FORE/V,N,NTSTEPS/ V,Y,LMAX/V,N,FKMAX/S,N,NG0 $
242 CYC2 ERRUC1,NG0 $
243 CHKPNT PXTRZ1 $
244 EQUIV PXTRZ1,PFZ1/NCR02 $
245 COND LBLPO2A,NORL2 $
246 MPYAD PXTRZ1,KEORDER2, / PFZ1 /C,N,0 $
247 LABEL LBLRO2A $
248 EQUIV PFZ1,PF1 $
249 CHKPNT PF1 $
250 JUMP LBLTRL3 $
251 LABEL LBLTRL2 $
252 MPYAD POT,REORDER1, / PDTRZ2 / C,N,0 $
253 CYC1 PDTRZ2 / PXTP22,GCYCF3 /V,N,CTYPE/C,N,FCRE/V,N,NTSTEPS/V,Y,LMAX/ V,Y,NSEG/S,N,NG0 $
254 COND ERRUC2,NG0 $
255 CHKPNT PXTRZ2 $

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LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

256 EQUIV PXTRZ2, PXTR2/NORO2 $
257 CND LBLRO28, NORO2 $
258 MPRAD PXTRZ2, REORDER2; / PXTR2 /C, N, 0 $
259 LABEL LBLRO29 $
261 CONV ERRORC1, NOGO $
262 EQUIV PXFZ2, PXF1 $
263 CHKPT PXF1 $ $
264 LABEL LBLTRL3 $ $
265 COPY PXF1 / PXF2 $  CONVERT REAL PXF1 TC COMPLEX PXF. $
266 ADD PXF1, PXF2 / PXF / C, N, (0.5, 1.0) / C, N, (0.5, -1.0) $ $
267 PARAM //C, N, ADD /V, N, NLOAD /V, N, FLMAX /C, N, 0 $ NLOAD = FLMAX $
268 LABEL LBLPDONE $ $
269 PARAM //C, N, ADD /V, N, KINDEX /V, Y, KMIN=0 /C, N, 0 $ INITIALIZE KINDEX $ $
270 PARAM //C, N, ADD /V, N, KMINL /V, Y, KMIN /C, N, -1 $ $
271 CONV NOKMINL, KMINL $ $
272 PARAM //C, N, ADD /V, N, KMINV /C, N, 0 /C, N, 0 $ $
273 JUMP KMINLOOP $ $
274 LABEL KMINLOOP $ $
275 CYCT2 CYCUD,, PXF,, / PTFKZ,, / C, N, FORC/V, Y, NSEG/V, N, KMINV/V, N, CYCSEG/V, N, LOADAD/S, N, ACRO $ $
276 CONV ERRORC1, NOGO $ $
277 ADD PKF2, / LKV2 / C, N, (0.0, 0.0) $ $
278 CYCT2 CYCUD,, LKV2,, / UXVF,, / C, N, BACK/V, Y, NSEG/V, N, KMINV/V, N, CYCSEG/V, N, LOADAD/S, N, ACRO $ $
279 CONV ERRORC1, NOGO $
LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

280  PARAM  //C,N,ADD /V,N,KMINV /V,N,KMINV /C,N,1 $
281  REPT  KMINLOOP,KHIAL $
282  LABEL  NOKMINL $
283  JMP  TOPCYC $
284  LABEL  TOPCYC $ LOOP ON KINDEX
285  COND  NOKPRT,NOKPRT $
286  PRTPARM  //C,N,0 /C,N,KINDEX $
287  LABEL  NOKPRT $
288  CYCT2  CYCODD,KDD,MOD... /KKKF,HHKF... /C,N,FORE/V,Y,NSEGS / V,N,KINDEX/V,N,CYSEQ=-1/V,N,LOAD/S,N,NGCC $
289  COND  ERRRC1,NOGU $
290  CHKPTN  KKKF,HHKF $
291  PARAM  //C,N,SYST //C,N,58 /C,N,2 $ METHOD 37 IN CYCT2 PRODUCES
292  CYCT2  CYCODD,DD,XXFX... /BKK,PPKF... /C,N,FORE/V,Y,NSEGS/ V,N,KINDEX/V,N,CYSEQ/V,N,ALCAD/S,N,NOGO $
293  PARAM  //C,N,SYST //C,N,58 /C,N,0 $ RESET MPYAD METHOD CONTROL.
294  COND  ERRRC1,NOGU $
295  CHKPTN  BKKF,PKF $
296  FRD2  BKKF,BKKF,HHKF...PKF,FCL / UKVF /C,N,0.0/C,N,0.0/C,N,-1.0 $
297  CHKPTN  UKVF $
298  CYCT2  CYCOD,...LKVF... /UXVF... /C,N,BACK/V,Y,NSEGS/V,N,KINDEX/ V,N,CYSEQ/V,N,ALCAD/S,N,NGCC $
299  COND  ERRRC1,NOGU $
300  CHKPTN  UXVF $
302  PARAM  //C,N,SUB /V,N,DONE /V,Y,PKAX /V,N,KINDEX $
303  COND  LCYC2,DONE $ IF KINDEX .GT. KMAX THEN EXIT

2.28
LEVEL 2.0 NASTRAN DHAP COMPILERS - SOURCE LISTING

304 REPT TOPCYC=100 $
305 JUMP ERROR3 $
306 LABEL LCYC2 $
307 EQUIV UXVF,UDVF / CYCIO $
308 CHKPT UDVF $
309 COND LCYC3,CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
310 CYC1 UXVF / UDVF,GCYCL1 / V,N,CYPE/C,N,BACK/V,Y,NSEG3/V,Y,KMAX/
            V,N,NLOAD $
311 CHKPT UDVF $
312 LABEL LCYC3 $
313 COND LBLTRL4,NOTIME $
314 EQUIV PXF,PDF2 / CYCIO $
315 COND LCYC4,CYC4U $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
316 CYC1 PXF / PDF2,GCYCL2 / V,N,CYPE/C,N,BACK/V,Y,NSEG3/V,Y,KMAX/
            V,N,NLOAD $
317 LABEL LCYC4 $
318 SXR1 USETD,,PDF2,,GOU,,GMD,.. / PPFZ,, / C,N,1 / C,N,DYNAMICS $
319 SGR2 USETD,GMD,YS,KS,,GOU,,PPFZ / ,PCDUP,PSFZ,PLDUM $
320 EQUIV PPFZ,PPF // PSFZ,PSF $
321 CHKPT PPF,PSF $
322 LABEL LBLTRL4 $
323 VDR CASEXX,EQDY,1,USETD,LDVF,FCL,XYCOB, / GUOVC1,,C,N,FREQPESP/C,N,
            DIRECT/S,N,NOSORT2/S,N,NOD/S,N,NCP/C,N,0 $
324 COND LBL15,NOD $
325 COND LBL15A,NOSORT2 $
326 SDR3 UUOVC1,,UOVC2,,UOVC3, UOVC5, S,$
327 OEP UOVC2,,UOVC3,, / S,N,CARDNC $

2.29
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

328 XYTRAN XYCUB,OUVVC 2, /, /XYPLTF/A/#FREQ#/#DSET#/#NPFIL#/S,N,CARDNO $
329 XYPLTF XYPLTF/A/ $  
330 JUMP LBL15 $  
331 LABEL LBL15A $  
332 QFP OUDVC1, /, /S,N,CARDNC $  
333 LABEL LBL15 $  
334 COND LBL20, NUP $  
335 EQUIV UDVF, UPVC/NOA $  
336 COND LBL19, NUA $  
337 SDR1 USETO, UDVF, /, GUD, GM0, PSF, KFS, /, UPVC, /, QPC/1/#DYNAMICS# $  
338 LABEL LBL19 $  
339 SDR2 CASEXX, LSTN, MPT, O1T, EDOYN, S1LD, /, BGPDP, FUL, QPC, JPVCE, EST, XVCUB, PPF/OPPC1, QPCL, QPVC1, GESCI, CECF1, PUPVC1/C,N, FREQRESP/ S,N, NUSURT2 $  
340 CUDY LBL17, NUSURT2 $  
341 SDR3 OPPC1, OPPC1, QPVC1, GESCI, GECF1, /, OPPC2, QPCC2, QPVC2, GESC2, OECF2, $  
342 QFP OPPC2, OPPC2, QPVC2, GESC2, CESC2, /, S,N, CARDNC $  
343 XYTRAN XYCUB, OPPC2, QPCL2, QPVC2, GESC2, CESC2, XYPLTF/#FREQ#/PSSET#/ $, NPFIL#/S,N,CARDNO $  
344 XYPLTF XYPLTF/A/ $  
345 COND LBL16, NOPSDL $  
346 FANDLM XYCUB, DIT, PSOL, UPVVC2, OPPC2, QPCL2, GESC2, CESC2, CASEXX/PSDF, AUTO/ S,N, NORD $  
347 CUDY LBL16, NORD $  
348 XYTRAN XYCUB, PSDF, AUTO, /, /XYPLTR/#RAND#/PSST#/S,N,PFPIL#/ $, S,N, CARDNO $  
349 XYPLTF XYPLTR/A/ $  

2.30
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

350 JUMP LBL16 $
351 LABEL LBL17 $
352 JFP UPVC1,OPPC1,OPPC1,CEFC1,GESCI,/'S,A,CARDAC $
353 LABEL LBL16 $
354 GOTO LBL20, JUMP2LOT $
355 PLOT PLTPAR,GPOSETS,ELSSETS,CASEXX,BUDPDT,EQEXIN,SIP,UPVC1, GPECT, GESCI/PLTX2/NSIL/LUSEP/JUMP2LOT/PLTFLG/ $,N, PFILE $
356 PRTMSG PLOTX2// $ 
357 LABEL LBL20 $ 
358 GOTO FINIS:REPEATF $ 
359 KEPT LBL13,100 $ 
360 LABEL ERROR3 $ 
361 PRTPAR ///-3/*DIRFRAD $ 
362 JUMP FINIS $ 
363 LABEL ERROR4 $ 
364 PRTPAR ///-4/*DIRFRAD $ 
365 LABEL ERRRC1 $ CHECK NSEG5, KMAX AND OTHER CYCLIC DATA. 
366 PRTPAR //C,N,-7 /C,N,CYCSTAS $ 
367 LABEL ERRRC2 $ COUPLED MASS NOT ALLOWED. 
368 PRTPAR //C,N,0 /C,Y,COUPPASS $ 
369 JUMP FINIS $ 
370 LABEL ERRRC3 $ SUPPORT BULK DATA NOT ALLOWED. 
371 PRTPAR //C,N,-6 /C,N,CYCSTAS $ 
372 LABEL ERRRC4 $ EPOINT BULK DATA NOT ALLOWED. 
373 PRTPAR //C,N,0 /C,N,NOUE $ 
374 JUMP FINIS $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

375 LABEL
ERRORS & NEITHER FREQ OR TSTEP HERE IN BULK DATA DECK.

376 PRTPARM //Csets CNO /C, NCTRL

377 PRTPARM //C, CNO /C, NCTRL

378 JUMP FINIS $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.

379 LABEL
ERRORS & BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.

380 PRTPARM //C, CNO /C, NCTRL

381 PRTPARM //C, CNO /C, NCTRL

382 JUMP FINIS $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.

383 LABEL
ERRORS & BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.

384 END
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.4.3 Description of DMAP Operations for Forced Vibration Analysis of Rotating Cyclic Structures

5. Go to DMAP No. 365 if user has not specified parameter NSEGS.
6. Go to DMAP No. 365 if user has not specified parameter KMAX.
8. Go to DMAP No. 365 if user has not specified parameter CYCIO.
11. Go to DMAP No. 365 if KMAX > NSEGS/2.
18. Go to DMAP No. 367 if user has requested consistent mass.
20. GPI generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.
23. Go to DMAP No. 141 if only Direct Matrix Input.
24. GP2 generates Element Connection Table with internal indices.
27. Go to DMAP No. 35 if no plot output is requested.
28. PLTSET transforms user input into a form used to drive structure plotter.
29. PRTMSG prints error messages associated with structure plotter.
32. Go to DMAP No. 35 if no undeformed structure plots are requested.
33. PLT generates all requested undeformed structure plots.
34. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
36. GP3 generates Grid Point Temperature Table.
38. TAI generates element tables for use in matrix assembly and stress recovery.
41. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations \( R_g \{ u_g \} = 0 \).
45. Go to DMAP No. 370 and print error message if free-body supports are present.
46. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.
48. Go to DMAP No. 375 and print parameters NOFRL and NOTRL if there was no FREQ or TSTEP bulk data.
55. Go to DMAP No. 379 and print parameters NOFREQ and NOTIME if both FREQUENCY and TSTEP were requested in the Case Control deck.

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57. Go to DMAP No. 372 and print parameter NOUE if extra points are present.
58. GPCYC prepares segment boundary table (CYCDD).
59. Go to DMAP No. 365 and print error message if CYJOIN data is inconsistent.
61. Go to DMAP No. 95 if there are no structural elements.
66. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.
67. Go to DMAP No. 69 if no stiffness matrix is to be assembled.
68. EMA assembles stiffness matrix \( [K_{gg}] \) and Grid Point Singularity Table.
73. Go to DMAP No. 75 if no mass matrix is to be assembled.
74. EMA assembles mass matrix \( [M_{gg}] \).
76. DUMMOD1 generates modified Frequency Response List, FRLX, Coriolis acceleration coefficient matrix \( [B\text{1GG}_{gg}] \), centripetal coefficient matrix \( [M\text{1GG}_{gg}] \), Base acceleration coefficient matrix \( [M2\text{GG}_{gg}] \), Base acceleration matrix \( \text{BASEXG}_{gg} \) and load modification matrix, \( \text{PDZERO}_{gg} \), for base acceleration problems.
79. Equivalence FRLX to FRL if FRLX was generated by DUMMOD1.
82. Go to DMAP No. 84 if no viscous damping matrix is to be assembled.
83. EMA assembles viscous damping matrix \( [B_{gg}] \).
85. Go to DMAP No. 87 if no structural damping matrix is to be assembled.
86. EMA assembles structural damping matrix \( [K^A_{gg}] \).
91. Go to DMAP No. 95 if no weight and balance is requested.
92. Go to DMAP No. 363 and print error message if no mass matrix exists.
93. GPWG generates weight and balance information.
94. OFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.
96. Equivalence \( [K^X_{gg}] \) to \( [K_{gg}] \) if no general elements.
97. Go to DMAP No. 99 if no general elements.
98. SM3A3 adds general elements to \( [K^X_{gg}] \) to obtain stiffness matrix \( [K_{gg}] \).
100. Go to DMAP No. 109 if parameter RPS = 0.0 or if no mass matrix is present.
104. ADD assembles the Coriolis acceleration matrix into the viscous damping matrix \( [B\text{1GG}_{gg}] = [B_{gg}] + (4 \cdot \text{RPS}) [B\text{1GG}_{gg}] \)
105. Equivalence $[BGG]_{gg}$ to $[B_{gg}]$.

106. ADD assembles the centripetal acceleration matrix into the stiffness matrix.

$$[KGG]_{gg} = [K_{gg}] - \left(\frac{2 \pi \cdot \text{RPS}}{2}\right)^2 [M_{GG}]_{gg}$$

107. Equivalence $[KGG]_{gg}$ to $[K_{gg}]$.

108. Go to DMAP No. 117 if general elements present.

109. Go to DMAP No. 117 if no structural elements.

110. GPSP determines if possible grid point singularities remain.

111. Go to DMAP No. 117 if no grid point singularities exist.

112. OFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

113. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

114. Go to DMAP No. 117 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

115. MCE1 partitions multipoint constraint equations $[R_g] = [R_m^T][R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m^T][R_n]$.

116. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \begin{bmatrix} [K_{nn}] & [K_{mn}] \\ [K_{nm}] & [K_{mm}] \end{bmatrix}, \quad [M_{gg}] = \begin{bmatrix} [M_{nn}] & [M_{mn}] \\ [M_{nm}] & [M_{mm}] \end{bmatrix}$$

$$[B_{gg}] = \begin{bmatrix} [B_{nn}] & [B_{mn}] \\ [B_{nm}] & [B_{mm}] \end{bmatrix}, \quad [K^4_{gg}] = \begin{bmatrix} [K^4_{nn}] & [K^4_{mn}] \\ [K^4_{nm}] & [K^4_{mm}] \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [R_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [R_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [B_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K^4_{nn}] = [K^4_{nn}] + [G_m^T][K^4_{mn}] + [K^4_{mn}^T][G_m] + [G_m^T][K^4_{mm}][G_m].$$

117. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no singlepoint constraints.
124. Go to DMAP No. 126 if no single-point constraints.

125. SCE1 partitions out single-point constraints:

\[
\begin{bmatrix}
\mathbf{K}_{nn} & \mathbf{K}_{fs} \\
\mathbf{K}_{sf} & \mathbf{K}_{ss}
\end{bmatrix}, \quad \begin{bmatrix}
\mathbf{M}_{nn} & \mathbf{M}_{fs} \\
\mathbf{M}_{sf} & \mathbf{M}_{ss}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\mathbf{B}_{nn} & \mathbf{B}_{fs} \\
\mathbf{B}_{sf} & \mathbf{B}_{ss}
\end{bmatrix}
\]

and \[
\begin{bmatrix}
\mathbf{K}_s^4 & \mathbf{K}_{fs}^4 \\
\mathbf{K}_{fs}^4 & \mathbf{K}_{ss}^4
\end{bmatrix}
\]

127. Equivalence \([\mathbf{K}_{ff}] \) to \([\mathbf{K}_{aa}] \) if no omitted coordinates.

128. Equivalence \([\mathbf{M}_{ff}] \) to \([\mathbf{M}_{aa}] \) if no omitted coordinates.

129. Equivalence \([\mathbf{B}_{ff}] \) to \([\mathbf{B}_{aa}] \) if no omitted coordinates.

130. Equivalence \([\mathbf{K}^4_{ff}] \) to \([\mathbf{K}^4_{aa}] \) if no omitted coordinates.

131. Go to DMAP No. 141 if no omitted coordinates.

132. SMP1 partitions constrained stiffness matrix

\[
\begin{bmatrix}
\mathbf{K}_{aa} & \mathbf{K}_{ao} \\
\mathbf{K}_{oa} & \mathbf{K}_{oo}
\end{bmatrix}
\]

solves for transformation matrix \([\mathbf{G}_0] = -[\mathbf{K}_{oo}]^{-1}[\mathbf{K}_{oa}]\)

and performs matrix reduction \([\mathbf{K}^1_{aa}] = [\mathbf{K}_{aa}] + [\mathbf{K}_{ao}][\mathbf{G}_0].\)

133. Go to DMAP No. 135 if \(\mathbf{M} \) mass matrix.

134. SMP2 partitions constrained mass matrix

\[
\begin{bmatrix}
\mathbf{M}_{aa} & \mathbf{M}_{ao} \\
\mathbf{M}_{oa} & \mathbf{M}_{oo}
\end{bmatrix}
\]

and performs matrix reduction \([\mathbf{M}^1_{aa}] = [\mathbf{M}_{aa}] + [\mathbf{M}_{ao}][\mathbf{G}_0] + [\mathbf{M}_{ao}^T] + [\mathbf{G}_0^T][\mathbf{M}_{oo}][\mathbf{G}_0]\)

136. Go to DMAP No. 138 if no viscous damping matrix.
137. SMP2 partitions constrained viscous damping matrix

\[
[B_{ff}] = \begin{bmatrix}
B_{aa} & G_{ao} \\
G_{oa} & B_{oo}
\end{bmatrix}
\]

and performs reduction

\[
\]

139. Go to DMAP No. 141 if no structural damping matrix.

140. SMP2 partitions constrained structural damping matrix

\[
[K_{ff}] = \begin{bmatrix}
K_{aa} & K_{ao} \\
K_{oa} & K_{oo}
\end{bmatrix}
\]

and performs matrix reduction

\[
[K_{aa}]^T = [K_{aa}] + [K_{ao}] [G_o] \cdot [K_{ao}G_o]^T + [G_o]^T[K_{oo}][G_o]
\]

142. Equivalence \([G_o] \cdot [G_o]^{-1}\) and \([G_o] \cdot [G_o]^{-1}\) if no extra points introduced for dynamic analysis.

145. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

148. Go to DMAP No. 150 if no fluid-structure interface is defined.

14. MTRXIN generates fluid boundary matrices \([A_{b,fL}]\) and \([K_{b,fL}]\) if a fluid-structure interface is defined. The matrix \([K_{b,fL}]\) is generated only for a nonzero gravity in the fluid.

151. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

152. Beginning of loop for additional sets of direct input matrices.

154. CASE extracts user requests from CASECC for current loop.

155. MTRXIN selects the direct input matrices for the current loop, \([K_{pp}^{2d}], [M_{pp}^{2d}]\) and \([B_{pp}^{2d}]\).

158. Equivalence \([M_{pp}^{2d}]\) to \([M_{pp}^{2d}]\) if no \([A_{b,fL}]\).

159. ADDS adds \([K_{b,fL}]\) and \([K_{pp}^{2d}]\) and subtracts \([A_{b,fL}]\) from them to form \([K_{pp}^{2d}]\).
160. Go to DMAP No. 163 if 
161. Transpose \([A_b, f_2]\) to obtain \([A_b, f_2]^T\).
162. ADD assembles input matrix \([H_{pp}^2]\) = \(MFACT [A_b, f_2]^T + [M_{pp}]\).
169. Go to DMAP No. 172 if transient type GKAD matrices are to be generated.
170. Equivalence \([H_{pp}^2]\) to \([H_{dd}^2]\), \([B_{pp}^2]\) to \([B_{dd}^2]\) and \([K_{pp}^2]\) to \([K_{dd}^2]\) if no constraints applied, \([M_{aa}^1]\) to \([M_{dd}^1]\) if no direct input mass matrices and no extra points and \([B_{aa}^1]\) to \([B_{dd}^1]\) if no direct input damping matrices and no extra points.
172. Go to DMAP No. 175.
173. Equivalence \([H_{pp}^2]\) to \([H_{dd}^2]\), \([B_{pp}^2]\) to \([B_{dd}^2]\) and \([K_{pp}^2]\) to \([K_{dd}^2]\) if no constraints applied, \([M_{aa}^1]\) to \([M_{dd}^1]\) if no direct input mass matrices and no extra points, and \([K_{aa}^1]\) to \([K_{dd}^1]\) if no direct input stiffness matrices and no extra points.
176. Go to DMAP No. 178 if only extra points are defined.
177. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response, if parameter GKAD = FREQRESP.
\[
K_{dd}^1 = (1 + ig)K_{dd}^1 + K_{dd}^2 + iK_{dd}^4 \]
\[
M_{dd}^1 = [M_{dd}^1] + [M_{dd}^2] \]
\[
B_{dd}^1 = [B_{dd}^1] + [B_{dd}^2] \]
Direct input matrices may be complex.
\textbf{or}
GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response if parameter GKAD = TRANRESP.
\[
K_{dd}^1 = K_{dd}^1 + K_{dd}^2 \]
\[
M_{dd}^1 = [M_{dd}^1] + [M_{dd}^2] \]
and \([B_{dd}^1] = [B_{dd}^1] + [B_{dd}^2] + \frac{g}{\omega_3} [K_{dd}^1] + \frac{1}{\omega_4} [K_{dd}^4] \],
where
\[
\begin{bmatrix}
K_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow [K_{dd}^1],
\]
\[
\begin{bmatrix}
M_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow [M_{dd}^1],
\]
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\[
\begin{bmatrix}
B_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow \begin{bmatrix} B_{dd} \\ 0 \end{bmatrix},
\]
and
\[
\begin{bmatrix}
K_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow \begin{bmatrix} K_{dd} \\ 0 \end{bmatrix}.
\]

All matrices are real.

179. Go to DMAP No. 102 if transient type GKAD matrices were generated.

180. Equivalence \([K_{dd}^2]\) to \([K_{dd}]\) if all stiffness is Direct Matrix Input, \([M_{dd}^2]\) to \([M_{dd}]\) if all mass is Direct Matrix Input and \([B_{dd}^2]\) to \([B_{dd}]\) if all damping is Direct Matrix Input.

181. Go to DMAP No. 104.

183. Equivalence \([B_{dd}^2]\) to \([B_{dd}]\) if all damping is Direct Matrix Input, \([M_{dd}^2]\) to \([M_{dd}]\) if all mass is Direct Matrix Input and \([K_{dd}^2]\) to \([K_{dd}]\) if all stiffness is Direct Matrix Input.

185. Go to DMAP No. 208 if loading is frequency-dependent.

189. Beginning of loop for additional subcases for time-dependent loads.

190. CASE extracts user requests from CASECC for the current loop.

193. TRLG generates matrices of loads versus time. \([P_{t}^d]\) is generated with one column per output time step. \([P_{d}^t]\) is generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.

194. SDRI appends \([P_{t}^d]\) to \([P_{d}^t]\).

195. SDRI appends \([P_{t}^d]\) to \([P_{d}^t]\).

197. Go to DMAP No. 200 if no additional time-dependent loads need to be processed.

198. Go to DMAP No. 109 if additional time-dependent loads need to be processed.

199. Go to DMAP No. 360 and print message if more than 100 loops.

202. Equivalence \([P_{d}^t]\) to \([P_{d}^t]\) if the output times are the same as the solution times.

204. DUMM0D2 generates a Frequency Response List (FRLZ), and a Frequency Output List (FOL), from the Transient Output List (TOL). Load reordering matrices REORDER1 and REORDER2 are generated based on parameter values. This module, in effect, generates data blocks necessary to convert time-dependent loads into frequency dependent loads.

205. Equivalence FRLZ to FRL and FOLZ to FOL.
Go to DMAP No. 234.

FRLG forms the dynamic load vectors \( \{P^T_p\} \), \( \{P^T_s\} \), \( \{P^T_d\} \) and Frequency Output List (FOL) for frequency-dependent loads.

Go to DMAP No. 213 if FRLX was not generated by DUMMOD1.

MPYAD uses PDZERO from DUMMOD1 to zero out selected columns of \( \{P^T_p\} \) in base acceleration problems.

Equivalence \( \{P^T_p\} \) to \( \{P^T_p\} \).

Go to DMAP No. 222 if not a base acceleration problem.

MPYAD forms the complete base acceleration matrix, \( \{M_2\text{BASE}\}_g^f = [M_2\text{GG}_g^f] \cdot \{\text{BASE}\}_g^f \).
216. ADD assembles the frequency domain loads and the loads due to base acceleration.
\[
\{P_{1_{\text{p}}}^{f}\} = \{P_{\text{p}}^{f}\} - \{N2BA\}
\]

Note that the p-set and g-set are the same because no extra points are allowed.

217. Equivalence \(\{P_{1_{\text{p}}}^{f}\} \) to \(\{P_{\text{p}}^{f}\}\).

218. Go to DMAP No. 221 if there are no SPC's, MPC's or OMITs.

219. SSG2 applies constraints to \(\{P_{\text{p}}^{f}\}\).

220. CYCT1 transforms loads on analyses points to symmetric components.

221. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

222. Go to DMAP No. 268 if parameter CYCIO = -1.

223. Go to DMAP No. 251 if parameter CYCIO = +1.

224. Equivalence \(\{p_{d}^{t}\}\) and \(\{PDTRZ1\}\) if REORDER1 was not generated by DUMMOD2.

225. Go to DMAP No. 240 if REORDER1 was not generated.

226. MPYAD reorders columns of \(\{P_{d}^{t}\}\).

227. CYCT1 transforms loads on analysis points to symmetric components, in time.

228. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

229. Equivalence \(\{PXTRZ1\}\) and \(\{PXFZ1\}\) if REORDER2 was not generated by DUMMOD2.

230. MPYAD reorders columns of \(\{PXTRZ1\}\).

231. Equivalence \(\{PXFZ1\}\) to \(\{PXF1\}\).

232. Go to DMAP No. 264.

233. MPYAD reorders columns of \(\{p_{d}^{t}\}\).

234. CYCT1 transforms loads on analysis points to symmetric components, in time.

235. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

236. Equivalence \(\{PXTRZ2\}\) to \(\{PXTR2\}\) if REORDER2 was not generated.

237. Go to DMAP No. 259 if REORDER2 was not generated.

238. MPYAD reorders columns of \(\{PXTRZ2\}\).

239. CYCT1 transforms symmetric components, in time, to symmetric components.

240. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

241. Equivalence \(\{PXFZ2\}\) to \(\{PXF1\}\).

242. COPY makes a physical copy of \(\{PXF1\}\) called \(\{PFX2\}\).
266. ADD makes loads complex, since SCR2 expects complex loads in a frequency response problem. Time-dependent loads are real.

\[ (PFX) = (0.5, \text{i}0) \cdot (PFX1) \cdot (0.5, -\text{i}0) \cdot (PFX2) \]

271. Go to DMAP No. 282 if \( KMIN = 0 \).

274. Beginning of loop to create \( KMIN \) null columns of \( \{UV_{X}^{f}\} \) for \( KINDEX = 0 \) to \((KMIN-1)\). These leading null columns are necessary because CYCT1 expects columns for \( KINDEX = 0 \) to \( KMAX \).

275. CYCT2 transforms loads from symmetric components to solution set for rotational symmetry. This operation is necessary to get a correct size matrix for generating null \( \{UV_{X}^{f}\} \) columns.

276. Go to DMAP No. 365 and print error message if a CYCT2 error was found.

277. ADD generates a null vector \( \{UV_{Z}^{f}\} = \{PZ_{k}^{f}\} \cdot 0.0 \).

278. CYCT2 finds symmetric components of displacements from solution set data and appends it to \( \{UV_{X}^{f}\} \).

279. Go to DMAP No. 365 and print error message if a CYCT2 error was found.

280. PARAM increments the value of \( KMINV=KMINV+1 \).

281. Go to DMAP No. 274 if more null vectors are to be generated for \( \{UV_{X}^{f}\} \). If the initial \( \{UV_{X}^{f}\} \) for \( KINDEX \) values 0 to \((KMIN-1)\) has been completed then go to DMAP No. 282.

284. Beginning of loop for cyclic index value \( (KINDEX) \), for values \( KINDEX = KMIN \) to \( KMAX \).

288. CYCT2 transforms stiffness and mass matrix from symmetric components to solution set for rotational symmetry by the equation:

\[
[k_{kk}] = [G_{c}^{T}][k_{aa}][G_{c}] + [G_{s}^{T}][k_{aa}][G_{s}]
\]

291. CYCT2 transforms damping and loads from symmetric components to solution set for rotational symmetry by the equations:

\[
[B_{kk}] = [G_{c}^{T}][b_{aa}][G_{c}] + [G_{s}^{T}][b_{aa}][G_{s}]
\]

\[
[P_{k}] = [G_{c}^{T}][P_{c}] + [G_{s}^{T}][P_{s}]
\]

294. Go to DMAP No. 365 and print error message if CYCT2 error was found.

296. FRRD2 solves for the displacements using the following equation:

\[
[-M_{dd}w^{2} + \text{i}B_{dd}w + K_{dd}](u_{d}) = \{P_{d}\}.
\]

298. CYCT2 finds symmetric components of displacement from solution set data and appends to output for each \( KINDEX \).

299. Go to DMAP No. 365 and print error message if CYCT2 error was found.
301. PARAM increments the value of KINDEX = KINDEX + 1.
303. Go to DMAP No. 306 if all cyclic index values are complete.
304. Go to DMAP No. 284 if additional index values are needed.
305. Go to DMAP No. 360 and print error message if more than 100 loops on KINDEX.
307. Equivalence \( U_x^f \) to \( U_d^f \) if parameter CYCIO = -1.
309. Go to DMAP No. 312 if parameter CYCIO = -1.
310. CYCTI transforms displacements from symmetrical components to physical components.
313. Go to DMAP No. 322 if loads were frequency-dependent.
314. Equivalence \( P_x^f \) to \( P_d^f \) if parameter CYCIO = -1.
315. Go to DMAP No. 317 if parameter CYCIO = -1.
316. CYCTI transforms loads from symmetrical components to physical components if loads were time-dependent.
318. SDR1 recovers dependent loads \( \{ P_d^p \} \).
319. SSG2 applies constraints to \( \{ P_d^p \} \) to form \( \{ P_d^s \} \).
320. Equivalence \( \{ P_d^p \} \) to \( \{ P_x^f \} \) and \( \{ P_d^s \} \) to \( \{ p^f \} \).
323. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.
324. Go to DMAP No. 333 if no output request for the independent degrees of freedom.
325. Go to DMAP No. 331 if no output request for independent displacements sorted by point number.
326. SDR3 sorts the independent displacements by point number.
327. ØFP formats the requested independent displacements, sorted by point number, prepared by SDR3 and places them on the system output file for printing.
328. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.
329. XYPL0T prepares the requested X-Y plots of the independent displacements vs. frequency.
332. ØFP formats the requested independent displacements, sorted by frequency, prepared by VDR and places them on the system output file for printing.
334. Go to DMAP No. 357 if no output requests for forces and stresses.

335. Equivalence \( \{u_d\} \) to \( \{u_p\} \) if no constraints applied.

336. Go to DMAP No. 338 if no constraints applied.

337. SDR1 recovers independent components of displacements

\[
\begin{align*}
\{u_o\} &= [G^d_0]\{u_d\}, \\
\left\{ \begin{array}{c}
u_f + u_e \\ u_0
\end{array} \right\} &= \{u_f + u_e\}, \\
\left\{ \begin{array}{c}
u_n + u_e \\ u_s
\end{array} \right\} &= \{u_n + u_e\}, \\
\left\{ \begin{array}{c}
u_m + u_e \\ u_m
\end{array} \right\} &= \{u_m\}
\end{align*}
\]

and recovers single-point forces of constraint \( q_s = -\{P_s\} + [K^T_{fs}](u_f) \).

339. SDR2 calculates element forces (\( \Omega_{EFC1} \)) and stresses (\( \Omega_{ESC1} \)) and prepares load vectors (\( \Omega_{PPC1} \)), displacement vectors (\( \Omega_{UPVC1} \)), and single-point forces of constraint (\( \Omega_{QPC1} \)) for output sorted by frequency.

340. Go to DMAP No. 351 if no output requests sorted by point number of element number.

341. SDR3 prepares requested output sorted by point number or element number.

342. DFP formats tables prepared by SDR3, sorted by point number or element number, and places them on the system output file for printing.

343. XYTRAN prepares the input for requested X-Y plots.

344. XYPL0T prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

345. Go to DMAP No. 353 if no Power Spectral Density List

346. RANDOM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTD) using the previously calculated frequency response.

347. Go to DMAP No. 353 if no RANDOM calculations requested.

348. XYTRAN prepares the input for requested X-Y plots of the RANDOM output.

349. XYPL0T prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

350. Go to DMAP No. 353 if no frequency response output requests sorted by frequency.
352. GFIP formats frequency response output requests prepared by SDR2, sorted by frequency, and places them on the system output file for printing.

354. Go to DMAP No. 357 if no deformed structure plot are requested.

355. PLOT generates all requested deformed plots.

356. PRTMSG prints plotter data and engineering data for each deformed plot generated.

358. Go to DMAP No. 383 if no additional sets of direct input matrices need to be processed.

359. Go to DMAP No. 152 if additional sets of direct input matrices need to be processed.

361. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

364. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 4 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

366. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 7 - CYCLIC SYMMETRY DATA ERROR.

368. Coupled mass is not allowed - Print parameter COUPMASS.

371. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 6 - FREE-BODY SUPPORTS NOT ALLOWED.

373. EPoint bulk data not allowed - Print parameter NOUE.

376. Neither FREQ or TSTEP were in bulk data - Print parameters NOFRL and NOTRL.

380. Both FREQ and TSTEP were selected in case control - Print parameters NOFREQ and NOTIME.

384. END of DMAP sequence.
2.4.4 **CASE CONTROL DECK AND PARAMETERS FOR FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES**

The following items relate to subcase definition and data selection for Forced Vibration and Random Response of Rotating Cyclic Structures:

1. The SPC and MPC request must appear above the subcase level and may not be changed.
2. Either FREQUENCY or TSTEP must be selected and must be above the subcase level.
3. If selected, FREQUENCY must be used to select one and only one FREQ, FREQ1 or FREQ2 card from the Bulk Data deck.
4. If selected, TSTEP must be used to select the time-steps to be used for load definition via a TSTEP Bulk Data card and must be defined above the subcase level.
5. Direct input matrices are not allowed.
6. OFREQ must not be used.
7. A separate group of subcases must be defined for each symmetric segment.
8. DLOAD must be used to define a frequency or time-dependent loading condition for each subcase. For frequency-dependent loads, subcases without loads need not refer to a DLOAD card. For time-dependent loads, subcases without loads must refer to a DLOAD card that explicitly generates a null load.
9. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYC1D is included and the load components for each index are defined directly within each group for the various loading conditions.
10. If Random Response calculations are desired, RANDOM must be used to select RANPS and RANDT1 cards from the Bulk Data Deck.

The following printed output, sorted by frequency (SORT1) or by point number or element number (SORT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SOLUTION points (points used in formulation of the general K system).
2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.
3. Stresses and forces in selected elements (ALL available only for SORT1).

The following plotter output is available for Frequency Response calculations:
1. Undeformed plot of the structural model.

2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SOLUTION point.

3. X-Y plot of any component of the applied load vector or single-point force of constraint.

4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following items relate to Bulk Data restrictions:

1. SUPPORT cards are not allowed.

2. EPOINT cards are not allowed.

3. SPOINT cards are not allowed.

4. CYJOIN cards are required.

5. If a TSTEP card is used then it must not be continued since only one uniform time step interval must be specified. The skip factor for output, NO, on the TSTEP card must be 1.

The following parameters are used in Forced Vibration and Random Response of Rotating Cyclic Structures:

1. GRIDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WIMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. COUPMASS - fixed - Only lumped mass matrices must be used.
4. **GKAD - optional** - The BCD value of this parameter is used to tell the GKAD module the desired form of matrices KDD, BDD and MDD. The BCD value can be FREQRESP or TRANRESP. The default is TRANRESP. 
   **NOTE:** Remember to define parameters G, N3 and W4. See Section 9.3.3 (DIRECT DYNAMIC MATRIX ASSEMBLY) Pages 9.3-7 and 9.3-8 of the NASTRAN theoretical manual for further details.

5. **LGKAD - optional** - The integer value of this parameter is used in conjunction with parameter GKAD. If GKAD = FREQRESP then set LGKAD = 1, if GKAD = TRANRESP set LGKAD = -1. The default value is -1.

6. **G - optional** - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems (use GE on MAT1).

7. **W3 - optional** - The real value of this parameter is used as a pivotal frequency for uniform structural damping if parameter GKAD = TRANRESP. In this case W3 is required if uniform structural damping is desired. The default value is 0.0.

8. **W4 - optional** - The real value of this parameter is used as a pivotal frequency for element structural damping if parameter GKAD = TRANRESP. In this case W4 is required if structural damping is desired for any of the structural elements. The default value is 0.0.

9. **NSEGS - required** - The integer value of this parameter is the number of identical segments in the structural model.

10. **CYCLO - required** - The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. There is no default.

11. **CYCSEQ - fixed** - The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The value of CYCSEQ has been set to -1.

12. **CTYPE - fixed** - The BCD value of this parameter defines the type of cyclic symmetry as follows:
    
    (1) R0T - rotational symmetry

13. **KMAX - required** - The integer value of this parameter specifies the maximum value of the harmonic index. There is no default for this parameter. The maximum value that can be specified is NSEGS/2.

14. **KMIN - optional** - The integer value of this parameter specifies the minimum value of the harmonic index to be used in the solution loop. KMIN can equal KMAX. The default is 0.

15. **NLOAD - fixed** - The integer value of this parameter is the number of static loading conditions. The value of NLOAD is internally computed.
16. **NOKPRT** - optional - An integer value of +1 for this parameter will cause the current harmonic index, KINDEX, to be printed at the top of the harmonic loop. The default is +1.

17. **LMAX** - optional - The integer value of this parameter specifies the maximum harmonic in the fourier decomposition of periodic, time-dependent loads. The default value is NTSTEPS/2, where NTSTEPS = N+2 where N is from the TSTEP bulk data card.

18. **RPS** - optional - The real value of this parameter defines the rotational speed of the structure in revolutions per unit time. The default is 0.0.

19. **BXTID, BYTID, BZTID, BXPTID, BYPTID, BZPTID** - optional - The positive integer values of these parameters define the set identification numbers of the TABLE1 bulk data cards which define the components of the base acceleration vector. The tables referred to by BXTID, BYTID and BZTID define magnitude (LT-2) and tables referred to by BXPTID, BYPTID and BZPTID define phase (degrees). The default values are -1, which means that the respective terms will be ignored.
3.1 DATA BLOCK AND TABLE DESCRIPTION

3.1.1 Data Blocks Output from Module DUMMOD

3.1.1.1 FRLX (TABLE)

Description

Frequency Response List

The FRLX contains one log. rec. record for each different set defined in the bulk data. Each record contains a sorted list of frequencies defined in the set.

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1, 2</td>
<td>BCD</td>
<td>Data block name</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>Set ID₁</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Set IDₙ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+n</td>
<td>I</td>
<td>Radian frequencies belonging to set ID₁ (w = 2πF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1-m</td>
<td>R</td>
<td>Radian frequencies belonging to set IDₙ (w = 2πF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>1-k</td>
<td>Radian frequencies belonging to set IDₙ (w = 2πF)</td>
</tr>
<tr>
<td></td>
<td>n+1</td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>

Table Trailer:

Word 1 = number of frequency sets
Word 2-6 = zero

3.1.1.2 BIGG (MATRIX)

Description

[BIGG₉₉] = Coriolis acceleration coefficient matrix - g set.

3.1.1.3 M1GG (MATRIX)

Description

[M1GG₉₉] = Centripetal acceleration coefficient matrix - g set.

3.1.1.4 M2GG (MATRIX)

Description

[M2GG₉₉] = Base acceleration coefficient matrix - g set.
3.1.1.5 BASEXG (MATRIX)

Description

[BASEXG] - Base acceleration matrix - g set.

3.1.1.6 PDZERO (MATRIX)

Description

[PDZERO] - Load modification matrix in base acceleration problems - g set.

3.1.2 Data Blocks Output from Module DUMMOD2

3.1.2.1 FRL (TABLE)

Description

Frequency Response List

The FRL output by DUMMOD2 contains one logical record. This logical record contains a sorted list of frequencies.

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,2</td>
<td>BCD</td>
<td>Data Block Name</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>I</td>
<td>Set ID = 1</td>
</tr>
<tr>
<td>1</td>
<td>1-m</td>
<td>R</td>
<td>Radian frequencies (w = 2πF)</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>

Table Trailer

Word 1 = 1
Word 2-6 = zero

3.1.2.2 FOL (TABLE)

Description

Frequency Response Output List

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-2</td>
<td>BCD</td>
<td>Table Name</td>
</tr>
<tr>
<td></td>
<td>3-NFREQ+2</td>
<td>R</td>
<td>Frequencies F (w = 2πF)</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>
Table Trailer

Word 1 = Number of frequencies (NFREQ)
Word 2 = Frequency set record number (=1)
Word 3-6 = zero

3.1.2.3 REORDER1 (MATRIX)

Description


Matrix Trailer

Number of columns = \( \text{NTSTEPS} \times \text{FKMAX} \), if CYCIO = -1
Number of rows = \( \text{NTSTEPS} \times \text{NSEGS} \), if CYCIO = +1
Form = square
Type = real single precision

3.1.2.4 REORDER2 (MATRIX)

Description


Matrix Trailer

Number of columns = \( \text{FLMAX} \times \text{FKMAX} \), if CYCIO = -1
Number of rows = \( \text{FLMAX} \times \text{NSEGS} \), if CYCIO = +1
Form = square
Type = real single precision
3.2.1 Functional Module DUMMOD1

3.2.1.1 Entry Point: DUMMOD1

3.2.1.2 Purpose

To generate the Coriolis, centripetal and base acceleration coefficient matrices and the base acceleration matrix for a forced vibration response analysis of rotating structures.

3.2.1.3 DMAP Calling Sequence

DUMMOD1 CASECC, BGPDT, CSTM, DIT, FRL, MGG,,/FRLX, B1GG, M1GG, M2GG,
BASEXG, PDZERO,,/V, N, NOMGG/V, Y, CYCIO/V, Y, NSEGS/V, Y,
KMAX/V, N, FKMAX/V, Y, BXTID=-1/V, Y, BXPTID=-1/V, Y, BYTID=-1/V,
Y, BYTID=-1/V, Y, BYPTID=-1/V, Y, BZTID=-1/V, Y, BZPTID=-1/V,
V, N, NOBASEX/V, N, NOFREQ/V, N, OMEGA $

3.2.1.4 Input Data Blocks

CASECC - Case Control.
BGPDT - Basic Grid Point Definition Table.
CSTM - Coordinate System Transformation Matrices.
DIT - Direct Input Tables
FRL - Frequency Response List (radians).
MGG - Partition of mass matrix (g-set).

Notes: 1. All input data blocks can be purged if only parameters FKMAX and NOBASEX are to be computed.
2. CASECC, DIT and FRL can be purged if output data blocks FRLX and BASEXG are purged.

3.2.1.5 Output Data Blocks

FRLX - Frequency Response List (modified)
B1GG - Coriolis acceleration coefficient matrix (g-set)
M1GG - Centripetal acceleration coefficient matrix (g-set)
M2GG - Base Acceleration coefficient matrix (g-set)
BASEXG - Base acceleration matrix (g-set x f)
PDZERO - Load modification matrix in base acceleration problems (g-set x f)

Notes: 1. All output data blocks can be purged if parameter NOMGG=-1.
2. B1GG and M1GG can be purged if NOMGG=-1 or if OMEGA=0.0.
3. FRLX and PDZERO can be purged if OMEGA=0.0.
4. FRLX, PDZERO, X2GG and BASEXG can be purged if NOMGG=-1 or if
   NOFREQ=-1 or if CYCIO=-1 or if all three parameters BXTID=BYTID=
   BZTID=-1.

3.2.1.6 Parameters

- **NOMGG**: Input-integer-no default. NOMGG was not generated if NOMGG=-1.
- **CYCIO**: Input-integer-no default. This parameter specifies the form of the
  input and output data from cyclic structures. A value of +1 is used
  to specify physical segment representation and a value of -1 for
  cyclic transformation representation.
- **NSEGS**: Input-integer-no default. The number of identical segments in the
  structural model.
- **KMAX**: Input-integer-no default. KMAX specifies the maximum value of the
  harmonic index. The maximum value that can be specified for KMAX
  is NSEGS/2.
- **FKMAX**: Output-integer-no default. FKMAX is a function of KMAX.
- **NOBASEX**: Output-integer-no default. NOBASEX=-1 if data block BASEXG is not
  generated.
- **NOFREQ**: Input-integer-no default. NOFREQ=-1 if FREQUENCY was not selected
  in the Case Control deck.
- **OMEGA**: Input-real-no default. Rotational speed of the structure in radians.
  OMEGA = 2π·RPS.
- **BXTID**: Input-integer-defaults. The values of these parameters define the
  set identification numbers of the TABLED Bulk Data cards which define
  the components of the base acceleration vector. The tables referred
  to by BXTID, BYTID and BZTID define magnitude (LT-2) and the tables
  referred to by BXPTID, BYPTID and BZPTID define phase (degrees). The
  default values are -1 which means that the respective terms are
  ignored.

3.2.1.7 Method

Parameters NOBASEX and FKMAX are computed depending on the values of various
input parameters. Parameter NOBASEX is set equal to -1 if parameters NOMGG=-1
or CYCIO=-1 or NOFREQ=-1 or if parameters BXTID=BYTID=BZTID=-1, otherwise NOBASEX
is set equal to +1 indicating that base acceleration data blocks are to be
generated.
If parameter \( \text{CYCIO} = -1 \), then parameter \( \text{FKMAX} \) is computed as follows. If \( \text{NSEGS} \) is odd then \( \text{FKMAX} = 2 \times \text{KMAX} + 1 \). If \( \text{NSEGS} \) is even and \( \text{KMAX} = \text{NSEGS}/2 \), then \( \text{FKMAX} = \text{NSEGS} \), otherwise \( \text{FKMAX} = 2 \times \text{KMAX} + 1 \).

If parameter \( \text{NOMGG} = -1 \) then no data blocks are generated and an exit is made from module DUMMOD1, otherwise computations proceed in three phases. In the first phase B1GG and M1GG are generated unless parameter \( \text{OMEGA} = 0.0 \). M2GG is generated if parameter \( \text{NOBASEX} = +1 \). The second and third phases generate data blocks associated with base acceleration problems and are only executed if \( \text{NOBASEX} = +1 \). In the second phase FRLX and PDZERO are generated unless parameter \( \text{OMEGA} = 0.0 \). Data block BASEXG is generated and output in phase three.

3.2.1.7.1 Phase 1 - Generation of B1GG, M1GG and M2GG

Phase one begins with a request for open core and buffer allocation. If \( \text{OMEGA} = 0.0 \) then B1GG anf M1GG are not output and their buffers, IBUF3 and IBUF4, are not allocated and IBUF5 is set equal to IBUF3. If coordinate system transformations exist then the CSTM data block is open and the coordinate system information is placed in core and readied for use by subroutine PRETRD.

The primary loop in phase one is controlled by the number of grid points in the Basic Grid Point Definition Table (BGPDT), scalar points are not allowed by DUMMOD1. Each grid point in the BGPDT is considered in order and the corresponding columns of the mass matrix, MGG, are processed to form B1GG, M1GG and M2GG. When all grid points have been processed the necessary trailers are written. For the \( i \)th grid point in the BGPDT the corresponding translational terms of MGG are unpacked and the diagonal terms are isolated into a \( 3 \times 3 \) matrix \( [M_i^j] \). If the grid point is not in the basic system then subroutine TRANSO calculates the \( 3 \times 3 \) transformation matrix \( [T_i] \) from global coordinates to basic coordinates for the grid point and \( [M_i^j] \) is transformed to the basic system to form \( [\tilde{M}_i^j] \). The average of the three diagonal terms of \( [\tilde{M}_i^j] \) is then used to form \( [BT_i], [MT_i] \) and \( [M2_i] \). These three submatrices are then transformed back to the global coordinate system, if necessary. The \( 3 \times 3 \) matrices \( [BT_i], [MT_i] \) and \( [M2_i] \) are then packed into the B1GG, M1GG and M2GG matrices.

\[
[MGG]_{g \times g} = \begin{bmatrix}
[M_1]
&M_2 & 0 \\
0 & \ldots & [M_n]
\end{bmatrix}
\]

where \( n \) is the total number of grid points.

3.6
where 
\[ [M_i]_{6x6} = \begin{bmatrix} [M_{11}] & \cdots & [M_{1n}] \\ \vdots & \ddots & \vdots \\ [M_{61}] & \cdots & [M_{6n}] \end{bmatrix} \]
for i = 1, n

and
\[ [H_i]_{3x3} = \begin{bmatrix} m_i & 0 & 0 \\ 0 & m_i^{T2} & 0 \\ 0 & 0 & m_i^{T3} \end{bmatrix} \]

(b) Transform \([M_i]\) from global to basic coordinate system
\[ [\bar{M}_i]_{3x3} = [T_i] [M_i] [T_i]^T \]

(c) Compute average of \([\bar{M}_i]\)
\[ \bar{m}_i = \frac{3}{k} \bar{m}_i^K \]
where \(\bar{m}_i^K\) is the mass (in the basic coordinate system) at the \(i\)th node point of the total of \(n\) nodes in the \(k\)th direction.

(d) Form \(B_{1GG}\)
\[ [B_{1GG}]_{g\times g} = \begin{bmatrix} [B_{11}] & \cdots & [B_{1n}] \\ 0 & \ddots & \vdots \\ 0 & \cdots & [B_{1n}] \end{bmatrix} \]
where
\[ [B_{1i}]_{6x6} = \begin{bmatrix} [B_{1i1}] & \cdots & [0] \\ \vdots & \ddots & \vdots \\ [0] & \cdots & [B_{1in}] \end{bmatrix} \]

and
\[ [B_{1i}]_{3x3} = [T_i] [0] [0] [m_i^T] [T_i]^T \]

(e) Form \(M_{1GG}\)
\[ [M_{1GG}]_{g\times g} = \begin{bmatrix} [M_{11}] & \cdots & [0] \\ \vdots & \ddots & \vdots \\ 0 & \cdots & [M_{1n}] \end{bmatrix} \]
where
\[
[M1]_{6x6} = \begin{bmatrix}
[M1]_f & \vdots \\
0 & \vdots \\
\vdots & \vdots \\
0 & 0 & [0]
\end{bmatrix}
\]

and
\[
[M1]_{3x3} = [T_1]^T \begin{bmatrix}
0 & 0 & 0 \\
0 & \tilde{m}_1 & 0 \\
0 & 0 & \tilde{m}_1
\end{bmatrix} [T_1]
\]

3.2.1.7.2 Phase 2 - Generation of FRLX and PDZERO

In this phase the FREQUENCY set selected in the Case Control deck is located in data block FRL and stored in core. If parameter OMEGA=0.0 or if parameters BYTID=-1 and BZTID=-1 then phase two is complete, otherwise phase two processing continues. The Frequency Response List must be modified to include an expanded set of frequencies. Read and copy from FRL to FRLX record 0 and all logical records up to the selected frequency set. The only set that will be modified in FRL is the selected frequency set. Once the set of selected frequencies have been found and stored in core a vector for FRLX and PDZERO are generated using the FRL frequencies stored in core and parameter OMEGA. Let \( \omega_i \) for \( i = 1, NFREQ \) be the frequencies (in radians) from FRL.

If \( \omega_i \neq 0.0 \), create 3 entries, 0.0, 1.0 and 0.0 for PDZERO and create 3 entries, \(|\omega_i - \text{OMEGA}|, \omega_i, \text{ and } |\omega_i + \text{OMEGA}| \) for FRLX.
If $\omega_1 = 0.0$, create 2 entries, 1.0 and 0.0 for PDZERO and create 2 entries, 0.0 and $|\Omega|$ for FRLX.

After the expanded list of frequencies is generated call routine DUM01E to sort it in ascending order. DUM01E also returns a sorting index so other vectors may be sorted the same as FRLX. Sort PDZERO using this sorting index. Output this FRLX vector and continue copying the remaining records of FRL to FRLX. Output data block PDZERO by writing out the PDZERO vector $F$ times, thus creating $F$ columns. The original unexpanded frequencies from FRL and the sorting index stored in core are retained for phase 3 processing.

3.2.7.3 Phase 3 - Generation of BASEXG.

If NOBASEX=-1 then this phase is skipped, otherwise processing continues.

A unique list of table IDs using parameters BXTID, BYTID, BZTID, BXPTID, BYPTID and BZPTID is generated and a call to PRETAB is made so that tables TABLED1, TABLED2, TABLED3 and TABLED4 can be interpolated by calls to TAB. Routines DUM01A, DUM01B, DUM01C and DUM01D are used to generate data block BASEXG. Routine DUM01A calls the routines to generate the BASE table and outputs the BASEXG matrix. The BASE table is used to generate up to three groups of $NFREQX$ columns, where $NFREQX$ is the number of expanded frequencies from phase two, in the BASEXG matrix. Routine DUM01B is called to generate the BASE table if the original FRL frequency list was not expanded, see phase two, otherwise routine DUM01C is called. Routine DUM01D sorts the columns of the BASE table so that they are arranged in the same order as the modified frequency set if FRLX was generated in phase two. The following is a mathematical description of matrix BASEXG.

(a) Let $X_0(f_i)$, $X_t(f_i)$, $Y_0(f_i)$, $Y_t(f_i)$, $Z_0(f_i)$, $Z_t(f_i)$ be input via frequency dependent tables TABLEDi where the table IDs are defined by parameters BXTID, BXPTID, BYTID, BYPTID, BZTID and BZPTID respectively. $X_0$, $Y_0$ and $Z_0$ are magnitudes in $\ell^2$ units while $\theta_x$, $\theta_y$ and $\theta_z$ are phase angles in degrees.

(b) Define control flag MODFRL.

If parameter $\Omega$-BXTID=-1 then set MODFRL to false, otherwise MODFRL is true.

(c) Let FRL be a vector of $NF$ frequencies (in radians).

\[
FRL = [\omega_1, \omega_2, \omega_3, \ldots, \omega_NF]
\]

(d) If MODFRL is false then generate complex base table BASE of order $3 \times NF$.

\[
[BASE]_{3\times NF} = [\{BASE(f_1)\} \cdot \cdot \cdot \{BASE(f_NF)\}]_{3\times 1}
\]
where $f_i = \omega_i/2\pi$ for $i = 1, 2, \ldots, NF$ and

$$\{\text{BASE}(f_i)\}_{3x1} = \left\{ \begin{array}{c}
\tilde{x}_0(f_i) - e^{i\theta_x(f_i)} \\
\tilde{y}_0(f_i) - e^{i\theta_y(f_i)} \\
\tilde{z}_0(f_i) - e^{i\theta_z(f_i)}
\end{array} \right\}_{3x1}$$

(e) If MODFRL is true then generate complex base table BASE of order $3 \times \text{NFX}$ where NFX is an expanded number of frequencies as defined below.

$$\text{BASE} = [\text{BASE}(f_1)] \cdot [\text{BASE}(f_2)] \cdots [\text{BASE}(f_{\text{NF}})]$$

where $f_i = \omega_i/2\pi$ for $i = 1, 2, \ldots, NF$

and each $\{\text{BASE}(f_i)\}$ is either $3 \times 2$ if $\omega_i = 0.0$ or $3 \times 3$ if $\omega_i \neq 0.0$.

(e.1) If $\omega_i = 0.0$, then $\{\text{BASE}(f_i)\}_{3x2}$ is defined as follows:

$$\text{BASE}(f_i)_{3x2} = \begin{bmatrix} A & 0 \\ 0 & B \\ 0 & C \end{bmatrix}$$

where

- SGN = 1.0 if parameter OMEGA $\geq 0.0$, otherwise SGN$=-1.0$
- $A = \tilde{x}_0(f_i) \cdot e^{i\theta_x(f_i)}$
- $B = \tilde{y}_0(f_i) \cdot \cos(\theta_y(f_i)) - i \cdot SGN \cdot \tilde{z}_0(f_i) \cdot \cos(\theta_z(f_i))$
- $C = \tilde{z}_0(f_i) \cdot \cos(\theta_z(f_i)) + i \cdot SGN \cdot \tilde{y}_0(f_i) \cdot \cos(\theta_y(f_i))$

(e.2) If $\omega_i \neq 0.0$, then $\{\text{BASE}(f_i)\}_{3x3}$ is defined as follows:

$$\text{BASE}(f_i)_{3x3} = \begin{bmatrix} 0 & A & 0 \\ B & 0 & C \\ 0 & D & 0 \end{bmatrix}$$

where

- SGN1 = 1.0 if $(\omega_i - \text{OMEGA}) \geq 0.0$, otherwise SGN1 = -1.0
- SGN2 = 1.0 if $(\omega_i + \text{OMEGA}) \geq 0.0$, otherwise SGN2 = -1.0

and

- $A = \tilde{x}_0(f_i) \cdot e^{i\theta_x(f_i)}$
- $B = 0.5 \times \left[ \tilde{y}_0(f_i) \cdot e^{i \cdot \text{SGNA} \cdot \theta_y(f_i)} - \text{SGNA} \cdot \tilde{z}_0(f_i) \cdot e^{i \cdot \text{SGNA} \cdot (\theta_z(f_i) - \text{SGNB})} \right]$
(f) Define the complex base acceleration matrix $\text{BASEXG}$ of order $G \times (NF \cdot \text{FKMAX})$ as follows:

Let $NF$ be the number of frequencies in the $\text{BASE}$ matrix, i.e., let $NF = NF$ if MODFRL was false or $NF = NF \times \text{FKMAX}$ if MODFRL was true.

$$[\text{BASEXG}]_{g \times (NF \cdot \text{FKMAX})} = [\text{BASEXG}^1]_{g \times NF} [\text{BASEXG}^2]_{g \times NF} [\text{BASEXG}^3]_{g \times NF} \ldots [\text{BASEXG}^\text{FKMAX}]_{g \times NF}$$

where

$$[\text{BASEXG}^i]_{g \times NF} = \begin{bmatrix}
[\text{BASEX}^i]_{6 \times NF} \\
\vdots \\
[\text{BASEX}^i]_{6 \times NF}
\end{bmatrix}$$

for $i = 1, 2$ and $3$

and

$$[\text{BASEXG}^i]_{g \times NF} = [0]$$

for $i = 4, 5, 6, \ldots, \text{FKMAX}$

NOTE: $[\text{BASEX}^i]$ is repeated $N$ times where $N = g/6$ and $g$ is the g-set size. Scalar points are not allowed so each node has 6 degrees of freedom.

$$[\text{BASEX}^i]_{6 \times NF} = \begin{bmatrix}
\text{BASE}(1,1) & \text{BASE}(1,2) & \ldots & \text{BASE}(1,NF)
\end{bmatrix}$$

3.11
3.2.1.8 Subroutines

Utility subroutines GMATD, PRETD, TRANSD, PRETAB and TAB are used. See subroutine descriptions, Section 3 of NASTRAN Programmer's Manual.

3.2.1.8.1 Subroutine Name: DUM01A

1. Entry Point: DUM01A

2. Purpose: To define and output the complex single precision base acceleration matrix BASEXG.

3. Calling Sequence: Call DUM01A (BASE, BASE1, Z, W, BUF, INDEX, MODFRL, BASEXG, NROW, NF, NFX, FKMAX, OMEGA)

BASE - Storage for BASE matrix - complex S.P. - input.
BASE1 - Storage for sorted BASE matrix - complex S.P. - input.
Z - Storage for one column of matrix BASEXG - complex S.P. - input.
W - Frequencies (radians) from data block FRL - real - input.
BUF - GINO buffer for BASEXG - real - input.
INDEX - Sorting index - integer - input.
MODFRL - Flag to indicate if frequency list was expanded - logical - input.
BASEXG - GINO file number of BASEXG - integer - input.
NROW - G-set size - integer - input.
NF - Number of frequencies in FRL data block - integer - input.
NFX - Expanded number of frequencies - integer - input.
FKMAX - Function of parameter KMAX - integer - input.
OMEGA - Rotational speed of structure in radians - real - input.
3.2.1.8.2 Subroutine Name: DUMO1B

1. Entry Point: DUMO1B

2. Purpose: To define the complex single precision BASE matrix used in generating the complete base acceleration matrix BASEXG. This routine is only called if MODFRL is false.

3. Calling Sequence: CALL DUMO1B (BASE, W, NF)

   BASE - BASE matrix - complex S.P. - output
   W - Frequencies from data block FRL - real (radians) - input.
   NF - Number of frequencies in W - integer - input.

   COMMON/CONDAS/PI, T0PI, RADEG, DEGRA, 4APISQ
   COMMON/BLANK/DUM(5), BXID, BXPTID, BYTID, BYPTID, BZTID, BZPTID

3.2.1.8.3 Subroutine Name: DUMO1C

1. Entry Point: DUMO1C

2. Purpose: To define the complex single precision BASE matrix used in generating the complete base acceleration matrix BASEXG. This routine is only called if MODFRL is true.

3. Calling Sequence: CALL DUMO1C (BASE, W, OMEGA, NF)

   BASE - BASE matrix - complex S.P. - output.
   W - Frequencies from data block FRL - real (radians) - input.
   OMEGA - Rotational speed of the structure in radians - real - input.
   NF - Number of frequencies in W - integer - input.

   COMMON/CONDAS/PI, T0PI, RADEG, DEGRA, 4APISQ
   COMMON/BLANK/DUM(5), BXID, BXPTID, BYTID, BYPTID, BZTID, BZPTID

3.2.1.8.4 Subroutine Name: DUMO1D

1. Entry Point: DUMO1D

2. Purpose: To sort the columns of matrix BASE in the same order as the expanded frequencies in data block FRLX.

3. Calling Sequence: CALL DUMO1D (BASE, BASE1, INDEX, NFX)

   BASE - BASE matrix - complex S.P. - input/output
   BASE1 - Temporary storage used for sorting matrix BASE - complex S.P. - input.
   INDEX - Sorting key - integer - input
NFX - Number of columns of matrix BASE and length of INDEX - integer - input.

3.2.1.8.5 Subroutine Name: DUM01E

1. Entry Point: DUM01E

2. Purpose: To sort the list of expanded frequencies of data block FRXX and to supply an index key so these vectors can be sorted the same way.

3. Calling Sequence: CALL DUM01E(A,K,N)

   A - Vector to be sorted - real - input/output.
   K - Sort index key - integer - output
   N - Length of A and K

3.2.1.9 Design Requirements

a) Open core is defined at /DUM1XX/
b) No scratch files are used
c) DUM01 resides in LINKNS07
d) Open core for five GINO buffers is needed.
e) The layout for open core is as follows:

Phase I

COMMON/DUM1XX/ Z

\[
\begin{array}{|c|c|}
\hline
\text{Z(1)} & \text{Column of MGG} \\
\hline
\text{FREE} & \text{NTYPE*G-set} \\
\hline
\text{Z(ICSM) } & \text{CSTM DATA} \\
\text{LCST} & \\
\hline
\text{Z(IBUF5) } & \text{M2GG} \\
\text{GINO BUFFER} & \\
\hline
\text{Z(IBUF4) } & \text{M1GG} \\
\text{GINO BUFFER} & \\
\hline
\text{Z(IBUF3) } & \text{BIGG} \\
\text{GINO BUFFER} & \\
\hline
\text{Z(IBUF2) } & \text{BPDT} \\
\text{GINO BUFFER} & \\
\hline
\text{Z(IBUF1) } & \text{CSTM/MGG} \\
\text{GINO BUFFER+1} & \\
\hline
\end{array}
\]
### Phase II

**COMMON/DUMIXX/Z**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL)</td>
<td>FRL DATA</td>
<td>NF</td>
</tr>
<tr>
<td>Z(INDEX)</td>
<td>SORT INDEX KEY</td>
<td>3*NF</td>
</tr>
<tr>
<td>Z(IFRLX)</td>
<td>FRLX DATA</td>
<td>3*NF</td>
</tr>
<tr>
<td>Z(IPDZ)</td>
<td>PDZERO DATA</td>
<td>3*NF</td>
</tr>
</tbody>
</table>

**FREE**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IBUF3)</td>
<td>PDZERO</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF2)</td>
<td>CASELL/FRLX</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>FRL</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

### Phase III

**COMMON/DUMIXX/Z**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL)</td>
<td>FRL DATA</td>
<td>NFS</td>
</tr>
<tr>
<td>Z(INDEX)</td>
<td>SORT INDEX</td>
<td>3*NFSX</td>
</tr>
<tr>
<td>Z(ITAB)</td>
<td>PRETAB TABLE DATA</td>
<td>NTABLE</td>
</tr>
<tr>
<td>Z(N1)</td>
<td>BASE MATRIX</td>
<td>((3*NFSX)^2)</td>
</tr>
<tr>
<td>Z(N2)</td>
<td>BASE1 MATRIX</td>
<td>((3*NFSX)^2)</td>
</tr>
<tr>
<td>Z(N3)</td>
<td>COLUMN OF BASEXG</td>
<td>((G-set)^2)</td>
</tr>
</tbody>
</table>

**FREE**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IBUF1)</td>
<td>DIT/BASEXG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

#### 3.2.1.10 Diagnostic Messages

The following fatal error messages may occur:

3091, 3002, 3003, 3008 and 3031.
3.2.2 Functional Module DUMMOD2

3.2.2.1 Entry Point: DUMMOD2

3.2.2.2 Purpose

To generate tables FRL and FOL and matrices REORDER1 and REORDER2 to be used in a forced vibration response analysis of rotating cyclic structures. Parameters LMAS, NTSTEPS, FLMAX, NOR01 and NOR02 are also computed.

3.2.2.3 DMAP Calling Sequence

DUMMOD2 TOL, , , , , , / FRL, FOL, REORDER1, REORDER2, , , , / V, Y, NSEGS/ V, Y, CYCIO/ V, Y, LMAX=-1/ V, N, FKMAX/ V, N, FLMAX/ V, N, NTSTEPS/ V, N, NOR01/ V, N, NOR02 S

3.2.2.4 Input Data Blocks

TOL - Time output list.

NOTES: 1. TOL must be present

3.2.2.5 Output Data Blocks

FRL - Frequency Response List

FOL - Frequency Output List

REORDER1 - Load reordering matrix for time-dependent frequency response problems.

REORDER2 - Load reordering matrix for time-dependent frequency response problems.

NOTES: 1. FRL and FOL cannot be purged.

3.2.2.6 Parameters

NSEGS - Input-integer-no default. NSEGS is the number of identical segments in the structural model.

CYCIO - Input-integer-no default. The value of this parameter specifies the form of the input and output data for cyclic structures. A value of +1 is used to specify physical segment representation and a value of -1 for cyclic transformation representation.

LMAX - Input/output-integer-default. LMAX specifies the maximum time-harmonic index for cyclic structures. The default value is NTSTEPS/2, where NTSTEPS is defined below.

FKMAX - Input-integer-no default. FKMAX is a function of parameter KMAX.

FLMAX - Output-integer-no default. FLMAX is a function of parameter LMAX.

3.16
NTSTEPS - Output-integer-no default. The number of time steps from data block TOL.

NORO1 - Output-integer-no default. NORO1=-1 if matrix REORDER1 is not generated, +1 otherwise.

NORO2 - Output-integer-no default. NORO2=-1 if matrix REORDER2 is not generated, +1 otherwise.
3.2.2.7 Method

Computations proceed in three phases. Parameters NTSTEPS, LMAX and FLMAX are computed in Phase I. Data blocks FRL and FOL are generated and output in Phase II and matrix data blocks REORDER1 and REORDER2 and their respective parameters NORO1 and NORO2 are generated and output in Phase III.

3.2.2.7.1 Computation of Parameters NTSTEPS, LMAX and FLMAX

Data block TOL is open and the list of output times is read from the header record and stored for use by Phase II. Let NTIMES be the number of times read.

   a) Parameter NTSTEPS

   If CYCIO=-1, then NTSTEPS=(NTIMES*NSEGS)/NSEGS
   If CYCIO=+1, then NTSTEPS=(NTIMES*NSEGS)/NSEGS

   b) Parameter LMAX

   If LMAX<0, then the default value of LMAX is set equal to NTSTEPS/2.

   c) Parameter FLMAX

   If NTSTEPS is even and LMAX=NTSTEPS/2, then FLMAX=NTSTEPS, otherwise FLMAX=2*LMAX+1.

3.2.2.7.2 Generation of tables FOL and FRL

The list of times read from TOL are now converted to the frequency domain. The number of frequencies, NFREQ, is set equal to FLMAX.

Let PERIOD = TIME(2) + TIME(NTSTEPS)
then,   FOL(1) = 0.0
   FOL(i) = (i-1/2)*(1.0/PERIOD) for i = 2,4,6,...,NFREQ
and   FOL(j) = FOL(j-1) for j = 3,5,7,...,NFREQ-1

Data block FOL is then output and data block FRL is then generated from FOL by converting the FOL frequencies in hertz to FRL frequencies in radians,
   FRL(i) = FOL(i)*2π for i = 1, NFREQ.

3.2.2.7.3 Computation of parameters NORO1 and NORO2 and matrices REORDER1 and REORDER2.

REORDER 1 and REORDER2 are used for reordering columns of a matrix by post-multiplying the matrix whose columns are to be reordered. Routine DUMO2A is called twice, once to generate and output REORDER1 and once to generate and output REORDER2. See the subroutine description of DUMO2A for details.
3.2.2 Subroutines

DUMOD2 uses standard NASTRAN GINO routines and utility routines.

3.2.2.1 Subroutine Name: DUM02A

1. Entry Point: DUM02A

2. Purpose: To generate and output column reordering matrices REORDER1 and REORDER2 and to compute parameters NORO1 and NORO2.

3. Calling Sequence: CALL DUM02A(FILE, KK1, KK2, NORO, BUFFER)

   FILE - GINO file number of REORDER1 or REORDER2 - integer - input.
   KK1 - Reordering row index - integer - input.
   KK2 - Reordering column index - integer - input.
   NORO - NORO=+1 if reordering matrix was generated, -1 otherwise - integer - output.
   BUFFER - GINO buffer - real - input

4. Method: If KK1 = 1 or KK2 = 1 then set parameter NORO=-1, otherwise set parameter NORO=+1 to indicate that the reordering matrix was generated. If NORO=-1, then return otherwise continue processing.

   Generate a real single precision reordering matrix of order KK1*KK2 by post-multiplying the matrix whose columns are to be reordered.
   Column i of the reordering matrix contains a 1.0 in row j if column j is to become column i of the reordered matrix. For example, if column 5 is to become column 1 of the new matrix then the reordering matrix contains a 1.0 in row 5 of column 1.

3.2.2.9 Design Requirements

a) Open core is defined at /DUM2XX/
b) DUMOD2 resides in LINKNS07
c) No scratch files are used
d) Open core for one BUFFER+1 is required.
The layout of open core is as follows:

COMMON/DUM2XX/

<table>
<thead>
<tr>
<th>Z(ITOL)</th>
<th>TOL TIME DATA</th>
<th>TIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFOL)</td>
<td>FOL/FRL DATA</td>
<td>FLMAX</td>
</tr>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>TOL/FOL/FRL/REORDER</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

3.2.2.10 Diagnostic Messages

The following fatal error messages may occur: 3001, 3002, 3008, 3037
3.3 OVERLAY CHARTS

3.3.1 IBM OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
**NASTRAN L17.7 (IBM)**

**LINE 3006**

![Diagram of NASTRAN L17.7 (IBM) Line 3006]

- **Root**
  - XSEMOX
  - OUTPUT

- **Reig**
  - ...
  - ...
  - ...

- **Lee**
  - ...
  - ...
  - ...

- **Output**
  - ...
  - ...
  - ...

- **X** - Denotes new routines
- + - Denotes existing routines new to this link
- XSEMOX,
- OPEN CASE - / ALOXX must be placed after the
  - longest link of printing
  - link, output and output

**LINKDIT (Control)**

- **CHANGE CSA unbelievable**
- **EXCLUDE LINE (ALLOXX)**
- **CHANGE PLOT (RETURN), SYMBOL (RETURN), NUMBER (RETURN)**
- **INCLUDE LIB (ALLOXX)**
- **CHANGE ALLOXX, SYMBOL (RETURN)**
- **INCLUDE LIB (ALLOXX)**
- **CHANGE PLOT (RETURN), LINE (RETURN), AXIS (RETURN)**
- **INCLUDE LIB (ALLOXX)**
NASTRAN L179 (IBM)

LINK routine

MODIFIED EXISTING ROUTINES: CYCLE, DNF, DNF2
MODIFIED EXISTING ROUTINES: FA2
3.3.2 UNIVAC OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
Frequency Response of a 12-Bladed Disc
(Examples 1-5) by the Direct Method

A. General Description

Five inter-related examples are presented to illustrate various features of this new capability to conduct forced vibration analysis of rotating cyclic structures. A 12-bladed disc is used for demonstration.

The capability includes the effects of Coriolis and centripetal accelerations on the rotating structure which can be loaded with:

1. directly applied loads moving with the structure, and

2. inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

Example 1 is conducted on a finite element model of the complete structure (Figure 1). Examples 2 through 5 use a finite element model of one rotationally cyclic sector (Figure 2). Results of example 1 are used to verify some of the results obtained in the remaining examples. Table 1 summarizes the principal features demonstrated by these examples.

Steady-state frequency-dependent (sinusoidal) or time-dependent (periodic) loads are applied to selected grid point degrees of freedom. The specified loads can represent either the physical loads on various segments or their circumferential harmonic components. For illustration purposes only, the frequency band of excitation, 1700-1920 Hz, due to directly applied loads and base acceleration is selected to include the second bending mode of the disc for a circumferential harmonic index \( k = 2 \). The 'blade-to-blade' distribution of the directly applied loads also corresponds to \( k = 2 \). Table 2 lists the first few natural frequencies of the bladed disc for \( k = 0, 1 \) and 2. Modes for \( k = 2 \) are shown in Figure 3.

B. General Input

1. Parameters:

   Diameter at blade tip = 19.4 in.
   Diameter at blade root = 14.2 in.
   Shaft diameter = 4.0 in.
Disc thickness = 0.25 in.
Blade thickness = 0.125 in.
Young's modulus = $30.0 \times 10^6$ lbf/in$^2$
Poisson's ratio = 0.3
Material density = $7.4 \times 10^{-4}$ lbs-sec$^2$/in$^4$
Uniform structural damping ($g$) = 0.02

2. Constraints:

All constraints are applied in body-fixed global coordinate system(s). All grid points on the shaft diameter are completely fixed. Rotational degrees of freedom $\theta_z$ at remaining grid points are constrained to zero.
EXAMPLE 1

A. Description
This example uses the direct frequency response capability in NASTRAN, RF8, and forms the basis to verify some of the results of examples 2 through 5.

B. Input
1. Parameters:
   Same as general input parameters.

2. Constraints:
   Same as general input constraints.

3. Loads:
   \[ P(f;n) = A(f) \cos \left( n - T \cdot \frac{2\pi}{12} \right) \]
   \[ \text{where } n \text{ is the segment number, } \]
   \[ k = 2, \]
   \[ \text{represents the total number of segments in the bladed disc.} \]
   \[ P \text{ is specified using RLOAD1 bulk data cards.} \]

C. Results
Sample plots of grid point displacement and element stress response are shown in Figures 4 through 6. The expected behavior about a \( k = 2 \) natural frequency of the bladed disc can be seen in all these figures.
### D. Driver Decks and Bulk Data

#### NASTRAN EXECUTIVE CONTROL DECK ECHO

<table>
<thead>
<tr>
<th>ID</th>
<th>NASA, EXAMPLE1</th>
</tr>
</thead>
<tbody>
<tr>
<td>APP</td>
<td>DISP</td>
</tr>
<tr>
<td>SOL</td>
<td>0</td>
</tr>
<tr>
<td>TIME</td>
<td>15. $ IBM 370/3031</td>
</tr>
<tr>
<td>DIAG</td>
<td>14.21</td>
</tr>
</tbody>
</table>

---

4.4
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 1 (FULL MODEL,FREQ LOADS)

INDEX 2C TYPE LOADS

CASE CONTROL DECK ECHO

CARD
COUNT
1
$TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
2
SUBTITLE = BLADED DISC EXAMPLE 1 (FULL MODEL,FREQ LOADS)
3
LABEL = INDEX 2C TYPE LOADS
4
$
5
$SPC = 30
6
FREQ = 1
7
LOAD = 1
8
OUTPUT
9
SET 1 = 0,22,24,50,64,78,92,106,120,134,148,162,
10
16,30,44,58,72,86,100,114,128,142,156,170,
11
18,32,46,60,74,88,102,116,130,144,158,172
12
LOAD = 1
13
DISP(SORT2, PHASE) = ALL
14
STRESS(SORT2, PHASE) = ALL
15
OUTPUTXYPLOT
16
PLOTTER NASTPLT, MODEL .0, 0.
17
XPAPER = 8.0
18
YPAPER = 10.5
19
XAXIS = YES
20
YAXIS = YES
21
XGRID LINES = YES
22
YGRID LINES = YES
23
CURVELINESYMBOL = 1
24
VLOG = YES
25
XTITLE = FREQUENCY (HERTZ)
26
YTITLE = GRID POINT DISPLACEMENTS ( MAGNITUDE, INCH )
27
XYPLOT, XYPRINT DISP RESPONSE /14(T3RH), 18(T3RM), 95(T3RH)
28
XYPLOT, XYPRINT STRESS RESPONSE /14(T3RH), 18(T3RM), 95(T3RH)
29
YTITLE = ELEMEN T STRESSES ( MAGNITUDE, PSI )
30
TCURVE = 11(13), 11(5), 11(7), 11(10), 11(12), 11(14)
31
XYPLOT, XYPRINT STRESS RESPONSE /11(3), 11(5), 11(7),
32
11(10), 11(12), 11(14)
33
TCURVE = 109(3), 109(5), 109(7), 109(10), 109(12), 109(14)
34
XYPLOT, XYPRINT STRESS RESPONSE /109(3), 109(5), 109(7),
35
109(10), 109(12), 109(14)
36
BEGIN BULK
37

SER INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
### Sorted Bulk Data Echo

<table>
<thead>
<tr>
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ENDDATA
EXAMPLE 2

A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output data for loads, displacements, stresses, etc., pertain to the physical representation of the various segments of the bladed disc. The frequency-dependent applied loads correspond to \( k = 2 \), and hence the solution loops on the circumferential harmonic index \( k \) are restricted to \( k = 2 \) only via parameters \( KMIN \) and \( KMAX \).

B. Input

1. Parameters:
   In addition to general input parameters,
   - \( CYCIO = +1 \) physical cyclic input/output data
   - \( KMIN = 2 \) minimum circumferential harmonic index
   - \( KMAX = 2 \) maximum circumferential harmonic index
   - \( NSEGS = 12 \) number of rotationally cyclic segments
   - \( RPS = 0.0 \) rotational speed
   - \( GKAD = \text{FREQRESP} \) Specify the form in which the damping parameters
   - \( LGKAD = +1 \) are used.

2. Constraints:
   Same as general input constraints.

3. Loads:
   \[
   P^n(f) = A(f) \cos \left( \frac{n - 2 + \frac{2\pi}{12}}{2} \right),
   \]
   where
   - \( n \) is the segment number,
   - \( \frac{2\pi}{12} \) represents \( k = 2 \),
   - \( \frac{2\pi}{12} \) represents the total number of segments in the bladed disc.
   \( P \) is specified using RLOADi bulk data cards.

C. Results

Displacement and stress output results for selected grid points and elements are presented in Figures 7 through 10. Agreement between results of Figures 7-8 and Figure 4, Figure 9 and Figure 5, and Figure 10 and Figure 6 is excellent.
D. **Driver Decks and Bulk Data**

**NASTRAN EXECUTIVE CONTROL DECK ECHO**

**ID:** NASA.EXAMPLE2

**APP:** DISP

**SOL:** 8

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**BEGINNING OF RF ALTEK 01 - RF 8 / SERIES R (L17.7) / 1-20-82 / M.G. 5**

**PURPOSE - TO MODIFY THE DIRECT FREQUENCY AND RANDOM RESPONSE RIGID**

**FORMAT TO ENABLE THE USER TO PERFORM A FORCED VIBRATION**

**RESPONSE ANALYSIS OF ROTATING CYCLIC STRUCTURES.**

**$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

**EXECUTIVE DECK INPUT -**

1. SOL 8
2. R.F. ALTEK

**CASE CONTROL DECK INPUT -**

1. ALL SPC AND MPC CONSTRAINTS MUST BE ABOVE THE SUBCASE LEVEL.
2. EITHER FREQUENCY OR TSTEP MUST BE SELECTED AND MUST BE ABOVE THE SUBCASE LEVEL.
3. IF SELECTED, FREQUENCY MUST BE USED TO SELECT ONE AND ONLY ONE FREQ, FNGLQ1 OR FREW2 CARD FROM THE BULK DATA DECK AND MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
4. IF SELECTED, TSTEP MUST BE USED TO SELECT THE TIME-STEP TO BE USED FOR LOAD DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. OFREQUENCY MUST NOT BE USED.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEFINED FOR EACH SYMMETRIC SECTOR.
8. DLOAD MUST BE USED TO DEFINE A FREQUENCY OR TIME-DEPENDENT LOADING CONDITION FOR EACH SUBCASE.
   FOR FREQUENCY-DEPENDENT LOADS, SUBCASES WITHOUT LOADS NEED NOT REFER TO A DLOAD CARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO A DLOAD CARD THAT GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF SUBCASES FOR EACH HARMONIC INDEX. K. THE PARAMETER CYCIO IS INCLUDED AND THE LOAD COMPONENTS FOR EACH INDEX ARE DEFINED DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

**BULK DATA DECK INPUT -**

**ORIGINALLY PUBLISHED**

**OF POOR QUALITY.**

4.15
1. SUPPORT BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPPOINT BULK DATA CARDS ARE NOT ALLOWED.
4. CJOIN BULK DATA CARDS ARE REQUIRED.
5. IF A TSTEP CARD IS USED THEN IT MUST NOT BE CONTINUED SINCE ONLY ONE UNIFORM TIME STEP INTERVAL MUST BE SPECIFIED.
6. THE SKIP FACTOR FOR OUTPUT NO. ON THE TSTEP CARD MUST BE 1.

PARAMETERS USED ARE:

A. NSEGS - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF IDENTICAL SEGMENTS IN THE STRUCTURAL MODEL.

B. CYCLO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA. A VALUE OF 1 IS USED TO SPECIFY PHYSICAL SEGMENT REPRESENTATION, A VALUE OF -1 IS USED TO SPECIFY CYCLIC TRANSFORMATION REPRESENTATION. THERE IS NO DEFAULT, A VALUE MUST BE INPUT.

C. CYCSEG - FIXED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE PROCEDURE FOR SEQUENCING THE EQUATIONS IN THE SOLUTION SET. THE VALUE OF THIS PARAMETER HAS BEEN SET TO -1 TO SPECIFY ALTERNATING CUSINE AND SINE TERMS.

D. LTYPE - FIXED - THE GCD VALUE OF THIS PARAMETER DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE OF THIS PARAMETER HAS BEEN SET TO 1 TO SPECIFY ROTATIONAL SYMMETRY.

E. KMAX - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MAXIMUM VALUE OF THE HARMONIC INDEX. THERE IS NO DEFAULT FOR THIS PARAMETER. THE MAXIMUM VALUE THAT CAN BE SPECIFIED IS NSEGS/2.

F. KMIN - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MINIMUM VALUE OF THE HARMONIC INDEX TO BE USED IN THE SOLUTION LOOP. KMIN CAN EQUAL KMAX. THE DEFAULT VALUE IS 0.


H. NLOAD - FIXED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF LOADING CONDITIONS. THE VALUE OF THIS PARAMETER IS INTERNALLY CALCULATED.

I. RPS - OPTIONAL - THE REAL VALUE OF THIS PARAMETER DEFINES THE ROTATIONAL SPEED OF THE STRUCTURE IN REVOLUTIONS PER UNIT TIME. THE DEFAULT VALUE IS 0.0.

**NASTRAN EXECUTIVE CONTROL DECK ECHO**

**UPTID**
Tables referred to by UXTID, UYXID, and UZTID

**DZTID**
Define magnitude (\(zt=1\)) and the tables referred to by UXTID, UYXID, and UZTID define phase (degree).

The default values are -1 which means that the respective terms are ignored.

**K. NUKPRT**
Optional - An integer value of 61 for this parameter will cause the current harmonic index, KINDEX, to be printed at the top of the harmonic loop. The default value is 61.

**L. GRPNT**
Optional - A positive integer value of this parameter will cause the grid point weight generator to be executed and the resulting weight balance information to be printed. Default is -1.

**M. HTHASS**
Optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in ENG. The default is 1.0.

**N. GUPMASS**
Fixed - Only lumped mass matrices must be used.

**O. GJKAD**
Optional - The BCD value of this parameter is used to tell the GJKAD module the desired form of matrices K00, B00 and D00. The BCD value can be FREKESP or TRANRESP. The default is TRANRESP.

**SL**: Section 9.3.3 (Direct dynamic matrix assembly) pages 9.3-7 and 9.3-8 of the NASTRAN THEORETICAL MANUAL.

**P. LGKAD**
Optional - The integer value of this parameter is used in conjunction with parameter GJKAD. If GJKAD=FREKESP then set LGKAD=1. If GJKAD=TRANRESP then set LGKAD=-1. The default value is -1.

**Q. G**
Optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamical problems.

**R. H3**
Optional - The real value of this parameter is used as a pivotal frequency for uniform structural damping if parameter GJKAD=TRANRESP. In this case H3 IS REQUIRED IF UNIFORMED STRUCTURAL DAMPING IS DESIRED. The default value is 0.0.

**S. H4**
Optional - The real value of this parameter is used as a pivotal frequency for element structural damping if parameter GJKAD=TRANRESP. In this case H4 IS REQUIRED IF STRUCTURAL DAMPING IS DESIRED FOR ANY OF THE STRUCTURAL ELEMENTS. DEFAULT IS 0.0.

**REMARKS**

1. The analysis will loop thru a range of the cyclic index.

KINDEX = KMIN TO KMAX.
FILE UVF=APPEND/PDF=APPEND
$ PERFORM INITIAL ERROR CHECKS ON NSEG5 AND KMAX.
COND ERRORC1*NSEG5 IF USER HAS NOT SPECIFIED NSEG5.
CONC ERRORC1*NMAX5 IF USER HAS NOT SPECIFIED KMAX.
PARAM //CN,EU //VN,CYC10ERR /V,Y,CYCI0=0 /CN,0 $.
CONC ERRORC1*CYC10ERR IF USER HAS NOT SPECIFIED CYC10.
PARAM //CN,DUV /V,Y,NSEG5 /V,Y,NSEG5 /CN,2 & NSEG5 = NSEG5/2.
PARAM //CN,SUB /V,Y,NMAXERR /V,Y,NSEG5 /V,Y*KMAX5 $.
COND ERRORC1*NMAXERR IF KMAX GT NSEG5/2.
$ SET DEFAULTS FOR PARAMETERS.
PARAM //CN,NUP /V,Y,NUKPT5=61 /V,Y,LGKAD5=-1 $.
$ CALCULATE OMEGA, 2*OMEGA AND OMEGA**2 FROM RPS. SET DEFAULT KPS.
PARAM //CN,MPY /V,Y,OMEGA /V,Y,RP5=0.0 /CN,283185 $.
PARAM //CN,MPY /V,Y,UMEGA2 /CN,2.0 /V,Y,UMEGA $.
PARAM //CN,MPY /V,Y,UMEGASQR /V,Y,OMEGA /V,Y,OMEGA $.
$ GENERATE NURPS FLAG IF KPS IS ZERO.
PARAM //CN,EU //V,Y,RP5 /CN,0.0 //V,Y,NURPS $.
$ MAKE SURF COUPLED MASSES HAVE NOT BEEN REQUESTED.
PARAM //CN,NUT /V,Y,NLOMUL /V,Y,CLUPMASS=-1 $.
CONC ERRORC2*NULMP5
ALTER 21 $ ADD SLT TO OUTPUT FOR TRLG.
GP3 GEUM3,ELXIL,GEUM2 / SLT,GPIT / V,N,NUGRAV $.
LHPNI SLT,GPIT $.
ALTER 23 $.
$ SINGLE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT
$ MAKE ERROR CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.
$ ADD YS NEEDED FOR PSF RECOVERY IN SSG5.
PARAM //CN,MPY /V,Y,NSkip5 /CN,0 /CN,0 $.
GP4 CASECC,ULOM5,ELXIL5,GPITB,GPITC,CS11M/KG,YS,USET,ASET/V,Y,LUSET/
PUHC M/GMD/MPCF1/GD,CM,CM,T/ FS,PSF,/GPC/SINGLE5 $.
LHPNI GM/GMD,CM,CM,GU,UD, FS,PSF,/GPC,USET,Y5 $.
$ SUPORT BULK DATA IS NOT ALLOWED.
PARAM //CN,NUT /V,Y,READDATA /V,N,REACT $.
CONC ERRC1*READDATA $.
$ EXECUTE DPD NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.
DPD DYNAMICS,GPL,SIL,USET / GPUL,SIL,USETD,TFOOL/DLT,PSDL,FLR $.
$ MUST HAVE LDFPAIR OR TSTEP BULK DATA.
PARAM //CN,NFTE /V,N,NOFRL /V,N,NOTRL $.
CLND ERROCR5*FILTE $.
$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL.
PARAML CASECC //CN,UTI /CN,1 /CN,14 //V,N,FREWSET $.
PARAML CASECC //CN,UTI /CN,1 /CN,38 //V,N,TIMSEET $.
PARAM //CN,MPY /V,N,FRDSET /V,N,FREWSET /V,N,TIMSEET $.

4.18
NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NOT /V,N,FTEKI /V,N,FROUTINE $
PARAM //C,N,LE /V,N,NUFRE /V,N,FRESET /C,N,O $
PARAM //C,N,LE /V,N,NOTICE /V,N,TIMESET /C,N,O $
COND ERRORCO,FTEKI $ BOTH FREQ AND TSTEP IN CASE CONTROL DECK.$
$ ERRORTI,ULK DATA NOT ALLOCED
PARAM //C,N,NOT /V,N,EXTRAPTS /V,N,NOUE $
COND ERRORCO,EXTRAPTS $
$ GENERATE DATA FOR CYC2 TO MODULE.
CPYC GEOMG,COUNT,EDEED /CYCD $ /V,N,CTYPE=ROT /$S,N,NOGU $
CCND ERRORCI,NUGC $
CHKNT CYCDO $
ALTER 32 $ $ PRI-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED
PARAM //C,N,OK /V,N,NUOHML /V,N,NGMCG /V,N,NUKPS $
PURGE DIGG,MLIG /NCHMI $
PURGE M2GG,M2BASEXG /NUMCG $
ALTER 33 $ $ GENERATE DATA BLOCKS FRLX, BIGG, MLIG, M2GG AND BASEXG.
$ GENERATE PARAMETERS KMEX AND NCBASEX.
ZMMOD1 CASECC,BUPOT,CSTM,DIT,FRLX,MLIG / M2GG,BASEXG,POZRSG / V,N,NGMCG/V,Y,LYCIC/V,Y,NGSEG$/$
V,Y,KMAX/SN,FKMAX/V,Y,BXTID=-1/V,Y,BPTID=-1/
V,Y,BXPTID=-1/V,Y,BXPID=1/V,Y,BZTID=-1/
V,Y,DZPTID=-1/S,N,NUBSEX/V,N,NOHEV/V,N,UHEGA $
PARAML FRLX //C,N,PRESUXE //V,N,NGPRLX $
COND LBLFRXL,NUFRXL $
EQUIV FRLX,FLK $
LABEL LBLFRXL $
CHKNT FRLX,BIGG,MLIG,M2GG,BASEXG $
ALTER 42 $ $ REDEFINE BGG AND KGG.
PARAM //C,N,ADD /V,N,NUOHML /V,N,NUHM1 /C,N,U $ RESET NUHGG.
ALTER 52 $ $ REDEFINE BGG AND KGG.
COND LBLLIA,NUM1 $
PARAM //C,N,COMPLEX //V,N,MEGA2 /C,N,0.0 /V,N,CMPLX1 $
PARAM //C,N,SUB /V,N,MEGASG /C,N,U.0 /V,N,OMEGASG $
PARAM //C,N,COMPLEX //V,N,MEGASG /C,N,0.0 /V,N,CMPLX2 $
ADD BGG+311G / BGG1 / C,N,(L.0,0.0) /V,N,CMPLX1 $
EQUIV BGG1, BGG $
ADD KGG+MLIG / KGG1 / C,N,(L.0,0.0) /V,N,CMPLX2 $
EQUIV KGG1,KGG $
CHKNT BGG,KGG $
LABEL LBL11A $
ALTER 53,55 $ GP4 HAS BEEN MOVED-UP.
ALTER dB8.68 $ LPU HAS BEEN MOVED-UP.
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LGKAD FOR FREQ OR TRAN.
PARAM //C,N,AND /V,N,SCRLK /V,N,NUOUE /V,N,NGK2PP $
COND LGKAD1, LGKAD $ BRANCH IN NOT FREQRES.
ALTER 115 $ SEE ALTER 114 COMMENT.
JUMP LGKAD2 $
LABEL LGKA01 $
    KAA,KDD/KDEKA $
CKPNT K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MOD $
LABEL LGKA02 $
ALTER 117/117 5 ADD PARAMETERS GKAU, n3 AND n7 TO GKAU.
GKAU USFTD,GM,G0,KAA,DA,VAA,K4AA,K2PP,M2PP,B2PP,KDD,BDD,MOD,GID,
    C,Y,0=0.0/C,0=0.0/V,N,0=0/V,N,OK2PP/V,N,NUM2PP/
    V,N,NGB2PP/V,N,MPCFL/V,N,SITC/LE/V,N,UHIT/V,N,NGUE/V,N,NK4GG/
    V,N,NODG0/V,N,KDEK2/L,N,-1 $
ALTER 118 $ SEE ALTER 114 COMMENT.
CNDU LGKA03,LGKA05 $ BRANCH IF NOT FREGRES.
ALTER 119 $ SEE ALTER 114 COMMENT.
JUMP LGKA04 $ 
LABEL LGKA03 $ 
EQUIV B2DD,GDD/NOSDNT/M2DD,MOD/NOSIMP/K2DD,KDD/KDEK2 $
LABEL LGKA04 $ 
ALTER 120/123 $ 
$ NEW SOLUTION LOGIC $ 
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL. 
CNDN TRLTRL/NOTIME $ 
$ LOOP THRU ALL SUBCASES FOR TIME-DEPENDENT LOADS. 
PARAM //C,N,MPY /V,N,REPEATT /C,N,1 /C,N,-1 $ 
JUMP TRLGLOOP $ 
LABEL TRLGLOOP $ 
CASE CASECC,/CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NOLOOP1 $ 
CKPNT CASEYY $ 
PARAM //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1 $ 
TRLG CASEYY,USETD,ULT,SLT,SGPUD,STL,CSIT,TRL,UIT,GMD,GUD,EST,HGG/
    *PD1,PD1,1CL/ V,N,NUSET/S,N,POPDDO/V,N,INCOL $ 
SDR1 TRLGPD1,11111111 / *PD1 /V,N,APPFLG/C,N,DYNAMICS $ 
SDR1 TRLGPD1,11111111 / *PD /V,N,APPFLG/C,N,DYNAMICS $ 
CNDN TRLGONE,REPEATT $ 
KEPT TRLGLOOP,1CG $ 
JUMP LRDR03 $ 
LABEL TRLGONE $ 
CKPNT PDD,PD,1CL $ 
EQUIV PD,PD,POPDDO $ 
CKPNT PCT $ 
DUMOUD2 TDL,11111111 / FRLZ,FULZ,REGDER1,KEEGER2,11111111 /
    V,N,SEG/0/V,N,CYUG/S,Y,LMAX=-1/V,N,LMAX/
    S,N,FLMAX/S,N,NSTEPS/S,N,NGCL/S,N,NGK2 $ 
EQUIV FRLZ,FULZ // FULZ,FCL $ 
CKPNT FRL,FCL,KEEGER1,KEEGER2 $ 
JUMP LBL,FKL2 $ 
LABEL LBLTRL1 $ 
$ GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC. 

4.20
NASTRAN EXECUTIVE CONTROL DECK ECH

FRLG  CASEXX,USERTD,DLT,FRL,GHD,GOO,DT, / PPF,PSF,PDF,FUL,PFQDM / C,N,DIRECL/V,N,FREYu/C,N,FREQ /  
COND.  LBLFRLX1,NOFLX $ ZERO OUT LOAD COLUMNS IF FRLX WAS GENERATED.  
MPYAD  PPF,POZERD, / PPFX / C,N,0 $  
EQUIV  PPFX,PF $  
LABEL  LBLFRLX1 $  
$ FORM NEW LOADS.  
COND  LBLFRL1,NOBASEX $  
MPYAD  M2G,GHD,LXG, / M2BASEXG / C,N,0 $  
ADL  PPF,M2BASEXG / PPF1 / C,N,(-1.0,0,0) / C,N,(-1.0,0,0) $  
EQUIV  PPF1,PF $  
COND  LBLBASE1,NASET $  
SSQ2  USERTD,GHD,VS,AFS,GW,PPF / PDDUM1,PSF1,PDF1 $  
EQUIV  PSF1,PSF / PDF1,PDF $  
LABEL  LBLBASE1 $  
LABEL  LBLFRL1 $  
EQUIV  PPF,PDF/NASET $  
CHKPT  PPF,PSF,PDF,FCL $  
$ LOADS ARE FREQUENCY-DEPENDENT  
$ PERFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=-1.  
PARAM  PDF / C,N,TNQILER / C,N,1 / V,N,POFCOLS $  
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=-1.  
PARAM  / C,N,OIV / V,N,NCAD / V,N,POFCOLS / V,N,FKMAX $ NLOAD = NF/FKMAX  
EQUIV  PDF,PF/CYCIC $  
COND  LBLPODNE,CYCIC $  
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1.  
PARAM  / C,N,OIV / V,N,NCAD / V,N,POFCOLS / V,N,NSEGS $ NLOAD = NF/NSEGS  
CYCT1  PDF / PAF,CLCYC1 / V,N, CType / C,N,FKRE / V,N,NSEGS=-1 / V,N,FKMAX=-1 / V,N,NILOAD / S,N,NCGU $  
COND  ERRRCL,NGGU $  
CHKPT  PAF $  
JUMP  LBLPODNE $  
LABEL  LBLFRL2 $  
$ LOADS ARE TIME-DEPENDENT  
PARAM  / C,N,N01 / V,N,NOTCYCIC / V,Y,CYCIC $  
$ BRANCH DEPENDING ON VALUE OF CYCIC  
COND  LULTRL2,NOTCYCIC $  
$ CYCIC=-1  
EQUIV  PDT,PDTZ21/NUR01 $  
COND  LBLRU1A,NUR01 $  
MPYAD  PRT,REDKQER1, / PDRZ1 / C,N,0 $  
LABEL  LBLRU1A $  
CYCT1  PDRZ21 / PFRZ21,GCLCYF2 / V,N, CType / C,N, FKRE / V,N,NTSTEPS / V,N,FAKMAX/V,N,FKMAX/S,N,NCGU $  
COND  ERRRCL,NGGU $  
CHKPT  PXXRL1 $  
EQUIV  PXXRL1,PFZ21/NUR02 $  
COND  LBLK02A,NUR02 $  
MPYAD  PXXRL1,REDKQER2, / PFX21 / C,N,0 $  
LABEL  LBLK02A $  

4.21
EQUIV PXF21, PXF1 $
CHKPNT PXF1 $
JUMP LBLTRL3 $
LABEL LBLTRL2 $
$ CYC1 = 01
MPYAD PDT, REORDER1, / POTRZ2 / C N O$

CYC11 POTRZ2 / PXTRZ2, GCYCF3 / V N CTYPE/C N FORE/V Y NSEGS/V Y NMAX/

V Y NSEGS/ S N NOGC $

COND ERRORC1, NOGC $
CHKPNT PXTRZ2 $
EQUIV PXTRZ2, PXTR2/NUR2 $
COND LBLR2B, NUR2 $
MPYAD PXTRZ2, REORDER2, / PXTR2 / C N O$

LABEL LBLR2B $
NCYC2 PXTR2 / PXF21, GCYCF4 / V N CTYPE/C N FORE/V Y NSEGS/V Y KMAX/

V Y FLMAX/ S N NOGC $

COND ERRORC1, NOGC $
EQUIV PXF21, PXF1 $
CHKPNT PXF1 $
LABEL LBLTRL3 $
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND
$ TO FREQUENCY DEPENDENT LOADS. ALSO SOR2 EXPECTS LOADS TO BE COMPLEX
$ IN FREQUENCY PROBLEMS.
COND / C N ADD / V N LOAD / V Y FLMAX / C N O $

PARAM NLCAD = FLMAX

LABEL LBLPGNE $
PARAM // C N, ADD / V N, KINDEX / V Y, KMIN = 0 / C N O $

$ INITIALIZE UXVF IF KMIN IS NOT ZERO.
$ PARAM / C N, ADD / V N, KMINL / V Y, KMIN / C N, O $ 

COND NOKMINL, KMINL $
PARAM // C N, ADD / V N, KMINV / C N, O $

JUMP KMINLUP $
LABEL KMINLUP $
NCYC2 CYCDD... PXF... /... PKF2... / C N FORE/V Y NSEGS/

V N, KMINV/V N, CYCSEQ/V N, NLCAD/S N, NOGC $

COND ERRORC1, NOGC $
ADD PKF2, / UXVFZ / C N, (0, C N, O, O) $

CYC2 CYCDD... LKVF... /... UXVF... / C N, BACK/V Y NSEGS/

V N, KMINV/V N, CYCSEQ/V N, NLOAD/S N, NOGC $

COND ERRORC1, NOGC $
PARAM // C N, ADD / V N, KMINV / V N, KMINV / C N, I $ 

REPT KMINLUP, KMINL $
LABEL NOKMINL $
$ JUMP TUPCYC $
LABEL TUPCYC $ LOOP ON KINDEX
CONU  NOKPRT,NOKPRT $  
PRXPAK  //C,N,0 /C,N,KINDEX $  
LABEL  NOKPRT $  
CYCT2  CYCDD,KDD,MDD... /KKKF,MMKF... /C,N,FORE/V,Y,NSEG $  
CONU  ERRORC1,NOGU $  
CHKPNT  KKF,MMKF $  
PARAM  //C,N,SYST //C,N,50 /C,N,2 $ METHOD 3T IN CYCT2 PRODUCES $ UNDERFLOW FOR PXF. USE METHOD 2.  
CYCT2  CYCDD,BDD,PFX... /KKKF,MMKF... /C,N,FORE/V,Y,NSEG $  
CONU  ERRORC1,NOGU $  
CHKPNT  KKF,MMKF $  
$ SOLUTION  
PRX2  KKF,MMKF,PFK,PFL / UKVF /C,N,0,0/C,N,0,0/C,N,-1,0 $  
CHKPNT  UKVF $  
CYCT2  CYCDD,UKVF... /C,N,BACK/V,Y,NSEG/V,N,KINDEX/ V,N,CYCSLO/V,N,LOAD/S,N,NOGU $  
CONU  ERRORC1,NOGU $  
CHKPNT  UKVF $  
PARAM  //C,N,AUX /V,N,KINDEX/V,N,KINDEX/C,N,1 $ KINDEX = KINDEX + 1  
PARAM  //C,N,AUX /V,N,BACK/V,Y,NSEG/V,N,KINDEX $  
CONU  LCY2,UDNE $ IF KINDEX .GT. KMAX THEN EXIT  
REPT  TUPLY,UIC $  
JUMP  ERROR3 $  
LABEL  LCY2 $  
EQUIV  JXVF,UDVF / LCYI $  
CHKPNT  UDFV $  
CONU  LCY3,LCYI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.  
CYLTI  UDFV / UDF,V,LCYD1 / V,N,CTYPE/C,N,BACK/V,Y,NSEG/V,Y,KMAX/ V,N,LOAD $  
CHKPNT  JXVF $  
LABEL  LCY3 $  
CONU  LBLTL4,NOTIML $  
EQUIV  PXF,PDFZ / LCYI $  
CONU  LCY4,LCYI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.  
CYLTI  PXF / PDFZ,LCYB2 / V,N,CTYPE/C,N,BACK/V,Y,NSEG/V,Y,KMAX/ V,N,LOAD $  
LABEL  LCY4 $  
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF.  
SDR1  USETS,PDF2,.../UDD,GMD,... / PPFZ... /C,N,1 /C,N,DYNAM $  
SSC2  USETS,GMD,Y,KS,FU,PPF2 / PCDUM,PSFZ,PLDDUM $  
EQUIV  PPFZ,PPF // PSFZ,PSF $  
CHKPNT  PPF,PSF $  
LABEL  LBLTL4 $  
ALTER 124,124 $ USE FULL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  
VON  CASEXX,LOOKUP,USETS,UDVF,FCL,XYCD,UDVFCL+/C,N,FREQSP/C.N.  
DIREC/ /C,N,RO,CRT2/S,N,NOD/3A,ANUP/C,N,0 $  
ALTER 140,140 $ USE FULL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  

4.23
SAK2

CASE XY.CSM.WRT.JU.HD.SILD**.BG.DP.FL/.C12.VIVC.SD.1.ECL.PUPVC1.FREQRES.

4.24

4.24

IBM 370/3031
CASE CONTROL DECK ECHO

CARD
COUNT
1
2  TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
3  SUBTITLE = BLADED DISC EXAMPLE 2 (CYC MODEL: FREQ LOADS; PHYSICAL I/O)
4  $
5  SPC = 30
6  FREQ = 1
7  OUTPUT
8  SET 1 = 0.16,18
9  DLOAD = 1
10  DISP(SORT2,PHASE) = ALL
11  STRESS(SORT2,PHASE) = ALL
12  SUBCASE 1
13    LABEL = SEGMENT 1
14    DLOAD = 1 $ FREQ DEPENDENT LOADS
15  SUBCASE 2
16    LABEL = SEGMENT 2
17    DLOAD = 2 $ FREQ DEPENDENT LOADS
18  SUBCASE 3
19    LABEL = SEGMENT 3
20    DLOAD = 3 $ FREQ DEPENDENT LOADS
21  SUBCASE 4
22    LABEL = SEGMENT 4
23    DLOAD = 4 $ FREQ DEPENDENT LOADS
24  SUBCASE 5
25    LABEL = SEGMENT 5
26    DLOAD = 5 $ FREQ DEPENDENT LOADS
27  SUBCASE 6
28    LABEL = SEGMENT 6
29    DLOAD = 6 $ FREQ DEPENDENT LOADS
30  SUBCASE 7
31    LABEL = SEGMENT 7
32    DLOAD = 7 $ FREQ DEPENDENT LOADS
33  SUBCASE 8
34    LABEL = SEGMENT 8
35    DLOAD = 8 $ FREQ DEPENDENT LOADS
36  SUBCASE 9
37    LABEL = SEGMENT 9
38    DLOAD = 9 $ FREQ DEPENDENT LOADS
39  SUBCASE 10
40    LABEL = SEGMENT 10
41    DLOAD = 10 $ FREQ DEPENDENT LOADS
42  SUBCASE 11
43    LABEL = SEGMENT 11
44    DLOAD = 11 $ FREQ DEPENDENT LOADS
45  SUBCASE 12
46    LABEL = SEGMENT 12
47    DLOAD = 12 $ FREQ DEPENDENT LOADS
48  OUTPUT(XYPLOT)
49    PLOTTER NASTPLT, MODEL D,0
50  XPAPER = 8.0
CASE CONTROL DECK ECHO

CARD COUNT
51  YPAPER = 10.5
52  XAXIS = YES
53  YAXIS = YES
54  XGRID LINES = YES
55  YGRID LINES = YES
56  CURVELINESYMBOL = 1
57  YLOG = YES
58  XTITLE = FREQUENCY (HERTZ)
59  YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
60  TCURVE = 14(T3RH),18(T3RH)
61  XYPLT,XYPRINT DISP RESPONSE 1 /14(T3RH),18(T3RH)
62  TCURVE = 2(T3RH)
63  XYPLT,XYPRINT DISP RESPONSE 8 /2(T3RH)
64  YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
65  TCURVE = 11(3),11(5),11(7),11(10),11(12),11(14)
66  XYPLT,XYPRINT STRESS RESPONSE 1 /11(3),14(5),11(7),
67  11(10),11(12),11(14)
68  TCURVE = 1(3),1(5),1(7),1(10),1(12),1(14)
69  XYPLT,XYPRINT STRESS RESPONSE 10 /1(3),1(5),1(7),
70  1(10),1(12),1(14)
71  BEGIN BULK

INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
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OF POOR QUALITY
EXAMPLE 3

A. Description
This example uses the forced vibration capability with cyclic symmetry. The user input/output data pertain to harmonic representation, frequency-dependent excitation is provided by both directly applied and base acceleration loads.

B. Input
1. Parameters:
   In addition to general input parameters,
   CYCIO = -1 harmonic cyclic input/output data
   KMIN = 0 minimum circumferential harmonic index
   KMAX = 2 maximum circumferential harmonic index
   NSEG5 = 12 number of rotationally cyclic sectors
   RPS = 600.0 revolutions per second
   BXTID, BYTID, BZTID \ Refer to TABLE6i bulk data cards to specify
   BAPTID, BYPTID, BZPTID\ magnitude and phase of base acceleration
   components.
   GKAD = FREQRESP \ Specify the form in which damping parameters are
   LGKAD = +1 \ used.

2. Constraints:
   Same as general input constraints.

3. Loads:
   a) p0.2c = A(f) specified on RLOADi bulk data cards.
   b) Base acceleration as shown in Figure 11.

C. Results
   Results are shown in Figures 12 through 20.
   Figures 12 and 13 present k = 0 results (subcase 1). The excitation consists of axial base acceleration and directly applied loads. The selected frequency band of excitation, 1700-1970 Hz, lies between the second out-of-plane disc bending mode frequency (1577 Hz, k = 0, Table 2) and the first in-plane shear mode frequency (1994 Hz, k = 0, Table 2). Since the excitation is parallel to the axis of rotation, only the former mode responds.
Figures 14 through 18 present k = 1 results (subcases 2 (k = 1c) and 3 (k = 1s)). The excitation is due to lateral base acceleration only. Although the frequency band of input base acceleration is 1700-1920 Hz, the rotation of the bladed disc at 600 Hz (parameter RPS) splits the input bandwidth into two effective bandwidths:

\[(1700 - 600) = 1100 \text{ to } (1920 - 500) = 1320 \text{ Hz, and}\]
\[(1700 + 600) = 2300 \text{ to } (1920 + 600) = 2520 \text{ Hz.}\]

The only k = 1 mode in these effective bandwidths is the first torsional mode of the blade with the disc practically stationary (2460 Hz, k = 1, Table 2). This is shown by the out-of-plane displacement magnitudes of grid points 18 (blade) and 8 (disc) respectively (Figures 14 (k = 1c) and 17 (k = 1s)). The corresponding phase responses of these grid points are shown in Figure 16.

Figures 19 and 20 present k = 2 results (subcase 4 (k = 2c)). The excitation consists of directly applied k = 2c loads. The out-of-plane displacement magnitude of grid point 18 (Figure 19) compares well with that obtained in example 2 (Figure 7). Table 3 lists the out-of-plane displacement response of grid point 18 as obtained in examples 2 and 3. The marginal difference in response in example 3 is due to the Coriolis and centripetal acceleration effects at a rotational speed of 600 revolutions per second.

No k = 2s loads are applied in this example (subcase 5).
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

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CASE C007-D-0-2-G-G-0-2-G-O-B-

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SUBTITLE = BLADE DISC EXAMPLE 2 (CIC MODEL, FREE BASE ACCN LOAD, HARM 1/0)

$ SPC = 30
FREQ = 1

OUTPUT

SET 1 = 0,16,18
SET 2 = 11
DLOAD = 1
DISP(SORT2,PHASE) = 1
STRESS(SORT2,PHASE) = 2

SUBCASE 1
LABEL = KINDEX 0
DLOAD = 1 $ FREQ DEPENDENT LOADS

SUBCASE 2
LABEL = KINDEX 1G

SUBCASE 3
LABEL = KINDEX 1S

SUBCASE 4
LABEL = KINDEX 2G
DLOAD = 1 $ FREQ DEPENDENT LOADS

SUBCASE 5
LABEL = KINDEX 2S

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XPAPER = 8.0
YPAPER = 10.5
XAXIS = YES
YAXIS = YES
XGRID LINES = YES
YGRID LINES = YES
CURVELINESYMBOL = 1
XTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
YTITLE = FREQUENCY (HERTZ)
YLOG = YES
TCURVE = 0(T3RH),18(T3RH)
XYPLOT,XPRINT DISP RESPONSE 1 /0(T3RH),10(T3RH)
XYPLOT,XPRINT DISP RESPONSE 2 /0(T3RH),10(T3RH)
XYPLOT,XPRINT DISP RESPONSE 3 /0(T3RH),10(T3RH)
XYPLOT,XPRINT DISP RESPONSE 4 /0(T3RH),10(T3RH)

YTITLE = GRID POINT DISPLACEMENTS (PHASE DEGREE)
YLOG = NO
TCURVE = 0(T31P),18(T31P)
XYPLOT,XPRINT DISP RESPONSE 2 /0(T31P),10(T31P)

YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
YLOG = YES

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A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output pertains to physical representation. Periodic loads are specified as functions of time on the segments of the bladed disc corresponding to \( k = 2 \). For clarity of illustration only, sinusoidal loads of varying amplitudes at a frequency of 1814 Hz are specified. The Fourier decomposition of these sine functions obviously contains contributions from first harmonic alone (\( \ell = 1 \))-- the parameter LMAX accordingly has been set at 1 (\( \ell = 0, 1, 1_s \)).

B. Input

1. Parameters:
   
   In addition to general input parameters,
   
   \( \text{CYCIO} = +1 \) physical cyclic input/output data
   \( \text{KMIN} = 2 \) minimum circumferential harmonic index
   \( \text{KMAX} = 2 \) maximum circumferential harmonic index
   \( \text{LMAX} = 1 \) maximum harmonic in the Fourier decomposition of periodic, time-dependent loads,
   \( \text{NSEGS} = 12 \) number of rotationally cyclic sectors
   \( \text{RPS} = 600.0 \) revolutions per second
   \( \text{GKAD} = \text{FREQRESP} \) Specify the form in which the damping parameters are used.
   \( \text{LGKAD} = +1 \) used.

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[ P^n(t) = A(t) \cos \left( n - 1 \cdot \frac{2\pi}{12} \right) \]

   where
   \( n \) is the segment number,
   \( \Box \) represents \( k = 2 \),
   \( \Box \) represents the total number of segments in the bladed disc,
   \( A(t) = A \cdot \sin \left( 2\pi \cdot 1814 \cdot t \right) \).
   \( P \) is specified on TLOADi bulk data cards.
C. Results

Results are presented in Table 4 and are in good agreement with those from example 3.
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID          NASA, EXAMPLE4
APP         DISP
SOL         3
$           ALTER PACKAGE AS IN EXAMPLE2
$ TIME      4 $ IBM 370/3031
DIAG        8, 14, 21
CEND
CASE CONTROL DECK ECHO

CARD COUNT

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SUBTITLE = BLADED DISC EXAMPLE 4 (CYC MODELS, TIME DEP. LOAD, PHYS I/O)
$ SPC = 30
TSTEP = 1
OUTPUT
SET. 1 = 8,16,10
SET 2 = 11
DLOAD = 1
DISP (SORT2,REAL) = 1
STRESS (SORT2,REAL) = 2
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4.42
SORTED BULK DATA ECHO

1  2  3  4  5  6  7  8  9  10
ENDDATA
EXAMPLE 5

A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output pertains to harmonic representation. Periodic loads are specified as functions of time for the circumferential harmonic index \( k = 2 \). For clarity of illustration only, sinusoidal loads are selected.

B. Input

1. Parameters:

   In addition to general input parameters,
   
   CYCIO = -1  harmonic cyclic input/output data
   KNIN = 2  minimum circumferential harmonic index
   KMAX = 2  maximum circumferential harmonic index
   LMAX = 1  maximum harmonic in the Fourier decomposition of periodic, time-dependent loads.
   NSEGS = 12  number of rotationally cyclic sectors
   RPS = 600.0  revolutions per second
   GKA0 = FREQESP \( \) Specify the form in which the damping parameters
   LGKAD = +1  \( \) are used.

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[ p^{2c}(t) = A \cdot \sin(2\pi \cdot 1814 \cdot t) \]
   specified on TLOADi bulk data cards.

C. Results

   Results are presented in Table 4 and agree well with those from example 3.
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID         NASA, EXAMPLE5
APP        DISP
SOL        8
$           ALTER PACKAGE AS IN EXAMPLE2
$           TIME 3 $ IBM 370/3031
DIAG       8, 14, 21
CEND
CASE CONTROL DECK. ECHO

CARD
COUNT

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
SUBTITLE = BLADED DISC EXAMPLE 5 (CYC MODEL, TIME DEP. LOAD, PARM I/O)

$ SPC = 30
STEP = 1

OUTPUT
SET 1 = 0.16; 16
SET 2 = 11
LOAD = 1
DISP(SCCT2,REAL) = 1
STRESS(SCCT2,REAL) = 2

SUBCASE 1
LABEL = KINDEX 0
LOAD = 99 & NULL LOAD

SUBCASE 2
LABEL = KINDEX 1C
LOAD = 99 & NULL LOAD

SUBCASE 3
LABEL = KINDEX 1S
LOAD = 99 & NULL LOAD

SUBCASE 4
LABEL = KINDEX 2C
LOAD = 1 & TIME DEPENDENT LOADS

SUBCASE 5
LABEL = KINDEX 2S
LOAD = 99 & NULL LOAD

BEGIN BULK

"SCRT "SCRT 207, BULK DATA NOT SCRTED, XSCRT WILL RE-ORDER DECK."

4.46
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4.47
### TABLE 1: PRINCIPAL FEATURES DEMONSTRATED BY EXAMPLE PROBLEMS

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<th>Finite Element Model of</th>
<th>Applied loads specified as functions of</th>
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<th>Rotational Speed</th>
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<td>Time (periodic)</td>
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<td>Circum.Harmonic Components</td>
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**Table 2: Bladed-Disc Natural Frequencies**

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<th>Mode Description</th>
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<td>591 (2) 594 (2) 622 (2)</td>
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<td>1577 (3) 1633 (3) 1814 (3)</td>
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<td>2468 (5)** 2460 (4) 2433 (4)</td>
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* k is the circumferential harmonic index

** Mode No. 4 for k = 0 at 1994 Hz represents an in-plane shear mode not excited by the applied forces.
TABLE 3: EFFECT OF CORIOLIS AND CENTRIPETAL ACCELERATIONS ON THE DISPLACEMENT RESPONSE OF GRID POINT 18 AT 600 RPS.

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<th>Example 3: k = 2c (subcase 4)</th>
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<td>Mag. (in)/Phase (deg)</td>
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<td>1832</td>
<td>3.4146 E-4/224.9</td>
<td>3.2655 E-4/225.5</td>
</tr>
<tr>
<td>1850</td>
<td>2.1451 E-4/206.6</td>
<td>2.0742 E-4/209.3</td>
</tr>
<tr>
<td>1880</td>
<td>1.2433 E-4/195.6</td>
<td>1.2214 E-4/199.2</td>
</tr>
<tr>
<td>1920</td>
<td>7.6125 E-5/190.4</td>
<td>7.5397 E-5/194.3</td>
</tr>
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</table>
TABLE 4: COMPARISON OF RESPONSE AT 1814 Hz

<table>
<thead>
<tr>
<th>Grid Pt. Disp. or Elem. Stresses</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$k = 2c$ (subcase 4)</td>
<td>Segment 1 (subcase 1)</td>
<td>$k = 2c$ (subcase 4)</td>
</tr>
<tr>
<td></td>
<td>Mag. (in)/Phase (deg)</td>
<td>Mag. (in)/Phase (deg)</td>
<td>Mag. (in)/Phase (deg)</td>
</tr>
<tr>
<td>8 (T3RM), $u_z$</td>
<td>5.4297 E-4/82.6</td>
<td>5.4299 E-4/82.6</td>
<td>5.4299 E-4/82.6</td>
</tr>
<tr>
<td>18 (T3RM), $u_z$</td>
<td>4.9177 E-4/266.8</td>
<td>4.9180 E-4/266.8</td>
<td>4.9180 E-4/266.8</td>
</tr>
<tr>
<td>11 (3), $\sigma_{xx,1}^*$</td>
<td>1.4841 E 3/84.7</td>
<td>1.4842 E 3/84.7</td>
<td>1.4842 E 3/84.7</td>
</tr>
<tr>
<td>11 (5), $\sigma_{yy,1}$</td>
<td>2.0891 E 2/83.4</td>
<td>2.0892 E 2/83.4</td>
<td>2.0892 E 2/83.4</td>
</tr>
<tr>
<td>11 (7), $\tau_{xy,1}$</td>
<td>1.0774 E 2/64.7</td>
<td>1.0775 E 2/64.7</td>
<td>1.0775 E 2/64.7</td>
</tr>
<tr>
<td>11 (10), $\sigma_{xx,2}^*$</td>
<td>1.4677 E 3/263.3</td>
<td>1.4678 E 3/263.3</td>
<td>1.4678 E 3/263.3</td>
</tr>
<tr>
<td>11 (12), $\sigma_{yy,2}$</td>
<td>2.2489 E 2/260.3</td>
<td>2.2491 E 2/260.4</td>
<td>2.2491 E 2/260.4</td>
</tr>
<tr>
<td>11 (14), $\tau_{xy,2}$</td>
<td>1.8510 E 2/253.0</td>
<td>1.8511 E 2/253.0</td>
<td>1.8512 E 2/253.0</td>
</tr>
</tbody>
</table>

* Fibre distances 1 and 2.
Figure 2: NASTRAN Cyclic Model of the 12-Bladed Disc
Figure 3: $k=2$ Modes of Bladed Disc
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
INDEX 2C TYPE LOADS

Figure 4
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 1  (FULL MODEL, FREQ LOADS)
KINDEX 2C TYPE LOADS

Figure 5
FORCED VIBRATION ANALYSIS OF ROTATING CYLIC STRUCTURES

Figure 6
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL 1/0)
SEGMENT 1
SUBCASE 1

Figure 7
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

BLADED DISC EXAMPLE 2 (CYC MODEL, FRF LOADS, PHYSICAL 1/3)
SEGMENT I
SUBCASE 1

Figure 9
Figure 10

FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FAST LOADS, PHYSICAL 17/0)
SEGMENT 10

SUBCASE 10

1131, 1135, 1171, 1191, 1192, 1194

4.62
Figure 11: Base Acceleration Data in an Inertial Coordinate System
Figure 12

FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ=BASE ACCN LOAD, HARM 1/6
INDEX 0, SUBCASE 1

4.64
Figure 13
Figure 14

FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 ICYC MODEL, FREO=BASE ACCN LOAD, MAAM 1/0
KINDEX 1C

Figure 14
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ BASE ACCN LOAD, HARM 1/0
KINDEX 10
SUBCASE 2

Figure 15

4.67
Figure 16
FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL BLADED DISC EXAMPLE 3 (CT1) MODEL, FREE-BASE, SUBCASE 2, INDEX IC

<table>
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<tr>
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</tr>
</tbody>
</table>

EJEXTED FREQUENCY (HERTZ)
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

BLADED DISC EXAMPLE 3 1ETC MODEL, FREQ BASE ACCH LOYD, HARSH I/O
KINDEX 15
SUBCASE 3

Figure 17
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ=BASE ACN LOAD, HARM 1/0
KINDEX 15, SUBCASE 3)

Figure 18
Figure 19

Bladed Disc Example 3, ITC Model, Free-Base ACC Load, MRRM 1°0, SUBCASE 4

KINDX 2C

4.71
Figure 20

Forced vibration analysis of rotating cyclic structures
Bladed disc example 3, CFC model, freq. base mean 1500 rpm, Mach 1.0
KINDEX 20
SUBCASE 4

4.72