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FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
IN NASTRAN

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by

V. Elchuri
A. Michael Gallo
S. L. Skalski

Bell Aerospace Textron
P. O. Box One
Buffalo, New York 14240

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS3-22533

NASA Lewis Research Center
Cleveland, Ohio 44135

December 1981
Forced Vibrations, Rotating Cyclic Structures, NASTRAN, Finite Elements, Turbomachines, Propellers, Base Excitation
FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
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ABSTRACT

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.
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1. THEORETICAL MODEL
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

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 bladed 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-sectoréd 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
\[ M^n u^n + B^n u^n + K^n u^n = P^n - M_2^n, \quad n = 1, 2, \ldots, N. \] (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 \(-M_2^n\) represents the inertial
loads on \( u^n \) due to base acceleration \( \tilde{R} \). The damping matrix \( B^n \) consists of the
viscous and structural damping, and the contribution due to the Coriolis
acceleration, i.e.,
\[ B^n = B^n_{\text{viscous}} + 2\Omega B^n_{\text{Coriolis}}, \]
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 \( M^n_2 \)
is given in Reference 1.

Equations (1) supplemented by the inter-segment boundary compatibility
conditions (Section 4.5.1, Reference 2),
\[ u_{\text{side 1}}^{n+1} = u_{\text{side 2}}^n, \quad n = 1, 2, \ldots, N, \] (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

$$
p^n = p^n + \sum_{\lambda=1}^{M/2} \left[ p^n \cos(\pi T \lambda) + p^n \sin(\pi T \lambda) \right] + (-1)^{m-1} p^n, \quad (5)
$$

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

$$
p^n = \frac{1}{M} \sum_{m=1}^{M} p^n, \quad (\lambda = 0) \quad \text{part of (6)}
$$
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

\[
\mathbf{p}^n = \frac{2}{M} \sum_{m=1}^{M} p^n_m \cos(n - 1/2) + \frac{2}{M} \sum_{m=1}^{M} p^n_m \sin(n - 1/2), \quad (k=1, 2, \ldots, k_L)
\]

where \( n = 1, 2, \ldots, N \),

\( "\mathbf{p}^n_m" \) = 0; \( k_c, k_s, k = 1, 2, \ldots, k_L; M/2 \)

\( a = 2\pi/N \)

\( k_L = (N-1)/2 \) for \( N \text{ odd} \)

\( k_L = (N-2)/2 \) for \( N \text{ even} \)

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

\[
"\mathbf{p}^n_m" = \frac{1}{N} \sum_{n=1}^{N} p^n_m \cos(n - 1/2) + \frac{2}{N} \sum_{n=1}^{N} p^n_m \sin(n - 1/2), \quad (k=1, 2, \ldots, k_L)
\]

\[
"\mathbf{p}^n_m" = \frac{1}{N} \sum_{n=1}^{N} (-1)^{n-1} p^n_m \quad (N \text{ even only}) \quad (k = N/2).
\]
The terms $\tilde{P}_m^k$ ($\tilde{\omega}_m = 0; \omega_c, \omega_s, \omega = 1, 2, \ldots, \omega_L; N/2$ and $\tilde{\omega}_m = \tilde{\omega}_c, \tilde{\omega}_s, \omega = 1, 2, \ldots, \omega_L; N/2$) are the transformed frequency-dependent circumferential harmonic components of the directly applied loads $p_m^k$ ($m = 1, 2, \ldots, M$ and $n = 1, 2, \ldots, N$).

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

Such loads can be represented as

$$
\frac{n}{\tilde{P}_m^k} = \frac{0}{\tilde{P}_m^k} + \sum_{k=1}^{\omega_L} \left[ \frac{-\tilde{\omega}_c}{\tilde{P}_m^k} \cos(m-1\omega_c) + \frac{-\tilde{\omega}_s}{\tilde{P}_m^k} \sin(m-1\omega_s) \right] + (-1)^{m-1} \tilde{P}_m^k, \quad (10)
$$

where $m = 1, 2, \ldots, M$ represent the time instances at which harmonic components $\tilde{\omega}_m = 0; \omega_c, \omega_s, \omega = 1, 2, \ldots, \omega_L; N/2$ of directly applied loads are specified. The coefficients $\frac{n}{\tilde{P}_m^k}$ on the right hand side of equation (10) are obtained using equations (6) with sector number $n$ replaced by harmonic number $\tilde{\omega}_m$.

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

This type of loads can be represented as

$$
p^k_n = p_0 + \sum_{k=1}^{\omega_L} \left[ \frac{-\tilde{\omega}_c}{\tilde{P}_m^k} \cos(n-1\omega_c) + \frac{-\tilde{\omega}_s}{\tilde{P}_m^k} \sin(n-1\omega_s) \right] + (-1)^{n-1} \tilde{P}_m^{k/2}, \quad (11)
$$

where $\tilde{\omega}_m$ ($= 1, 2, \ldots, F$) now represents the frequencies at which excitation is specified. The transformed frequency-dependent circumferential harmonic components $\frac{n}{\tilde{P}_m^k}$ ($\tilde{\omega}_m = 0; \omega_c, \omega_s, \omega = 1, 2, \ldots, \omega_L; N/2$) are obtained using equations (9) with $\tilde{\omega}_m$ as defined above.

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

These loads are the transformed frequency-dependent circumferential harmonic components $\frac{n}{\tilde{P}_m^k}$ ($\tilde{\omega}_m = 0; \omega_c, \omega_s, \omega = 1, 2, \ldots, \omega_L; N/2$ with $\tilde{\omega}_m$ ($= 1, 2, \ldots, F$) 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:

1.5
1. Axial component contributes to $\bar{P}^\nu_k$ where $\nu^k = 0$, and $\nu^2$ represents the specified excitation frequencies.

2. Lateral components contribute to $\bar{P}^\nu_k$ where $\nu^k = 1c$ and $1s$, and $\nu^2$ represents the effective excitation frequencies which are shifted from the specified frequencies by $\omega$, the rotational frequency.

The user specifies the components of the base acceleration vector $\ddot{R}$ as functions of frequency. The program computes the inertial loads $-\ddot{M}_2 R$ 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:

$$
\begin{align*}
\bar{u}_2^0 &= \bar{u}_1^0 \\
\bar{u}_2^{1c} &= \bar{u}_1^{1c} \cos(ka) + \bar{u}_1^{1s} \sin(ka) \\
\bar{u}_2^{1s} &= -\bar{u}_1^{1c} \sin(ka) + \bar{u}_1^{1s} \cos(ka)
\end{align*}
$$

and

$$
\bar{u}_2^{-N/2} = -\bar{u}_1^{-N/2} \\
\bar{u}_2^{N/2} = -\bar{u}_1^{N/2}
$$

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

$$
\begin{align*}
\bar{u}^{1c} &= G_{ck}(k) \bar{u}^K, \text{ and} \\
\bar{u}^{1s} &= G_{sk}(k) \bar{u}^K
\end{align*}
$$

$\bar{u}^{1c}$ and $\bar{u}^{1s}$ 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)

\[
\mathbb{H}^K u^K + \mathbb{B}^K \bar{u}^K + \mathbb{\bar{K}}^K \bar{u}^K = p^K,
\]

where

\[
\begin{align*}
\mathbb{H}^K &= g_{ck}^T H^n G_{ck} + G_{sk}^T N^n G_{sk}, \\
\mathbb{B}^K &= g_{ck}^T B^n G_{ck} + G_{sk}^T B^n G_{sk}, \\
\mathbb{\bar{K}}^K &= g_{ck}^T K^n G_{ck} + G_{sk}^T K^n G_{sk}, \text{ and} \\
p^K &= \bar{p}^{kc} + \bar{p}^{ks}.
\end{align*}
\]

As discussed in subsection 1 of Section 1.2.2, $\bar{p}^{kc}$ and $\bar{p}^{ks}$ are the transformed frequency-dependent circumferential harmonic components of the directly applied and base acceleration loads.

At any excitation frequency $\omega^e$, let

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

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

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

The excitation frequency $\omega^e$ is given by

\[
\begin{cases}
\omega^e = \omega \text{ for all directly applied and axial true acceleration loads, and} \\
\omega^e = \omega^B \text{ for lateral base acceleration loads.}
\end{cases}
\]

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 $\omega_n^k = 0$; $\omega_n^k, n = 1, 2, \ldots, \omega_{max}$. 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 $u_n^k$ in various segments with $\omega_n$ 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
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 RLOAD bulk data cards. The general periodic loads are specified as functions of time using the TLOAD bulk data cards.

The following notes apply when using TLOAD bulk data cards:

1. Time delay \( \tau \) must be set to zero.
2. In conjunction with the TSTEP bulk data card, TLOAD information is used to discretely define \( P(t) \) at \( M \) time instances as \( p_1 \) or \( p_M \) \( (m = 1, 2, \ldots, M) \), as discussed in Section 1.2.2 of the Theoretical
1. \( N(1) \) of TSTEP bulk data card = \( M-2 \)
   \( DT(1) \) 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 \textbf{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, SYTID, 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 \( M_{dd} \) in the Functional module GKAD as per equations 16 through 21, pages 9.3-7 and 9.3-3, 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, ≤NSEG5/2 for even NSEG5, ≤(NSEG5-1)/2 for odd NSEG5) determine the number, order and meaning of subcases as follows:

**CYCIO=+1**

The number of subcases is equal to NSEG5, independent of KMAX.

- **Subcase 1 (Segment No. 1)**
- **Subcase 2 (Segment No. 2)**
- ...
- **Subcase NSEG5 (Segment No. NSEG5)**

**CYCIO=-1**

The number of subcases is equal to FMAX, where

\[
FMAX = \begin{cases} 
1, & \text{if } KMAX = 0, \\
1 + 2 \cdot KMAX, & \text{if } 0 < KMAX \leq (NSEG5-1)/2, \text{ NSEG5 odd}, \\
1 + 2 \cdot KMAX, & \text{if } 0 < KMAX \leq (NSEG5-2)/2, \text{ NSEG5 even, and} \\
NSEG5, & \text{if } KMAX = NSEG5/2, \text{ NSEG5 even.}
\end{cases}
\]

- **Subcase 1 ('k' = 0)**
- **Subcase 2 ('k' = 1c)**
- **Subcase 3 ('k' = 1s)**
- **Subcase 4 ('k' = 2c)**
- **Subcase 5 ('k' = 2s)
- ...
- **Subcase FMAX ('k' = KMAXs)**

In the event that NSEG5 is even and KMAX = NSEG5/2, Subcase FMAX will represent 'k' = KMAXs as KMAXs 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 Is 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. RF. 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 FREQUENCY, FREQ OR FREQ 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 LOCAL 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 SEGMENT.
8. UNLOAD 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 UNLOAD CARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO A UNLOAD CARD THAT GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF SUBCASES FOR EACH HARMONIC INDEX. IN THIS CASE, THE PARAMETER CYCLO IS INCLUDED AND THE LOAD COMPONENTS FOR EACH INDEX ARE DEFINED DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

BULK DATA DECK INPUT -
1. SUPERTI BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPOINT BULK DATA CARDS ARE NOT ALLOWED.
4. CYJO IN 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, NC, OR THE TSTEP CARD MUST BE 1.

PARAMETERS USED ARE -

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<th>Parameter</th>
<th>Description</th>
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<tr>
<td>A. NSEGS</td>
<td>REQUIRED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF IDENTICAL SEGMENTS IN THE STRUCTURAL MODEL.</td>
</tr>
<tr>
<td>B. CYCLO</td>
<td>REQUIRED - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA. A VALUE OF 61 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.</td>
</tr>
<tr>
<td>C. CYCS/2</td>
<td>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.</td>
</tr>
<tr>
<td>D. CTYPE</td>
<td>FIXED - THE BCV VALUE OF THIS PARAMETER DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE OF THIS PARAMETER HAS BEEN SET TO -ROT- FOR ROTATIONAL SYMMETRY.</td>
</tr>
<tr>
<td>E. KMAX</td>
<td>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.</td>
</tr>
<tr>
<td>F. KMIN</td>
<td>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.</td>
</tr>
<tr>
<td>G. LMAX</td>
<td>OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER SPECIFIES THE MAXIMUM TIME HARMONIC INDEX. THE DEFAULT VALUE IS NTSTEPS/2, WHERE NTSTEPS EQUALS N (FROM TSTEP CARD) PLUS 2.</td>
</tr>
<tr>
<td>H. NLOAD</td>
<td>FIXED - THE INTEGER VALUE OF THIS PARAMETER IS THE NUMBER OF LOADING CONDITIONS. THE VALUE OF THIS PARAMETER IS INTERNALLY CALCULATED.</td>
</tr>
<tr>
<td>I. RPS</td>
<td>OPTIONAL - THE REAL VALUE OF THIS PARAMETER DEFINES THE ROTATIONAL SPEED OF THE STRUCTURE IN REVOLUTIONS PER UNIT TIME. THE DEFAULT VALUE IS 0.</td>
</tr>
<tr>
<td>J. DXTID</td>
<td>OPTIONAL - THE POSITIVE INTEGER VALUES OF THESE PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS.</td>
</tr>
<tr>
<td>BYID</td>
<td>OF THE TABLED BULK DATA CARDS. THE VALUES ARE INCREMENTED EACH TIME A NEW FILE IS OPENED.</td>
</tr>
<tr>
<td>BZTID</td>
<td>COMPONENTS OF THE BASE ACCELERATION VECTOR. THE</td>
</tr>
</tbody>
</table>
**Remarks**

1. The analysis will loop thru a range of the cyclic index,
   KINDX = KMIN TO KMAX.
ORIGINAL PAGE IS OF POOR QUALITY

NASTRAN EXECUTIVE CONTROL DECK ECH

ALTER 3 $  
FILE UXVF=APPEND/PDI=APPEND/PD=APPEND $  
$ PERFORM INITIAL ERROR CHECKS ON NSEG AND KMAX.  
COND ERRORC1,NSEG $ IF USER HAS NOT SPECIFIED NSEG.  
COND ERRORC1,KMAX $ IF USER HAS NOT SPECIFIED KMAX.  
PARAM //C,N,NO $ IF USER HAS NOT SPECIFIED CYCLO ERR.  
COND ERRORC1, CYCLO ERR. $ IF USER HAS NOT SPECIFIED CYCLO ERR.  
PARAM //C,N,DIV $ NSEG = NSEG / C,N,2 $ NSEG = NSEG / 2  
PARAM //C,N,SB $ NSEG = NSEG / V,Y,KMAX $  
COND ERRORC1,KMAX $ IF KMAX GT NSEG / 2  
$ SET DEFAULTS FOR PARAMETERS.  
PARAM //C,N,NOP $ V,Y,NCRACK=01 $ V,Y, LGKAD=-1 $  
$ CALCULATE OMEGA, 2*OMEGA AND OMEGA*2 FROM EPS. SET DEFAULT EPS.  
PARAM //C,N,MPY $ V,Y,EPS=0 $ C,N,2023185 $  
PARAM //C,N,MPY $ V,Y,OMEGA2 / C,N,2 $ V,Y,OMEGA $  
PARAM //C,N,MPY $ V,Y,OMEGA*2 / V,Y,OMEGA $  
$ GENERATE NURBS IF EPS IS ZERO.  
PARAM //C,N,NEW ///V,Y, EPS / C,N,0 $ ///V,Y, N/DURPS $  
$ MAKE SURE COUPLED FACES HAVE NOT BEEN REQUESTED.  
PARAM //C,N,NUT / V,Y, CGUPMAG==1 $  
CUND ERRORC2,NLUMP $  
ALTRN 21,21 $ ADD SLT TO OUTPUT FOR TRLG.  
GP3 GEM3,EU2X1N,EU2 / SLT,GPTT / V,N,NOGRAV  
CUND SLT,GPTT $  
ALTRN 23 $  
$ SINCE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT  
$ MORE ERROR CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.  
$ ADD YS NEEDED FOR PSF RECOVERY IN SG2.  
PARAM //C,N,MPY $ V,N,NKIP / C,N,0 / C,N,0 $  
GP4 CASELC, GEM4, EU2X1N, SGUPT, BWPDT, CST/KG, YS, USET, ASET/V,Y, LUSET/  
S,N, MPFC / S,N, MPFC2 / S,N, SINGLE/S,N,OMPFT/S,N,REACT/S,N,NKIP/  
S,N,KGPLAT/S,N, NUSET/S,N, NCL/S,N, NDA/CY, ASETLUT/S,Y, AUTO/SPC $  
PURGE GM, GMU/MPF-1/GOOD/OMPFTK/S, PSF, OPL/ SINGLE $  
CUND GPTT $ GM, GND, GCD, GP, PSF, OPC, S, Y, USET $  
$ SUPPORT BULK DATA IS NOT ALLOWED.  
PARAM //C,N,NUT / V,N, REACDATA / V,N, REACT $  
CUND ERRORC3,REAQUIT $  
$ EXECUTE EPS NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.  
DPL DYNAMICS, GPL, SIL, USET / GPLD, SILD, USETD, TFGPL, DLT, PSDL, FRU,  
TRL, ECYN / V,N, USET / S,N, LUSET / V,N, NGTFL / S,N, NOULT /  
S,N,NUPSDL / S,N, NUFL / V,N, NGDLFT / S,N,NUKRTL / V,N, NGEEPL / C,N,  
S,N, NOUE $  
$ MUST HAVE EITHER FREW OR TSTEP BULK DATA.  
PARAM //C,N, ANV/V,N,FREK / V,N,FREK $  
CUND ERRORC5, FRIKK $ NO FREW OR TSTEP BULK DATA.  
$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL  
PARAM //C,N, NUM / V,N,FREKW / V,N, TSTEP $  
PARAM //C,N, MPY / V,N,FREKTIME / V,N, FRESET $  
PARAM //C,N, MINP / V,N,FREKTIME / V,N, TSTEP $  
2.9
PARAM //C,N,NUT /V,N,F3TYRUI /V,N,F3QTIME $ 
PARAM //C,N,NLE /V,N,NFREEW /V,N,FREESET /C,N,0 $ 
PARAM //C,N,NLE /V,N,F3TIME /V,N,T3SEET /C,N,O $ 
COND ERRORM3 /F3RE3 $ BOTH F3RE3 AND T3STEP IN CASE CONTROL DECK. 
$ EPI3NT BULK DATA NOT ALL3C3D 
PARAM //C,N,NF /V,N,EX3TRAPTS /V,N,NOU3 $ 
COND ERRORM3 /EX3TRAPTS $ 
$ GENERATE DATA FOR CYCT2 MODULE. 
G3CYC - 3E3U4,M3U3NW,UNSET /CY3DU /V,N,CTYPE=RTU /S0N,NGGU $ 
COND ERRORM3 /NGGU $ 
CH3PNT CY3D3 $ 
AL3R 32 $ 
$ PRE-PURGE DATA BLOCKS THAT WILL NOT BE GENERA3ED 
PARAM //C,N,UR /V,N,NU3M3L /V,N,3OMGG /V,N,3ORKS $ 
PURGL .316G,MI0G /NU3M3L $ 
PUR3L H2G,M2BASE3XG /NGGG $ 
AL3R 35 $ 
$ CL3NIKATE DATA BLOCKS FRLX, B1GG, M1GG, M2GG AND BAS3GX. 
$ GENERATE PARAMETER3 MK3AX AND NBASEX. 
DU3M03U1 CAS3LC,303DU,33TH,3IT,FR3L,M3GG$ / FRLX,B1GG,31GG, M2GG,3A3LC,303DU,33TH,3IT,FR3L,M3GG, M2GG,3A3LC,303DU,33TH,3IT,FR3L,M3GG, M2GG,3A3LC,303DU,33TH,3IT,FR3L,M3GG, M2GG $ 
COND FRLX /C,N,PRESENCE //C,N,3OCFRLX $ 
COND L3LFR3LX,NOCFR3LX $ 
EQU3V FRLX,FRL $ 
LABEL L3LFR3LX $ 
CH3PNT FRLX,B1GG,M1GG,M2GG,BASEXG $ 
AL3R 42 $ 
PARAM //C,N,ADD /V,N,NU3BGG /V,N,NU3M3L /C,N,0 $ RESET N0BGG. 
AL3R 52 $ 
$ R3L33I NEXT BGG AND KGG. 
COND L3L11A,NU3M3L $ 
PARAM //C,N,COMPLEX /V,N,OMEGA2 /C,N,0,0 /V,N,COMPLX1 $ 
PARAM //C,N,3UB /V,N,MCM3GA3Q /C,N,0,0 /V,N,UM3GASOR $ 
PARAM //C,N,COMPLEX /V,N,OMEGA3Q /C,N,0,0 /V,N,COMPLX2 $ 
ADD BGG,B1GG /BGG /C,N,(1,0,0,0) /V,N,COMPLX1 $ 
EQU3V BGG,BGG $ 
ADD KGG,M1GG /KGG /C,N,(1,0,0,0) /V,N,COMPLX2 $ 
EQU3V KGG,KGG $ 
CH3PNT BGG,KGG $ 
LABEL L3L11A $ 
AL3R 53,55 $ G3+ HAS BEEN MO3E3D UP. 
AL3R 69,68 $ LDP HAS BEEN MO3E3D UP. 
$ P3RAM AND EQU3V LOGIC DEPENDING ON L3KAD FOR F3RE3 OR TRAN. 
PARAM //C,N,AND /V,N,KDEK /V,N,NOU3 /V,N,NO2P $ 
COND L3KAD,L3KAD $ BRANCH IN NOT F33KESP. 
AL3R 114 $ SEE AL3R 114 Comments. 
JUMP L3KAD2 $ 

2.10
NASTRAN EXECUTIVE CONTROL DECK ECHO

LABEL LOKAD1 $
LABEL LOKAD3 $
LABEL LOKAD4 $
LABEL LOKAD2 $
ALTLK 120, 123 $  "NEW SOLUTION LOGIC"
$ "GENERATE TIME-DEPENDENT LOADS IF TSTEP HAS REQUESTED IN CASE CONTROL".
CCN1 "SOLUTION LOGIC"
$ ".populate ALL SubCASES FOR TIME-DEPENDENT LOADS"
PARAM " /C, N, NP/ /C, N, REPEAT /C, N, -1 $"
PARAM " /C, N, ADD /C, N, APPFLG /C, N, 1 /C, N, 0 $ INITIALIZE FOR SOL1"
JUMP TRLGLOOP $  "TRANSLATE TO "
LABLE TRLGLOOP $  "TRANSLATE TO "
CASE CASLCC /CASEYY /C, N, TRAN /S, N, REPEAT /S, N, NOTCPI $  "SOLUTION LOGIC"
CHKPNT CASLyy $  "SOLUTION LOGIC"
PARAM " /C, N, NP/ /C, N, NCOL /C, N, 0 /C, N, 1 $"
TRLG CASLyy, USEFLU, UFLK, SLT, UFLG0T, SLE, CSTM, TRL, UFL, GMU, GUU, EST, HGU/  "SOLUTION LOGIC"
" /C, N, PD1, T/ /C, N, NCSLTY /S, N, PDEPGU /V, N, NCOL $"
SUR1 TRL, UFLD1, ****** /P, PD1 /V, N, APPFLG /C, N, DYNAMICS $  "SOLUTION LOGIC"
SU1 TRL, UFLD1, ****** /P, PD1 /V, N, APPFLG /C, N, DYNAMICS $  "SOLUTION LOGIC"
CCN1 "TRANSLATE TO REPEAT $"
REPI TRLGLOOP, 10C $  "TRANSLATE TO "
JUMP LRRGK3 $  "TRANSLATE TO "
LABEL TRLGUNL $  "TRANSLATE TO "
CHKPNT PTL, PD0, TOL $  "TRANSLATE TO "
EQUIV PC, PGT, PFLPDO $  "TRANSLATE TO "
LABLE LRRGK4 $  "TRANSLATE TO "
PARAM KRUUOFLD TOL, ****** /FRLZ, TGLZ, KREDERR1, KRECUE2, ****** /V, Y, POSIG /V, Y, CYCIG /S, N, MAX = -1 /V, N, PKMAX /
S, N, FLMAX /S, N, NTSEPS /S, N, KRC1 /S, N, KRC2 $  "TRANSLATE TO "
EQUIV FRLZ, FRLZ /FLZ, FCL $  "TRANSLATE TO "
CHKPNT FRLZ, FCL, KREDERR1, KRECUE2 $  "TRANSLATE TO "
JUMP LRRGK2 $  "TRANSLATE TO "
LABEL LRRGK1 $  "TRANSLATE TO "
$ "GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC."

2.11
NASTRAN EXECUTIVE CONTROL DECK ECHO

PLAY
CASEXX, USENL,DLT,FRK, GCR, GOL, T1T, / PPF, PSF, PDF, FOL, PFMUN / C, N, DIREC1 / V, N, FREQ1 / C, N, FREQ2 $
LVLX LBLFRX1, NOFRX S ZEROFILL LOADS IF FRLX WAS GENERATED.
MPYAD PPF, PZEC, / PDFX / C, N, 0 $
LIVAL LBLFRLX1 $
$ FROM NEW LOADS.
CCON LBLFRX1, NOBASEX $
MPYAD M2G, BASEXG, / M2BASEXG / C, N, 0 $
ACC PPF, M2BASEXG, / PDF1 / C, N, (1.0, 0.0) / C, N, (-1.0, 0.0) $
EQUV PPF1, PPF $
CCON LBLBASE1, NOSET $
SY2 USEAD, UMO, YS, KS, GDD, PPF, / PDDM1, PSF1, PDF1 $
EQUV PDF1, PSF / PDF1, PDF $
LABEL LBLBASE1 $
LABEL LBLFRX1 $
EQUV PPF, PPF, NOSL $
CHPNT PPF, PSF, PDF, FOL $
$ LOADS ARE FREQUENCY-DEPENDENT
$ PLFFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=61.
PARAM PDF / C, N, TRAILK / C, N, 1 / V, N, PDFCOLS $
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1.
PARAM / C, N, O, DIV / V, N, NLOAD / V, N, PDFCOLS / V, N, PKMAX $ NLOAD = NF/PKMAX
EQUV PDF, PXF, CYCIC $
CCON LBLPQCN, CYCIC $
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1.
PARAM / C, N, O, DIV / V, N, NLOAD / V, N, PDFCOLS / V, N, PKMAX $ NLOAD = NF/NSEG
CYC1 PDF / PXF, GYCF / V, N, CYTE / C, N, FORE / V, Y, NSEG = 1 /
V, Y, PKMAX = -1 / V, N, NLOAD / S, N, NSEG $
CCON ERRORC1, NUGO $
CHPNT PXF $
JUMP LBLPCN $
LABEL LBLFRX2 $
$ LOADS ARE TIME-DEPENDENT
PARAM / C, N, NLT / V, N, NYLCYCIU / V, Y, CYCIC $
$ CYCLE DEPENDING ON VALUE OF CYCIC
CCON LBLTRL2, NYLCYCIU $ CYCIC = -1
EQUV PDT, PDTR21, NUKU1 $
CCON LBLRCIA, NUGC1 $ MPYAD PDT, REORJER1, / PDTR21 / C, N, 0 $
LABEL LBLRCIA $ CYC1 PDT21 / PXTR21, GYCF2 / V, N, CYTE / C, N, FORE / V, Y, NSEG / V, Y, PKMAX / S, N, NUGO $
CCON ERRORC1, NUGO $ CHPNT PXTRZ1 $
JUMP PXTRZ1, PXTRZ1, NUKO2 $
CCON LBLROD2A, NUKO2 $ MPYAD PXTRZ1, KLRERKZ2, / PXFZ1 / C, N, 0 $
LABEL LBLROD2A $
NASTRAN EXECUTIVE CONTROL DECK ECHO

CCND NOKPRT,NOKPRT $
PKTPARM //C.N+0/C.N+KINDEX $
LABEL NOKPRT $
CYCT2 CYCU,KDU,MDU... /KKK,KKKF... /C.N,FCRE/V.V,Y,NSEGS /
V.N,KINDEX/V.N,CYSEU=-1/V.N,NLOAD/S,N,NGCC $
COND ERKDFL1,NGCC $
CHMPNT KKKF,KKKF $
PARAM //C.N,SYST //C.N,58 /C.N+0 $
COND METHOD 3T IN CYCT2 PRODUCES $
$ UNDERFLOW FOR PXF. USE METHOD 2 $
LYCDU,BDU... /KKK,PKF... /C.N,FUCR/V.V,Y,NSEGS /
V.N,KINDEX/V.N,CYSEU/V.N,NLOAD/S,N,NGCC $
PARAM //C.N,SYST //C.N,58 /C.N+0 $
COND ERKDFC1,NGCC $
CHMPNT KKKF,PKF $
$ SOLUTION $
FRKD2 KKKF,KKKF,PKF... /FKF,FOL /UKVF /C.N+0.0/C.N+0.0/C.N+1.0 $
CHMPNT UKVF $
LYCDR,KDR... /UKVF... /C.N,BACK/V.V,Y,NSEGS/V.N,KINDEX /
V.N,CYCEU/V.N,NLOAD/S,N,NGCC $
COND EKDFL1,NGCC $
CHMPNT UKVF $
PARAM //C.N,ADD /V.V,Y,NSEGS/V.N,KINDEX/C.N+1 $
PARAM //C.N,SLB /V.V,Y,NSEGS/V.V,Y,KMAX/V.N,KINDEX $
COND LCYC2,DONE $ IF KINDEX GT KMAX THEN EXIT $
KEEP TLPFLY,1CC $ $
JUMP EKDFL3 $
LABEL LCYC2 $
EQUIV UXVF,UDVF /CYCLO $
CHMPNT UDVF $
COND LCYC3,LYCL $ IF CYCID GE 0 THEN TRANSFORM TO PHYSICAL $
CYT1 UXVF /UDVF,LYCLO /V.N,CNRTYPE/C.N,BACK/V.V,Y,NSEGS/V.V,Y,KMAX/
V.N,NLOAD $
CHMPNT UDVF $
LABEL LCYC3 $
COND LCTRL4,NOTIME $
EQUIV PXF,PFF2 / CYCIC $
COND LCYC4,LYCL $ IF CYCID GE 0 THEN TRANSFORM TO PHYSICAL $
CYT1 PXF /PFF2,LYCLO /V.N,CNRTYPE/C.N,BACK/V.V,Y,NSEGS/V.V,KMAX/
V.N,NLOAD $
LABEL LCYC4 $
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF. $
SDF1 USEDF,PPF2... /C.N,1/C.N,DYNA $
SDF2 USEDF,PPF2... /C.N,SLU,PPFZ /PCDUM,PSF2,PLDUM $
EQUIV PPFZ,PSF // PSFZ,PSF $
CHMPNT PPFZ,PSF $
LABEL LCTRL4 $
ALT1 124,129 USE FQL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST. $
VOR CASEXX,EDYN,USEDF,UDVF,FGL,XYCDU /UDVCL /C.N,FREQRES/C.N,
DIRECT/S,N,NOGR12/S,N,NOUP/S,N,NOO $ $
ALT1 140,140 USE FQL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.
NASTRAN EXECUTIVE CONTROL DECK ECHO

SUR2 CASEXX, CSTH, MPT, J1T, E0DYN, SLDR: EBPDP, FLL1, UPC, UPVC, EST, XYGCB,
PPF/UPPL1, UPC1, OUPVC1, UESC1, CEPCL1, PUPVC1/C, N, FREOREP/ S, N, NOSURT2 $
ALTER 160 $ ADD LABEL FOR ERROR3.$
LABEL ERROR3 $ ALTER 163, 166 $ REMOVE ERROR1 AND ERROR2.$
ALTER 168 $ FORCED VIBRATION ERRORS
LABEL ERRORC 1 $ CHECK NSCEGS, KMAX AND OTHER CYCLIC DATA.
PKTPARM //C, N, -7 //C, N, CYCSTATICS 8
LABEL ERRORC 2 $ COUPLED MASS NOT ALLOWED.
PKTPARM //C, N, 0 //C, Y, COUPMASS 8
JUMP FINIS 8
LABEL ERRORC 3 $ SUPRT BULK DATA NOT ALLOWED.
PKTPARM //C, N, 0 //C, N, CYCSTATICS 8
LABEL ERRORC 4 $ EPUINT BULK DATA NOT ALLOWED.
PKTPARM //C, N, 0 //C, N, NGUE 8
JUMP FINIS 8
LABEL ERRORC 5 $ NEITHER FREU OR TSTEP WERE IN BULK DATA DECK.
PKTPARM //C, N, 0 //C, N, NFREU 8
PKTPARM //C, N, 0 //C, N, NOUTR $
JUMP FINIS 8
LABEL ERRORC 6 $ BOTH FREU AND TSTEP WERE SELECTED IN CASE CONTROL.
PKTPARM //C, N, 0 //C, N, NOFREU 8
PKTPARM //C, N, 0 //C, N, NOUTIME 8
JUMP FINIS 8
LNLALTEK
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 KGKX=TAPE/KGG=TAPE/GUG=SAVE/GMD=SAVE/NUD=SAVE/BDU=SAVE $
4 FILE UXVF=APPEND/PDT=APPEND/PD=APPEND $
5 CUND ERR=RC1,NSEGS IF USER HAS NOT SPECIFIED NSEGS.
6 CUND ERR=RC1,KMAX IF USER HAS NOT SPECIFIED KMAX.
7 PARAM /C,N,EJ /V,N,CYCO/CR /V,Y,CYCO=0 /C,N,0 $
8 CUND ERR=RC1,CYCOERR IF USER HAS NOT SPECIFIED CYCO.
9 PARAM /C,N,DIV /V,N,NSEG2 /V,Y,NSEG2 /C,N,2 NSEG2 = NSEGS/2
10 PARAM /C,N,SUB /V,N,KMAXERR /V,N,NSEG2 /V,Y,KMAX $
11 CUND ERR=RC1,KMAXERR IF KMAX GT NSEGS/2
12 PARAM /C,N,NUP /V,Y,NOKPRT=1 /V,Y,KGKAD=-L $
13 PARAM /C,N,MPY /V,N,OMEGA /V,Y,RPS=0 /C,N,6.283185 $
14 PARAM /C,N,MPY /V,N,OMEGA2 /C,N,2.0 /V,N,CMEGA $
15 PARAM /C,N,MPY /V,N,OMEGA2 /V,N,CMEGA $
16 PARAM /C,N,EQ /V,Y,RPS /C,N,0.0 /// /V,N,NURPS $
17 PARAM /C,N,NUC /V,N,NOLUMF /V,Y,COUPMASS=-1 $
18 CUND ERR=RC2,NOLUMF $
19 PARAM /UMPY#/KARDAG/0/C $
20 GPL GEOM1,GEOM2,GRL,EXIN,GPOT,CSTP,BGPDOT,SIL/SN,LUSET/ SN, NUGPOT $
21 PLTRN BGPOT,SIL/BUDPDP,SIP/LUSET/SN,LUSEP $
22 PURGE USET,GM,GO,KAA,RAA,MAA,KAA,KFS,PSF,OPC,EST,ECT,PLTSTX,PLTPAR, GPSETS,ELSETS/NUGPOT $

2.16
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

23  COND  LBL5,NOGPD "$L,

24  GP2  GEOM2,EQEXIN/ECT "$L,

25  PARAM  PCDB//*PRES=//NOGPD "$L,

26  PURGE  PLTSETX,PLTPAR,GPSETS,ELSETS/HOPCDB "$L,

27  COND  PL1,NOGPD "$L,

28  PLTSET  PLCDH,EQEXIN/ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/ECT,NSIL/LUSET/S,N,JUMPPLOT=1 "$L,

29  PURGE  PLTSETX/ "$L,

30  PARAM  //*MPY/*PLTFLG/1/ "$L,

31  PARAM  //*MPY/*PFILE/0/0 "$L,

32  COND  PL1,JUMPPLOT "$L,

33  PLT  PLTPAR,GPSETS,ELSETS,CASECC,BGPDTEQEXIN,SIL,ECT,/*PLOTX1/

34  PURGE  PLTSETX/ "$L,

35  LABEL  PL "$L,

36  GP3  GEOM3,EQEXIN,GEOM2/SLT,GP1T/V,N,NOGRAV "$L,

37  CHKPTI  SLT,GP1T "$L,

38  TAIL  ECT,GP1T,BGPDTSIL,GP1T,CSTM/EST,GEI,GP1CT,/*LUSET/S,N,NGSIMP=-1/L/S,N,NGSIMP=-1/S,N,GENEL "$L,

39  PURGE  K406,GPST,0,GPST,NCG,K4NN,K4AE1/IN,MAA,MAA,BNN,BAA,BAA,

40  PARAM  //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 "$L,


42  PURGE  GM,GMD/MPCF1/GO,GCD/OMIT/KFS,PSF,QPC/SINGLE "$L,

43  CHKPTI  GM,GMD,RG,GO,GCD,KFS,PSF,QPC,USET,YS "$L,

2.17
LEVEL 2.0 NASTRAN DNAP Compiler - Source Listing

44 PARAM //C,N,NOT /V,N,REALDATA /V,N,REACT $
45 COND ERRORC3,REALDATA $  
46 UPD DYNAMICS,GPL,SIL,USET /GPL,D,SILD,USETU,TEPQ,PLL,OLTD,PSD,FRL,  
TRL;/EQS, /V,N,LUSET/S,N,LUSETU/V,N,KUFL/S,N,NOOLDT/  
S,N,NGP,SDL/S,N,NOFRL/V,N,NOTLFT/S,N,NOTRSL/V,N,NOEDD/C,N/  
S,N,NOUE $  
47 PARAM //C,N,AND/V,N,FTERR /V,N,NCFRL /V,N,NOTRSL $  
48 COND ERRORC9,FTERR $ NC FREQ OR TSTEP BULK DATA.  
49 PARAM CASECC //C,N,DTI /C,N,1 /C,N,14 //V,N,FREQSET $  
50 PARAM CASECC //C,N,DTI /C,N,1 /C,N,38 //V,N,TIMESET $  
51 PARAM //C,N,MPY /V,N,FREETIME /V,N,FREQSET /V,N,TIMESET $  
52 PARAM //C,N,N /V,N,FTERRL /V,N,FTETIME $  
53 PARAM //C,N,LE /V,N,NOFREQ /V,N,FREQSET /C,N,0 $  
54 PARAM //C,N,LE /V,N,NOTIME /V,N,TIMESET /C,N,0 $  
55 COND ERRORC6,FTERRL $ BOTH FREQ AND TSTEP IN CASF CONTROLS DECK.  
56 PARAM //C,N,NOT /V,N,EXTRAPTS /V,N,NGUE $  
57 COND ERRORC4,EXTRAPTS $  
58 GPCYC GEOM4,SEQ,USETU /CYCDD /V,N,CTYPE=ROT /S,N,NOG $  
59 COND ERRORC1,NOG $  
60 CHKPT CYCDD $  
61 COND LBL1,NUSIMP $  
62 PARAM //ADD*/NUKGGX/1/0 $  
63 PARAM //ADD*/NUKGG/1/0 $  
64 PARAM //ADD*/NUBBG=1/1/0 $  
65 PARAM //ADD*/NUKGG/1/0. $  
66 EMG EST,CM1,MPF,DTI,GEOM2,/KEML,KUICT,HELM,MDICT,DELM,DDICT/  
CPV/C,Y,CPVD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIAL/C,Y,  

2.18
LEVEL 2.0 NASTRAN DRAP COMPILED - SOURCE LISTING


67 COND LBLKGGX,NOKKGGX $

68 EMA GPECT,KDICT,KELM/KGGX,GPST $

69 LABEL LBLKGGX $

70 PARAM //C,N,OK/V,N,NOBML /V,N,NOMGG /V,N,NOKPS $

71 PURGE BIGG,H1GG /NOBML $

72 PURGE M2GG,H1BASEXG /NOMGG $

73 COND LBLMGG,NOMGG $

74 EMA GPECT,KDICT,MELM/MGG,-1/C,Y,hMSS=1.0 $

75 LABEL LBLMGG $


77 PARAM FRLX //C,N,PRESENCE // /V,N,NOFRLX $

78 COND LBLFRLX,NOFRLX $

79 EQUIV FRLX,FRL $

80 LABEL LBLFRLX $

81 CHKPNT FRLX,B1GG,M1GG,M2GG,BASEXG $

82 COND LBLBBGG,NOBGG $

83 EMA GPECT,KDICT,BELM/REG, $

84 LABEL LBLBBGG $

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,NORMI//C,N,0 $; RESET NOBGG.
90 PURGE RNN,OFF,BAA/NOBGG S
91 COND LBL1,GRDPNT S
92 COND ERRDR4,NOBGG S
93 GPGG BGPDP,CSTH,EQEXIN,NOG/CUPHG/V,Y,GRDPNT=-1/C,Y,NTMASS $
94 DPP UGPGG++,++;//S,N,CARDNO S
95 LABEL LBL1 S
96 EQUIV KGGX,KGG/NOGENL S
97 COND LBL11,NOGENL S
98 SMA3 GEI,KGGX/KGG/LUSET/NOGENL/NOSIMP S
99 LABEL LBL11 S
100 COND LBL11A,NORMI S
101 PARAM //C,N,COMPLEX//V,N,OMEGA2/C,N,0.0/V,N,CMPLX1 S
102 PARAM //C,N,SUB//V,N,OMEGASQ/C,N,0.0/V,N,CMPEGASQ S
103 PARAM //C,N,COMPLEX//V,N,OMEGASQ/C,N,0.0/V,N,CMPLX2 S
104 ADD BGG,1LGG/1GGI/C,N,(1.0,0.0)/V,N,CMPLX1 S
105 EQUIV BGG1,BGG S
106 ADD KGG,1LGG/KGGI/C,N,(1.0,0.0)/V,N,CMPLX2 S
107 EQUIV KGG1,KGG S
108 CHKPT S BGG,KGG S
109 LABEL LBL11A
110 COND LBL4,GENEL S
111 COND LBL4,NOSIMP S
112 PARAM //EQG/GSPFGLG/AUTOSPC/O S
113 COND LBL4,GSPFGLG S
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**LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING**
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

139 COND   LBS5,NOK4GG $
140 SYM2   USET,GO,K4FL/K4AA $
141 LABEL   LBS5 $
142 EQIV   GO,GOU/NOUE/GM,GND/NCLE $
143 PARAM   /*ADD*/NEVER/1/0 $
144 PARAM   /*MPY*/REPEATF/-1/1 $
145 BKG   MATPOOL,BGPDT,EQEXIN,CFMN/BDPCCL/S,N,NCKHFL/S,N,NOABFL/S,N, MFACT $
146 PARAM   /*AND*/NOFL/NOABFL/NOKBF $
147 PURGE   KBFL/NOKBF/ ABFL/NCABFL $
148 COND   LBLFL3,NCFL $
149 MTRXIN. ,HUPool,EQDYN,,/ABFL,KRFL/LUSETO/S,N,NOABFL/S,N,NOKBF/0 $
150 LABEL   LBLFL3 $
151 JUMP   LBL13 $
152 LABEL   LBL13 $
153 PURGE   OUUVCI,OLUVCI,XYPLTF,UPPCI,GQPCI,GUPVC1,CEFCL,UPPC, DQPCI,2,UQVCI,2,DESC2,GEFC2,XYPLTF,PSDF,AUTG,XYPLTF, K2PP, M2PP, B2PP, K2DPP, M2DPP, B2DO/NEVER $
154 CASE   CASECC,PSDL/CASEXX/*FREQ*/S,N,REPEATF/S,N,NOLOOP $
155 MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPCOL/K2PPP,M2PPP,B2PP/LUSETO/S,N, NOK2DPP/S,N,NOABFL/S,N,NCB2DPP $
156 PARAM   /*AND*/NOK2PP/NOFL/NCK2DPP $
157 PARAM   /*AND*/NOK2PP/NOFL/NCK2DPP $
158 EQIV   M2DPP,M2PP/NOABFL $
159 ADDS   ABFL,KBFL,K2DPP,,/K2PP/1-1.0,0.0 $
160 COND   LBLFL2,NCABFL $
161 TRNSP   ABFL/AULFT $
LEVEL 2.0 NASTRAN MAP COMPILER - SOURCE LISTING

162 ADD ABFLT,M200P/M2PP/IMPACT $
163 LABEL LBLFL2 $
164 PARAM //~AND*/BDEBA/NOUE/NB2PP $
165 PARAM //~AND*/KDEK2/NOGENL/NOSIMP $
166 PARAM //~AND*/MDEMA/NOUE/NCH2PP $
167 PURGE K200/NOK2PP/M200/NOK2PP/B200/NOB2PP $
168 PARAM //~C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NCK2PP $
169 COVD LGKAD1, LGKAD $ BRANCH IN NCT FREQRESP.
171 JUMP LGKAD2 $
172 LABEL LGKAD1 $
174 CHKPT K2PP,M2PP,B2PP,K200,M200,B200/KOD,MOO $
175 LABEL LGKAD2 $
176 COVD LBL1R,NOGPD $
178 LABEL LBL18 $
179 COVD LGKAD3, LGKAD $ BRANCH IF NOT FREQRESP.
180 EQIV B200,BOD/NOBPP/M200,MOO/NOSIMP/ K200,KDD/KDEK2 $
181 JUMP LGKAD4 $
182 LABEL LGKAD3 $
183 EQIV B200,BOD/NOGPD/M200,MOO/NOSIMP/K200,KDD/KDEK2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

184 LABEL                             LOCAD4 $
185 COND                              LBLTRL,NOTIME $
186 PARAM                              //C,N,MPY /V,N,REPEATT /C,N,1 /C,N,-1 $
188 JUMP                              TRLGLOOP $
189 LABEL                              TRLGLOOP $
190 CASE                               CASECC,/CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NCLGLOP1 $
191 CHKPTN                             CASEYY $
192 PARAM                              //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1 $
193 TRLG                               CASEYY,USE TO,DLT,SLT,BGPDT,SIL,CTKM,TRL,DIT,GMOD,GOV,EST,MGG/ $ ,PDT1,PD1,IDL/V,N,NGSET/S,N,PDEPDC/V,N,NCOL $
194 SDR1                               TRL,PDT1,,FAKE, /PDT1, /V,N,APPFLG/C,N,DYNAMICS $ 
195 SDR1                               TRL,PD1 ,FAKE, /PDT1, /V,N,APPFLG/C,N,DYNAMICS $ 
197 COND                              TRLGDONE,REPEATT $
198 REPT                               TRLGLOOP,100 $ 
199 JUMP                               ERROR3 $ 
200 LABEL                              TRLGDONE $ 
201 CHKPTN                             PD1,PD,IDL $ 
202 EQJIV                               PD,PUT/PDEPDC $ 
203 CHKPTN                             PD1 $ 
204 DUMMOD2                            TUL,,FAKE, /FRLZ,FGLZ,RECORDER1,RECORDER2,,FAKE $ / V,Y,NSLGS/V,Y,CYCLIC/S,Y,LMAX=-1/V,N,FKMAX/ S,N,FLMAX/S,N,NTSTEPS/S,N,NGRO1/S,N,NGRO2 $ 
205 EQJIV                               FRLZ,FRL // FOLZ,FCL $ 
206 CHKPTN                             FRL,FOL,RECORDER1,RECORDER2 $ 
207 JUMP                               LBLFRL2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

208 LABEL LBLTRL1 $
209 PRLG CASEXX,USETO,ULF,FRM,GMN,GCQ,DIT, / PPF,PSF,PDF,FOL,PDUM / C,N,DIRECT/V,N,FREQ/C,N,FREQ $
210 COND LBLFRLX1,NOFRX X ZERO OL. LOAD COLUMNS IF FRLX HAS GENERATED.
211 MPYAD PPF,PDZERU, / PPFX /C,N,0 $
212 EQJ IV PPFX,PPF $
213 LABEL LBLFRLX1 $
214 COND LBLFRL1,NOBASEX $
215 MPYAD M2G,BASEEXG, / M2BASEXG /C,N,0 $
216 ADD PPF,M2BASEXG / PPF1 /C,N,(1.0,0.0) /C,N,(-1.0,0.0) $
217 EQJ IV PPF1,PPF $
218 COND LBLBASE1,NOSET $
219 SSG2 USETO,GMN,YS,KFS,GCQ,PPF / POOUM1,PSFL,PDF1 $
220 EQJ IV PSFL,PSF // PDF1,PDF $
221 LABEL LBLBASE1 $
222 LABEL LBLFRL1 $
223 EQJ IV PPF,PDF/NOSET $
224 CHKNT PPF,PSF,PDF,FOL $
225 PARAML PDF /C,N,TRAILFR /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,PFH.FCIC $
228 COND LBLDUNL,CYCIO $
229 PARAM /C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,Y,NSEG $ NLOAD = NF/NSEG
230 CYCT1 PDF / PXF,GCYCF1 /V,N,CTYPE /C,N,FCRE /V,Y,NSEG =-1 / V,Y,KMAX=-1 / V,N,HLLAD /S,N,NOGO $
231 COND ERRORCL,NOGO $

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LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

232 CHKPNT PXF $
233 JUMP LBLPDONE $
234 LABEL LBLTLRL2 $
235 PARAM /C,N,KUT /V,N,NOTCYCIO /V,Y,CYCIO $
236 COND LBLTRL2,NOTCYCIO $
237 EQUIV POT,PDTRZ1/NCROL $
238 COND LBLRO1A,NORU1 $
239 MPYAD POT,ROIORDER1, / PDTRZ1 / C,N,0 $
240 LABEL LBLRO1A $
241 CYCT1 PDTRZ1 / PXTRZ1,GCYCF2 /V,N,CTYPE/C,N,FORE/V,N,NTSTEPS/
V,Y,LMAX/V,N,FMAX/S,N,NGO $ 
242 CYCTC ERRURC1,NGO $
243 CHKPNT PXTRZ1 $ 
244 EQUIV PXTRZ1,PFZ1/NCKO2 $
245 COND LBLPD2A,NORL2 $
246 MPYAD PXTRZ1,ROIORDER2, / PXFZ1 /C,N,0 $
247 LABEL LBLRO2A $
248 EQUIV PXFZ1,PFZ1 $ 
249 CHKPNT PFZ1 $ 
250 JUMP LBLTRL3 $ 
251 LABEL LBLTRL2 $
252 MPYAD POT,ROIORDER1, / PDTRZ2 / C,N,0 $
253 CYCT1 PDTRZ2 / PXTPZ2,GCYCF3 /V,N,CTYPE/C,N,FCRE/V,N,NTSTEPS/V,Y,LMAX/
V,Y,NSEGS/S,N,NGO $ 
254 COND ERRURC1,NGO $
255 CHKPNT PXTRZ2 $ 

2.26
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

256 EQUIV PXTRZ2,PXTRZ2/NORO2 $
257 COND LBLRO2B,NOR02 $
258 MPYAD PXTRZ2.REORDERZ2 / PXTRZ2 /C,N=0 $
259 LABEL LBLRO2B $
260 CYCT1 PXTRZ2 / PXFZ2,GCYCF4 / V,Y,NCTYPC/C,N,FORE/V,Y,NSEG/S,Y,KMAX/
V,Y,FLMAX/S,N,ACGG $
261 CONV ERRORC1,NOGO $
262 EQUIV PXFZ2,PXF1 $
263 CHKNT PXF1 $
264 LABEL LBLTRL3 $
265 CUPY 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,Y,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 CYCM,PFZ2 /,,PKFZ2,, / C,N,FORE/V,Y,NSEG/S,
V,N,KMINV/V,N,VCYSEG/V,N,NLCA/SL,N,ACGC $
276 CONV ERRORC1,NOGO $
277 ADD PKFZ2 / LKVF2 / C,N,(0.0,0.0) $
278 CYCT2 CYCM,ULKVF2,, /,,UXVF2,, / C,N,BACK/V,Y,NSEG/S,
V,N,KMINV/V,N,VCYSEG/V,N,NLCA/SL,N,ACGC $
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,KMINL 
282 LABEL NOKMINL 
283 JMP TOPCYC 
284 LABEL TOPCYC & LUOP ON KINDEX 
285 COND NOKPRT,NOKPRT 
286 PRTPARM /C,N,0 /C,N,KINDEX 
287 LABEL NOKPRT 
288 CYCT2 CYCODD,BDD,MOD, /KKKF,MMKF, /C,N,FORE/V,Y,NSEGS /V,N,KINDEX/V,N,CYCSEQ=-1/V,N,NLLOAD/S,N,NCGC 
289 COND ERRORC1,NOGU 
290 CHKPN T KKKF,MMKF 
291 PARAM /C,N,SYST /C,N,58 /C,N,2 4 M ETHOC 37 IN CYCT2 PRODUCES 
292 CYCT2 CYCODD,BDD,PPX, /BKKF,PKF, /C,N,FORE/V,Y,NSEGS/ 
293 PARAM /C,N,SYST /C,N,58 /C,N,0 & RESET MPYAD METHOD CONTROL. 
294 COND ERRORC1,NOGU 
295 CHKPN T BKKF,PKF 
296 FRED2 KKKF,BKKF,MMKF,PKF,FCL / UKVF /C,N,0.0/C,N,0.0/C,N,-1.0 
297 CHKPN T UKVF 
298 CYCT2 CYCODD, ,LKVF, /UXVF, /C,N,ACK/V,Y,NSEGS/V,N,KINDEX/ 
299 COND ERRORC1,NOGU 
300 CHKPN T 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
LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

304  REPT   TOPCYC,100 $
305  JUMP   ERROR3 $
306  LABEL  LCYC2 $
307  EQUIV  UXVF,UDVF / CYCIO $
308  CHKPT  UDFV $
309  CUND   LCYC3,CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
310  CYCT1  UXVF / UDFV,GCYCL1 / V,X,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/
311  CHKPT  UDFV $
312  LABEL  LCYC3 $
313  CUND   LBLTRL4,NOMTE $
314  EQUIV  PXF,PDF2 / CYCIO $
315  CUND   LCYC4,CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
316  CYCT1  PXF / PDF2,GCYCL2 / V,X,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/
317  LABEL  LCYC4 $
318  SUI1   USETDF,PDF2,...,GMD,... / PPFZ,... / C,N,1 / C,N,DYNAMICS $
319  SSG2   USETDF,GMD,YS,DFS,GDF,...,PPFZ / / PCDUP,PSFF,PLDUM $
320  EQUIV  PPFZ,PF / PSFZ,PSF $  
321  CHKPT  PPF,PSF $
322  LABEL  LBLTRL4 $  
323  VDR    CASEXX,EQDY1,USETO,UDVF,FLL,XYCJL,/GUOVC1,/C,N,FREQPES/P,C,N,  
324  CUND   LBL15,NOD $  
325  CUND   LBL15A,NOSORT2 $  
326  SDR 3  OUVVC1,,,,/,GUOVC2,,,, $  
327  ODP    OUVVC2,,,,/,S,N,CARDNC $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

328 XYTRAN  XYCUB,OUVVC2,.../XPITFA/*FREQ*/*OSET*/S,N,PFIL/5,N,CARIND $
329 XYPLUT  XYPITFA/* $  
330 JUMP  LBL15 $  
331 LABEL  LBL15 $  
332 QFP  OUDVC1,...,/*S,N,CARIND $  
333 LABEL  LBL15 $  
334 COND  LBL20,NUP $  
335 EQUIV  UDVF,UPVC/NOA $  
336 COND  LBL19,NUA $  
337 SDR1  USETD,UDVF,...GMD,PSF,KFS,.../UPVC,...QPC/1/*DYNMICS*/ $  
338 LABEL  LBL19 $  
339 SDR2  CASEXX,CLSM,MPT,DIT,EOYNE,SLD,...,BGDNP,FUL,OPC,JUPVC,EST,XYCOB,
            PPF,OPPC1,OPPC2,UPVC1,GESCI,CEFCl,PUPVC1/C,N,FREQRESP/
            S,N,NOSRJT2 $  
340 CLVD  LBL17,NOSRJT2 $  
341 SDR3  OPCC1,OPPC1,UPVC1,GESCI,CEFCl,OPPC2,OPPC2,UPVC2,GESCI, 
            QEF2, $  
342 QFP  OPPC2,OPPC2,UPVC2,CEF2,CESC2,...S,N,CARIND $  
343 XYTRAN  XYCUB,UPPC2,OPCC2,UPVC2,GESCI,CEF2/XPITFA/*FREQ*/*PSET*/ $,
            N,PFILT/S,N,CARIND $  
344 XYPLUT  XYPITFA/* $  
345 COND  LBL16,NOPSDL $  
346 FANDLM  XYCOB,DIT,PSDL,UPVC2,OPPC2,OPCC2,CESC2,CEF2,CASEXX/PSTF,
            AUTO/ 
            S,N,NORD $  
347 CLVD  LBL16,NORD $  
348 XYTRAN  XYCUB,PSLF,AUTO,.../XPITL/*RAND*/*PSTF*/S,N,PFIL/
            S,N, 
            CARIND $  
349 XYPLUT  XYPITL/* $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

350  JUMP   LBL16 $
351  LABEL   LBL17 $
352  JFP    UPVCI,OPPC1,OPPC1,CEFC1,ESC1,//S,*,CARDAC $
353  LABEL   LBL16 $
354  COVD   LBL20,JUMPPLCT $
355  PLOT   PLOTPAR,GPSETS,ELSETS,CASEXX,BUPDT,SEQEXN,SIP,UPVCI, GPECT, 
           ESC1/PLTX2/NSIL/LUSEP/JUMPPLCT/PLTFLG/ S,N,PFILN $ 
356  PRTMSG  PLOTX2// $ 
357  LABEL   LBL20 $ 
358  COVD   FINIS;REPEATF $ 
359  KEPT   LBL13,100 $ 
360  LABEL   ERROR3 $ 
361  PRTPARM  //3/*DIRFRRD* $ 
362  JUMP   FINIS $ 
363  LABEL   ERROR4 $ 
364  PRTPARM  //4/*DIRFRRD* $ 
365  LABEL   ERRORC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA. 
366  PRTPARM  //C,N,-7 /C,N,CYCSTATIC $ 
367  LABEL   ERRJRC2 $ COUPLED MASS NOT ALLOWED. 
368  PRTPARM  //C,N,0 /C,Y,CYMPASS $ 
369  JUMP   FINIS $ 
370  LABEL   ERRORC3 $ SUPPORT BULK DATA NOT ALLOWED. 
371  PRTPARM  //C,N,-6 /C,N,CYCSTATIC $ 
372  LABEL   ERRORC4 $ EPINT BULK DATA NOT ALLOWED. 
373  PRTPARM  //C,N,0 /C,N,NOUE $ 
374  JUMP   FINIS $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

375 LABEL ERRORC5 $ NEITHER FREQ OR TSTEP WERE IN BULK DATA DECK.
376 PRTPARM //C,N,O /C,N,NOFRL $  
377 PRTPARM //C,N,O /C,N,NCTRL $  
378 JUMP FINIS $  
379 LABEL ERRORC6 $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.
380 PRTPARM //C,N,O /C,N,NOFREQ $  
381 PRTPARM //C,N,O /C,N,NOTIME $  
382 JUMP FINIS $  
383 LABEL FINIS $  
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. GP1 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.
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.
60. Go to DMAP No. 95 if there are no structural elements.
61. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.
62. Go to DMAP No. 69 if no stiffness matrix is to be assembled.
63. EMA assembles stiffness matrix \( K_{g g}^X \) and Grid Point Singularity Table.
64. Go to DMAP No. 75 if no mass matrix is to be assembled.
65. EMA assembles mass matrix \( M_{g g} \).
66. DUMMOD1 generates modified Frequency Response List, FRLX, Coriolis acceleration coefficient matrix \( B_{gg} \), centripetal coefficient matrix \( M_{1gg} \), Base acceleration coefficient matrix \( M_{2gg} \), Base acceleration matrix \( BASEXG_g \) and load modification matrix, \( PDZERO_g \), for base acceleration problems.
67. Equivalence FRLX to FRL if FRLX was generated by DUMMOD1.
68. Go to DMAP No. 84 if no viscous damping matrix is to be assembled.
69. EMA assembles viscous damping matrix \( B_{gg} \).
70. Go to DMAP No. 87 if no structural damping matrix is to be assembled.
71. EMA assembles structural damping matrix \( K_{gg}^4 \).
72. Go to DMAP No. 95 if no weight and balance is requested.
73. Go to DMAP No. 363 and print error message if no mass matrix exists.
74. GPWG generates weight and balance information.
75. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.
76. Equivalence \( K_{gg}^X \) to \( K_{gg} \) if no general elements.
77. Go to DMAP No. 99 if no general elements.
78. SMA3 adds general elements to \( K_{gg}^X \) to obtain stiffness matrix \( K_{gg} \).
79. Go to DMAP No. 109 if parameter RPS = 0.0 or if no mass matrix is present.
80. ADD assembles the Coriolis acceleration matrix into the viscous damping matrix \( [B_GU_g] = [B_{gg}] + (4 \cdot \text{RPS}) [B_{1GG_g}] \).
105. Equivalence \([\text{BGG}_g g \text{g}] \) to \([B_{gg}]\).

106. ADD assembles the centrifugal acceleration matrix into the stiffness matrix.
\[
[K_{G G g g}] = [K_{gg}] - (2\pi . R P S)^2 [M_{GG g g}] 
\]

107. Equivalence \([\text{KGG}_g g \text{g}] \) to \([K_{gg}]\).

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

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

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

111. GPSP determines if possible grid point singularities remain.

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

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

114. Equivalence \([K_{gg}] \) to \([K_{nn}]\), \([M_{gg}] \) to \([M_{nn}]\), \([B_{gg}] \) to \([B_{nn}]\) and \([K_{4g}] \) to \([K_{4n}]\) if no multipoint constraints.

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

116. MCE1 partitions multipoint constraint equations \([R_g] = [K_m]^{-1} R_n\) and solves for multipoint constraint transformation matrix \([G_m] = [-R_m]^{-1} [R_n]\).

117. MCE2 partitions stiffness, mass and damping matrices
\[
\begin{align*}
[K_{gg}] &= \begin{bmatrix} K_{nn} & K_{mn} \\ K_{mn} & K_{nn} \end{bmatrix} = \begin{bmatrix} M_{nn} & M_{nm} \\ M_{nm} & M_{nn} \end{bmatrix} \\
[B_{gg}] &= \begin{bmatrix} B_{nn} & B_{mn} \\ B_{mn} & B_{nn} \end{bmatrix} = \begin{bmatrix} K_{nn} & K_{mn} \\ K_{nm} & K_{nn} \end{bmatrix} \\
[K_{4g}] &= \begin{bmatrix} K_{nn} & K_{mn} \\ K_{nm} & K_{nn} \end{bmatrix}
\end{align*}
\]

and performs matrix reductions
\[
\begin{align*}
[K_{nn}] &= [R_{nn}] + [G_m^T] [K_{nn}] + [K_{nn}] [G_m] + [G_m^T] [K_{nn}] [G_m], \\
[M_{nn}] &= [R_{nn}] + [G_m^T] [M_{mm}] + [M_{nn}] [G_m] + [G_m^T] [M_{mm}] [G_m], \\
[B_{nn}] &= [R_{nn}] + [G_m^T] [B_{nn}] + [B_{nn}] [G_m] + [G_m^T] [B_{nn}] [G_m], \\
[K_{nn}] &= [R_{nn}] + [G_m^T] [K_{nn}] + [K_{nn}] [G_m] + [G_m^T] [K_{nn}] [G_m].
\end{align*}
\]

118. Equivalence \([K_{nn}] \) to \([K_{ff}]\), \([M_{nn}] \) to \([M_{ff}]\), \([B_{nn}] \) to \([B_{ff}]\) and \([K_{nn}] \) to \([K_{ff}]\) if no multipoint constraints.
124. Go to DMAP No. 126 if no single-point constraints.

125. SCE1 partitions out single-point constraints

\[
[K_{nn}] = \begin{bmatrix}
K_{ff} & K_{fs} \\
K_{sf} & K_{ss}
\end{bmatrix}, \quad \begin{bmatrix}
M_{nn} \\
M_{sf}
\end{bmatrix} = \begin{bmatrix}
M_{ff} & M_{fs} \\
M_{sf} & M_{ss}
\end{bmatrix}
\]

\[
[B_{nn}] = \begin{bmatrix}
B_{ff} & B_{fs} \\
B_{sf} & B_{ss}
\end{bmatrix}
\]

and \([K^4_{nn}] = \begin{bmatrix}
K^4_{ff} & K^4_{fs} \\
K^4_{sf} & K^4_{ss}
\end{bmatrix}\]

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

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

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

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

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

132. SMP1 partitions constrained stiffness matrix

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

solves for transformation matrix \([G_0] = -[K_{oo}]^{-1}[K_{oa}]\)

and performs matrix reduction \([K^1_{aa}] = [K_{aa}] + [K_{ao}][G_0]\).

133. Go to DMAP No. 135 if \(n\) mass matrix.

134. SMP2 partitions constrained mass matrix

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

and performs matrix reduction

\[
[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_0] + [M_{ao}G_0^T] + [G_0^T][M_{oo}][G_0]
\]

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

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

and performs reduction

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

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

140 SMP2 partitions constrained structural damping matrix

\[
[K_{ff}] = \begin{bmatrix}
k_{aa}^4 & k_{ao}^4 \\
k_{oa}^4 & k_{oo}^4
\end{bmatrix}
\]

and performs matrix reduction

\[
[K_{aa}] = [k_{aa}^4] + [k_{ao}^4][G_o] + [k_{ao}^4G_o]^T + [G_o][k_{oo}^4][G_o]
\]

142. Equivalence \([G_o] \to [G_o]^d\) and \([G_m] \to [G_m]^d\) 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 \([A_{b,f_2}]\) and \([K_{b,f_2}]\) if a fluid structure interface is defined. The matrix \([K_{b,f_2}]\) 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 \([B_{pp}^2]\).

158. Equivalence \([M_{pp}^{2d}] \to [M_{pp}^{2d}]\) if no \([A_{b,f_2}]\).

159. ADDS adds \([K_{b,f_2}]\) and \([K_{pp}^{2d}]\) and subtracts \([A_{b,f_2}]\) from them to form \([K_{pp}^{2d}]\).
160. Go to DMAP No. 163 if

161. Transpose \([A_b, f_a]\) to obtain \([A_b, f_a]^T\).

162. ADD assembles input matrix \([N_{pp}^2] = MFACT [A_b, f_a]^T + [M_{pp}^2]\).

163. Go to DMAP No. 172 if transient type GKA matrices are to be generated.

164. Equivalence \([N_{pp}^2]\) to \([M_{dd}^2]\), \([B_{pp}^2]\) 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.

165. Go to DMAP No. 175.

166. Equivalence \([N_{pp}^2]\) to \([M_{dd}^2]\), \([B_{pp}^2]\) 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, \([K_{aa}^1]\) to \([K_{dd}^1]\) if no direct input stiffness matrices and no extra points.

167. Go to DMAP No. 178 if only extra points are defined.

168. GKA assembles stiffness, mass, and damping matrices for use in Direct Frequency Response, if parameter GKA = FREQRESP.

\[
[K_{dd}] = (1 + ig)[K_{dd}] + [K_{dd}^2] + [1][K_{dd}^3],
\]
\[
[M_{dd}] = [M_{dd}^1] + [M_{dd}^2] + [1][M_{dd}^3], \text{ and}
\]
\[
[B_{dd}] = [B_{dd}^1] + [B_{dd}^2].
\]

Direct input matrices may be complex.

or

GKA assembles stiffness, mass, and damping matrices for use in Direct Transient Response if parameter GKA = TRANRESP.

\[
[K_{dd}] = [K_{dd}^1] + [K_{dd}^2],
\]
\[
[M_{dd}] = [M_{dd}^1] + [M_{dd}^2],
\]

and \([B_{dd}] = [B_{dd}^1] + [B_{dd}^2] + \frac{1}{\omega_3} [K_{dd}^1] + \frac{1}{\omega_4} [K_{dd}^4]\),

where

\[
\begin{bmatrix}
K_{aa} & 0 \\
0 & K_{dd}
\end{bmatrix} \Rightarrow [K_{dd}^3],
\]
\[
\begin{bmatrix}
M_{aa} & 0 \\
0 & M_{dd}
\end{bmatrix} \Rightarrow [M_{dd}^3],
\]

2.38
and
\[
\begin{bmatrix}
B_{aa} & 0 \\
0 & 0 \\
\end{bmatrix} \Rightarrow [B_{dd}]
\]
\[
\begin{bmatrix}
K_{aa} & 0 \\
0 & 0 \\
\end{bmatrix} \Rightarrow [K_{dd}]
\]
All matrices are real.

179. Go to DMAP No. 182 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. 184.

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. 203 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. \(\{P_l^T\}\) is generated with one column per output time step. \(\{P_l^d\}\) is generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.

194. SDR1 appends \(\{P_l^T\}\) to \(\{P_d^T\}\).

195. SDR1 appends \(\{P_l^d\}\) to \(\{P_d^d\}\).

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

198. Go to DMAP No. 189 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 \(\{P_d^d\}\) if the output times are the same as the solution times.

204. DUMMOD2 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.
207. Go to DMAP No. 234.

209. FRLG forms the dynamic load vectors \( \{P_p^f\}, \{P_s^f\}, \{P_d^f\} \) and Frequency Output List (FOL) for frequency-dependent loads.

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

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

212. Equivalence \( \{P_X^f\} \) to \( \{P_p^f\} \).

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

215. MPYAD forms the complete base acceleration matrix, \( \{M2BASEXG^f_g\} = [M2GG_{gg}] \cdot \{BASEXG^f_g\} \).
216. ADD assembles the freq. loads and the loads due to base acceleration.

\[ \{P_f^p\} = \{P^f_p\} - \{\text{BASEEXG}\} \]

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

217. Equivalence \( \{P^f_p\} \) to \( \{P^f_p\} \).

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

219. SSG2 applies constraints to \( \{P^f_p\} \).

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

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

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

223. Go to DMAP No. 268.

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

225. Equivalence \( \{P^t_d\} \) and \( \{\text{PDTRZ1}\} \) if REORDER1 was not generated by DUMMOD2.

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

227. MPYAD reorders columns of \( \{P^t_d\} \).

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

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

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

231. MPYAD reorders columns of \( \{\text{PXTRZ1}\} \).

232. Equivalence \( \{\text{PXFZ1}\} \) to \( \{\text{PXF1}\} \).

233. Go to DMAP No. 264.

234. MPYAD reorders columns of \( \{P^t_d\} \).

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

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

237. Equivalence \( \{\text{PXTR2}\} \) to \( \{\text{PXTR2}\} \) if REORDER2 was not generated.

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

239. MPYAD reorders columns of \( \{\text{PXTRZ2}\} \).

240. CYCT1 transform symmetric components, in time, to symmetric components.

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

242. Equivalence \( \{\text{PXFZ2}\} \) to \( \{\text{PXF1}\} \).

243. Go to DMAP No. 264.

244. Equivalence \( \{\text{PXFZ2}\} \) to \( \{\text{PXF1}\} \).

245. COPY makes a physical copy of \( \{\text{PXF1}\} \) called \( \{\text{PFY2}\} \).
266. ADD makes loads complex, since SDR2 expects complex loads in a frequency response problem. Time-dependent loads are real.

$$(PFX) \cdot (0.5, 1.0j) \cdot (PFX1) \cdot (0.5, -1.0j) \cdot (PFX2)$$

271. Go to DMAP No. 282 if $K_{MIN} = 0$.

274. Beginning of loop to create $K_{MIN}$ null columns of $(UV_f^x)$ for $KINDEX = 0$ to $(K_{MIN}-1)$. These leading null columns are necessary because CYCT1 expects columns for $KINDEX = 0$ to $K_{MAX}$.

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 $(UV_f^x)$ columns.

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

277. ADD generates a null vector $(UV_f^z) = (PZ_f^x) \cdot 0.0$.

278. CYCT2 finds symmetric components of displacements from solution set data and prepends it to $(UV_f^x)$.

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 $(UV_f^x)$. If the initial $(UV_f^x)$ for $KINDEX$ values 0 to $(K_{MIN}-1)$ 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:

$$[K_{kk}] = [G_T^c][K_{aa}][G_c] + [G_T^s][K_{aa}][G_s]$$

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

$$[B_{kk}] = [G_T^c][B_{aa}][G_c] + [G_T^s][B_{aa}][G_s]$$

$$[P_k] = [G_T^c][P_c] + [G_T^s][P_s]$$

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:

$$[-M_{dd}w^2 + iB_{dd}w + K_{dd}](U_d) = (P_d)$$

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. CYCTL transforms displacements from symmetrical components to physical components.
311. 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. CYCTL transforms loads from symmetrical components to physical components if loads were time-dependent.
318. SDR1 recovers dependent loads \( P_p^f \).
319. SSG2 applies constraints to \( P_p^f \) to form \( P_p^f \).
320. Equivalence \( P_p^f \) to \( P_p^f \) and \( P_s^f \) to \( P_s^f \).
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 involving dependent degrees of freedom 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

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

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. DFIP 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. BFP 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 plots 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 CYC\( k \) 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
    RANDPS and RANDTI 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. SUPORT 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, W3 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 NSEG/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 TABLE_1 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 BUFXDD

3.1.1.1 FRLX (TABLE)

Description

Frequency Response List

The FRLX contains one log. . . 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></td>
<td>Set ID₁</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+n</td>
<td>I</td>
<td></td>
<td>Set IDₙ</td>
</tr>
<tr>
<td>1</td>
<td>1-m</td>
<td>R</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>n</td>
<td>1-k</td>
<td>R</td>
<td>Radian frequencies belonging to set IDₙ (w = 2πF)</td>
</tr>
<tr>
<td>n+1</td>
<td></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

\[[BIGG]_{gg}\] = Coriolis acceleration coefficient matrix - g set.

3.1.1.3 MGIG (MATRIX)

Description

\[[MIGG]_{gg}\] = Centripetal acceleration coefficient matrix - g set.

3.1.1.4 M2GG (MATRIX)

Description

\[[M2GG]_{gg}\] = Base acceleration coefficient matrix - g set.
3.1.1.5 BASEXG (MATRIX)

Description

\[ \text{BASEXG}_g^F \] - Base acceleration matrix - g set.

3.1.1.6 PDZERO (MATRIX)

Description

\[ \text{PDZERO}_g^F \] - 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>3</td>
<td></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 = 2\pi F) )</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 = 2\pi F) )</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 (NHFREQ)
Word 2 = Frequency set record number (=1)
Word 3-6 = zero

3.1.2.3 REORDER1 (MATRIX)

Description


Matrix Trailer

Number of columns = NTSTEPS*FKMAX, if CYCIO = -1
Number of rows = NTSTEPS*NSEGS, if CYCIO = +1
Form = square
Type = real single precision

3.1.2.4 REORDER2 (MATRIX)

Description


Matrix Trailer

Number of columns = FLMAX*FKMAX, if CYCIO = -1
Number of rows = FLMAX*NSEGS, if CYCIO = +1
Form = square
Type = real single precision
3.2 FUNCTIONAL MODULES

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


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, N2GG 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. N2GG 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.

NSEG5 - 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 NSEG5/2.

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 TABLE Di 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 CYCIO=-1, then parameter FKMAX is computed as follows. If NSEGS is odd then FKMAX=2*KMAX+1: if NSEGS is even and KMAX=NSEGS/2, then FKMAX=NSEGS, otherwise FKMAX=2*KMAX+1.

If parameter 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 OMEGA=0.0. M2GG is generated if parameter NOBASEX=-1. The second and third phases generate data blocks associated with base acceleration problems and are only executed if NOBASEX=-1. In the second phase FRLX and PDZERO are generated unless parameter 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 OMEGA=0.0 then B1GG and 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 ith grid point in the BGPDT the corresponding translational terms of MGG are unpacked and the diagonal terms are isolated into a 3 x 3 matrix [Mi]. If the grid point is not in the basic system then subroutine TRANSO calculates the 3 x 3 transformation matrix [Ti] from global coordinates to basic coordinates for the grid point and [Mi] is transformed to the basic system to form [Mi]. The average of the three diagonal terms of [Mi] is then used to form [BTi], [MTi] and [MTi]. These three submatrices are then transformed back to the global coordinate system, if necessary. The 3 x 3 matrices [BTi], [MTi] and [MTi] are then packed into the B1GG, M1GG and M2GG matrices.

(a) 

\[
[MGG]_{g x g} = 
\begin{bmatrix}
[M_{1}] & [M_{2}] & 0 \\
0 & \cdots & [M_{n}] \\
\end{bmatrix}
\]

where n = the total number of grid points.
where \[ M_i^{[1]} \] = \[
\begin{bmatrix}
M_{1i}^{[1]} \\
M_{2i}^{[1]} \\
M_{3i}^{[1]}
\end{bmatrix}
\] for \( i = 1, n \)

and

\[ M_i^{[2]} = \[
\begin{bmatrix}
m_i^{T1} & 0 & 0 \\
0 & m_i^{T2} & 0 \\
0 & 0 & m_i^{T3}
\end{bmatrix}
\]

(b) Transform \([M_i^{[1]}]\) from global to basic coordinate system

\[ M_i^{[3]} = [T_i^{[1]}] [M_i^{[1]}] [T_i^{[2]}]^T \]

(c) Compute average of \([M_i^{[3]}]\)

\[ \overline{m_i} = \frac{3}{3.0} \overline{m_i} \] where \( \overline{m_i} \) 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 \( B1GG \)

\[
[B1GG] = \begin{bmatrix}
[B1_1] & 0 \\
[B1_2] & \cdots & \vdots & \ddots & [B1_n]
\end{bmatrix}
\]

where

\[ B_i^{[1]} = \[
\begin{bmatrix}
B_{1i}^{[1]} \\
B_{2i}^{[1]} \\
\vdots \\
B_{ni}^{[1]}
\end{bmatrix}
\]

and

\[ B_i^{[2]} = [T_i^{[1]}]^T \begin{bmatrix}
0 & 0 & 0 \\
0 & 0 & -\overline{m_i} \\
0 & \overline{m_i} & 0
\end{bmatrix} [T_i] \]

(e) Form \( M1GG \)

\[
[M1GG] = \begin{bmatrix}
[M1_1] & 0 \\
[M1_2] & \cdots & \vdots & \ddots & [M1_n]
\end{bmatrix}
\]

3.7
where

\[
[M\hat{t}_i] = \begin{bmatrix}
\vdots \\
\vdots \\
\vdots \\
0
\end{bmatrix}
\]

and

\[
[M\hat{t}_i] = [T_i]^T \begin{bmatrix}
0 & 0 & 0 \\
0 & m_i & 0 \\
0 & 0 & m_i
\end{bmatrix} [T_i]
\]

(f) Form M2GG

\[
[M2GG] = \begin{bmatrix}
[M2_1] & \vdots & [M2_g] \\
0 & \ddots & [M2_n]
\end{bmatrix}
\]

where

\[
[M2_1] = \begin{bmatrix}
\vdots \\
\vdots \\
\vdots \\
0
\end{bmatrix}
\]

and

\[
[M2_i] = [T_i]^T \begin{bmatrix}
m_i & 0 & 0 \\
0 & m_i & m_i \\
0 & -m_i & m_i
\end{bmatrix} [T_i]
\]

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 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 \( i = 1, N\) 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, \( |\omega_i\) - OMEGA], \( \omega_i \), 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 $|\Omega G\rangle$ 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 $\text{FMAX}$ times, thus creating $\text{FMAX}$ 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 BXID, BYID, BZID, 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 $X_0(f_i), Y_0(f_i), Z_0(f_i)$ be input via frequency dependent tables TABLEDi where the table IDs are defined by parameters BXID, BXPTID, BYID, BYPTID, BZID and BZPTID respectively. $X_0, Y_0$ and $Z_0$ are magnitudes in L7-2 units while $\varphi_x, \varphi_y$ and $\varphi_z$ are phase angles in degrees.

(b) Define control flag MODFRL.

If parameter $\Omega G\rangle=0.0$ or parameters BYID=-1 and BZID=-1 then set MODFRL to false, otherwise MODFRL is true.

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

\[ \text{FRL} = [\omega_1, \omega_2, \omega_3, \ldots, \omega_{NF}] \]

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

\[ \text{BASE} = [\text{BASE}(f_1) \ldots \text{BASE}(f_{NF})] \]

\[ 3 \times NF \]

3.9
where $f_i = \omega_i/2\pi$ for $i = 1, 2, \ldots, \text{NF}$ and

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

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

$$\begin{bmatrix}
\text{BASE}\end{bmatrix}_{3x\text{NFX}} = \begin{bmatrix}
\{\text{BASE}(f_1)\} & \{\text{BASE}(f_2)\} & \ldots & \{\text{BASE}(f_{\text{NF}})\}
\end{bmatrix}$$

where $f_i = \omega_i/2\pi$ for $i = 1, 2, \ldots, \text{NF}$ 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 $\{\text{BASE}(f_i)\}$ is defined as follows:

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

where

- $\text{SGN} = 1.0$ if parameter $\text{OMEGA} \geq 0.0$, otherwise $\text{SGN} = -1.0$
- $A = \ddot{x}_0(f_i) \cdot e^{i\theta_x(f_i)}$
- $B = \ddot{y}_0(f_i) \cdot \cos(\theta_y(f_i)) - 1 \cdot \text{SGN} \cdot \ddot{z}_0(f_i) \cdot \cos(\theta_z(f_i))$
- $C = \ddot{z}_0(f_i) \cdot \cos(\theta_z(f_i)) + 1 \cdot \text{SGN} \cdot \ddot{y}_0(f_i) \cdot \cos(\theta_y(f_i))$

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

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

where

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

and

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

Let NF be the number of frequencies in the BASE matrix, i.e., let NF = NF if MODFRL was false or NF = NF x FKMAX if MODFRL was true.

\[
\begin{bmatrix}
\text{BASEXG} \\
\end{bmatrix}_{gx(NF \times FKMAX)} =
\begin{bmatrix}
\text{BASEXG}^1 \\
\text{BASEXG}^2 \\
\text{BASEXG}^3 \\
\vdots \\
\text{BASEXG}^{FKMAX}
\end{bmatrix}_{gxNF}
\]

where

\[
\begin{bmatrix}
\text{BASEXG}^i \\
\end{bmatrix}_{gxNF} =
\begin{bmatrix}
\text{BASEXG}^1 \\
\vdots \\
\text{BASEXG}^i \\
\vdots \\
\text{BASEXG}^{FKMAX}
\end{bmatrix}_{6xNF}
\]

and

\[
\begin{bmatrix}
\text{BASEXG}^i \\
\end{bmatrix}_{gxNF} = [0] \text{ for } i = 4, 5, 6, \ldots, FKMAX
\]

Note: \[
\begin{bmatrix}
\text{BASEXG}^i \\
\end{bmatrix}_{6xNF}
\]
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.
3.2.1.8 Subroutines

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

3.2.1.8.1 Subroutine Name: DUMO1A

1. Entry Point: DUMO1A

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

3. Calling Sequence: Call DUMO1A (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: DUM01B

1. Entry Point: DUM01B

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 DUM01B (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, THPI, RADEG, DEGRA, S4PISQ
   COMMON/BLANK/DUM(5), BXTID, BXPTID, BYTID, BYPTID, BZTID, BZPTID

3.2.1.8.3 Subroutine Name: DUM01C

1. Entry Point: DUM01C

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 DUM01C (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, THPI, RADEG, DEGRA, S4PISQ
   COMMON/BLANK/DUM(5), BXTID, BXPTID, BYTID, BYPTID, BZTID, BZPTID

3.2.1.8.4 Subroutine Name: DUM01D

1. Entry Point: DUM01D

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 DUM01D (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 FRLX 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) DUMOD1 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

<table>
<thead>
<tr>
<th>Z(1)</th>
<th>Column of MGG</th>
<th>NTYPE*G-set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(ICSTM)</td>
<td>CSTM_DATA</td>
<td>LCSTM</td>
</tr>
<tr>
<td>Z(IBUF5)</td>
<td>M2GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF4)</td>
<td>M1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF3)</td>
<td>B1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF2)</td>
<td>BGPDT</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>CSTM/MGG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>
### Phase II

**COMMON/DUMIXX/Z**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Size</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>
<tr>
<td>Z(IBUF3)</td>
<td>PDZERO</td>
<td></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>Size</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>NTABL</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>
<tr>
<td>Z(IBUF1)</td>
<td>DIT/BASEXG</td>
<td></td>
</tr>
</tbody>
</table>

#### 3.2.1.10 Diagnosis Messages

The following fatal error messages may occur:

3001, 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 $ 

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

NOR01 - Output-integer-no default. NOR01=-1 if matrix REORDER1 is not generated, +1 otherwise.

NOR02 - Output-integer-no default. NOR02=-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 NOR01 and NOR02 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*FKMAX)/FKMAX
   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 per second, FRL(i) = FOL(i)*2π for i = 1, NFREQ.

3.2.2.7.3 Computation of parameters NOR01 and NOR02 and matrices REORDER1 and REORDER2.

   REORDER1 and REORDER2 are used for reordering columns of a matrix by post-multiplying the matrix whose columns are to be reordered. Routine DUM02A is called twice, once to generate and output REORDER1 and once to generate and output REORDER2. See the subroutine description of DUM02A for details.
3.2.2.8 Subroutines

DUMOD2 uses standard NASTRAN GINO routines and utility routines.

3.2.2.8.1 Subroutine Name: DUM02A

1. Entry Point: DUM02A

2. Purpose: To generate and output column reordering matrices REORDER1 and REORDER2 and to compute parameters NOR01 and NOR02.

3. Calling Sequence: CALL DUM02A(FILE, KK1, KK2, NOR0, BUFFER)

   FILE - GINO file number of REORDER1 or REORDER2 - integer - input.
   KK1 - Reordering row index - integer - input.
   KK2 - Reordering column index - integer - input.
   NOR0 - NOR0=+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 NOR0=-1, otherwise set parameter NOR0=+1 to indicate that the reordering matrix was generated. If NOR0=-1, then return otherwise continue processing.

   Generate a real single precision reordering matrix of order KK1*KK2 by KK1*KK2. This matrix can be used to reorder columns of another matrix 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:

\[
\text{COMMON/DUM2XX/}
\]

\[
\begin{array}{|c|c|}
\hline
\text{Z(ITOL)} & \text{TOL TIME DATA} \\
\text{Z(IFOL)} & \text{FOL/FRL DATA} \\
\text{FREE} & \\
\text{Z(IBUF1)} & \text{TOL/FOL/FRL/REORDER} \\
\text{GINO BUFFER+1} & \\
\hline
\end{array}
\]

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
### NORMAL L117.7 (TDI)

**LINKED AT**

**NOTE - LINKEDIT CONTROLS**

CHANGED: LIN,TEX, ETC.

**INCLUDES** LIN, ETC.

X - Denotes New Routines
x - Denotes new routines
+ - Denotes existing routines now to this link
Must be added routines: XSERN06
OPEN file - /ALOXX/ must be placed after the
longest line of output
level output 0 and output 1

LINKEDIT (Control)
[CHANGE CSA(EBPN)]
[EXCLUDE LIBE (EBPN)]
[CHANGE PLOT (RETURN), SYMBOL (RETURN), NUMBER (RETURN)]
[INCLUDE LIBE (EBPN)]
[CHANGE POT (RETURN), SYMBOL (RETURN)]
[INCLUDE LIBE (EBPN)]
[CHANGE PLOT (RETURN), LINE (RETURN), AXIS (RETURN)]
[EXCLUDE LIBE (EBPN)]
MODIFIED EXISTING ROUTINES: FA2
3.3.2 UNIVAC OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
NASTRAN L17.7 (NONLINE)
LINKN51

ORIGINAL PROCEDURE
OF POOR QUALITY

MODIFIED EXISTING ROUTINE
FA2
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:

   \[ P(f;n) = A(f) \cos \left( \frac{n-\Omega}{2} \cdot \frac{2\pi}{\Omega} \right) \]

   where \( n \) is the segment number,
   \( \Omega \) represents \( k = 2 \),
   \( \Omega \) represents the total number of segments in the bladed disc.
   \( P \) 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

<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</td>
</tr>
<tr>
<td>DIAG</td>
<td>$IBM 370/3031</td>
</tr>
<tr>
<td>CEND</td>
<td>14.21</td>
</tr>
</tbody>
</table>
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
$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
$ SUBTITLE = BLADED DISC EXAMPLE 1  (FULL MODEL,FREQ LOADS)
$ LABEL = INDEX 2C TYPE LOADS
$ SPC = 30
FREQ = 1
LOAD = 1
OUTPUT
SET 1 = 0.22, 0.26, 0.30, 0.34, 0.38, 0.42, 0.46, 0.50, 0.54, 0.58, 0.62
66, 0.70, 0.74, 0.78, 0.82, 0.86, 0.90, 0.94, 0.98, 1.02, 1.06, 1.10, 1.14, 1.18, 1.22, 1.26, 1.30, 1.34, 1.38, 1.42
1.46, 1.50
LOAD = 1
DISP(SORT2, PHASE) = ALL
STRESS(SORT2, PHASE) = ALL
OUTPUT(XYPLT)
PLOTTER NASPLOT, MODEL 0,0
XPAPER = 8.0
YPAPER = 10.5
XAXIS = YES
YAXIS = YES
XGRID LINES = YES
YGRID LINES = YES
CURVE LINES SYMBOL = 1
VLOG = YES
XTITLE = FREQUENCY (HERTZ)
YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
XYPLT, XPRINT DISP RESPONSE /14(T3RH), 18(T3RH), 95(T3RH)
XYPLT, XPRINT STRESS RESPONSE /11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
BEGIN BULK

SER INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
<table>
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<th>1</th>
<th>2</th>
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<th>9</th>
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4.13
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 \( K\text{MIN} \) and \( K\text{MAX} \).

B. Input

1. Parameters:

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

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[
   p^n(f) = A(f) \cos \left( \frac{n \cdot \pi \cdot 2 \cdot \theta}{\theta_f} \right),
   \]

   where \( n \) is the segment number,
   
   \( \theta \) represents \( k = 2 \),
   
   \( \theta_f \) represents the total number of segments in the bladed disc.

   \( P \) is specified using \( R\text{LOADi} \) 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

NA STR A N  E X E C U T I V E  C O N T R O L  D E C K  E C H O

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APP       DISP
SUL 8

BEGINNING OF RF ALTER 851 - RF 8 / SERIES R (L1771) / 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. SUL 8
2. K.F. ALTERS

CASE CONTROL DECK INPUT -

1. ALL MPC 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, FREQ1 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-STEP TO BE USED FOR LOAD DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. FREQUENCY 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 GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF SUBCASES FOR EACH HARMONIC INDEX. K. THE PARAMETER CYCLO IS INCLUDED AND THE LOAD COMPONENTS FOR EACH INDEX ARE DEFINED DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

BULK DATA DECK INPUT -

ORIGINAL PAGE IS OF POOR QUALITY.
1. SUPPORT 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.

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 0 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 COSINE AND SINE TERMS.

D. CYTPR - FIXED - THE BCU VALUE OF THIS PARAMETER DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE OF THIS PARAMETER HAS BEEN SET TO -ROT- 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 LUMP. KMIN CAN EQUAL 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 NTSTEPS/2, WHERE NTSTEPS 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.

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.

BYPTID

BZPTID

TABLES REFERED TO BY BYPTID, BYPTID AND BZPTID

DEFINE MAGNITUDE (17-9) AND THE TABLES REFERED TO

BY BYPTID, BYPTID AND BZPTID 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. WIMASS - OPTIONAL - THE TERMS OF THE STRUCTURAL MASS

MATRIX ARE MULTIPLIED BY THE REAL VALUE OF THIS

PARAMETER WHEN THEY ARE GENERATED IN EMD. THE

DEFAULT IS 1.0.

N. COUPMASS - FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

O. GKAD - OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS

USED TO TELL THE GKAD MODULE THE DESIRED FORM OF

MATRICES KGD, BDD AND HOD. THE BCD VALUE CAN BE

FREQESP OR TRANRESP. THE DEFAULT IS TRANRESP.

NOTE - MEMBER TO DEFINE PARAMETERS G, W3 AND H4.

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 GKAD. IF

GKAD=FREQESP THEN SET LGKAD=1. IF GKAD=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 DYNAMICS PROBLEMS.

R. 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 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 GKAD=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 = KHIN TO KMAX.
NASTRA EXECUTIVE CONTROL DECK ECHO

FILE: UXVF=APPEND/PAT=APPEND/PD=APPEND
$ PERFL M INITIAL ERROR CHECKS ON NSEGS AND KMAX
CND ERRGRC1*NSEG & IF USER HAS NOT SPECIFIED NSEG
CNUM ERRGRC1*KMAX & IF USER HAS NOT SPECIFIED KMAX
PARAM //C,N,EQ /V,N,CYC10ERR /V,Y,CYC10=0 /C,N,0 $ CNUM ERRGRC1*CYC10ERR & IF USER HAS NOT SPECIFIED CYC10
$ SET DEFFALTS FOR PARAMETERS
PARAM //C,N,NUP /V,Y,NDKPKRT=61 /V,Y,LGKAD=1 $ $ CALCULATE OMEGA, 2*OMEGA AND OMEGA**2 FROM RPS, SET DEFAULT RPS
PARAM //C,N,HPY /V,N,OMEGA /V,Y,RPS=0.0 /C,N,0.283185 $ PARAM //C,N,MPY /V,N,OMEGA2 /C,N,2.0 /V,Y,OMEGA $ $ GENERATE NULLS FLAG IF KPS IS ZERO
PARAM //C,N,EQ //V,Y,RPS /C,N,0.0 //V,Y,NORPS $ $ MAKE SURF COUPLED MASSES HAVE NOT BEEN REQUESTED
PARAM //C,N,NUT /V,N,OLUMP /V,Y,CLUPMASS=-1 $ CNUM ERRGRC2,NULMP $ ALTEK 21,21 $ ADD SLT TO OUTPUT FOR TRLG
GP3 GEOM3,EWX1H,GEW2 / SLT,DPIT / V,N,NUGRAV $ CHKPNI SLT,DPIT $ ALTEK 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 SSG2
PARAM //C,N,NUT /V,N,REDIT/C,N,NUT $ CNUM ERRGRC3,READATA $ $ EXECUTE DPD NOW SO CHECKS CAN BE MADE, ADD TRL TO OUTPUT DATA BLOCKS
PARAM //C,N,AND/V,N,FRENR /V,N,NOTFL /V,N,NOTRL $ CNUM ERRGRC5,FREN $ $ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL
NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NOT /V,N,FTRYK1 /V,N,FREUTINE $  
PARAM //C,N,L /V,N,NUPREQ /V,N,FRESET /C,N,O $  
PARAM //C,N,L /V,N,NOTIME /V,N,TIMESET /C,N,O $  
CONC ERRORCO,FTERK1 $ BOTH FREQ AND STEP IN CASE CONTROL DECK.$  
$ EPPQNI BULK DATA NOT ALLCHED  
PARAM //C,N,NCT /V,N,EXTRAPTS /V,N,NOUE $  
CONC ERRORCS,EXTRAPTS $  
$ GENERATE DATA FOR CYCT2 MODULE.  
CPYCY GETHM,CLOYN,USEDO /CYCDD /V,N,CYPTYPE=RUT /S,N,NOGU $  
CCON ERRORCI,NUGC $  
CHKPNT CYCDD $  
ALTER J2 $.  
$ PRI-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED  
PARAM //C,N,OK /V,N,NUDBM1 /V,N,NOMGGG /V,N,NUKPS $  
PURGE B1GG,M1GG /NUDBM1 $  
PURGE M2GG,M2GG,BASEXG /NUMGG $  
ALTER 35 $.  
$ GENERATE DATA BLOCKS FRXLX, B1GG, M1GG, M2GG AND B1SEXG.  
$ GENERATE PARAMETERS FKMAX AND NCBASEX.  
DUMMO1 CASECC,dUPUT,CSTM,BIT,FRXLX,MUGG $ / FRXLX,B1GG,M1GG,  
M2GG,BASEXG,B1SEXG $ /V,N,NOMGGG/V,N,NOMGCG/V,N,LYCIC/V,N,NSEGS/  
V,Y,BMEXF=1/V,Y,BXPTD=-2/V,Y,BYPTD=-1/V,Y,BZPTD=-1/  
V,Y,BYPTD=-1/V,Y,BXPTD=-2/V,Y,BYPTD=-1/V,Y,BZPTD=-1/  
PARRAM FLRX //C,N,PRESOQUE ///V,N,NOFLRX $  
CONC LBLFRXLX,NUFLRX $  
EQUIV FRXLX,FLRX $  
LABEL LBLFRXLX $  
CHKPNT FRXLX,B1GG,M1GG,M2GG,BASEXG $  
ALTER 42 $.  
PARAM //C,N,ADD /V,N,NUDBG /V,N,NUDBM1 /C,N,O $ RESET NUBGG.  
ALTER 52 $.  
$ REDEFINE B1GG AND M1GG.  
CONC LBL11A,NUDBM1 $  
PARRAM //C,N,CMPLX //V,N,OMEGA2 /C,N,O $ /V,N,CMPLX1 $  
PARRAM //C,N,SUB /V,N,OMEGASUM /C,N,O $ /V,N,OMEGASUM $  
PARRAM //C,N,CMPLX //V,N,OMEGASUM /C,N,O $ /V,N,CMPLX2 $  
ACG B1GG,B1GG / B1GG /C,N,(1.0,0.0) $ /V,N,CMPLX1 $  
EQUIV B1GG,B1GG $  
ACG M1GG,M1GG / M1GG /C,N,(1.0,0.0) $ /V,N,CMPLX2 $  
EQUIV M1GG,M1GG $  
CHKPNT B1GG,M1GG $  
LABEL LBL11A $  
ALTER 53,55 $ GP4 HAS BEEN MOVED-UP.  
ALTER 56,66 $ LUH HAS BEEN MOVED-UP.  
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LGKAD FOR FREQ OR TRAN.  
PARRAM //C,N,AND/V,N,KULKA/V,N,NOUE/V,N,NGK2PP $  
CONC LGKAD1,LGKAD $ BRANCH IN NOT FREQRESP.  
ALTER 115 $ SEE ALTER 114 COMMENT.  
JUMP LGKAD2 $
NASTRAH EXECUTIVE CONTROL DECK

OF POOR QUALITY

PAGE 15
CASE: USE Q.D.T. SDEG = 1.0, SFL = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
CASES = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
CASE: USE Q.D.T. SDEG = 1.0, SFL = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
CASE: USE Q.D.T. SDEG = 1.0, SFL = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
CASE: USE Q.D.T. SDEG = 1.0, SFL = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
CASE: USE Q.D.T. SDEG = 1.0, SFL = 1.0, NF = 100, PF = 100, PDEG = 100, GP = 100,
EQUIV PXFL1, PXF1 $  
CHKPNT PXF1 $  
JUMP LBLTRI3 $  
LABEL LBLTRI2 $  
$ CYC11 = 11  
MPYAD PDT, REORDER1, / POTRZ2 / C.N.,0 $  
COND ERRORC1, NOGC $  
CHKPNT PXTRZ2 $  
EQUIV PXTRZ2, PXTRZ2/NUR02 $  
COND LBLR02B/NUR02 $  
MPYAD PXTRZ2, REORDER2, / PXTRZ2 / C.N.,0 $  
LABEL LBLR02B $  
COND ERRORC1, NOGC $  
EQUIV PXFZ2, PXF1 $  
CHKPNT PXF1 $  
LABEL LBLTRI3 $  
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND $  
$ TO FREQUENCY DEPENDENT LOADS. ALSC SDR2 EXPECTS LOADS TO BE COMPLEX $  
$ IN FREQUENCY PROBLEMS.  
COPY PXF1 / PXF2 $  
CONVERT REAL PXF1 TO COMPLEX PXF*.  
ADD PXF1, PXF2 / PXF / C.N.(0.5-1.0) / C.N.(0.5,-1.0) $  
$ DEFINE NLOAD FOR CYC12.  
PARAM //C.N, ADD /V.N, NLOAD /V.N, FLMAX /C.N,0 $  
$ NLCAD = FLMAX  
LABEL LBLPGONE $  
PARAM //C.N, ADD /V.N, KINDEX /V.Y, KMIN=0 /C.N,0 $  
INITIALIZE KINDEX.  
$  
$ INITIALIZE UXVF IF KMIN IS NOT ZERO.  
$  
PARAM //C.N, ADD /V.N,UXVF /V.Y, KMIN /C.N,-1 $  
COND NOKMINL, KMINL $  
PARAM //C.N, ADD /V.N,UXVF /C.N,0 /C.N,0 $  
JUMP KMINLUP $  
LAGEL KMINLUP $  
CYC2 CYC2, ..., PXF, ..., / C.N,FLRE/V.Y, NSEGS/V.N, KMIN/V.N, UXVF/UXVF, LMIN=0 /C.N,0 $  
COND ERRORC1, NOGC $  
ADD PKFZ, / UXVFZ / C.N.(0, C.O.0) $  
CYC2 CYC2, ..., UXVFZ, ..., / C.N, BACK/V.Y, NSEGS/V.N, KMIN/V.N, UXVF/UXVF, LMIN=0 /C.N,0 $  
COND ERRORC1, NOGC $  
PARAM //C.N, ADD /V.N, KMINV /V.N, KMINV /C.N,1 $  
REPT KMINLUP, KMINL $  
LABEL NOKMINL $  
$  
JUMP TUPCYC $  
LABEL TUPCYC $  
LOCOP ON KINDEX
NASTRAN EXECUTIVE CONTROL DECK ECHO

CONDU  NOKPRT, NOKPRT "$  
PRTPARM  //C,N,O /C,N,INDEX "$  
LABEL  NOKPRT "$  
CYCT2  CYCDU, KDD, MDD, ... /KKKF, HKKF, ... /C,N,FORE/V,Y,NSEG'S /  
V,N,INDEX/V,N,CYSEQ=-1/V,N,NLOAD/S,N,NOGD "$  
CONU  ERROCLI, NOGU "$  
CHKPNT  KKAF, HKAF "$  
PARAM  //C,N,SYST //C,N,58 /C,N,2 "$  METHOD 3T IN CYCT2 PRODUCES  
$ UNDERFLOWS FOR PZF. USE METHOD 2 "$  
CYCT2  CYCDU, BDD, PZF, ... /BKKF, PKF, ... /C,N,FORE/V,Y,NSEG'S /  
V,N,INDEX/V,N,CYSEQ/V,N,NLOAD/S,N,NOGD "$  
PARAM  //C,N,SYST //C,N,58 /C,N,0 "$  RESET MPYAU METHOD CONTROL "$  
CONU  ERROCLI, NOGU "$  
CHKPNT  BKAF, PKF "$  
$ SOLUTION "$  
PRT2D  KKF, BKKF, HKKF, PKF, FGL / UKVF /C,N,0,0/C,N,0,0/C,N,1,0 "$  
CHKPNT  UKVF "$  
CYCT2  CYCDU, UKVF, ... /UXVF, ... /C,N,BACK/V,Y,NSEG'S/V,N,INDEX/  
V,N,LCYGLQ/V,N,NLOAD/S,N,NOGD "$  
CONU  ERROCLI, NOGU "$  
CHKPNT  UXVF "$  
PARAM  //C,N,ADDI /V,N,INDEX/V,N,INDEX/C,N,1 "$  KINDEX = KINDEX + 1 "$  
PARAM  //C,N,ADDI /V,N,INDEX/V,N,INDEX/C,N,1 "$  KINDEX = KINDEX + 1 "$  
CONU  LCYCI2, UGNE "$ IF KINDEX .GE. KMAX THEN EXIT "$  
REPT  TUPLY, JCC "$  
JUMP  ERR03 "$  
LABEL  LCYCI2 "$  
EQUIV  JUXV, UDVF / CYCIU "$  
CHKPNT  UDVF "$  
CONU  LCYCI3, CYCIU "$ IF CYCI0 .GE. 0 THEN TRANSFORM TO PHYSICAL "$  
CYT1  UXVF / UDVF, LCYCI1 / V,N,CTYPE/C,N,BACK/V,Y,NSEG'S/V,Y,KMAX/  
V,N,NLOAD "$  
CHKPNT  UDVF "$  
LABEL  LCYCI3 "$  
EQUIV  PPF, PDF2 / CYCIU "$  
CONU  LCYCI4, CYCIU "$ IF CYCI0 .GE. 0 THEN TRANSFORM TO PHYSICAL "$  
CYT1  PPF / PDF2, LCYCI2 / V,N,CTYPE/C,N,BACK/V,Y,NSEG'S/V,Y,KMAX/  
V,N,NLOAD "$  
LABEL  LCYCI4 "$  
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PDF "$  
SDR1  USETH, PFF2, ... / PPF2, ... /C,N,1 /C,N,DYNAMICS "$  
SSC2  USETH, GMDF, KSDF, UDD, PPF2, ... / PCDUM, PSF2, PLEDUM "$  
EQUIV  PPFE, PPF / PSF2, PSF "$  
CHKPNT  PPF, PSF "$  
LABEL  LBL1RL4 "$  
ALTER 124, 124 "$ USE FULL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST "$  
CONU  CASEXX, EQUDI, USEUD, UDVF, FC1, XYCDU, UODVCI / C,N,FREQESP/C,N,  
DIRECT/S,N,NOD/C,N,UP/C,N,0 "$  
ALTER 140, 140 "$ USE FULL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST "$  
ALTER 4.23
NASTRAN EXECUTIVE CONTROL DECK ECHO

SDM2 CASEXX,CSTM,MP,T,U,EDYN,SILD...,BGDDP,FLL,QPC,UPVC,EST,XYCDB,
PPF/UPPC1,GCPC1,UPVC1,ESC1,CEPC1,UPVC1/C,N,FREQRESP/
S,N,NOSORT2 S
ALTER 160 $ ADD LABEL FOR ERROR3.
LABEL ERROR3 S
ALTER 163,166 $ REMOVE ERROR1 AND ERROR2.
ALTER 168 $ FORCED VIBRATION ERRORS
LABEL ERRORC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
PRIPARM //C,N,-7 /C,N,CYCGSTATICS S
LABEL ERRORC2 $ COUPLED MASS NOT ALLOWED.
PRIPARM //C,N,0 /C,N,COUPMASS S
JUMP FINIS S
LABEL ERRORC3 $ SUPPORT BULK DATA NOT ALLOWED.
PRIPARM //C,N,-6 /C,N,CYCGSTATICS S
LABEL ERRRC4 $ EPCINT BULK DATA NOT ALLOWED.
PRIPARM //C,N,0 /C,N,NGUE S
JUMP FINIS S
LABEL ERRORC5 $ NEITHER FREW OR TSTEP WERE IN BULK DATA DECK.
PRIPARM //C,N,0 /C,N,VFLRL S
PRIPARM //C,N,0 /C,N,VNTRL S
JUMP FINIS S
LABEL ERRORC6 $ BOTH FREW AND TSTEP WERE SELECTED IN CASE CONTROL.
PRIPARM //C,N,0 /C,N,VDFREG S
PRIPARM //C,N,0 /C,N,VNOTIME S
JUMP FINIS S
ENDALTRK
TIME 5 $ IBM 370/3031
DIAG 14.21
CEND

4.24
CARD
COUNT

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
$ SUBTITLE = BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL I/O)
$ SPC = 30
$ FREQ = 1

OUTPUT
SET 1 = 8, 16, 18
OLOAD = 1
DISP(SORT2, PHASE) = ALL
STRESS(SORT2, PHASE) = ALL

SUBCASE 1
LABEL = SEGMENT 1
OLOAD = 1 $ FREQ DEPENDENT LOADS

SUBCASE 2
LABEL = SEGMENT 2
OLOAD = 2 $ FREQ DEPENDENT LOADS

SUBCASE 3
LABEL = SEGMENT 3
OLOAD = 3 $ FREQ DEPENDENT LOADS

SUBCASE 4
LABEL = SEGMENT 4
OLOAD = 4 $ FREQ DEPENDENT LOADS

SUBCASE 5
LABEL = SEGMENT 5
OLOAD = 5 $ FREQ DEPENDENT LOADS

SUBCASE 6
LABEL = SEGMENT 6
OLOAD = 6 $ FREQ DEPENDENT LOADS

SUBCASE 7
LABEL = SEGMENT 7
OLOAD = 7 $ FREQ DEPENDENT LOADS

SUBCASE 8
LABEL = SEGMENT 8
OLOAD = 8 $ FREQ DEPENDENT LOADS

SUBCASE 9
LABEL = SEGMENT 9
OLOAD = 9 $ FREQ DEPENDENT LOADS

SUBCASE 10
LABEL = SEGMENT 10
OLOAD = 10 $ FREQ DEPENDENT LOADS

SUBCASE 11
LABEL = SEGMENT 11
OLOAD = 11 $ FREQ DEPENDENT LOADS

SUBCASE 12
LABEL = SEGMENT 12
OLOAD = 12 $ FREQ DEPENDENT LOADS

OUTPUT(XYPLT)

PLOTTER NASTPLT, MODEL 0.0
X PAPER = 8.0

4.25
CASE CONTROL DECK ECHO

CARD COUNT
51YPAPER = 10.5
52XAXIS = YES
53YAXIS = YES
54XGRID LINES = YES
55YGRID LINES = YES
56CURVELINESYMBOL = 1
57YLOG = YES
58XTITLE = FREQUENCY (HERTZ)
59YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
60TCURVE = 14(T3RH), 18(T3RH)
61XYPLOT, XYPRINT DISP RESPONSE 1 / 14(T3RH), 18(T3RH)
62TCURVE = 2(T3RH)
63XYPLOT, XYPRINT DISP RESPONSE 8 / 2(T3RH)
64YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
65TCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
66XYPLOT, XYPRINT STRESS RESPONSE 1 / 11(3), 14(5), 11(7),
6711(10), 11(12), 11(14)
68TCURVE = 1(3), 1(5), 1(7), 1(10), 1(12), 1(14)
69XYPLOT, XYPRINT STRESS RESPONSE 10 / 1(3), 1(5), 1(7),
701(10), 1(12), 1(14)
71BEGIN BULK

FORMAT MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
<table>
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<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>CQUAD2</td>
<td>4</td>
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ENDDATA
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
- NSEGS = 12 number of rotationally cyclic sectors
- RPS = 600.0 revolutions per second
- BXTID, BYTID, BZTID \ Refer to TABLE1i bulk data cards to specify
- BXPRTID, 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) \rho^{0.2c} = A(f) specified on RLOAD1 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, 1700-1920 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:

\[
(1700 - 600) = 1100 \text{ to } (1920 - 600) = 1320 \text{ Hz, and}
\]

\[
(1700 + 600) = 2300 \text{ to } (1920 + 600) = 2520 \text{ Hz.}
\]

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

NASA, EXAMPLE 3

APP
DISP
SOL
TIME
DIAG

$ ALTER PACKAGE AS IN EXAMPLE 2

$ 12 $ IBM 370/3031

14,21
CASE C007-Q-02-Q-EG-E-01B

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTOR DISC RIGID CASES
SUBTITLE = BLADED DISC EXAMPLE 3 (ICT COLLEGE PROGRAM, ACCT CODE: I/D)

SPC = 30
FREQ = 1

OUTPUT
SET 1 = 0,4G,10
SET 2 = 11
OLOAD = 1
DISP(SORT2, PHASE) = 1
STRESS(SORT2, PHASE) = 2
SUBCASE 1
  LABEL = KINDEX 0
  DLOAD = 1 $ FREQ DEPENDENT LOADS
  SUBCASE 2
  LABEL = KINDEX 1C
  $ $ LATERAL BASE ACCN LOADS VIA PARAM OYTD, OXPTD
  SUBCASE 3
  LABEL = KINDEX 1S
  $ $ LATERAL BASE ACCN LOADS VIA PARAM OZTD
  SUBCASE 4
  LABEL = KINDEX 2C
  DLOAD = 1 $ FREQ DEPENDENT LOADS
  SUBCASE 5
  LABEL = KINDEX 2S

OUTPUT(XYPLOT)
  PLOTTER NASTPLT, MODEL D,0
  XPAPER = 8.0
  YPAPER = 10.5
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  YAXIS = YES
  XGRID LINES = YES
  YGRID LINES = YES
  CURVELINESYMBOL = 1
  XTITLE = FREQUENCY (HERTZ)
  YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
  YLOG = YES
  TCURVE = 8(T3RH),18(T3RH)
  XYPLOT.XYPRI NT DISP RESPONSE 1 /8(T3RH),18(T3RH)
  XYPLOT.XYPRI NT DISP RESPONSE 2 /8(T3RH),18(T3RH)
  XYPLOT.XYPRI NT DISP RESPONSE 3 /8(T3RH),18(T3RH)
  XYPLOT.XYPRI NT DISP RESPONSE 4 /8(T3RH),18(T3RH)
  VTITLE = GRID POINT DISPLACEMENTS (PHASE, DEGREE)
  YLOG = NO
  TCURVE = 8(T3IP),18(T3IP)
  XYPLOT.XYPRI NT DISP RESPONSE 2 /8(T3IP),18(T3IP)
  YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
  YLOG = YES

4.33
CASE CONTROL DECK ERROR

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53 XYPLOT,XYPRINT STRESS RESPONSE 2 111(10) 12(12) 11(14)
54 XYPLOT,XYPRINT STRESS RESPONSE 3 11(10) 21(12) 11(14)
55 XYPLOT,XYPRINT STRESS RESPONSE 4 11(10) 21(12) 11(14)
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60 BEGIN BULK

MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECKS.
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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 (λ = 1) -- the parameter LMAX accordingly has been set at 1 (λ = 0, 1, 1s).

B. Input

1. Parameters:

   In addition to general input parameters,
   
   CYCIO = +1 physical cyclic input/output data
   KM IN = 2 minimum circumferential harmonic index
   KM AX = 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
   G KAD = FREQRESP Specify the form in which the damping parameters are used.
   LGKAD = +1

2. Constraints:

   Same as general input constraints.

3. Loads:

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

   where
   \[ n \] is the segment number,
   \[ T \] represents k = 2,
   \[ \frac{2\pi}{12} \] represents the total number of segments in the bladed disc,
   \[ A(t) = A \cdot \sin (2\pi \cdot 1814 \cdot t) \]
   \[ P \] 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**

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CASE  CONTROL  DECK  ECHO

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2  SUBTITLE = BLADED DISC EXAMPLE 4  (CYC MODEL TIME DEP. LOAD PHYS 1/0)
3  $  SPC  =  30
4  TSTEP  =  1
5  OUTPUT
6  SET 1 = 8, 16, 10
7  SET 2 = 11
8  DLOAD  =  1
9  DISP (SORT2, REAL)  =  1
10  STRESS (SORT2, REAL)  =  2
11  SUBCASE 1
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13  DLOAD  =  1  $ TIME DEPENDENT LOADS
14  SUBCASE 2
15  LABEL = SEGMENT 2
16  DLOAD  =  2  $ TIME DEPENDENT LOADS
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43  DLOAD  = 11  $ TIME DEPENDENT LOADS
44  SUBCASE 12
45  LABEL = SEGMENT 12
46  DLOAD  = 12  $ TIME DEPENDENT LOADS
47  BEGIN BULK
48  $  INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
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**SCRTED BULK DATA ECHO**

**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,
   
   \[
   \begin{align*}
   & \text{CYCIO} = -1 \quad \text{harmonic cyclic input/output data} \\
   & \text{KNIN} = 2 \quad \text{minimum circumferential harmonic index} \\
   & \text{KMAX} = 2 \quad \text{maximum circumferential harmonic index} \\
   & \text{LMAX} = 1 \quad \text{maximum harmonic in the Fourier decomposition of periodic, time-dependent loads.} \\
   & \text{NSEGS} = 12 \quad \text{number of rotationally cyclic sectors} \\
   & \text{RPS} = 600.0 \quad \text{revolutions per second} \\
   & \text{GKA0} = \text{FREQRESP}\quad \text{Specify the form in which the damping parameters} \\
   & \text{LGKAD} = +1 \quad \text{are used.}
   \end{align*}
   \]

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**

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<td>$</td>
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<tr>
<td>$</td>
<td>ALTER PACKAGE AS IN EXAMPLE2</td>
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<tr>
<td>TIME</td>
<td>3 $ IBM 370/3031</td>
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CASE CONTROL DECK, ECHO

CARD
COUNT
$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
$ SUBTITLE = BLADED DISC EXAMPLE 5 (CYC MODEL, TIME DEP. LOAD, PARK I/O)
$ SPC = 30
STEP = 1
OUTPUT
SET 1 = 0,16,18
SET 2 = 11
LOAD = 1
DISP(SCRT2,REAL) = 1
STRESS(SCRT2,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

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

4.46
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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Table 2: Bladed-Disc Natural Frequencies

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<td>208 (1)</td>
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<td><strong>k = 1</strong></td>
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<td>591 (2)</td>
<td>594 (2)</td>
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<td><strong>k = 2</strong></td>
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<td>1577 (3)</td>
<td>1633 (3)</td>
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<tr>
<td><strong>k = 4</strong></td>
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<tr>
<td>2468 (5)**</td>
<td>2460 (4)</td>
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</table>

* 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 CENTRIFUGAL ACCELERATIONS ON THE
DISPLACEMENT RESPONSE OF GRID POINT 18 AT 600 RPS.

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<th>Example 3</th>
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<td>k = 2c (subcase 4)</td>
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<td>Mag. (in)/Phase (deg)</td>
<td>Mag. (in)/Phase (deg)</td>
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<td>Grid Pt. Disp. or Elem. Stresses</td>
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<td>Example 4</td>
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<td>k = 2c (subcase 4)</td>
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<td>Mag (in)/Phase (deg)</td>
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<tr>
<td>11 (14), $\tau_{xy,2}$</td>
<td>1.8510 E 2/253.0</td>
<td>1.8511 E 2/253.0</td>
</tr>
</tbody>
</table>

* Fibre distances 1 and 2.
Figure 1: NASTRAN Model of the 12-Bladed Disc
Figure 2: NASTRAN Cyclic Model of the 12-Bladed Disc
Figure 3: $\tilde{k} = 2$ 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
Figure 5

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

FREQUENCY (HERTZ)

1E 1

1.68 1.72 1.76 1.80 1.84 1.88 1E 3

1E 3

1E 4

1E 4

1E 1

1E 1

1E 1

1E 1

1E 1

1E 1

1E 1

1E 1
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLaded DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
KINDEX PC TYPE LOADS

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

Figure 7
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL,FREQ LOADS, PHYSICAL 1/D)
SEGMENT 1
SUBCASE 1

Figure 9
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL 1/D)
SEGMENT 10
SUBCASE 10

Figure 10
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=CASE ACCN LOAD, HARMA 1/0
INDEX 0
SUBCASE 1

G(3AM), (B13AM)
G, t3AM, (B3AM)
G, 3AM, (B3AM)
Forced vibration analysis of rotating cyclic structures.
Bladed disc example 3 (CTE model, freq. base accn load, MAM 1/0, subcase 2
Kindex IC)

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

Figure 15
Figure 16

Forced vibration analysis of rotating cyclic structures (bladed disc example 3) model-free base case. Index IC.
Figure 17

FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES

BI-PLANE, BI-PLANE

GRID POINT DISPLACEMENTS

MAGNITUDE INCH

0.7 1.2 1.5 2.0 2.4 E3

FREQUENCY (HERTZ)

1E-7 1E-6 1E-5 1E-4
Figure 18: Forced vibration analysis of rotating cyclic structures. Bladed disc example 3 (cyclic model, freq. base acc. load, harm 1/0) KINDEX 15 SUBCASE 3
Figure 20

4.72
End of Document