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EXPERIMENTAL MODAL ANALYSIS AND DYNAMIC COMPONENT SYNTHESIS

VOL VI - Software Users Guide

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This report is one of six reports that represent the final technical report on the work involved with United States Air Force Contract F33615-83-C-3218, Experimental Modal Analysis and Dynamic Component Synthesis. The reports that are part of the documented work include the following:

- Vol. I AFWAL-TR-87-3069 Summary of Technical Work
- Vol. II AFWAL-TR-87-3069 Measurement Techniques for Experimental Modal Analysis
- Vol. III AFWAL-TR-87-3069 Modal Parameter Estimation
- Vol. IV AFWAL-TR-87-3069 System Modeling Techniques
- Vol. V AFWAL-TR-87-3069 Universal File Formats
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1. INTRODUCTION

1.1 HISTORY

This document describes briefly the history and current state of development of the Real Time Executive (RTE) Modal Program at the University of Cincinnati Structural Dynamics Research Laboratory (UC-SDRL). The purpose of this document is to provide a reference for the operation of the RTE Modal Program and to provide a reference for future program development.

The RTE Modal Program has been developed as a replacement of an earlier program (User Program 9) that was written for the HP-5451-B Fourier system. The original concept of an RTE based program began in 1978 but was not realized in a working form until early in 1981. Based on the operating system of the HP-5451-B, Basic Control System (BCS), continued expansion of that software is prohibitive due to the inflexible programming environment and the memory limitations. To address these problems, the RTE Modal Program utilizes the overhead functions of the File Management Program under (RTE), an operating system available on Hewlett Packard computers, to provide flexibility that does not have to be built into the modal software. The emphasis of the modal software development in the RTE environment is toward supportability rather than efficiency. For future development reasons and based upon the research nature of the Structural Dynamics Research Laboratory, the ability of graduate students to extend and enhance the current software is always the primary consideration. In this way, the modal software can eventually support any type of data acquisition system as well as interface through file structures to related software such as finite element analysis packages.

1.2 SYSTEM(S)

The HP-5451-C Fourier System was originally the primary target for the initial version of the RTE Modal Program. This system provides a BCS programming environment for the estimation of frequency response functions and the storage of the frequency response functions to disc media compatible with the RTE environment. Current software is compatible with HP-1000 systems with either 21-MX-E or 21-MX-F processors or HP A Series computers such as the A-700 or A-900. In this mode of operation, data acquisition will be provided by a HP-5451-B/C, a HP-5420-A, a HP-5423-A an S/K-LMS FMON, or a Genrad 2515 Fourier System. Data will be available on disc media via the FMTXX structure defined by the HP-5451 Fourier Systems. Compatibility of data from these as well as other Fourier systems is always available through the Universal File Structure supported by SDRC and UC-SDRL. Documentation on this file structure may be found in Appendix I.

1.3 HARDWARE

The RTE Modal Program is designed to be executed on an HP-5451-C Fourier System with multiple HP-7900 Discs, an HP-7906 Disc or an HP-7925 Disc. The minimum memory configuration is 128K words but portions of the RTE Modal Program will run more efficiently if more memory is available (256K words or larger). At the present time, the Extended Memory Area (EMA) and the Vector Instruction Set (VIS) are not utilized in any of the primary programs. These capabilities are utilized in some of the advanced parameter estimation and modal animation programs. Due to the increasing memory requirements and computational load of many of the parameter estimation algorithms currently under evaluation, these options will probably be utilized even more in the future.

1.3.1 MEMORY

The RTE Modal Program involves the operation of multiple programs through a series of monitors. Programs may be suspended as other programs are executed or multiple programs may be executed simultaneously. For this reason, the optimum memory size currently would require five partitions of 28K words available to the RTE Modal Program at one time. This allows all dormant, suspended programs as well as active programs to be memory resident and reduces the program swapping time. If this much memory is not available, dormant programs will be swapped to disc to allow active programs to be executed. Therefore, in this situation, more work track area will be required on the system discs to swap dormant programs.

1.3.2 DISC(S)

The RTE Modal Program is designed to run most efficiently on a multiple HP-7900 Disc system, a HP-7906 Disc, or a HP-7925 Disc, all of which are supported as BCS environment options on the HP-5451-C Fourier System. The RTE Modal Program will run on a HP-5451-C Fourier System with only one HP-7900 Disc but file storage is minimal.

1.3.3 GRAPHICS VECTOR DISPLAY(S)

Originally, the HP-5460-A Display Unit was the primary graphics vector display that was supported as part of the RTE Modal Program for data evaluation and modal vector animation. Additionally, several other graphics vector display devices are currently supported. The HP-1351 Vector Graphics Generator is supported as an optional display for the HP-1000 systems that do not normally include a high speed vector display. Both the HP-5460 and the HP-1351 displays are controlled from RTE using the Universal Interface Driver (DVM72) supported by Hewlett-Packard as part of the RTE operating system. Both displays are interfaced via the Data Control Interface Card (HP-05460-60025). The HP-1351 Vector Graphics Generator requires the 16 Bit Parallel Interface (Option 002) to operate in this format. Operation of the HP-1351 Graphics Vector Generator also requires the maximum amount of memory available for the unit.

In addition to these two displays, support of the HP-134x displays has recently been added. Support for the HP-1345 involves a 16 bit parallel interface with the use of the Universal Interface Driver and support for the HP-1347 involves an IEEE-488 interface with the use of the appropriate HP-IB driver.

1.3.4 PLOTTER(S)

All HP plotters interfaced via the HP-IB, the HP-7210 Digital Plotter, and all Tektronix 40xx Terminals will operate with the current software. Logical units have been defined within the RTE Modal Program to include up to five plotter logical units to allow for future plot flexibility. The tentative plan is to eventually include the HP-264X Graphics Terminal.

1.4 OPERATING SYSTEM SOFTWARE

The RTE Modal Program currently runs in any revision of RTE later than Revision 2140 of RTE-4-

B. RTE software is not part of the standard HP-5451-C Fourier System. Therefore, any group or facility that would wish to run the RTE Modal Program in this environment must purchase this software from Hewlett-Packard. This software can be generated on either a session or non-session basis. The non-session structure is for a limited number of users with no accounting feature. The session structure is for multiple users and uses an account structure to restrict access to portions of the system. In the session type of environment, the RTE Modal Program runs in a multi-user situation, allowing multiple copies of a program to run and managing resources such as modal animation devices and data logical units based upon the workstation that is in use.

1.4.1 RTE-4-B (NON-SESSION)

RTE-4-B (Non-Session) is an RTE environment that is currently supported by Hewlett-Packard. This is compatible with the FSDS systems that are supported with the HP-5451-C systems but includes a newer revision operating system and the loader program.

1.4.2 RTE-4-B (SESSION)

RTE-4-B (Session) is an RTE environment for multiple users that is currently supported by Hewlett-Packard. While this operating system is not the same as RTE-4-B (Non-Session), the RTE Modal Program will currently run in this environment.

1.4.3 RTE-6-VM

RTE-6-VM is the virtual memory RTE environment which is available as of Revision 2201. While this is not a true virtual memory operating environment, this system is expected to reduce the overhead of working with large arrays. It is expected that conversion to the RTE-6-VM will require changes that will not be downward compatible but, due to the attractive characteristics of the operating system, the eventual target environment will most likely be RTE-6-VM.

1.4.4 RTE-A

RTE-A is the virtual memory RTE environment available for the A Series Hewlett Packard computers. This operating system is very similar to the RTE-6-VM operating system.

1.5 OPERATING SYSTEM REQUIREMENTS

Within the structure of the RTE Operating System, certain system capabilities must be available. First of all, the RTE Modal Program makes use of a minimum of 432 blocks of 128 words as a temporary area for the storage of arrays during program execution. This working space is located on disc and serves as the database for the RTE Modal Program. Therefore, if sufficient disc space is not available, the program will terminate execution at the initialization stage. Additionally, if memory is at a minimum, more disc space will be required by the RTE Operating System to swap dormant programs to the disc in order to run active programs. If sufficient disc space is not available, a currently active program will not be able to schedule a son program without suspending the RTE Modal Program while waiting for disc space to become available. Unfortunately, it is unlikely that any activity, except for the removal of a dormant program from the program stack with the 'OF,NAMR,1', will ever release disc space so that the suspended program can continue. Therefore, in minimum memory configurations, more disc space must be made available so the RTE Modal Program cannot be suspended. The current version of the software requires a minimum of 25 work tracks for operation in a 96K word RTE Operating System.

The only other system capability that is used by the RTE Modal Program is the System Available Memory (SAM). This buffer in the system must be at least 3000 words in length for class I/O data transfers used by the RTE Modal Program.

1.6 TERMINOLOGY AND CONVENTIONS

Most terminology used in RTE Modal Program and associated documentation is consistent with prevailing usage in the modal analysis area. Certain conventions that are used are based upon previous practice in the BCS Modal Program (User Program Nine) or based upon common usage in the HP-5451-A/B/C Fourier Systems.

A specific example of this is the use of the channel designation. This is a convention that arises from the HP-5451-A/B/C Fourier Systems and refers to the specific, digital time history point or frequency spectral value. Possible confusion may result when using the channel designation since channels are numbered starting with zero rather than one. The zero channel number refers to the digital value at the minimum time or minimum frequency.

2. PROGRAM OVERVIEW

2.1 PROGRAM PHILOSOPHY

The RTE Modal Program development is structured to emphasize simplicity rather than efficiency. For this reason, approximately 90% of the software code is in Fortran, ANSI 1966 or ANSI 1977. Many operations could proceed faster or more efficiently if written in Assembly language but, as the software and hardware changes in the future, the overhead required to recode these operations is not efficient in the long term sense and would not be efficient with regards to the long term goals of the research program at the University of Cincinnati.

Much of the function of the RTE Modal Program is designed to facilitate access to other related programs and their data sets as well as to provide other programs access to the data sets created from the RTE Modal Program. In this way, the RTE Modal Program can use or provide information from/to a finite element program or alternate experimental data analysis techniques.

The structure of the monitor and commands within the RTE Modal Program is intended to facilitate a tutorial approach to the use of the program. Each monitor has a help feature where the available commands can be determined as well as a short description covering the use of each command. The individual commands often involve multiple optional parameters which provide the experienced user with the ability to streamline the use of the command and answer a minimum number of questions.

2.2 MONITOR STRUCTURE

The RTE Modal Program is structured as a nested set of monitors where each monitor exits to the next higher monitor until the File Manager (FMGR) monitor is reached. At the current time, no capability of sequencing commands either within or among the monitors in an automatic way is provided. In the future, this type of programming is an obvious extension to the current capability.

2.3 COMMAND FORMAT

The following format will be used whenever a monitor commmand is described within this program documentation. The general format is also that used by the Help Command (??) available in every monitor.

```
 ----------------------------------------------------------------
|    MODAL MONITOR COMMAND                                        |
|-----------------------------------------------------------------|
|    COMMAND FUNCTION:    A BRIEF DESCRIPTION OF THE PURPOSE      |
|                         OF THE COMMAND WILL APPEAR HERE         |
|-----------------------------------------------------------------|
|    COMMAND MNEMONIC:    XX                                      |
|-----------------------------------------------------------------|
|    HP-5451 KEYBOARD:    NONE                                    |
|-----------------------------------------------------------------|
|    N1   = FIRST INTEGER PARAMETER                               |
|    N2   = SECOND INTEGER PARAMETER                              |
|    N3   = THIRD INTEGER PARAMETER                               |
|    N4   = FOURTH INTEGER PARAMETER                              |
|    N5   = FIFTH INTEGER PARAMETER                               |
|    N6   = SIXTH INTEGER PARAMETER                               |
 ----------------------------------------------------------------
```

The typical command entry format in response to a monitor prompt is as follows: 'XX N1 N2 N3 N4 N5 N6'

2.4 HELP COMMAND

Each monitor contains a user help feature that gives the user access to an on-line user manual. This help feature can be accessed in each monitor to determine what commands are available and specifically how to exercise the command. The Help Command has the following format:

```
 ----------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                         |
|-----------------------------------------------------------------|
|    COMMAND FUNCTION:    USER HELP FEATURE                       |
|-----------------------------------------------------------------|
|    COMMAND MNEMONIC:    ??                                      |
|-----------------------------------------------------------------|
|    HP-5451 KEYBOARD:    POINT BUTTON (?b)                       |
|-----------------------------------------------------------------|
|    N1   = TWO LETTER COMMAND                                    |
|                                                                 |
|    IF N1 IS DEFAULTED, ALL AVAILABLE COMMANDS ARE LISTED        |
 ----------------------------------------------------------------
```

If the user needs to correct or enhance the information provided by the HELP Command, this information is located in the files named "CMND in ASCII format. This information is easily edited using the RTE EDIT or EDITR programs. If the ASCII help file is edited, a new binary file must be created using the program UCHLP that is provided. This binary file must be available and must be named !CMND.

2.5 RTE FILE STRUCTURE

The RTE Modal Program generates and uses two types of FMGR files in order to facilitate data storage and retrieval as well as to provide data sets to other programs. The two file types are designated as Project Files and Modal Files. The use of Project Files is intended to provide data storage and retrieval for the RTE Modal Program while the use of Modal Files is to create a file format that is documented (Appendix D) to be used to transfer modal data files between the RTE Modal Program and other programs. Modal Files are also convenient for storing only a small portion of the total modal data set. Component defination information, coordinates, display sequence, frequency and damping information or a subset of the modal vectors may individually stored in a modal file. Refer to the File Store Command for details.

2.5.1 PROJECT FILES

Project Files are binary files consisting of 128 word records. Within the FMGR concept, this is designated as a Type 1 File. The Project File is a block image of the data storage area managed by the RTE Modal Program. Note that a block is defined as 128 words of storage either in memory or on disc. Effectively, this data area contains the current state of all important variables and data arrays so that the operation of the program can be restarted in a given state very easily.

2.5.2 MODAL FILES

Modal Files are binary files consisting of 16 word records. Within the FMGR concept, this is designated as a Type 2 File. The Modal File is a structured copy of a specific part of the modal data set that exists at the time the file is created. Within the RTE Modal Program, five Modal Files have been defined currently which can be stored in this manner.

2.5.3 UNIVERSAL FILES

Data can be written to or read from other system types and other programs by means of universal files. Universal files are ASCII files with defined formats for storing data, including modal parameters, structure geometry, display sequences, frequency response functions and general measurements. For a complete description of available universal file formats see Appendix I.

This concept thus allows communication between any programs supporting universal files such as data acquistion, parameter estimation, modal modification and finite element programs.

These universal file formats were originally developed at Structural Dynamics Research Corporation.

2.6 DATA ACQUISITION

Data acquisition was originally expected to take place on a HP-5451-B/C Fourier System. The resulting frequency response function data is placed on a data disc according to a table contained within the subroutine FMTXX. This table, DIFS, is used by the BCS operating environment to determine where any record of any of nine file types is located on the data disc. This same subroutine, FMTXX, is loaded with the RTE Modal Program so that the same DIFS table is available to the RTE Modal Program. This table can be altered at any time thru use of the Measurement Format Command to accomodate users with multiple FMTXX structures.

Data acquisition is also now supported on several other devices. First of all, any device that supports the Universal File structure can serve as a source of modal data using File Type 58. This Universal File Structure is documented in Appendix I. In addition to this possible form of support, data acquired from the HP-5423-A, data acquired and coded from SMS modal software, and data acquired from the S/K-LMS Fourier System (FMON) is supported by way of the Measurement Format Command and the Measurement. Header Command. Data acquisition can take place on a HP-5420-A or a HP-5423-A if the data can be moved to the data disc in a format compatible with the HP-5451 Fourier System. User programs exist for the HP-5451-C Fourier system to do this in a BCS operating environment. The programs for the HP-5423-A are User Program 80 and 81 while the programs for the HP-5420-A are User Programs 82 and 83. The standard versions of these programs do not provide any modal information in the header of the resulting HP-5451-C Fourier System data record. This information must be added using the Data Setup Command. The versions of the User Programs 80 and 81 in use at the University of Cincinnati for the HP-5423-A automatically insert the 63 header words from the HP-5423-A in words 14 through 76, inclusive, of the 128 word header of the HP-5451-C Fourier System data record. In this way, modal data taken on a HP-5423-A can immediately be processed by choosing the proper format using the Measurement Source Command.

2.7 GRAPHICS VECTOR DISPLAYS

Within the RTE Modal Program, all data and display animations occur on one of several graphics vector displays. Graphics vector displays are used due to the higher quality of the vector displays compared to raster scan displays. Currently, several graphics displays (HP-5460, HP-1345, HP-1347, HP-1351) are supported. Any number of graphics vector displays in any combination may be present in the system at any time in order to support multiple display requirements as well as multiple users.

The user is often required to interact with the RTE Modal Program by providing information based upon the data currently displayed on the graphics vector display unit. This interaction normally occurs via control of the cursor, mode, and scaling functions of the graphics vector display unit. Since different vector display units may be utilized, particular information concerning the control of each vector display unit is given in the following sections.

2.7.1 GRAPHICS VECTOR DISPLAY (HP-5460-A)

Control of the HP-5460-A Display Unit within the RTE Modal Program is essentially the same as that used by the HP-5451-C Fourier System. The mode and scale switches are active as well as the computer switch register for use in controlling the cursor movement. The following is a summary of the use of the computer switch register to control the cursor:

```
Switch 7     Fast right
Switch 9     Step right
Switch 8     Fast left
Switch 10    Step left
Switch 13    Expand the display  around cursor position
Switch 11    Return data to the program (Accept)
Switch 6     Reset cursor to zero channel and display
             all data
Switch 10    Curser on/off
Switch 14    Abort or Exit
```

2.7.2 *GRAPHICS VECTOR DISPLAY (HP-13XX)*

2.7.2.1 *OVERVIEW*

Since the use of the HP-13XX Graphics Vector Displays is primarily developed for the HP-1000, the use of the computer switch register to control the cursor in this environment is not as attractive due to physical location or multiple user requirements. For this reason, the interaction with this display unit occurs via a monitor.

2.7.2.2 *COMMAND SUMMARY*

The following commands are currently available for controlling the HP-13XX Graphics Vector Displays:

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
R	REAL DISPLAY
I	IMAGINARY DISPLAY
PO	POLAR DISPLAY
LG	LOG MAGNITUDE DISPLAY
PH	PHASE DISPLAY
T	TIME DOMAIN DISPLAY
C	CURSOR (ABSOLUTE POSITION)
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
E	EXPAND ABOUT CURSOR
U	UNEXPAND
B	BANDWIDTH EXPAND
S	VERTICAL SCALING
P	PRINT CURSOR POSITION
X	EXIT

2.7.2.3 *ARGAND DISPLAY COMMANDS*

MODAL SYSTEM: HP-13XX DISPLAY COMMAND
COMMAND FUNCTION: DISPLAY DATA IN ARGAND FORMAT
COMMAND MNEMONIC: A
HP-5451 KEYBOARD: NONE
NO PARAMETERS REQUIRED

2.7.2.4 REAL DISPLAY COMMANDS

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	DISPLAY REAL PART OF DATA
COMMAND MNEMONIC:	R
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.5 IMAGINARY DISPLAY COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	DISPLAY IMAGINARY PART OF DATA
COMMAND MNEMONIC:	I
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.6 POLAR DISPLAY COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	DISPLAY DATA IN POLAR FORMAT
COMMAND MNEMONIC:	PO
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.7 LOG MAGNITUDE DISPLAY COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND
COMMAND FUNCTION: DISPLAY DATA IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC: LG
HP-5451 KEYBOARD: NONE
NO PARAMETERS REQUIRED

2.7.2.8 PHASE DISPLAY COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND
COMMAND FUNCTION: DISPLAY DATA IN PHASE FORMAT
COMMAND MNEMONIC: PH
HP-5451 KEYBOARD: NONE
NO PARAMETERS REQUIRED

2.7.2.9 TIME DOMAIN DISPLAY COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND
COMMAND FUNCTION: DISPLAY DATA IN TIME DOMAIN FORMAT
COMMAND MNEMONIC: T
HP-5451 KEYBOARD: NONE
NO PARAMETERS REQUIRED

2.7.2.10 CURSOR (ABSOLUTE POSITION) COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	POSITION CURSOR TO ABSOLUTE LOCATION
COMMAND MNEMONIC:	C
HP-5451 KEYBOARD:	NONE
N1 =	CHANNEL NUMBER

2.7.2.11 CURSOR (RELATIVE POSITION) COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	MOVE CURSOR RELATIVE TO PRESENT POSITION
COMMAND MNEMONIC:	M
HP-5451 KEYBOARD:	NONE
N1 =	NUMBER OF CHANNELS TO MOVE (+ OR -)

2.7.2.12 MAGNITUDE DISPLAY COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	DISPLAY DATA IN MAGNITUDE FORMAT
COMMAND MNEMONIC:	MA
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.13 CURVE-FIT ACCEPTANCE COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	ACCEPT CURVE FIT
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

2.7.2.14 EXPAND ABOUT CURSOR COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	EXPAND DISPLAY AROUND CURRENT CURSOR POSITION
COMMAND MNEMONIC:	E
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.15 UNEXPAND COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	UNEXPAND DISPLAY TO INITIAL DISPLAY LIMITS
COMMAND MNEMONIC:	U
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.16 BANDWIDTH COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND	
COMMAND FUNCTION:	DISPLAY A SELECTED BANDWIDTH OF THE DATA
COMMAND MNEMONIC:	B
HP-5451 KEYBOARD:	NONE
N1 = FIRST CHANNEL NUMBER N2 = LAST CHANNEL NUMBER	

2.7.2.17 SCALE COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND	
COMMAND FUNCTION:	SCALE DISPLAY BY POWER OF TWO
COMMAND MNEMONIC:	S
HP-5451 KEYBOARD:	NONE
N1 = POWER OF TWO	

2.7.2.18 PRINT COMMAND

MODAL SYSTEM: HP-13XX DISPLAY COMMAND	
COMMAND FUNCTION:	PRINT CURSOR POSITION
COMMAND MNEMONIC:	P
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

2.7.2.19 EXIT COMMAND

MODAL SYSTEM:	HP-13XX DISPLAY COMMAND
COMMAND FUNCTION:	EXIT TO SCHEDULING PROGRAM
COMMAND MNEMONIC:	X
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

3. MODAL SYSTEM MODULE

3.1 OVERVIEW

The Modal System Module is the heart of the RTE Modal Program and contains the primary monitor which allows the user to initiate any other program contained within the RTE Modal Program. This monitor controls the basic movement of modal and display information from one program to another and can be used to call stand alone programs that may or may not be associated with the current modal data set. Currently this monitor schedules, via an EXEC call, any of the programs that have been defined in the program MODAL. In order to add additional programs, a small change can be made in this Fortran program (&MODAL) to schedule any program that the user may require.

3.2 COMMAND SUMMARY

The following list of commands is currently available from the Modal System Monitor:

SUMMARY OF MODAL SYSTEM COMMANDS	
IN	MODAL FILE INPUT
PR	MODAL FILE PRINT
ST	MODAL FILE(S) STORE
LO	MODAL FILE(S) LOAD
MD	MODAL DISPLAY
RS	RESET MODAL FILE POINTER
DD	DATA DISPLAY
RL	DATA RUN LOG
PE	PARAMETER ESTIMATION
MH	MEASUREMENT HEADER
MF	MEASUREMENT FORMAT
LL	LOGICAL LIST DEVICE
LU	LOGICAL UNIT SUMMARY
FM	FILE MANAGER OPERATION
CC	MODAL ASSURANCE CRITERION
ME	MODAL ENHANCEMENT
SC	MODAL SCALING
Y9	USER PROGRAM NINE READ/WRITE
M4	SMS MODAL 4.0 COMPATABILITY
RB	LEAST SQUARES RIGID BODY COMPUTATION
DY	DYNOPS MODAL MOD/SENS ANALYSIS
SS	SENSITIVITY PREDICTION
RO	CALCULATE ROTATIONAL FRF
MK	ANALYTICAL M-K-C MODAL ANALYSIS
DS	DATA SETUP
FE	FEM DATA BASE TO/FROM RTE MODAL FILES
UF	UNIVERSAL FILE STRUCTURE
HT	HILBERT TRANSFORM
SN	SYNTHESIZE MEASUREMENT
RU	RUN PROGRAM
EX	PROGRAM EXIT
??	COMMAND SUMMARY

3.3 MODAL FILE INPUT COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	INPUT ANY OF THE MODAL FILES FROM THE TERMINAL
COMMAND MNEMONIC:	IN
HP-5451 KEYBOARD:	KEYBOARD BUTTON (Kb)
N1 = MODAL FILE NUMBER = 0 TEST IDENTIFICATION = 1 COMPONENT INFORMATION = 2 COORDINATE INFORMATION = 3 DISPLAY SEQUENCE INFORMATION = 4 FREQUENCY/DAMPING INFORMATION = 5 MODAL VECTOR INFORMATION	

Schedules and transfers data to program 'FLIO'. This command is used to initiate the input of the various files required by the RTE Modal Program. The active structure of each input sequence is explained in Section 4.

3.4 MODAL FILE PRINT COMMAND

```
 -------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                      |
|--------------------------------------------------------------|
|    COMMAND FUNCTION:    PRINT ANY OF THE MODAL FILES TO     |
|                         THE CURRENTLY ACTIVE LOGICAL          |
|                         LIST DEVICE                           |
|--------------------------------------------------------------|
|    COMMAND MNEMONIC:    PR                                   |
|--------------------------------------------------------------|
|    HP-5451 KEYBOARD:    PRINT BUTTON (Wb)                    |
|--------------------------------------------------------------|
|    N1   = MODAL FILE NUMBER                                  |
|         = DFLT  MODAL SYSTEM FILE PARAMETERS                  |
|         = 0     TEST IDENTIFICATION                           |
|         = 1     COMPONENT INFORMATION                         |
|         = 2     COORDINATE INFORMATION                        |
|         = 3     DISPLAY SEQUENCE INFORMATION                  |
|         = 4     FREQUENCY/DAMPING INFORMATION                 |
|         = 5     MODAL VECTOR INFORMATION                      |
|                                                              |
| FOR N1 = 0:                                                  |
|                                                              |
|    N2   = DFLT  TEST IDENTIFICATION AND DATE                  |
|         = 0     DETAILED DATA INFORMATION                     |
|                                                              |
| FOR N1 = 4:                                                  |
|                                                              |
|    N2   = DFLT  FREQUENCY/DAMPING TABLE                       |
|         = 0     DETAILED MODAL VECTOR INFORMATION             |
 -------------------------------------------------------------
```

Schedules and transfers data to program 'FLIO'. Prints any file to the logical unit currently designated in the Logical List Command.

3.5 RTE FILE STORE COMMAND

```
--------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                      |
|--------------------------------------------------------------|
|    COMMAND FUNCTION:    STORES PROJECT OR MODAL FILES TO     |
|                         ANY AVAILABLE RTE LIBRARY CARTRIDGE  |
|--------------------------------------------------------------|
|    COMMAND MNEMONIC:    ST                                   |
|--------------------------------------------------------------|
|    HP-5451 KEYBOARD:    STORE BUTTON (X>)                    |
|--------------------------------------------------------------|
|    N1    = MODAL FILE NUMBER                                 |
|          = 1      COMPONENTS                                 |
|          = 2      COORDINATES                                |
|          = 3      DISPLAY SEQUENCE                           |
|          = 4      FREQUENCY/DAMPING                          |
|          = 5      MODAL VECTORS                              |
|                                                              |
|    N2    = RECORD NUMBER (0-99)                              |
|                                                              |
|    N3    = FILE SECURITY CODE                                |
|                                                              |
|    N4    = FILE CARTRIDGE NUMBER                             |
|                                                              |
|    IF ALL PARAMETERS ARE DEFAULTED, A PROJECT FILE WILL      |
|    BE STORED VIA INTERACTIVE QUESTIONS                       |
--------------------------------------------------------------
```

Schedules and transfers data to program 'LSPF' or 'LSMF'. This command is used to store Project or Modal Files to the File Logical Unit according to the parameters given.

3.5.1 PROJECT FILES

If all parameters in the File Store Command are defaulted, a Project File will be stored. In this mode of operation a FMGR file name is requested(NAMR:SC:CRN) and the current project information will be stored into this file name on the cartridge specified. If this file name already exists, the user will be asked if the file can be overwritten. If the user does not wish to store the current status of the RTE Modal Program into the existing Project File, the existing file will not be altered.

Since the modal vectors take up the bulk of the file, only valid modal vectors should be stored with the project file so that the file length can be minimized. If intermediate calculations have been made in the parameter estimation module, particularly the formulation of the covariance matrix during the least squares time domain calculation, this information is stored with the project file when it is written.

Note that, while the RTE Modal Program will protect the logical unit defined for data usage, the use of a cartridge specification in the FMGR file name convention overrides this protection.

3.5.2 MODAL FILES

As long as the N1 and N2 parameters are entered in the File Store Command the RTE Modal Program will create a FMGR file name of "MFN1N2" with the security code of N3 on the cartridge N4. If a current Modal File of the same name exists, the user will be asked if the existing file can be overwritten with the contents of the file within the RTE Modal Program.

Note that, while the RTE Modal Program will protect the logical unit defined for data usage, the use of a cartridge number in the command overrides this protection.

3.6 RTE FILE LOAD COMMAND

```
-------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                   |
|-----------------------------------------------------------|
|    COMMAND FUNCTION:   LOADS PROJECT OR MODAL FILES FROM  |
|                        ANY AVAILABLE RTE LIBRARY CARTRIDGE|
|-----------------------------------------------------------|
|    COMMAND MNEMONIC:   LO                                 |
|-----------------------------------------------------------|
|    HP-5451 KEYBOARD:   LOAD BUTTON (X<)                   |
|-----------------------------------------------------------|
|    N1   = MODAL FILE NUMBER                               |
|         = 1      COMPONENTS                               |
|         = 2      COORDINATES                              |
|         = 3      DISPLAY SEQUENCE                         |
|         = 4      FREQUENCY/DAMPING                        |
|         = 5      MODAL VECTORS                            |
|                                                           |
|    N2   = RECORD NUMBER (0-99)                            |
|                                                           |
|    N3   = FILE SECURITY CODE                              |
|                                                           |
|    N4   = FILE CARTRIDGE NUMBER                           |
|                                                           |
|    IF ALL PARAMETERS ARE DEFAULTED, A PROJECT FILE WILL   |
|    BE LOADED VIA INTERACTIVE QUESTIONS                    |
-------------------------------------------------------------
```

Schedules and transfers data to program 'LSPF' or 'LSMF'. This command is used to load Project or Modal Files to the project area within the RTE Modal Program.

3.6.1 PROJECT FILES

The information relevant to this command is the same as that for the File Store Command in Section 3.5.1.

3.6.2 MODAL FILES

The information relevant to this command is the same as that for the File Store Command in Section 3.5.2.

3.7 MODAL ANIMATION COMMAND

```
 ----------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                        |
|----------------------------------------------------------------|
|    COMMAND FUNCTION:    TRANSFER CONTROL TO THE MODAL          |
|                         ANIMATION MONITOR(S)                   |
|----------------------------------------------------------------|
|    COMMAND MNEMONIC:    MD                                     |
|----------------------------------------------------------------|
|    HP-5451 KEYBOARD:    DISPLAY BUTTON (Db)                    |
|----------------------------------------------------------------|
|    N1   = ANIMATION PROGRAM TO BE SCHEDULED                    |
|         = 0 (DEFAULT)   ANIMATION MONITOR (ENHANCED)           |
|         = -99           ANIMATION MONITOR (ORIGINAL)           |
 ----------------------------------------------------------------
```

Schedules and transfers data to program 'MDSPL' (original) or to the program 'MDSP' (enhanced). For details concerning control of Modal Animation, refer to Section 5.

3.8 RESET FILE POINTER COMMAND

```
 ----------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                        |
|----------------------------------------------------------------|
|    COMMAND FUNCTION:    RESET MODAL FILE POINTER               |
|----------------------------------------------------------------|
|    COMMAND MNEMONIC:    RS                                     |
|----------------------------------------------------------------|
|    HP-5451 KEYBOARD:    NONE                                   |
|----------------------------------------------------------------|
|    N1   = MODAL FILE NUMBER                                    |
|         = 1      COMPONENT INFORMATION                         |
|         = 2      COORDINATE INFORMATION                        |
|         = 3      DISPLAY SEQUENCE INFORMATION                  |
|         = 4      FREQUENCY/DAMPING INFORMATION                 |
|                                                                |
|    N2   = NEW POINTER VALUE                                    |
 ----------------------------------------------------------------
```

3.9 DATA DISPLAY COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	TRANSFER CONTROL TO DATA DISPLAY PROGRAM FOR DISPLAYING FRF DATA FROM A HP-5451 DATA FORMAT
COMMAND MNEMONIC:	DD
HP-5451 KEYBOARD:	TRANSFER FUNCTION BUTTON (CH)
N1 = FILE ONE RECORD NUMBER	

Schedules and transfers data to program 'DSPL'. Once a display is requested, control of the display is governed by the cursor controls of the particular display in use. These cursor controls are explained in Section 2.7, Graphics Vector Displays.

3.10 RUN LOG COMMAND

```
 ---------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                       |
|---------------------------------------------------------------|
|    COMMAND FUNCTION:   OUTPUT OF A RUN LOG OF THE CURRENT     |
|                        FREQUENCY RESPONSE FUNCTION DATA       |
|                        SET TO THE CURRENT LIST LOGICAL        |
|                        UNIT                                   |
|---------------------------------------------------------------|
|    COMMAND MNEMONIC:   RL                                     |
|---------------------------------------------------------------|
|    HP-5451 KEYBOARD:   LOG MAGNITUDE BUTTON (TL)              |
|---------------------------------------------------------------|
|    N1  = RUN LOG FORMAT                                       |
|        = 1     ALL FRF DATA WITH TEST IDENTIFICATION          |
|        = 2     ONLY FRF DATA WITH SPECIFIC TEST               |
|                IDENTIFICATION (FIRST TEN CHARACTERS)          |
|        = 3     RUN LOG DIRECTORY TABLE                        |
|                (NOTE: This table MUST be defined before       |
|                       any parameter estimation can be         |
|                       performed!!!)                           |
|                                                               |
|    N2  = FIRST RECORD NUMBER                                  |
|                                                               |
|    N3  = LAST RECORD NUMBER                                   |
 ---------------------------------------------------------------
```

Schedules and transfers data to program 'RNLG'. Three types of run logs are available. N1=1, gives sequential run log of all test identifications and zoom ranges stored on disk between records N2 and N3. N1=2, gives a run log listing of disk data records between N2 and N3, that contain the test identification and zoom range specified. After the command is entered, the user is prompted for the test identification (only if no current test identification exists) and zoom range. If "ZA" is entered for the zoom range, then all zoom ranges are listed.

Type three (N1=3) run log interactively manages a data file directory. This directory MUST be written to the project area before any parameter estimation can be done. The result of this type run log is a table. Each point number occupies three rows (one for each direction), and there are six columns (one for each of the possible references). Entries within the table indicate the record where the specified measurement (point number, direction and reference number) is stored. After creating a directory table, it is necessary to write it to the project area before exiting to the main monitor. Once a current directory has been stored, it may be recalled later, as long as the project area has not been released or re-initialized.

Output consists of a continuous listing with a single header at the top. If the output device is the lineprinter, then the number of lines per page is adjusted for an 11 inch page. If the output device is the terminal, a RESET PAGE command is sent to the terminal before the first page is listed. The number of lines per page is adjusted to fill the terminal screen. A header is printed at the top of each page. If switch register 0 is on, then the paging feature is defeated and the output consists of continuous lines with a single header at the beginning of the list. Paging resumes when bit 0 is turned off.

3.10.1 RUN LOG EXAMPLE

3.10.1.1 EXAMPLE OF RL,1

**RL,1,1,15 perform a Run Log of all modal data on the data disc from records 1 through 15.

RECORD	TEST ID	ZOOM	POINT	ORIENT	POINT	ORIENT
1	TPLATE	ZO	9	1	9	-1
2	TPLATE	ZO	9	1	1	-2
3	TPLATE	ZO	9	1	2	-2
4	TPLATE	ZO	9	1	3	-2
5	TPLATE	ZO	9	1	4	-2
6	TPLATE	ZO	9	1	5	-2
7	TPLATE	ZO	9	1	6	-2
8	TPLATE	ZO	9	1	7	-1
9	TPLATE	ZO	9	1	8	-1
10	TPLATE	ZO	9	1	10	-1

**

3.10.1.2 EXAMPLE OF RL,2

```
**RL,2,1,25                 perform a Run Log of modal data on
                            the data disc with a particular data
                            header from records 1 through 25.

ENTER TEST IDENTIFICATION:
TPLATE

ENTER ZOOM RANGE :
ZO


 RUN LOG FOR TEST:   TPLATE

 ZOOM PARAMETER:      ZO
```

RECORD	POINT	ORIENT	DATE	ZOOM	FREQUENCY MINIMUM	FREQUENCY MAXIMUM
1	9	-1	83 12 01	ZO	0.0000	1000.0000
2	1	-2	83 12 01	ZO	0.0000	1000.0000
3	2	-2	83 12 01	ZO	0.0000	1000.0000
4	3	-2	83 12 01	ZO	0.0000	1000.0000
5	4	-2	83 12 01	ZO	0.0000	1000.0000
6	5	-2	83 12 01	ZO	0.0000	1000.0000
7	6	-2	83 12 01	ZO	0.0000	1000.0000
8	7	-1	83 12 01	ZO	0.0000	1000.0000
9	8	-1	83 12 01	ZO	0.0000	1000.0000
10	10	-1	83 12 01	ZO	0.0000	1000.0000

```
**
```

3.10.1.3 EXAMPLE OF RL,3

```
**RL,3                     setup a data directory

ENTER DIRECTORY OPTION:
     1)  READ CURRENT DIRECTORY
     2)  WRITE CURRENT DIRECTORY
     3)  CREATE NEW DIRECTORY
     4)  PRINT CURRENT DIRECTORY
     5)  EXIT TO MONITOR
3

CURRENT TEST IDENTIFICATION IS:

WISH TO CHANGE?
YES

NEW TEST IDENTIFICATION:
TPLATE

ENTER NUMBER OF CHARACTERS REQUIRED FOR MATCH:
4

ENTER ZOOM RANGE OF DATA:
Z0

ENTER NUMBER OF REFERENCES (INPUTS):
1

INPUT NUMBER:  1  POINT NUMBER:
9

INPUT NUMBER:  1  POINT DIRECTION:
1

ENTER RANGE OF DISC RECORDS FOR CURRENT DIRECTORY:(N1,N2)
          N1 = STARTING RECORD
          N2 = ENDING RECORD
1,15
```

```
ENTER OPTION FOR MEASURMENT SELECTION:
            1) MEASURMENT DIRECTION
            2) COMPONENTS
            3) POINT NUMBERS
            4) CONTINUE
            5) RESTART DIRECTORY DEFINITION
            6) RETURN TO MONITOR 4

RECORD NUMBER:  1 RECORD NUMBER:  2 RECORD NUMBER:  3 RECORD
NUMBER:   4  RECORD  NUMBER:   5  RECORD  NUMBER:   6  RECORD
NUMBER:   7  RECORD  NUMBER:   8  RECORD  NUMBER:   9  RECORD
NUMBER:  10  RECORD  NUMBER:  11  RECORD  NUMBER:  12  RECORD
NUMBER: 13 RECORD NUMBER: 14 RECORD NUMBER: 15

ENTER DIRECTORY OPTION:
       1)  READ CURRENT DIRECTORY
       2)  WRITE CURRENT DIRECTORY
       3)  CREATE NEW DIRECTORY
       4)  PRINT CURRENT DIRECTORY
       5)  EXIT TO MONITOR

2
```

```
ENTER DIRECTORY OPTION:
     1)   READ CURRENT DIRECTORY
     2)   WRITE CURRENT DIRECTORY
     3)   CREATE NEW DIRECTORY
     4)   PRINT CURRENT DIRECTORY
     5)   EXIT TO MONITOR

4

POINT:    1    DIRECTION:   1      -1    -1    -1    -1    -1
-1 POINT:    1    DIRECTION:  2     2    -1    -1    -1    -1
-1 POINT:    1    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    2    DIRECTION:  1    -1    -1    -1    -1    -1
-1 POINT:    2    DIRECTION:  2     3    -1    -1    -1    -1
-1 POINT:    2    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    3    DIRECTION:  1    -1    -1    -1    -1    -1
-1 POINT:    3    DIRECTION:  2     4    -1    -1    -1    -1
-1 POINT:    3    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    4    DIRECTION:  1    -1    -1    -1    -1    -1
-1 POINT:    4    DIRECTION:  2     5    -1    -1    -1    -1
-1 POINT:    4    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    5    DIRECTION:  1    -1    -1    -1    -1    -1
-1 POINT:    5    DIRECTION:  2     6    -1    -1    -1    -1
-1 POINT:    5    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    6    DIRECTION:  1    -1    -1    -1    -1    -1
-1 POINT:    6    DIRECTION:  2     7    -1    -1    -1    -1
-1 POINT:    6    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    7    DIRECTION:  1     8    -1    -1    -1    -1
-1 POINT:    7    DIRECTION:  2    -1    -1    -1    -1    -1
-1 POINT:    7    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    8    DIRECTION:  1     9    -1    -1    -1    -1
-1 POINT:    8    DIRECTION:  2    -1    -1    -1    -1    -1
-1 POINT:    8    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:    9    DIRECTION:  1     1    -1    -1    -1    -1
-1 POINT:    9    DIRECTION:  2    -1    -1    -1    -1    -1
-1 POINT:    9    DIRECTION:  3    -1    -1    -1    -1    -1
-1 POINT:   10    DIRECTION:  1    10    -1    -1    -1    -1
-1 POINT:   10    DIRECTION:  2    -1    -1    -1    -1    -1
-1 POINT:   10    DIRECTION:  3    -1    -1    -1    -1    -1
-1

ENTER DIRECTORY OPTION:
     1)   READ CURRENT DIRECTORY
     2)   WRITE CURRENT DIRECTORY
     3)   CREATE NEW DIRECTORY
     4)   PRINT CURRENT DIRECTORY
     5)   EXIT TO MONITOR 5

**
```

3.11 MODAL PARAMETER ESTIMATION COMMAND

```
-------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                    |
|------------------------------------------------------------|
|    COMMAND FUNCTION:    ENTER MODAL PARAMETER ESTIMATION   |
|                         PROGRAMS                           |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:    PE                                 |
|------------------------------------------------------------|
|    HP-5451 KEYBOARD:    ADD BUTTON (A+)                    |
|------------------------------------------------------------|
|    N1   = MODAL PARAMETER ESTIMATION PHASE                 |
|         = 1      FREQUENCY/DAMPING ESTIMATION              |
|         = 2      MODAL VECTOR ESTIMATION                   |
|                                                            |
| FOR N1 = 1:                                                |
|                                                            |
|    N2   = FREQUENCY/DAMPING ESTIMATION METHOD              |
|         = 1      MANUAL DETERMINATION                      |
|         = 2      CURSER DETERMINATION                      |
|         = 3      LEAST SQUARES TIME DOMAIN                 |
|         = 4      POLYREFERENCE TIME DOMAIN                 |
|         = 5      POLYREFERENCE FREQUENCY DOMAIN            |
|         = 6      ORTHOGONAL POLYNOMIAL                     |
|         = 7      IBRAHIM POLYREFERENCE                     |
|         = 8      MODIFIED IBRAHIM POLYREFERENCE            |
|         = 9      MULTI-MAC                                 |
|                                                            |
| FOR N1 = 1 AND N2 = 3:                                     |
|                                                            |
|    N3   = 1      DETERMINE FREQUENCY BANDWIDTH             |
|         = 2      DETERMINE MEASUREMENT SET                 |
|         = 3      DETERMINE FREQUENCY/DAMPING VALUES        |
|                                                            |
| FOR N1 = 2:                                                |
|                                                            |
|    N2   = MODAL VECTOR ESTIMATION METHOD                   |
|         = 1      COMPLEX MAGNITUDE                         |
|         = 2      IMAGINARY COMPONENT                       |
|         = 3      REAL COMPONENT                            |
|         = 4      REAL CIRCLE FIT                           |
|         = 5      COMPLEX CIRCLE FIT                        |
|         = 6      LEAST SQUARES FREQUENCY DOMAIN            |
|         = 7      POLYREFERENCE TIME DOMAIN                 |
|         = 8      POLYREFERENCE FREQUENCY DOMAIN            |
-------------------------------------------------------------
```

Schedules and transfers data to program 'MPE'. If no parameters are entered an interactive sequence is initiated. If a directory table has not been setup prior to this command the program automatically transfers to RL,3 to complete the directory. For complete details concerning the parameter estimations, refer to Sections 7, 8, and 9.

3.12 MEASUREMENT FORMAT COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	DEFINES THE FORMAT OF THE DATA LOCATION WITHIN THE DATA AREA
COMMAND MNEMONIC:	MF
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

When the measurements are stored to a disc in binary form, the location of the data varies with the type of system that is used to put the data on the disc. Three formats are supported in terms of the way this information is placed on the disc. First of all, the standard FMTXX structure used by Hewlett-Packard is the most common and primary method used. Secondly, a variation of this format used by SMS may be chosen in order to directly read data from an HP-5451-X system running SMS software. For these first two formats, any time a change is made, compatible changes using the Measurement Header Command and the Logical Unit Command may be required.

3.13 MEASUREMENT HEADER COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	DEFINES THE FORM OF DATA ANNOTATION (HEADER) USED BY THE CURRENT MEASUREMENT DATABASE
COMMAND MNEMONIC:	MH
HP-5451 KEYBOARD:	NONE

```
N1 = SOURCE OF FREQUENCY RESPONSE FUNCTION
     MEASUREMENT HEADER
   = 1      HP-5423-A
   = 2      HP-5451-B
   = 3      HP-5451-C (CINCINNATI)
   = 4      HP-5451-C (LUEVEN)
   = 5      HP-5451-C (SMS MODAL 4.0)
   = 6      FMON (S/K-LMS)
```

The ability to use the measurements for modal analysis requires knowledge of the test parameters. These test parameters are stored in the data annotation (header) that is associated with each measurement.

This data annotation (header) consists of 128 words that are considered part of the measurement data. For the HP-5451-B system, this identification record was created with the User Program Y0088. For the HP-5451-C system, the identification record is created with the User Program Y0888.

For the HP-5423-A system, the 63 word header is placed in words 14 through 76, inclusive, of the standard 128 word HP-5451 Fourier System data record by modified versions of User Program 80 and 81. In the current version,
HP-5423-A data must be taken with the local coordinates defined identical to the global coordinates. No direction cosines may be used.

For the SMS Modal 4.0 system and the S/K-LMS FMON system, the data annotation used in these cases is accessed directly just as in the HP-5451-X situations.

3.14 LOGICAL LIST DEVICE COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	CHANGE LIST DEVICE WITHIN PROGRAM TO ANY DEVICE AVAILABLE IN THE RESIDENT RTE SYSTEM
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST DEVICE LOGICAL UNIT NUMBER = 1 TERMINAL = 6 LINE PRINTER = 8 MAGNETIC TAPE	

Any output logical unit can be defined as the print logical unit as long as the user adds EOF marks, tape leader/trailer etc. with commands from File Manager before and after the write operation, as appropriate.

3.15 LOGICAL UNIT SUMMARY COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	INFORMATIONAL COMMAND TO GIVE STATUS OF CURRENT PROGRAM LOGICAL UNITS
COMMAND MNEMONIC:	LU
HP-5451 KEYBOARD:	LABEL BUTTON (Lb)
N1 = PROGRAM LOGICAL UNIT REFERENCE NUMBER N2 = NEW LOGICAL UNIT NUMBER FOR ENTRY N1 NO PARAMETERS REQUIRED TO PRINT CURRENT CONFIGURATION	

3.15.1 LOGICAL UNIT COMMAND EXAMPLE

```
**   LU

  1  SYSTEM TERMINAL LOGICAL UNIT..........     1
  2  SYSTEM PRINTER LOGICAL UNIT...........     1
  3  SYSTEM DISC LOGICAL UNIT..............     2
  4  DISC MODAL FILE LOGICAL UNIT..........    40
  5  FOURIER DATA DISC LOGICAL UNIT........     0
  6  FOURIER DATA DISC LOGICAL UNIT........    19
  7  FOURIER DATA DISC LOGICAL UNIT........     0
  8  FOURIER DATA DISC LOGICAL UNIT........     0
  9  FOURIER DATA DISC LOGICAL UNIT........     0
 10  FOURIER DATA DISC LOGICAL UNIT........     0
 11  FOURIER DATA DISC LOGICAL UNIT........     0
 12  FOURIER DATA DISC LOGICAL UNIT........     0
 13  FOURIER DATA DISC LOGICAL UNIT........     0
 14  FOURIER DATA DISC LOGICAL UNIT........     0
 15  PLOTTER LOGICAL UNIT (TEK)............     1
 16  PLOTTER LOGICAL UNIT (HP-7210)........     0
 17  PLOTTER LOGICAL UNIT (HP-IB)..........    15
 18  PLOTTER LOGICAL UNIT (HP-264X)........     0
 19  PLOTTER LOGICAL UNIT..................     0
 20  ANIMATION DISPLAY LOGICAL UNIT........    13
 21  HP-IB LOGICAL UNIT....................     0

**
```

3.16 FILE MANAGER COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	RUN THE FILE MANAGEMENT PROGRAM FROM WITHIN THE RTE MODAL PROGRAM
COMMAND MNEMONIC:	FM
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'FMGR' (session) or program 'FMGRM' (non-session). This command allows the user to perform any operation within the 'FMGR' program without losing the current state of the RTE Modal Program. Common examples of possible required action is to mount or dismount disc cartridges, obtain disc directory listings, or to control input/output devices such as printers or magnetic tape drives.

This command schedules a copy of the FMGR program. The user can then perform any function within FMGR but all modal information is preserved. When the FMGR operation is complete, control will pass back to the RTE Modal Program when the Exit Command, 'EX', is entered.

In order for this command to function in the non-session environment, a copy of 'FMGR' named do this is to save a copy of the permanent program named 'FMGR' with the Save Program FMGR Command, 'SP,FMGR'. This copy can then be renamed to 'FMGRM' by using the Rename Program FMGR Command, 'RN,FMGR,FMGRM'. To assure that WELCOM File using the Restore Program FMGR Command, 'RP,FMGRM'.

3.17 MODAL ASSURANCE CRITERION COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	COMPUTES MODAL ASSURANCE CRITERION FOR ALL COMBINATION OF MODES FROM MODE NUMBER N1 TO N2
COMMAND MNEMONIC:	CC
HP-5451 KEYBOARD:	CORRELATION BUTTON (CR)
N1 = FIRST MODE NUMBER (N1=0, MODE AVERAGING) N2 = LAST MODE NUMBER	

Schedules and transfers data to program 'MAC'.

3.17.1 MODAL ASSURANCE COMMAND EXAMPLE

```
**   CC 1 -1
ENTER OPTION FOR MODAL ASSURANCE CRITERIA:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
4

ENTER METHOD TO BE USED TO CALCULATE 'MAC':
          1) COMPLEX MODAL VECTOR
          2) REAL MODAL VECTOR

1

 TEST IDENTIFICATION:    SAILPLANE1

 REFERENCE   ANALYSIS    M.A.C.        M.S.F.        M.S.F.
   MODE        MODE                    (REAL)        (IMAG)


     1           1      1.0000000     1.0000000     0.0000000
     1           2       .0236804     -.5471559      .0000000
     1           3       .0008051      .0280721     -.0000000
     1           4       .0335236      .1227793     -.0000000
     1           5       .1262410     1.0049121     -.0000000
     1           6       .0000215     -.0094154      .0000000
     1           7       .0733592      .3033130     -.0000000
     1           8       .0900847      .2696154     -.0000000
     1           9       .0733592      .3033130     -.0000000
     1          10       .0900847      .2696154     -.0000000

**   CC 0

ENTER NUMBER OF MODES TO BE AVERAGED :
2

ENTER REFERENCE MODE NUMBER :
1

ENTER A MODE NUMBER, MSF (REAL), MSF (IMAG) :
2 .5471 0

ENTER DESTINATION MODE NUMBER :
10

**
```

3.18 MODAL ENHANCEMENT COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	COMPUTE AN ENHANCED FREQUENCY RESPONSE FUNCTION BASED UPON A CURRENT MODAL VECTOR AND FRF DATA SET
COMMAND MNEMONIC:	ME
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedule and transfer data to program 'EFRF'.

3.18.1 MODAL ENHANCEMENT EXAMPLE

```
**ME
ENTER OPTION FOR WEIGHTED AVERAGES:
          1) COMPUTE ENHANCED FREQUENCY RESPONSE FUNCTION
          2) ADD OR SUBTRACT MULTIPLE INPUT DATA
          3) RETURN TO MONITOR
1
ENTER OPTION FOR ENHANCED FREQUENCY RESPONSE FUNCTON:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
1
DIRECTION(S)?
2
DIRECTION(S)?
0
ENTER OPTION FOR WEIGHTED AVERAGES:
          1) COMPUTE ENHANCED FREQUENCY RESPONSE FUNCTION
          2) ADD OR SUBTRACT MULTIPLE INPUT DATA
          3) RETURN TO MONITOR
3
**
```

3.19 MODAL SCALING COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	SCALE ONE OR MORE OF THE CURRENT MODAL VECTORS ACCORDING TO A SPECIFIC CRITERIA
COMMAND MNEMONIC:	SC
HP-5451 KEYBOARD:	MULTIPLY BUTTON (*b)
N1 = FIRST MODE NUMBER TO BE SCALED N2 = LAST MODE NUMBER TO BE SCALED	

Schedules and transfers data to program 'MSCL'. The modal vector data is never altered after it is first estimated and stored using the Parameter Estimation Module. The Modal Scaling Command calculates an additional complex valued scale factor that is carried with each modal vector to reflect the type of scaling requested. The current calculation of modal mass is based upon the type of modal scaling requested and takes into account this scale factor. If at any time the user wishes to return to the original modal vector data as recorded, this can be done by resetting the scale factor to unity.

Upon execution of the Modal Scaling Command a table is printed showing mode number, frequency in Hertz, modal damping in percent of critical (zeta) and modal mass and stiffness. The units of modal mass and stiffness are consistent with the units of the calibrated measurement data.

3.19.1 MODAL SCALING EXAMPLE

```
**SC,1,4

ENTER MODAL VECTOR SCALING OPTION:

      0)  CLEAR PREVIOUS SCALING
      1)  MULTIPLY BY (jw)
      2)  MULTIPLY BY (jw)**2
      3)  MULTIPLY BY COMPLEX CONSTANT
      4)  DIVIDE BY (jw)
      5)  DIVIDE BY (jw)**2
      6)  DIVIDE BY COMPLEX CONSTANT
      7)  UNITY SPECIFIC MODAL VECTOR COMPONENT
      8)  UNITY LARGEST MODAL VECTOR COMPONENT
      9)  UNITY MODAL VECTOR LENGTH
     10)  UNITY MODAL MASS
     11)  RETURN TO MONITOR

8

  MODE    FREQUENCY    ZETA(%)        MASS          STIFFNESS

    1      271.5455     .34233     .64531E-02      .18785E+05
    2      411.0796    1.12644     .13414E-01      .89497E+05
    3      494.9085     .23296     .10498E-02      .10152E+05
    4      768.2258    8.95141     .10738E-02      .25220E+05

**
```

3.20 USER PROGRAM NINE READ/WRITE COMMAND

```
 -------------------------------------------------------------
|     MODAL SYSTEM COMMAND                                    |
|-------------------------------------------------------------|
|     COMMAND FUNCTION:    READ OR WRITE USER NINE MODAL FILES |
|                          FROM OR TO A FOURIER DISC          |
|-------------------------------------------------------------|
|     COMMAND MNEMONIC:    Y9                                 |
|-------------------------------------------------------------|
|     HP-5451 KEYBOARD:    NONE                               |
|-------------------------------------------------------------|
|     N1   = READ/WRITE CODE                                  |
|          = 1      READ                                      |
|          = 2      WRITE                                     |
 -------------------------------------------------------------
```

Schedules and transfers data to program 'USR9'. The operation of this command is through interactive questions. If a current data set has been archived with a version of the User Program Nine (BCS Modal Program), the data set can be retrieved and restructured into the RTE Modal Program by using this command. The only input required will be the starting record number (File One) that the data set is stored at on the data disc loaded in the disc logical unit defined for data.

3.21 SMS MODAL 4.0 COMPATIBILITY COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	READ/WRITE SMS MODAL 4.0 DATA FILES
COMMAND MNEMONIC:	M4
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'MOD4'.

3.22 LEAST SQUARES RIGID BODY COMPUTATION

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	COMPUTE LEAST SQUARES RIGID BODY MODAL VECTOR BASED UPON MEASURED RIGID BODY MODAL VECTOR
COMMAND MNEMONIC:	RB
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'RIGID'. This program uses a least squares error method to fit a rigid body mode to a specified set of degrees of freedom of a modal vector. This technique can be used to reduce errors in the modal coefficients for the points on the portion of a structure which is rigid at the frequency of the mode under consideration. This allows checking of transducer scaling and orientation. Also, the modal coefficients of unmeasured points on the rigid body can be calculated. This is useful if some points of interest on the rigid body are not accessible.

A rigid body computation example is listed on the following pages.

Define Points on Rigid Body - This menu is used to define the points which will have their modal coefficients recalculated to fit a rigid body mode.

Select Measured Degrees of Freedom - This menu is used to define the points which will be used to calculate the rigid body mode.

Enter Coordinate of Rigid Body Origin - Defines origin about which the X, Y, and Z translation and rotation components of the rigid body mode will be calculated.

Enter Modal Vectors - Defines the modal vectors which will be recalculated to force the degrees of freedom which are located on a rigid portion of the structure to conform to a rigid body mode. If the last parameter is -99 the recalculated rigid body degrees of freedom are not written over the original data.

Enter Error Tolerance - The amount of deviation from the calculated rigid body mode is calculated for each degree of freedom. If an error tolerance of E is entered all points with an error of E % or more of the maximum error found will be flagged. If E is positive the point numbers and error in each measurement direction will be printed. If E is negative the rigid body calculation will be redone excluding these points from the calculation.

3.22.1 RIGID BODY COMPUTATION EXAMPLE

```
**  RB
DEFINE POINTS ON RIGID BODY:
     1) COMPONENTS
     2) POINT NUMBERS
     3) PRINT
     4) DELETE
     5) CONTINUE
     6) RETURN TO MONITOR
1

 COMPONENT(S)?
3

 COMPONENT(S)?
0

DEFINE POINTS ON RIGID BODY:
     1) COMPONENTS
     2) POINT NUMBERS
     3) PRINT
     4) DELETE
     5) CONTINUE
     6) RETURN TO MONITOR
5

SELECT MEASURED DEGREES OF FREEDOM:
     1) SELECT DOF BY POINT NUMBER
     2) SELECT ALL DOF AVAILABLE
     3) PRINT
     4) CONTINUE
     5) RETURN TO MONITOR
2

SELECT MEASURED DEGREES OF FREEDOM:
     1) SELECT DOF BY POINT NUMBER
     2) SELECT ALL DOF AVAILABLE
     3) PRINT
     4) CONTINUE
     5) RETURN TO MONITOR
4

ENTER COORDINATE OF RIGID BODY ORIGIN
0 0 0

ENTER MODAL VECTOR(S) (IMODE,JMODE,IPAR):
     IMODE = FIRST MODAL VECTOR NUMBER
     IMODE = 0      RETURN TO MODAL MONITOR
     IMODE < 0      ENTER NEW DEGREES OF FREEDOM
     JMODE = LAST MODAL VECTOR NUMBER
     JMODE = -99    RESULTS NOT STORED
     IPARE = -99    RESULTS NOT STORED
1 -99 -99
```

```
ENTER ERROR TOLERANCE (0-100):
70

PROCESSING MODAL VECTOR NUMBER:    1
FREQUENCY (HERTZ):        9.80


  MODAL VECTOR NUMBER:    1
  FREQUENCY (HERTZ):        9.80

  TRANSLATION-ROTATION RESULTS (REAL PART)

     X TRANSLATION:  .2498
     Y TRANSLATION: -1.380
     Z TRANSLATION:  .2864
     X ROTATION:    -.6915E-03
     Y ROTATION:     .1677E-02
     Z ROTATION:     .7427E-02

  TRANSLATION-ROTATION RESULTS (IMAG PART)

     X TRANSLATION: -.1331
     Y TRANSLATION:  .7551
     Z TRANSLATION: -.7011
     X ROTATION:     .1931E-02
     Y ROTATION:    -.2793E-02
     Z ROTATION:    -.4131E-02
```

REAL CORRELATION=   .9585

POINT	EX	EY	EZ
77	.2855	.7461	1.0000
80	.8388	.3308	.0522
82	.0459	.0110	.8338
85	.9961	.1502	.4544

IMAGINARY CORRELATION=   .9381

POINT	EX	EY	EZ
70	.1602	.0725	.8265
80	.7012	.1934	.2989
82	.3019	.0295	.9235

```
ENTER MODAL VECTOR(S) (IMODE,JMODE,IPAR):
     IMODE = FIRST MODAL VECTOR NUMBER
     IMODE = 0      RETURN TO MODAL MONITOR
     IMODE < 0      ENTER NEW DEGREES OF FREEDOM
     JMODE = LAST MODAL VECTOR NUMBER
     JMODE = -99    RESULTS NOT STORED
     IPARE = -99    RESULTS NOT STORED -1

SELECT MEASURED DEGREES OF FREEDOM:
     1) SELECT DOF BY POINT NUMBER
     2) SELECT ALL DOF AVAILABLE
     3) PRINT
     4) CONTINUE
     5) RETURN TO MONITOR 5

**
```

3.23 DYNOPS COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	ACCESSES "DYNOPS PACKAGE" - MF MODIFICATION FILE GENERATION - MO MODAL OVERCOMPLEXITY CHECK - SM SENSITIVITY MODIFICATION - MS MODAL SYNTHESIS MODIFICATION
COMMAND MNEMONIC:	DY
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

The Dynops package is explained in detail in Chapter 10.

3.24 SENSITIVITY PREDICTION COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	SENSITIVITY PREDICTION
COMMAND MNEMONIC:	SS
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'SENAN'.

3.25 ROTATIONAL FRF CALCULATION COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	CALCULATE ROTATIONAL FRF
COMMAND MNEMONIC:	RO
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'CALRO'.

3.26 ANALYTICAL M-K-C MODAL ANALYSIS

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	CALCULATES QUADRATURE RESPONSE FROM ANALYTICAL DATA
COMMAND MNEMONIC:	MK
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

This module calculates the quadrature response (imaginary part of the frequency response function when measuring acceleration over force data) from mass, stiffness and damping matrices entered interactively from the terminal. The reference point is specified interactively. Output is damped natural frequencies, modal damping ratios and quadrature response at each degree of freedom.

3.27 DATA SETUP COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	MANAGES FILE SEVEN OR FILE NINE AREA ON A FOURIER DISC
COMMAND MNEMONIC:	DS
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'U8XX'. This command interactively allows the user to perform the same function from RTE as is performed by the User Programs 888-892 from the HP-5451C Fourier System. This allows the user to add test information to the File Nine area of a Fourier data disc (User Program 888) to set up the File Seven area in preparation for a test (User Program 889), to print the File Nine area of a specific data record (User Program 891), and to modify the File Nine area for specified data records (User Program 892,893).

Further details concerning the capability of these commands may be found in Section 3.10, Fourier System User Programs.

3.28 FEM DATA BASE COMPATABILITY COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	READ/WRITE FEM DATA BASE
COMMAND MNEMONIC:	FE
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'MTDB'.

3.29 UNIVERSAL FILE STRUCTURE COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	UNIVERSAL FILE STRUCTURE READ/WRITE
COMMAND MNEMONIC:	UF
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'UNVFL'. This program allows the user to store any of the modal files to a magnetic tape in a standardized format documented in Appendix I. This format represents an 80 character card image ASCII format that was originally documented by SDRC. The purpose of this format is to provide a standard, and not necessarily efficient, mechanism for movement of data and modal parameter information between different systems.

3.30 SYNTHESIZE MEASUREMENT COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	SYNTHESIZE MEASUREMENT
COMMAND MNEMONIC:	SN
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

Schedules and transfers data to program 'SYNTH'. This program allows the user to synthesize any arbitrary measurement based upon the current modal parameters. This measurement is displayed and may be stored for later recall.

3.31 EXIT COMMAND

MODAL SYSTEM COMMAND	
COMMAND FUNCTION:	EXIT TO CONTROL OF RTE FILE MANAGER
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN BUTTON (<b)
NO PARAMETERS REQUIRED	

Exits to 'FMGR' Monitor. Before allowing the project area used by RTE Modal to be released, it is necessary to answer "YES" to the "DO YOU WISH TO EXIT ?" question. To schedule 'FMGR' without releasing the project area, refer to the File Manager Command (FM).

4. MODAL FILE INPUT

4.1 OVERVIEW

The Modal File Input Command is used to enter all structure definition into the RTE Modal Program. In addition, modal parameters determined from other programs can be entered manually using this command in order to view animated modal vectors or to use any of the analysis routines available within the RTE Modal Program.

4.2 COMMAND FORMAT

The Modal File Input command has the following general form for any of the files that have been defined within the RTE Modal Program:

```
 ----------------------------------------------------------------
|    MODAL SYSTEM COMMAND                                        |
|----------------------------------------------------------------|
|    COMMAND FUNCTION:    INPUT ANY OF THE MODAL FILES FROM      |
|                         THE TERMINAL                           |
|----------------------------------------------------------------|
|    COMMAND MNEMONIC:    IN                                     |
|----------------------------------------------------------------|
|    HP-5451 KEYBOARD:    KEYBOARD BUTTON (Kb)                   |
|----------------------------------------------------------------|
|    N1   = MODAL FILE NUMBER                                    |
|                                                                |
|         = 0      TEST IDENTIFICATION                           |
|         = 1      COMPONENT INFORMATION                         |
|         = 2      COORDINATE INFORMATION                        |
|         = 3      DISPLAY SEQUENCE INFORMATION                  |
|         = 4      FREQUENCY/DAMPING INFORMATION                 |
|         = 5      MODAL VECTOR INFORMATION                      |
 ----------------------------------------------------------------
```

4.3 FILE ZERO - TEST IDENTIFICATION

File Zero consists of the test identification and the test date. While this entry does not really contain a significant amount of data, this entry is important since the RTE Modal Program will only recognize experimental data that contains the test identification designated by this input. The entry permits up to twenty characters to be used as a test identification but only the first ten characters are compared with the test identification that is carried as a part of each piece of data, in order to determine if the data is valid. Therefore, the last ten characters are informational only.

The date of the test is also requested as part of this file input. While this is important for record keeping reasons, the RTE Modal Program makes no use of the test date.

4.4 FILE ONE - COMPONENTS

File One consists of the origin and orthogonal orientation of each component with respect to a global coordinate system. More than one component is not required. However, component definition is advised to allow for partial displays during animation or plotting. To avoid confusion, when possible, define all points with respect to a global origin and orientation which allows the origin and orientation of each component to be identical. The following parameters must be entered on request: ICOMP,X,Y,Z,IX,IY,IZ,IC. The X,Y,Z coordinates of each component origin with respect to the global system must be input (X,Y,Z). The orientation of the component coordinate system axis with respect to the global system axis (IX,IY,IZ) and the code for rectangular or cylindrical coordinate system (IC) is also input.

The code, for inputting the orientation of the component coordinate system axis, is used to determine the direction of the X,Y,Z axis in the component system with respect to the global system axis. A plus or minus one, two, or three is input for the X,Y,Z axis respectively. For example, if the Y axis of the component runs in the +X direction of the global system, then a +2 is entered for IX. If the Z axis of the component runs in the negative Y direction of the global system, then IY = -3. The use of direction cosines is not permitted.

The code for the type of coordinate system(IC) is one (1) for rectangular and zero (0) for cylindrical. A zero or negative entry for component number (ICOMP) will terminate the entry. Editing is accomplished by re-entering the information for the incorrect component number. New information can be added by entering data for additional components.

4.5 FILE TWO - COORDINATES

File Two consists of the coordinates of each point with respect to a specific component number. A point can only exist on one component. The point number, X,Y,Z coordinates, and the component number are input for each point. A zero or negative entry of the point number will terminate the entry. To change a point or to edit, simply reenter the data for the desired point.

4.6 FILE THREE - DISPLAY SEQUENCE

4.6.1 OVERVIEW

The Display Sequence File is a sequence of numbers, each of which represents a point of the test structure. The sequence specifies the order in which the structure points are to be displayed and how these points are to be connected.

4.6.2 COMMAND SUMMARY

The following list of commands is available from the Display Sequence Monitor:

SUMMARY OF DISPLAY SEQUENCE COMMANDS	
IN	DISPLAY SEQUENCE INPUT
CT	SET DISPLAY SEQUENCE LENGTH
DL	DELETE DISPLAY SEQUENCE ENTRIES
/I	INSERT AFTER DISPLAY SEQUENCE ENTRY
RP	REPLACE DISPLAY SEQUENCE ENTRY
PR	PRINT DISPLAY SEQUENCE FILE
EX	PROGRAM EXIT
??	COMMAND SUMMARY

This is a very important input and great effort has been spent on trying to automate the Display Sequence File. The maximum number of connections cannot be greater than 500.

In this mode, a secondary monitor is used to input the display sequence. This monitor is denoted by "*C".

4.6.3 INPUT COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	INPUT OF DISPLAY SEQUENCE FILE
COMMAND MNEMONIC:	IN
HP-5451 KEYBOARD:	KEYBOARD BUTTON (Kb)
NO PARAMETERS REQUIRED	

The Input Command is used for entering the Diplay Sequence File. After the Input Command is issued, the computer waits for input (N1 and N2 can be entered). If N2 is greater than N1, the counter is incremented and the Display Sequence File from N1 to N2 is sequentially stepped. If N2 is defaulted, then N1 is added to the file and the counter is incremented. If N2 is less than N1 the file is incremented from N2 to N1. This input is terminated by inputting zero (0) for N1.

If it is desired to move from point A to another point B, without drawing a line, N1 should be equal to the negative of point B.

Line numbers are automatically calculated and updated by way of the counter. Termination returns the user to the Display Sequence Monitor.

4.6.4 RESET COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	RESET DISPLAY SEQUENCE FILE TO TO A CERTAIN LENGTH
COMMAND MNEMONIC:	CT
HP-5451 KEYBOARD:	COUNT BUTTON (_#b)
N1 = LENGTH OF DISPLAY SEQUENCE FILE	

This command can be used to reset the counter to value N1. The counter is the number of the last display vector entered. If a new display sequence is ever required, the old Display Sequence File can be eliminated by setting the counter to zero (N1 = 0). The Display Sequence File is stored using line numbers with one line number per vector (the vector is the point number of the Display Sequence File).

4.6.5 DELETE COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	DELETE A PORTION OF THE CURRENT DISPLAY SEQUENCE FILE
COMMAND MNEMONIC:	DL
HP-5451 KEYBOARD:	DELETE BUTTON (/D)
N1 = FIRST ENTRY TO BE DELETED N2 = LAST ENTRY TO BE DELETED	

This command will delete the Display Sequence File from counter N1 to N2. If N2 is defaulted then N1 will be deleted.

4.6.6 INSERT COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	INSERT A DISPLAY SEQUENCE AFTER A SPECIFIC ENTRY OF THE CURRENT FILE
COMMAND MNEMONIC:	/I
HP-5451 KEYBOARD:	INSERT BUTTON (/I)
N1 = ENTRY AFTER WHICH A DISPLAY SEQUENCE WILL BE ADDED	

This command will insert AFTER counter value N1. After the command is entered, then the computer will wait for an input where N2 is entered. The value N2 will be entered into the Display Sequence File. If, additional values are entered, these successive values will be inserted in the sequence entered as successive entries. No existing elements of the display sequence are lost, the existing contents of the display sequence are moved down by the number of elements added to the display sequence through the insert mode. At any time, if this entry mode is to be terminated, a zero value for N2 can be entered.

4.6.7 REPLACE COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	REPLACE A CURRENT DISPLAY SEQUENCE BEGINNING WITH A SPECIFIC ENTRY
COMMAND MNEMONIC:	RP
HP-5451 KEYBOARD:	REPLACE BUTTON (/R)
N1 = FIRST ENTRY TO BE REPLACED	

This command will replace line N1, with new input N2. After the command is input, the computer will wait for an input line, N2, to be entered. If additional lines are input, they will replace the corresponding consecutive lines following N1, until a zero value is entered and control is returned to the Display Sequence Monitor.

4.6.8 PRINT COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	PRINT CURRENT DISPLAY SEQUENCE FILE
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

This command will write the Display Sequence File for line number N1 to N2. If N1 is defaulted, then the complete file will be listed.

4.6.9 EXIT COMMAND

MODAL DISPLAY SEQUENCE COMMAND	
COMMAND FUNCTION:	EXIT TO CONTROL OF MODAL SYSTEM MONITOR
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN BUTTON (<b)
NO PARAMETERS REQUIRED	

This command will return control to the Modal System Monitor from the Display Sequence Monitor.

4.6.10 DISPLAY SEQUENCE EXAMPLE

Consider the simple plate structure of Figure 4-1a. After describing the locations of the four points, the description of the order in which the points must be connected must now be determined. One possible display sequence would be to start at point 1 (arbitrarily) and draw a solid line from point 1 around the structure in order of increasing point number to point 4 and back to point 1. The simplest display sequence which will accomplish this is:

Sequence	Point	
1	-1	start at point 1
2	2	solid line to point 2
3	3	solid line to point 3
4	4	solid line to point 4
5	1	solid line to point 1

The display will cycle through this display sequence in the manner shown to produce a display like that of Figure 4-1b (identical to that of Figure 4-1a).

If it is desired to blank (move without drawing a line) the display from point 2 to point 3, and from point 4 to point 1 (leaving horizontal lines only) the display sequence would be:

Sequence	Point	
1	-1	start at point 1
2	2	solid line to point 2
3	-3	blank to point 3
4	4	solid line to point 4
5	-1	blank to point 1

Note that to blank the display, the end point of the nonvisible vector is negative. The display for the above display sequence would be that of Figure 4-1c.

When constructing a display sequence, it is suggested that the following three rules be followed:

1) If possible, close all sequence loops explicitly within the display sequence. If this is not done, confusing displays may result (the deformed and undeformed structure may be connected, for example).

2) Points on the same component should be grouped together in the Display Sequence File, if possible.

3) The first point of a component should always be blanked to give correct partial displays by component.

The fact that structure components can be displayed individually must be taken into account when constructing a Display Sequence File. Adding duplicate, artificial, points may be necessary to obtain correct displays in all cases.

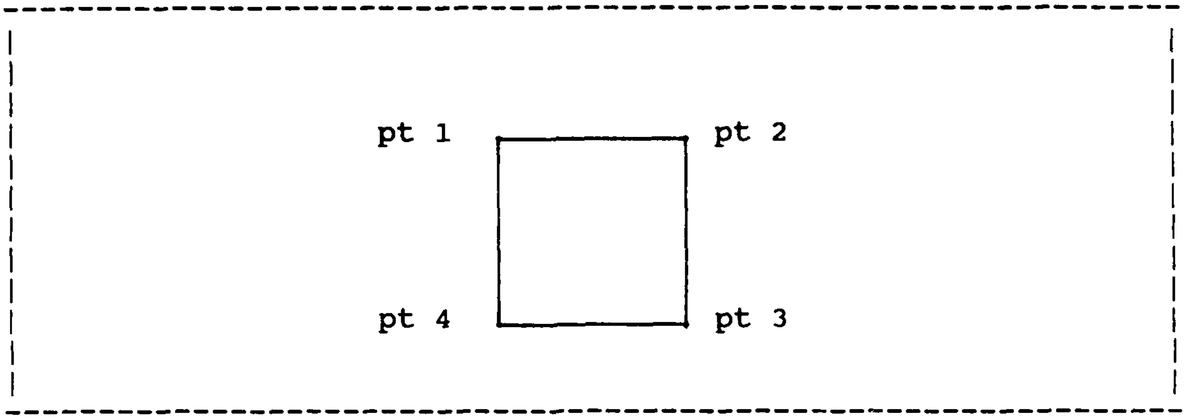

FIGURE 4-1a

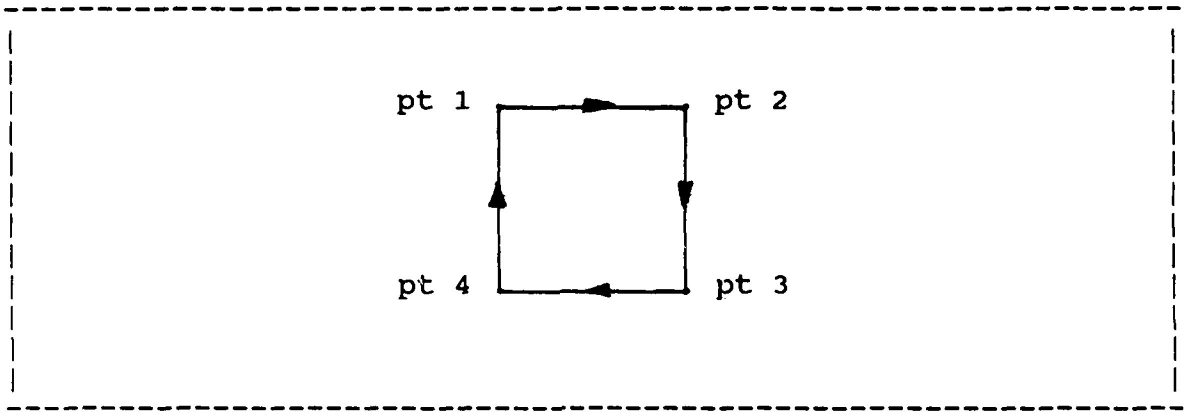

FIGURE 4-1b

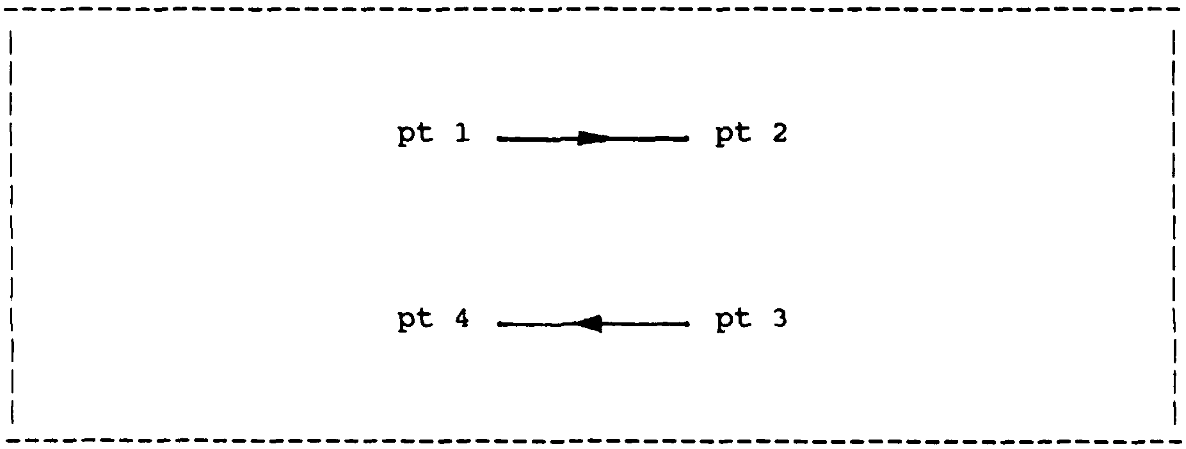

FIGURE 4-1c

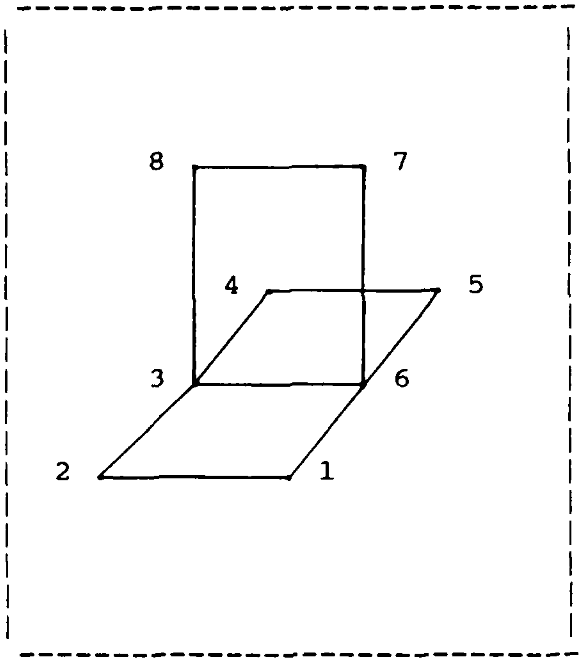

FIGURE 4-2a

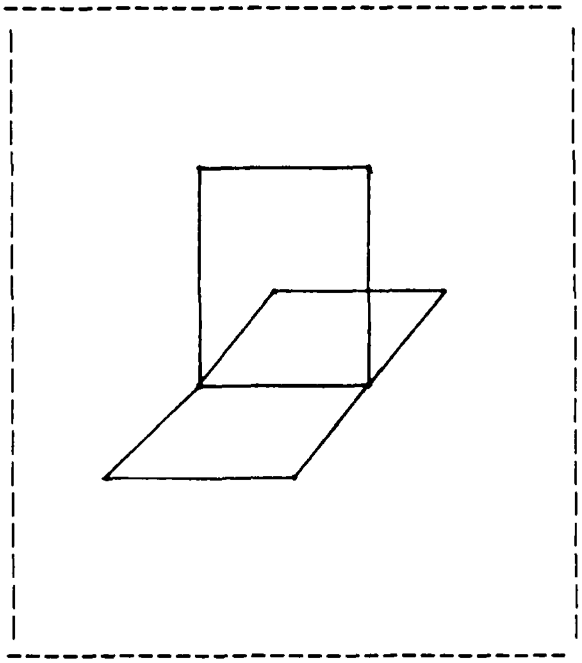

FIGURE 4-2b

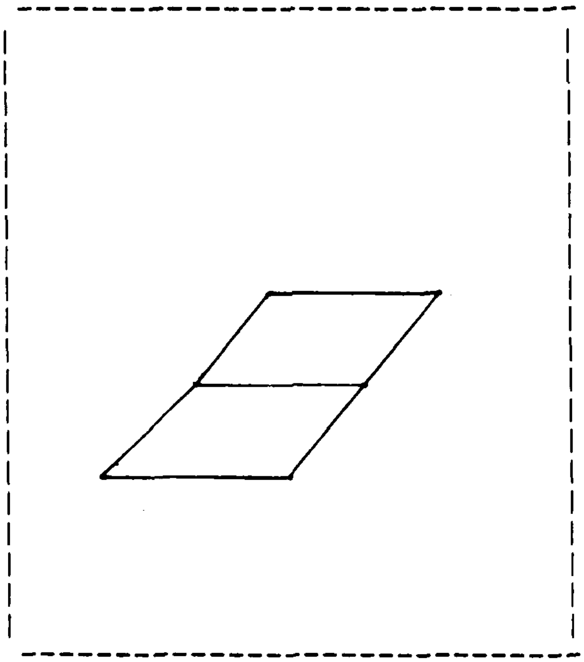

FIGURE 4-2c

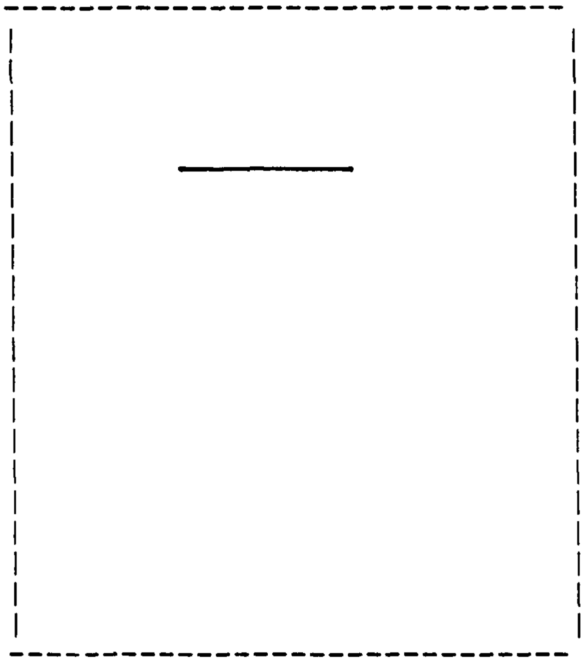

FIGURE 4-2d

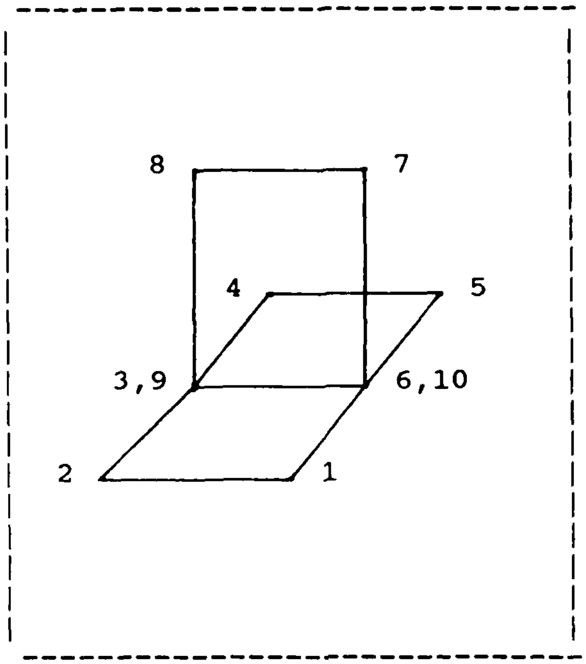

FIGURE 4-3a

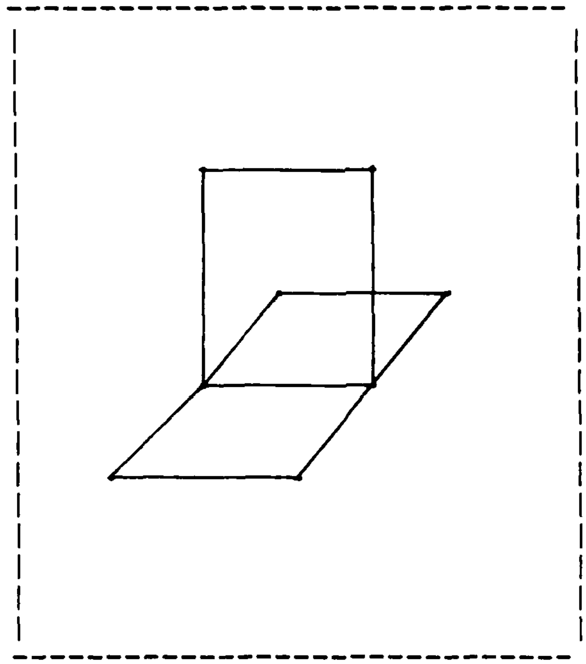

FIGURE 4-3b

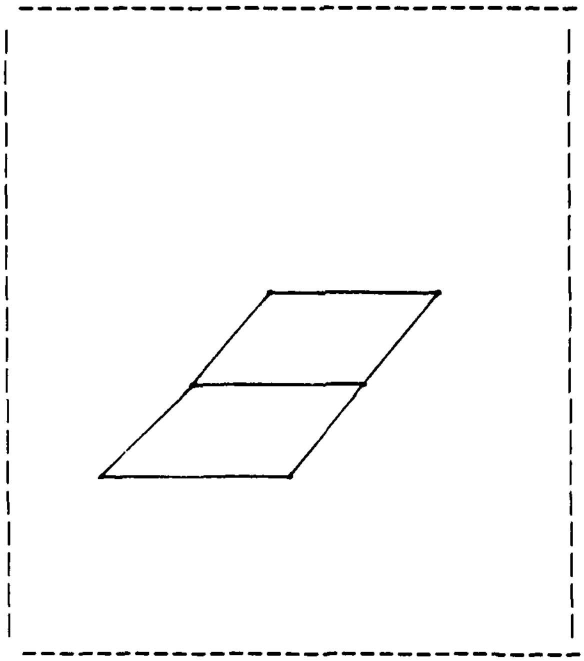

FIGURE 4-3c

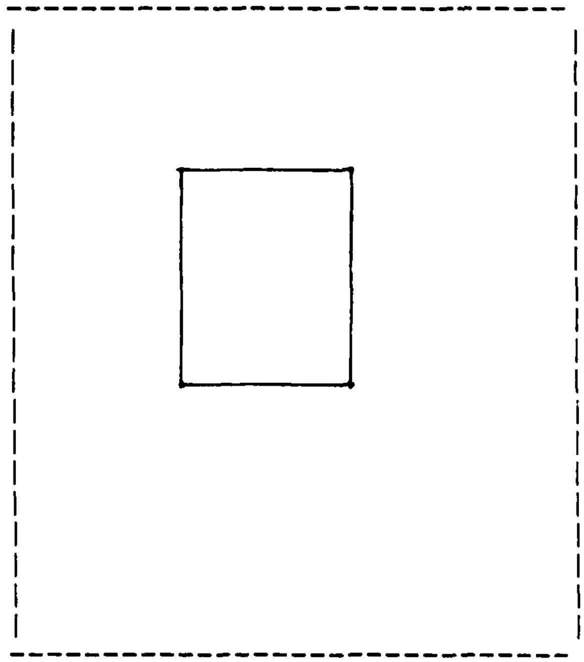

FIGURE 4-3d

For example, consider the T-plate structure shown in Figure 4-2. One possible display sequence for the T-plate is as follows:

Sequence	Point	(Component)
1	-6	1
2	1	1
3	2	1
4	3	1
5	4	1
6	5	1
7	6	1
8	7	2
9	8	2
10	3	1
11	6	1

Also, consider the T-plate comprised of two components, one for the horizontal plate and one for the vertical plate. Therefore, points 1 - 6 should be defined on component 1, and points 7 and 8 should be defined on component 2.

When both components 1 and 2 are displayed, the desired display of Figure 4-2b results. However, when only one of the two components is displayed, the display sequence for points on other components are effectively non-existent. When component 1 alone is displayed, this is of no consequence, as Figure 4-2c shows. However, the display of component 2 alone is incomplete due to the missing lines formerly provided by the simultaneous display of component 1 (Figure 4-2d).

Figure 4-3a shows the T-plate with artificial points 9 and 10, defined to be in the same location as points 3 and 6 except on component 2 rather than component 1.

The correct display sequence would now be:

Sequence	Point	(Component)
1	-6	1
2	1	1
3	2	1
4	3	1
5	4	1
6	5	1
7	6	1
8	-10	2
9	7	2
10	8	2
11	9	2
12	10	2
13	-3	1
14	6	1

The new displays are shown in Figures 4-3b, 4-3c, and 4-3d which display the structure and its components as desired.

The above Display Sequence File happens to be a good example of a display sequence following the rules given above. That is, all sequence loops(there are three--one for each component separately and one for the two components combined) are explicitly closed, and the points defining components 1 and 2 are grouped together in the file. To illustrate what happens if these rules are not followed, the user should consider the following Display Sequence File for the T-plate of Figure 4-3a:

Sequence	Point
1	6
2	1
3	2
4	3
5	8
6	7
7	6
8	5
9	4
10	9
11	10
12	6

4.7 FILE FOUR - FREQUENCY/DAMPING

The input of frequency and damping information from the terminal is a feature that is intended to be used to override information generated from the Parameter Estimation Module or to allow for entry of this information based upon results from other programs. The frequency and damping (per cent of critical) must be entered as well as valid parameters for frequency resolution, minimum frequency, reference point number and direction.

4.8 FILE FIVE - MODAL VECTORS

The input of modal vectors from the terminal is a feature that is intended to be used to correct specific invalid data points. If a modal vector is available from another source, the complete modal vector can be entered but certain calculations, such as scaling, that use this data will not necessarily be valid.

4.9 STRUCTURE DEFINITION EXAMPLE

As an example of how the points on a structure may be spatially described to the system, consider the structure of Figure 4-4 and assume that this structure is described in terms of two component systems. The two logical components would be a rectangular box and a cylinder. Also, assume that the spatial locations of the points marked PT 1 and PT 2 are to be described in terms of each component system.

First, the component origins, in rectangular coordinates (X,Y,Z), with respect to the global origin and the global axes must be established. The origin of component system 1 is thus determined to be (2,3,0), while that for component system 2 is (1,4,1).

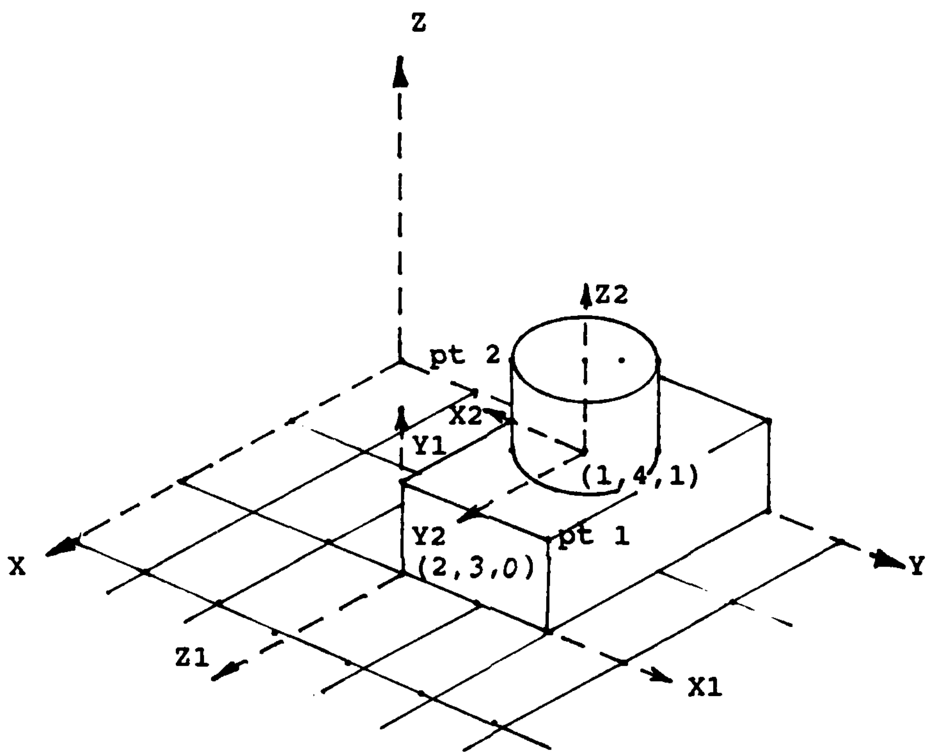

FIGURE 4-4

Next, it is necessary to describe the component system axis orientation with respect to the global system axes. All component axes must be co-linear with any one of the global axes so that only three variables are needed to describe the orientation for each component system. These variables are denoted IX, IY and IZ. Each of these variables is either plus or minus 1, 2, or 3 depending upon which component axis coincides with a particular X, Y or Z global axis.

The convention for determining IX, IY and IZ is easily established by considering the two sample components. For component system 1, the global positive X axis is in the component positive z (+3) direction (IX = +3), the global positive Y axis is in the component positive x (+1) direction (IY = +1), and the global positive Z axis is in the component positive y (+2) direction (IZ = +2). For component system 2, the global positive X axis is in the component positive y (+2) direction (positive THETA in cylindrical coordinates), (IX = +2), the global positive Y axis is in the component negative x (-1) direction (RADIUS in cylindrical coordinates), (IY = -1), and the global positive Z axis is in the component positive z (+3) direction (IZ = +3). NOTE: Each set of component axes must conform to the right-hand rule.

Now that the component information for this structure has been completely specified, it is necesary to enter the coordinates of each point on the structure relative to the component origins. Any combination of points may be defined to be on any component. It is most useful, however, to define points lying on a complete physical substructure to be on the same component. In the example, therefore, it would probably be most useful to consider points on the box in component 1, and points on the cylinder in component 2.

The coordinates of each point within a component system may be described in either cylindrical or rectangular coordinates, depending upon which description is most natural. The coordinate type(IC) is a variable that must be given along with the information for each component. Considering the example, again, the box part of the structure is most naturally described in rectangular coordinates, while the cylinder part of the total structure is most naturally described in cylindrical coordinates. Therefore, when describing points on these structure components, these corresponding coordinate types would be used for the description. When cylindrical coordinates are to be used, the following two rules apply:

1) The Z axis of the component system should coincide with the Z axis of the global system.

2) Angle Convention: Component X axis: = 0 degrees
   Component Y axis: = 90 degrees

Therefore, positive angle is determined by use of the right hand rule.

Using the above conventions, the coordinate data for the two points of interest may be easily described. Point 1, on structure component 1, is described in terms of component coordinate system 1 and rectangular coordinates, so that (X,Y,Z,IC) = (2,1,0,1) ... (IC , the coordinate type variable, is 0 for cylindrial and 1 for rectangular coordinates). Similarly, Point 2 on component 2 is described in cylindrical coordinates as (RADIUS,THETA,Z,IC) = (0.5,45.0,1.0,0)

For display purposes, it may at times be useful to define the component origin such that the structure is broken apart. For example, if the origin of component system 2 in Figure 4-4 had been defined to be at (1,4,3) rather than (1,4,1), the cylindrical portion of the structure would be separated in the Z direction from the rest of the structure on the display, and the hidden corner of the box would now be visible. This is easily done since the structure of the Data Setup Section allows the component origins and all other structure information to be altered at any time.

5. MODAL ANIMATION MODULE

5.1 OVERVIEW

Once the necessary steps of the Modal File Input and Modal Parameter Estimation have been performed, the Modal Animation Commands allow the user to obtain animated mode shape displays for the test structure. Two program modules have been developed for this purpose. The first program module (MDSPL), supports all graphics vector display devices regardless of whether the device has internal memory. This program module is the original modal animation program module. Due to lack of local memory, this program module cannot support extended display features such as rotation or multiple modes. For those graphics vector display devices that utilize local memory (HP-13XX), an enhanced modal animation program module (MDSP) is available which contains many extended features.

5.2 MODAL ANIMATION DISPLAY PROGRAM (ORIGINAL)

This program module is designed to utilize the host computer as both computation and memory for the modal animation program. This program, therefore, is the most general but lacks extended feature. This program was originally designed for the HP-5460 Display but has been upgraded to be compatible with all graphics vector displays that are supported by the RTE Modal Program.

5.2.1 AXIS ORIENTATION

The global coordinate system for display purposes is assumed to be as shown in Figure 5-1. The system resolves coordinates and deformations in the three global directions shown, into the two-dimensional system of the HP-5460 Display Unit as shown in Figure 5-2.

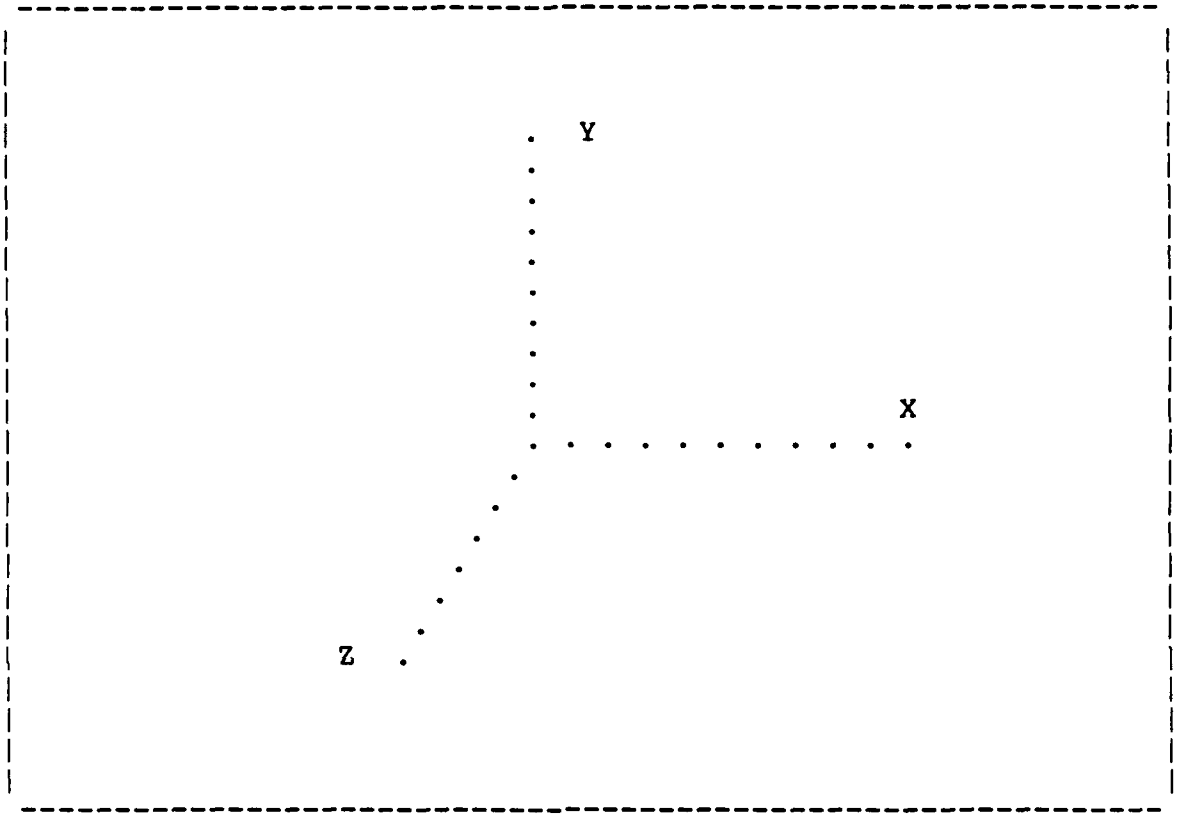

FIGURE 5-1

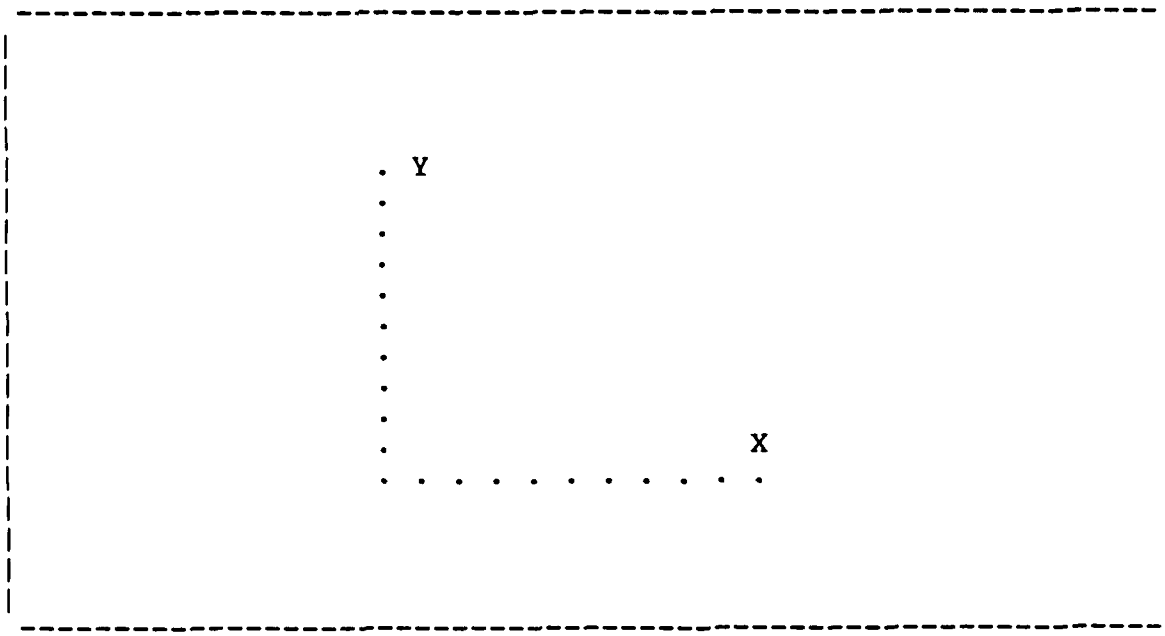

FIGURE 5-2

5.2.2 SCALING CONSIDERATIONS

The working arrays for the animated display vectors are defined relative to the vector display unit X-Y coordinate system. Ultimately, all structure coordinates and motion are broken down into coordinates and motion within this X-Y system.

The display calculation will automatically scale to 80% of the the full screen of the particular vector display unit being used. If the vector display unit is rectangular, the computation will be based upon the smaller of the X or Y screen size.

5.2.3 COMMAND SUMMARY

The following is a list of commands that are available from the Modal Display Monitor:

SUMMARY OF MODAL ANIMATION COMMANDS	
DI	DISPLAY ANIMATED MODE
DF	DISPLAY FORMAT
PD	PLOT DISPLAY
AS	ASCII DISPLAY TO CRT
VW	VIEW ORIENTATION
SD	SCALE DISPLAY
MO	MOVE DISPLAY
AA	ANIMATION AMPLITUDE
RO	ROTATE DISPLAY
SP	ANIMATION SPEED
IN	INTENSIFY POINT
EX	PROGRAM EXIT
??	COMMAND SUMMARY

5.2.4 DISPLAY COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY ANIMATED MODAL VECTOR
COMMAND MNEMONIC:	DI
HP-5451 KEYBOARD:	DISPLAY BUTTON (Db)
N1	= MODAL VECTOR NUMBER
N2	= NUMBER OF COMPONENTS
N3	= COMPONENT NUMBER 1
N4	= COMPONENT NUMBER 2
N5	= COMPONENT NUMBER 3
N6	= COMPONENT NUMBER 4

5.2.5 DISPLAY FORMAT COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	ALTER THE ANIMATED DISPLAY FROM REAL TO COMPLEX FORMAT
COMMAND MNEMONIC:	DF
HP-5451 KEYBOARD:	NONE
N1 = DISPLAY FORMAT = 1 AMPLITUDE = 2 IMAGINARY = 3 REAL = 4 COMPLEX	

5.2.6 PLOT DISPLAY COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	PLOT THE CURRENT ANIMATED DISPLAY
COMMAND MNEMONIC:	PD
HP-5451 KEYBOARD:	ANALOG OUT BUTTON (Bb)
N1 = PLOT DEVICE = 06 TEKTRONIX = 10 HP-7210 PLOTTER = 37 HP-IB PLOTTER N2 = ANIMATION CODE = 0 TURN OFF DISPLAY DURING PLOT	

Schedule and transfer data to program 'PLTXX', where XX=N1. If the operating system used by the RTE Modal Program consists of 64K, the animated display must be turned off during plotting. In all other cases, turning off the animated display during plotting, will speed up the plot slightly.

5.2.7 ASCII DISPLAY COMMAND

```
 ------------------------------------------------------------
|    MODAL ANIMATION COMMAND                                  |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   DISPLAY ASCII TEXT ON DISPLAY UNIT   |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   AS                                   |
|------------------------------------------------------------|
|    HP-5451 KEYBOARD:   LABEL BUTTON (Lb)                    |
|------------------------------------------------------------|
|    N1  = MODAL VECTOR NUMBER                                |
|                                                             |
|    THE FREQUENCY OF THE MODAL VECTOR REQUESTED WILL BE      |
|    DISPLAYED.                                               |
|                                                             |
|    IF NO MODAL VECTOR IS REQUESTED, THE TEXT TO BE          |
|    DISPLAYED WILL BE REQUESTED INTERACTIVELY.               |
 ------------------------------------------------------------
```

Schedules and transfers data to program 'ASCT'.

5.2.8 VIEW ORIENTATION COMMAND

```
 ------------------------------------------------------------
|    MODAL ANIMATION COMMAND                                  |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   SET VIEWING PERSPECTIVE              |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   VW                                   |
|------------------------------------------------------------|
|    HP-5451 KEYBOARD:   DIFFERENTIATE BUTTON (%b)            |
|------------------------------------------------------------|
|    N1  = X POSITION                                         |
|    N2  = Y POSITION                                         |
|    N3  = Z POSITION                                         |
 ------------------------------------------------------------
```

Sets viewing orientation to along vector from designated point in space to (0,0,0).

5.2.9 SCALE DISPLAY COMMAND

```
 ------------------------------------------------------------
|    MODAL ANIMATION COMMAND                                  |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   SCALE DISPLAY                        |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   SD                                   |
|------------------------------------------------------------|
|    HP-5451 KEYBOARD:   TRANSFER FUNCTION BUTTON (CH)        |
|------------------------------------------------------------|
|    N1  = PERCENT OF CURRENT DISPLAY                         |
 ------------------------------------------------------------
```

5.2.10 MOVE DISPLAY COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	MOVE DISPLAY POSITION
COMMAND MNEMONIC:	MO
HP-5451 KEYBOARD:	SHIFT BUTTON (_b)
N1 = PER CENT X MOVEMENT N2 = PER CENT Y MOVEMENT	

5.2.11 EXPAND ANIMATION AMPLITUDE COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	ANIMATION AMPLITUDE
COMMAND MNEMONIC:	AA
HP-5451 KEYBOARD:	DIVIDE BUTTON (:b)
N1 = PERCENT OF CURRENT ANIMATION AMPLITUDE	

5.2.12 ROTATE DISPLAY COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	ROTATE CURRENT DISPLAY ABOUT AXIS N1 BY N2 DEGREES.
COMMAND MNEMONIC:	RO
HP-5451 KEYBOARD:	NONE
N1 = AXIS (1,2,3) N2 = DEGREES OF ROTATION	

5.2.13 ANIMATION SPEED COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	ALTER SPEED OF ANIMATION DISPLAY
COMMAND MNEMONIC:	SP
HP-5451 KEYBOARD:	CONVOLUTION BUTTON (CV)
N1 = SPEED CODE (1-100) = 100 FASTEST = 1 SLOWEST	

Not operational on the HP-1351 display.

5.2.14 INTENSIFY POINT COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	INTENSIFY A SPECIFIC DISPLAY POINT
COMMAND MNEMONIC:	IN
HP-5451 KEYBOARD:	CURSOR BUTTON (/.)
N1 = COORDINATE POINT NUMBER TO BE INTENSIFIED	

5.2.15 EXIT COMMAND

MODAL ANIMATION COMMAND	
COMMAND FUNCTION:	EXIT TO CONTROL OF MODAL SYSTEM MONITOR
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN BUTTON (<b)
NO PARAMETERS REQUIRED	

Return to Modal Monitor.

5.3 MODAL ANIMATION DISPLAY PROGRAM (ENHANCED)

5.3.1 COMMAND SUMMARY

SUMMARY OF MODAL ANIMATION COMMANDS (ENHANCED)	
DI	DISPLAY ANIMATED MODE
DF	DISPLAY FORMAT
PD	PLOT DISPLAY
VW	VIEW ORIENTATION
SD	SCALE DISPLAY
MO	MOVE DISPLAY
AA	ANIMATION AMPLITUDE
RO	ROTATE DISPLAY
SP	ANIMATION SPEED
IN	INTENSIFY POINT
ES	EIGENVECTOR SCALING
AD	AXIS DEFINITION
SI	SINGLE MODAL VECTOR DISPLAY
DU	DUAL MODAL VECTOR DISPLAY
QD	QUAD MODAL VECTOR DISPLAY
PA	PAUSE DISPLAY
CO	CONTINUE DISPLAY
SS	SINGLE STEP DISPLAY
PE	PERSPECTIVE VIEW
CD	COMPONENT DEFINITION
AF	ADD DISPLAY FRAME
RF	REMOVE DISPLAY FRAME
CF	CHANGE DISPLAY FRAME
PF	PRINT DISPLAY FRAME
EX	PROGRAM EXIT
??	COMMAND SUMMARY

5.3.2 DISPLAY COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	COMPUTE ANIMATED MODAL DISPLAY FOR UP TO TWO MODAL VECTORS
COMMAND MNEMONIC:	DI
HP-5451 KEYBOARD:	DISPLAY BUTTON (Db)
N1 = FIRST MODAL VECTOR N2 = SECOND MODAL VECTOR	

5.3.3 *DISPLAY FORMAT COMMAND*

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	DEFINE THE TYPE OF ANIMATED DISPLAY FOR EACH DISPLAY FRAME
COMMAND MNEMONIC:	DF
HP-5451 KEYBOARD:	NONE
N1 = DISPLAY FORMAT = 0 UNDEFORMED = 1 IMAGINARY = 2 REAL = 3 COMPLEX = 4 AMPLITUDE N2 = FIRST FRAME NUMBER N3 = SECOND FRAME NUMBER	

5.3.4 *PLOT DISPLAY COMMAND*

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	PLOT THE CURRENT ANIMATED DISPLAY
COMMAND MNEMONIC:	PD
HP-5451 KEYBOARD:	ANALOG OUT BUTTON (Bb)
N1 = PLOT DEVICE = 6 TEKTRONIX = 10 HP-7210 PLOTTER = 37 HP-IB PLOTTER	

5.3.5 VIEW COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	SET VIEWING PERSPECTIVE
COMMAND MNEMONIC:	VW
HP-5451 KEYBOARD:	DIFFERENTIATE BUTTON (%b)

```
N1   = X POSITION
N2   = Y POSITION
N3   = Z POSITION
N4   = VIEW NUMBER
     = 4 - 10  (IF N4 DEFAULTED, ALL VIEWS ARE ENTERED)
```

5.3.6 SCALE DISPLAY COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	SCALE DISPLAY
COMMAND MNEMONIC:	SD
HP-5451 KEYBOARD:	TRANSFER FUNCTION BUTTON (CH)

```
N1   = PERCENT OF CURRENT DISPLAY
     = 0 - 1000
```

5.3.7 MOVE DISPLAY COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	MOVE DISPLAY POSITION
COMMAND MNEMONIC:	MO
HP-5451 KEYBOARD:	SHIFT BUTTON (b)
N1	= X MOVEMENT IN DISPLAY UNITS = 0 (DFLT)
N2	= Y MOVEMENT IN DISPLAY UNITS = 0 (DFLT)
N3	= FIRST WINDOW NUMBER = 1 - 7
N4	= LAST WINDOW NUMBER = 1 - 7

5.3.8 ANIMATION AMPLITUDE COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	ANIMATION AMPLITUDE
COMMAND MNEMONIC:	AA
HP-5451 KEYBOARD:	DIVIDE BUTTON (:b)
N1	= PERCENT OF CURRENT ANIMATION AMPLITUDE = 1 - 1000

5.3.9 DISPLAY ROTATION COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	ROTATE ANIMATED DISPLAY N1 DEGREES PER STEP AROUND THE VERTICAL AXIS AS SPECIFIED BY THE AXIS DEFINITION COMMAND.
COMMAND MNEMONIC:	RO
HP-5451 KEYBOARD:	NONE
N1 = DEGREES OF ROTATION PER STEP = -45 - +45	

5.3.10 ANIMATION SPEED COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	ALTER SPEED OF ANIMATION DISPLAY
COMMAND MNEMONIC:	SP
HP-5451 KEYBOARD:	CONVOLUTION BUTTON (CV)
N1 = SPEED CODE (1-100) = 1 SLOWEST = 50 (DFLT) = 100 FASTEST	

5.3.11 INTENSIFY POINT COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	INTENSIFY A SPECIFIC DISPLAY POINT
COMMAND MNEMONIC:	IN
HP-5451 KEYBOARD:	CURSOR BUTTON (/.)
N1 = COORDINATE POINT NUMBER TO BE INTENSIFIED = 0 (DFLT)	

5.3.12 COMPARATIVE SCALE COMMAND

```
 ----------------------------------------------------------------
|     MODAL ANIMATION COMMAND (ENHANCED)                         |
|----------------------------------------------------------------|
|     COMMAND FUNCTION:    SCALE TWO CURRENT MODAL VECTORS       |
|                          TO SAME LEVEL                         |
|----------------------------------------------------------------|
|     COMMAND MNEMONIC:    ES                                    |
|----------------------------------------------------------------|
|     HP-5451 KEYBOARD:    NONE                                  |
|----------------------------------------------------------------|
|     N1   = SCALING OPTION                                      |
|          = 0   (DFLT)   SCALE VECTORS INDEPENDENTLY            |
|          = 1   (DFLT)   SCALE VECTORS TO SAME LEVEL            |
|                                                                |
|     N2   = INTEGRATION SCALE FACTOR                            |
|     N2   = 0   (DFLT)                                          |
|          = -2 - +2                                             |
 ----------------------------------------------------------------
```

5.3.13 AXIS DEFINITION COMMAND

```
 ----------------------------------------------------------------
|     MODAL ANIMATION COMMAND (ENHANCED)                         |
|----------------------------------------------------------------|
|     COMMAND FUNCTION:    AXIS DEFINITION COMMAND               |
|----------------------------------------------------------------|
|     COMMAND MNEMONIC:    AD                                    |
|----------------------------------------------------------------|
|     HP-5451 KEYBOARD:    NONE                                  |
|----------------------------------------------------------------|
|     N1   = VERTICAL AXIS OF SCREEN                             |
|          = -3 - +3                                             |
|                                                                |
|     N2   = FIRST FRAME NUMBER                                  |
|                                                                |
|     N3   = LAST FRAME NUMBER                                   |
 ----------------------------------------------------------------
```

5.3.14 SINGLE FRAME COMMAND

```
 ----------------------------------------------------------------
|     MODAL ANIMATION COMMAND (ENHANCED)                         |
|----------------------------------------------------------------|
|     COMMAND FUNCTION:    SINGLE MODAL VECTOR DISPLAY           |
|----------------------------------------------------------------|
|     COMMAND MNEMONIC:    SI                                    |
|----------------------------------------------------------------|
|     HP-5451 KEYBOARD:    NONE                                  |
|----------------------------------------------------------------|
|     N1   = ACTIVE MODAL VECTOR NUMBER                          |
|          = 1 - 2                                               |
 ----------------------------------------------------------------
```

5.3.15 DUAL FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	DUAL MODAL VECTOR DISPLAY
COMMAND MNEMONIC:	DU
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.16 QUAD FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	QUAD MODAL VECTOR DISPLAY
COMMAND MNEMONIC:	QD
HP-5451 KEYBOARD:	NONE
N1 = ACTIVE MODAL VECTOR NUMBER = 1 - 2	

5.3.17 PAUSE ANIMATION COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	PAUSE ANIMATION
COMMAND MNEMONIC:	PA
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.18 CONTINUE ANIMATION COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	CONTINUE ANIMATION
COMMAND MNEMONIC:	CO
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.19 SINGLE STEP ANIMATION COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	SINGLE STEP ANIMATION - WHEN IN PAUSE MODE
COMMAND MNEMONIC:	SS
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.20 PERSPECTIVE VIEW COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	PERSPECTIVE VIEW
COMMAND MNEMONIC:	PE
HP-5451 KEYBOARD:	NONE
N1 = DISTANCE FROM OBJECT	

5.3.21 COMPONENT DEFINITION COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	COMPONENT DEFINITION
COMMAND MNEMONIC:	CD
HP-5451 KEYBOARD:	NONE
PARAMETERS ENTERED INTERACTIVELY	

5.3.22 ADD FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	ADD FRAME
COMMAND MNEMONIC:	AF
HP-5451 KEYBOARD:	NONE

```
N1  = ACTIVE MODAL VECTOR NUMBER (1-2)
N2  = WINDOW NUMBER (1-7)
    = 1   FULL SCREEN
    = 2   LEFT HALF SCREEN
    = 3   RIGHT HALF SCREEN
    = 4   TOP LEFT QUARTER SCREEN
    = 5   TOP RIGHT QUARTER SCREEN
    = 6   BOTTOM LEFT QUARTER SCREEN
    = 7   BOTTOM RIGHT QUARTER SCREEN
N3  = DISPLAY FORMAT (1-4)
N4  = VIEW FORMAT (1-10)
    = 1,2,3 PRINCIPLE VIEWS
    = 4-10  USER VIEWS
N5  = AXIS DEFINITION (1-3)
```

5.3.23 REMOVE FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	REMOVE LAST FRAME ADDED WITH 'AF'
COMMAND MNEMONIC:	RF
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.24 CHANGE FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	CHANGE FRAME
COMMAND MNEMONIC:	CF
HP-5451 KEYBOARD:	NONE

```
N1  = ACTIVE MODAL VECTOR NUMBER (1-2)
N2  = WINDOW NUMBER (1-7)
    = 1  FULL SCREEN
    = 2  RIGHT HALF SCREEN
    = 3  LEFT HALF SCREEN
    = 4  TOP RIGHT QUARTER SCREEN
    = 5  TOP LEFT QUARTER SCREEN
    = 6  BOTTOM RIGHT QUARTER SCREEN
    = 7  BOTTOM LEFT QUARTER SCREEN
N3  = DISPLAY FORMAT (1-4)
N4  = VIEW FORMAT (1-10)
    = 1,2,3 PRINCIPLE VIEWS
    = 4-10  USER VIEWS
N5  = AXIS DEFINITION (1-3)
N6  = FRAME NUMBER
```

5.3.25 PRINT FRAME COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	PRINT FRAME
COMMAND MNEMONIC:	PF
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

5.3.26 EXIT COMMAND

MODAL ANIMATION COMMAND (ENHANCED)	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

6. MODAL PLOT MODULE

6.1 OVERVIEW

The Modal Plot Module is actually a number of separate modules, one for each plotter present or required in the current RTE system. This structure allows only the modules to be loaded that will be needed for output; the overhead of the other Modal Plot Modules is only present if the plot devices are present. In general, the Modal Plot Module allows any frame of the current view of the animated modal vector to be plotted to the plot device specified. The annotation of the plot with a standard border, current test identification and frequency can be added to the plot if required. In order to document the point numbers with respect to the spatial description of the test structure, the Point Number Command can be toggled on for all points or a sequence of points.

6.2 COMMAND SUMMARY

The following is a list of the commands that are available from the Modal Plot Monitor:

```
-------------------------------------------------------------
|    SUMMARY OF MODAL PLOT COMMANDS                          |
|------------------------------------------------------------|
|    PL      PLOT MODAL VECTOR                               |
|    AN      ANNOTATE PLOT                                   |
|    PT      NUMBER POINTS                                   |
|    LT      LINE TYPE                                       |
|    LA      LABEL PLOT                                      |
|    EX      PROGRAM EXIT                                    |
|    ??      COMMAND SUMMARY                                 |
-------------------------------------------------------------
```

6.3 PLOT MODAL DISPLAY COMMAND

```
-------------------------------------------------------------
|    MODAL PLOT COMMAND                                      |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   PLOT MODAL VECTOR                   |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   PL                                  |
|------------------------------------------------------------|
|    HP-5451 KEYBOARD:   ANALOG OUT BUTTON (Bb)              |
|------------------------------------------------------------|
|    N1   = FRAME OF MOTION TO BE PLOTTED                    |
|         = 0      UNDEFORMED DISPLAY                        |
|         = 1-20   DEFORMED DISPLAY                          |
|         < 0      MULTIPLE DEFORMED POSITIONS               |
|    N2   = PEN NUMBER (HP-IB PLOTTERS ONLY)                 |
|                                                            |
|    BIT 14 WILL ABORT PLOTTING (NOT AVAIL. ON TEK PLOTTING).|
-------------------------------------------------------------
```

6.4 ANNOTATE PLOT COMMAND

MODAL PLOT COMMAND	
COMMAND FUNCTION:	ANNOTATE PLOT WITH BORDER, TEST IDENTIFICATION, AND FREQUENCY
COMMAND MNEMONIC:	AN
HP-5451 KEYBOARD:	LIST BUTTON (/L)
NO PARAMETERS REQUIRED	

6.5 POINT NUMBER LABEL COMMAND

MODAL PLOT COMMAND	
COMMAND FUNCTION:	ANNOTATE UNDEFORMED PLOT WITH POINT NUMBERS
COMMAND MNEMONIC:	PT
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
N1 = FIRST POINT NUMBER N2 = LAST POINT NUMBER N3 = X OFFSET N4 = Y OFFSET N5 = CHARACTER SIZE (NOT AVAILABLE ON TEK PLOTTING) IF N1,N2 ARE DEFAULTED, ALL POINTS WILL BE LABELED. IF N3-N5 ARE NOT ENTERED, DEFAULT VALUES WILL BE USED.	

6.6 LINE TYPE COMMAND

MODAL PLOT COMMAND	
COMMAND FUNCTION:	LINE TYPE
COMMAND MNEMONIC:	LT
HP-5451 KEYBOARD:	NONE
N1 = LINE TYPE CODE = 0 SOLID LINES (DEFAULT) = 1 DOTTED LINES	

6.7 LABEL PLOT COMMAND

MODAL PLOT COMMAND	
COMMAND FUNCTION:	LABEL PLOT
COMMAND MNEMONIC:	LA
HP-5451 KEYBOARD:	LABEL BUTTON (Lb)

```
N1  = X POSITION OF LABEL
N2  = Y POSITION OF LABEL
N3  = CHARACTER SIZE (NOT AVAILABLE ON TEK PLOTTING)
N4  = PEN NUMBER (HP-IB PLOTTERS ONLY)

THE LABEL WILL BE REQUESTED INTERACTIVELY.  IF N3,N4
ARE NOT ENTERED, DEFAULT VALUES WILL BE USED.

FOR HP-IB PLOTTERS, A LINE FEED IS GENERATED UPON THE
ENTRY OF A CARRIAGE RETURN.  ENTRY IS TERMINATED BY A
DECIMAL POINT AS THE FIRST CHARACTER OF THE LINE.
```

Upon issuing the Label Plot Command, the program will compute the maximum and minimum limits for X and Y label positions and report this to the user. The user must then enter the label position based upon this information. The pen will immediately move to this position before the label is to be entered. If the plot device has manual pen position control, the label position can be adjusted before the label is entered.

6.8 EXIT COMMAND

MODAL PLOT COMMAND	
COMMAND FUNCTION:	EXIT TO CONTROL OF MODAL DISPLAY MONITOR
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN BUTTON (<b)
NO PARAMETERS REQUIRED	

7. PARAMETER ESTIMATION MODULE

7.1 OVERVIEW

The Parameter Estimation Module of the RTE Modal Program is designed to automatically analyze data, for the current data set, to determine modal parameters; damped natural frequencies, modal damping values and real or complex modal coefficients. The module is subdivided into two tasks; frequency/damping estimation and modal vector estimation. Within these tasks are algorithms for single degree-of-freedom (SDOF) or multiple degree-of-freedom (MDOF) parameter estimation. The SDOF algorithms are simple computationally, but do not provide global modal parameters. The MDOF algorithms are, in general, more complex computationally, but use information from multiple measurements; and for the advanced algorithms, multiple references, to provide global modal parameters. An exception to the MDOF global modal parameters is the linear Least-Squares Time Domain program which calculates global frequency and damping values but not global modal vectors.

7.2 MEASUREMENT CONSIDERATIONS

In order to identify the modes of vibration of a structure, it is necessary that frequency response data be measured on the structure in such a way that the resulting data set is sufficient to identify all modes of interest at all points of interest. The RTE Modal Program requires that these measurements be made between fixed input points (the point at which the force is applied) and multiple response points (the point at which the response to the input force is measured), or fixed response points and multiple input points.

The frequency response measurements may be made using transient or continuous inputs and baseband or Band Selectable Fourier Analysis. The type of structure, testing convenience and desired quality of the results are the prime consideration in making choices between them. For HP-5451 users, any of the frequency response Keyboard Programs documented in the HP-5451 Operating Manual may be modified to measure the required data. However, since the measurement process is using most of the available program space, it will usually only be possible to annotate and store the frequency response data to the disk for later processing. For HP-1000-A900 F-Monitor users, any of the Command Programs documented in the F-Monitor Operating Manual may be used.

7.3 DATA SET CONSIDERATIONS

The data set to be accessed by the RTE Modal Program is defined by information stored in the header that is automatically stored to disc with every data record by the measurement system. In the standard HP-5451-B/C Fourier System this measurement header information is stored in File Nine record. The header record contains information relative to the test constraints as established prior to the acquisition of the measurements by the User Program 889 or the RTE Modal Program Data Setup Command, 'DS', for HP-5451-B/C Fourier systems, or by the measurement parameters in the FF monitor for the LMS F-monitor system.

This information includes test identification, date, calibration, frequency range, response and reference excitation position and direction, as well as, other documentation useful for later annotation of the test data. As any module in the RTE Modal Program accesses a disc record, a comparison is made between the header information and the information required by the RTE Modal Program. If a match is found on all pertinent documentation, the data record is included in the measurement directory. If a match is not found, the data record is completely ignored.

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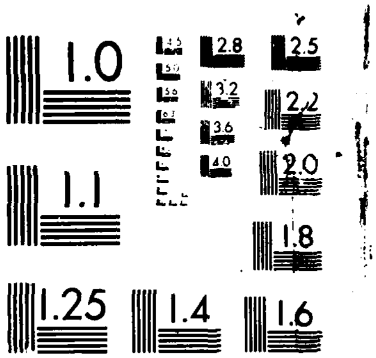

MICROCOPY RESOLUTION TEST CHA
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7.4 MEASUREMENT DATABASE OPTIONS

The RTE Modal Program is versatile in that measurements from a variety of sources, in a number of formats, may be analyzed. The previously acquired measurements are stored to an appropriate device, File One of the Mass Storage area of a HP-5451 disc, or a logical unit of a HP-CS-80 disc. The way in which measurements are placed on the disc, or in other words, the location of the measurements, varies with the type of system that is used to store the measurements. The three measurement formats supported are: the standard FMTXX structure used by Hewlett-Packard, the SMS FMTXX structure, and a format used by LMS for the HP-CS-80 disc. The Measurement Header Command defines the form of the data annotation used by the current measurement database. Measurement headers supported are: HP-5423-A, HP-5451-B, HP-5451-C (Cincinnati, Leuven, SMS Modal 4.0), and F-Monitor (LMS).

In summary, the Measurement Format Command, 'MF', and Measurement Header Command, 'MH', define the database for the measurements to be analyzed. If it is desired to analyze measurements from a source different than the installed default configuration, it will be necessary to execute 'MF' and/or the 'MH' command. In changing the default configuration, care must be exercised to select the proper combination of these commands in order for the program to access the data.

7.5 MEASUREMENT DIRECTORY

Note that the data set is identified via the information accumulated by the Run Log Command, Section 3.10. For the parameter estimation to proceed, the measurement directory MUST first be formulated by the Run Log 3 Command.

7.6 FREQUENCY/DAMPING AND MODAL VECTOR OPTIONS

The following table lists the modal coefficient methods that can be used for each frequency/damping method. That is, for the frequency/damping methods listed in the left column, any of the methods in the right column may be used for determining modal vectors.

TABLE 7-1. Allowable Modal Vector Methods for Frequency/Damping Methods

Frequency/Damping Method	Allowable Modal Vector Method
Manual Cursor	Complex Magnitude Imaginary Part Real Part Real Circle Fit Complex Circle Fit
Least-Squares Time Domain	Complex Magnitude Imaginary Part Real Part Real Circle Fit Complex Circle Fit Least-Squares Frequency Domain
Polyreference Time Domain Polyreference Frequency Domain Orthogonal Polynomial Modified Ibrahim Polyreference	Complex Magnitude Imaginary Part Real Part Real Circle Fit Complex Circle Fit Least-Squares Frequency Domain Polyreference Time Domain Polyreference Frequency Domain
Ibrahim Polyreference (1)	Complex Magnitude Imaginary Part Real Part Real Circle Fit Complex Circle Fit Least-Squares Frequency Domain Ibrahim Polyreference
Multi-Mac (2)	Multi-Mac

Notes:

1) Ibrahim Polyreference is a single stage solution process for all parameters (frequency, damping and modal coefficients), any of the other listed modal vector methods may also be used.
2) Multi-Mac is a multiple reference method for the determination of frequency and modal coefficients, any method may be used to determine modal damping values.

8. FREQUENCY/DAMPING ESTIMATION

8.1 OVERVIEW

The task of determining damped natural frequencies can be performed using one of the following methods:

- Manual (spectral line)
- Cursor (spectral line)
- Least Squares Complex Exponential (frequency and damping)
- Polyreference Time Domain (frequency and damping)
- Polyreference Frequency domain (frequency,damping and modal vectors)
- Orthogonal Polynomial (frequency and damping)
- Multi-Mac (frequency and modal vectors)
- Modified Ibrahim Time Domain (frequency and damping)

The first two methods, manual and cursor, are single degree-of-freedom (SDOF) approximation methods. With these methods, only one frequency response function can be used at a time. Therefore, it is wise to scan at least one frequency response from all major structure components so that no important modes are inadvertently missed. Operation of the cursor automatically stores the spectral line and frequency with the designated mode.

The remaining methods; Least Squares Complex Exponential (LSCE), Polyreference Time Domain (PTD), Polyreference Frequency Domain (PFD), Orthogonal Polynomial (OP), Multi-Mac (MM), and Modified Ibrahim Time Domain (MITD), are all multiple degree-of-freedom methods. In addition, the last five methods are multi-reference methods. However, they can also be used on single reference data.

The Least Squares Complex Exponential and the Polyreference Time Domain algorithm are basically the same methods. The last one is an extension of the first one to multiple references. They are both linear least squares time domain methods based upon complex exponentials. In the process of determining the frequency and damping, any and/or all of the measurements can be involved. An additional feature of the Polyreference Time Domain, as compared with the Least Squares Complex Exponential, is that the poles in the frequency range of interest can be determined based on different numbers of degrees-of-freedom (DOF), which can be sometimes advantageous.

The Polyreference Frequency Domain, Orthogonal Polynomial, and Multi-Mac methods are frequency domain methods. They have the advantage that any arbitrary frequency window can be selected out of the measured frequency range. They can also handle frequency response function data with variable frequency spacing. The disadvantage of these methods is that they become numerically unstable for wide frequency ranges and for high numbers of modes. The Polyreference Frequency Domain algorithm estimates the damping and damped natural frequency as well as the associated modal vectors in a single process. So this technique is a one-stage technique, while for all other methods, with the exception of Multi-Mac, the modal vectors are obtained in a second stage. Multi-Mac is the only method of these three methods that does not calculate the damping. Similar to the Least Squares Complex Exponential and Polyreference Time Domain, in the Polyreference Frequency Domain all measurements, or a subset of the measurements, can be included in the estimation of frequency and damping.

The Modified Ibrahim Time Domain algorithm is similar to the Polyreference Time Domain technique. Specifically, both are time domain techniques based upon complex exponentials, but the Modified Ibrahim Time Domain has the advantage of computing fewer computational poles. However, due to the fact that more memory is needed to calculate the frequency and damping values, the algorithm may not be able to simultaneously process all measurements. Therefore, data sets containing many measurements may have to be reduced to a subset, in order to use this method.

8.1.1 GENERAL PRACTICAL CONSIDERATIONS

In most algorithms there is a request for the disc record number of a typical data record. Any representative measurement may be chosen, but in general, a driving point measurement is used. At this point, a note is made in that if the user does not wish to continue, a negative one (-1) can be entered which will cause the program to exit.

As mentioned before, the frequency domain algorithms can process frequency response functions with variable frequency spacing. In addition, the frequency bandwidth is not limited to an integer power of two, that is, the bandwidth can be chosen arbitrarily.

For all of the algorithms the location of the poles in the frequency range of interest is very important. In general, poor damping values are estimated for poles too close to the edges of the frequency range. An exception to the previous constraint is the Orthogonal Polynomial algorithm.

A difficult task in modal parameter estimation is the determination of the order of the model, or the number of degrees of freedom of the system, such that, the estimating algorithm will find all structural poles. Three features are implemented to help in the process of deciding this value; an error chart, a stabilization diagram, and a rank estimate chart. These features will provide approximate values for the order, or degree of freedom of the system, but, in general, some judgement is still necessary to determine the "best" number for acceptable frequency/damping estimates.

The time domain algorithms tend to produce more computational poles than the frequency domain algorithms. On the other hand, frequency domain methods like Multi-Mac and Polyreference Frequency Domain, which force the modal vectors to be orthogonal, tend to have difficulties estimating the correct pole values; for close coupled poles, or for very local modes.

8.1.2 ERROR AND RANK CHART

Most of the advanced algorithms use an error chart and/or a rank estimate chart, to aid the user when a decision has to be made about the order of the model. An error chart basically explains what the error will be in predicting the next point in an impulse response function, based on the information of the previous points. The number of previous points used is, in this case, related to (2 or 4 times) the estimated order, or degree-of-freedom of the model. The error chart may be interpreted in the following way. In general, the error chart will have an area where the error rolls off drastically with increasing degree-of-freedom. This area can be approximated by a straight line with a slope equal to the roll off. In addition, there will be a second part in the error chart where the error will stabilize. This range can be approximated by another straight line. The two lines will intersect each other at the approximate order of the model. For the frequency domain methods this is approximately the number of degrees-of-freedom that has to be entered in order to get a good estimate of the poles in the frequency range of interest. For the time domain methods, this value will generate, in general, a reasonable estimate for the frequency values of the poles in the frequency range of interest. However, quite often a poor estimate of the damping value of the poles will be obtained for this degree-of-freedom. But, by entering this number of degree-of-freedom an idea is obtained about the number of effective poles in the frequency range of interest. This can be helpful later on, to distinguish the real poles from the computational poles when a higher degree-of-freedom is entered in the algorithm. For the time domain methods, the best pole estimates are obtained when the number of degrees-of-freedom chosen is equal to 1.5 to 2 times the estimated order of the model.

```
                 ERROR CHART                          RANK ESTIMATE
DOF  1 @**************************  |*                   |  1
DOF  2 @**************************  |*                   |  2
DOF  3 @**************************  |*                   |  3
DOF  4 @*************************   |*                   |  4
DOF  5 @*************************   |*                   |  5
DOF  6 @******************          |*                   |  6
DOF  7 @***************             |*                   |  7
DOF  8 @***********                 |*                   |  8
DOF  9 @**********                  |*                   |  9
DOF 10 @*******                     |********************| 10
DOF 11 @******                      |*                   | 11
DOF 12 @******                      |*                   | 12
DOF 13 @******                      |*                   | 13
DOF 14 @******                      |*                   | 14
DOF 15 @*****                       |*                   | 15
DOF 16 @*****                       |**                  | 16
DOF 17 @*****                       |*                   | 17
DOF 18 @*****                       |*                   | 18
DOF 19 @****                        |*                   | 19
DOF 20 @****                        |*                   | 20
```

Figure 8-1. A typical error chart and rank estimate chart

Some algorithms provide a rank estimate chart. This chart comes from a singular-value decomposition of a matrix, which is related, or equivalent, to the system matrix. The rank of this matrix is once again equal to the order of the model. The rank estimate chart is interpreted in much the same way as the error chart (see previous paragraph).

8.1.3 MEASUREMENT DIRECTORY

The data set (ie. data records) to be used in the frequency/damping estimation is identified by the Run Log 3 Command (Section 3.10). For frequency/damping estimation to proceed, the measurement directory MUST first be formulated by the Run Log 3 Command.

8.1.4 MEASUREMENT SELECTION OPTION

A subset of the data set, identified by the Run Log 3 Command and stored in the measurement directory, can be selected in the frequency/damping estimation phase. At times it may be desirable to exclude some measurements from the data set in the frequency/damping estimation process. For example, the estimation of a mode local to a specific direction, component, or set of points would be enhanced if only the direction, component, or points active in that mode are included in the estimation process. If all measurements are included, the local mode may be dominated by another structural mode and the algorithm might be unable to detect the local mode, or estimate it accurately. In the case of multiple references, a single reference may be excluded from the estimation process and instead used to synthesize frequency response functions in order to verify the modal model. For these and many other reasons, the measurement selection option is implemented. The measurement selection consists of the following options:

- Measurement Direction
- Components
- Point Numbers
- References

If a subset of the measurements is desired, one of the four options can be invoked. With the first three options, parameters can be input individually (N1), or sequentially (N1,N2) for all frequency/damping methods. The selection of references to be used is somewhat different for the multiple reference algorithms, but similar to the first three options for single degree-of-freedom and the Least-Squares Time Domain methods. In all cases, only the parameters entered for the option chosen are used to form the subset and the other options remain unchanged, unless they too are invoked. In other words, if the point number option is selected, only the point numbers entered would be used to form the subset (all other point numbers are excluded), but all directions, components and references remain active. To exit an option, zero is entered. "Continue" is selected after selecting the desired subset.

By using the measurement selection option, a subset of the measurements defined in the measurement directory can be selected for the estimation of frequency and damping values. This subset remains active only for the Frequency/Damping Estimation Monitor and all measurements in the measurement directory remain active for the estimation of modal coefficients, except for the Polyreference Frequency Domain method. For this method, the modal vectors will be determined ONLY for the same subset, since all modal parameters are determined in a single solution process.

8.2 MANUAL DETERMINATION

With this single degree-of-freedom method, a data record of representative data will be requested followed by a request for mode and zeta (percent of critical damping). After this, the spectral line number can be entered from the terminal. The information concerning damping is entered for reference purposes only; this value does not affect the computation of the modal coefficients, since the modal coefficient is always stored in the units of the data, proportional to the equivalent out-of-phase component.

Once the information is stored, the user is prompted for the next mode number and zeta. To exit, a mode number of zero is entered.

8.2.1 COMMAND SUMMARY

The following data display commands are available for the manual determination method. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

8.3 CURSOR DETERMINATION

In this single degree-of-freedom method, a request for a representative data record is followed by an option of manual mode , or automatic mode.

8.3.1 MANUAL MODE

When the manual mode is selected, a request is made for the mode number and zeta. After this data is entered, the frequency response function data is displayed with the curser superimposed. At this point, by use of the curser commands, a spectral line is selected as the damped natural frequency. This process is repeated for each mode. A mode can be redefined by entering its particular mode number and zeta value. To terminate, a mode number of zero is entered.

8.3.2 COMMAND SUMMARY FOR MANUAL MODE

The following data display commands are available for the manual cursor determination method. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

8.3.3 AUTOMATIC MODE

When this option is selected, the frequency response function data is displayed with cursers superimposed on every peak found in the frequency response function. The whole selection can be accepted by entering, "OK". A subset of these poles can be obtained by deleting the unwanted poles one by one. However, there are two additional options that aid in obtaining a subset of the poles. First, a subset can be obtained based on the slope around the pole by using the Choose Slope Command, "CS". Secondly, a selection can be made based on a comparison of the amplitude of the frequency response function at the different pole locations with the CLear modes Command, "CL". Of course, all three commands can be used in order to obtain a subset.

8.3.4 COMMAND SUMMARY FOR THE AUTOMATIC MODE

The following is a list of commands that are available from the Automatic Peak Search Monitor. Further explanation of these commands is in Section 8.10.

SUMMARY OF COMMANDS FOR AUTOMATIC PEAK SEARCH	
AD	ADd cursor
CL	CLear modes below level
CS	Choose modes according to Slope
DL	Delete cursor
EX	EXit the program
IN	INsert cursor
LG	Display Log amplitude
LL	Logical List device
MO	MOve cursor
OK	Accept frequency estimates
PR	Write or PRint cursor values
TR	Display rectangular
??	Help features

8.4 LEAST SQUARES TIME DOMAIN TECHNIQUE

8.4.1 OVERVIEW

This method calculates the frequency/damping values for the system in certain frequency ranges of interest. The first request will be made for a representative data record, followed by a request of starting spectral line (manual or cursor entry) and number of spectral lines that are to be involved in the calculation. The range of interest is defined by starting spectral lines and number of spectral lines to be used (64, 128, 256, 512).

After the initialization process, a request is made to make a selection between :

- Automoment of the F.R.F
- Automoment of the F.R.F (real)
- Automoment of the F.R.F (imaginary)

This information is used only in the calculation of the accumulated autopower spectrum. The first option, calculates the accumulated autopower spectrum by multiplying the frequency response function by its complex conjugate. For the two other options, the accumulated autopower spectrum is calculated by squaring the real, or imaginary, part of the frequency response function. The two last options have the advantage that they tend to produce more pronounced peaks in the autopower spectrum and might therefore be more helpful in the determination of the number of degrees of freedom in the frequency range of interest. The use of the real part of the frequency response function in calculating the automoment is for velocity data, where as, the use of the imaginary part is for displacement, or acceleration data.

Because the method uses many measurements, the range of data records to be used by the method MUST have been previously defined in the Measurement Table formed by the RUN LOG 3 Command (Section 3.10). The number of samples to be used from each data record will be calculated based upon the actual number of records available. This value may be altered (larger but not less than 60) if required.

After the error chart is plotted, the first command that has to be issued is the Degree-of-Freedom command, "DF".

In addition to the error chart, a stabilization diagram can be used in order to determine the optimal degree-of-freedom for the pole calculation. The diagram compares the estimated pole values for the current degree-of-freedom with the pole values found for the previous degree-of-freedom. The optimal degree-of-freedom to use, to calculate the pole values, is the one for which the frequency and damping values fall for the first time within the entered tolerances.

8.4.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

The following is a list of commands that are available for the Least Squares Time Domain Frequency/Damping Estimation Monitor:

SUMMARY OF LSTD FREQUENCY/DAMPING ESTIMATION COMMANDS	
DF	SET NUMBER OF DEGREES OF FREEDOM
DL	DELETE DEGREES OF FREEDOM
EX	PROGRAM EXIT
LG	DISPLAY IN LOG FORMAT
LL	LOGICAL LIST DEVICE
OK	ACCEPT FREQUENCY/DAMPING ESTIMATES
PR	PRINT FREQUENCY/DAMPING ESTIMATES
RT	DISPLAY IN RECTANGULAR FORMAT
SD	DISPLAY STABILITY DIAGRAM
??	COMMAND SUMMARY

8.4.3 DEGREE OF FREEDOM COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	CHOOSE APPROXIMATE NUMBER OF DEGREES OF FREEDOM
COMMAND MNEMONIC:	DF
HP-5451 KEYBOARD:	POWER SPECTRUM BUTTON (SP)
N1 = NUMBER OF DEGREES OF FREEDOM FOR: N1 < N2 DEGREES OF FREEDOM, REPEATS ERROR CHART FROM N1 TO N2 (NO CALCULATION OF POLES)	

If the parameter N1 is entered, the system poles will be calculated based upon N1 degrees of freedom. If the "DF" Command is repeated with parameters N1 and N2, where N1 is less than N2, the error chart is printed from N1 degrees of freedom, to N2 degrees of freedom.

8.4.4 DELETE COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DELETE A SPECIFIC DEGREE OF FREEDOM
COMMAND MNEMONIC:	DL
HP-5451 KEYBOARD:	DELETE BUTTON (/D)
N1 = FIRST DEGREE OF FREEDOM TO BE REMOVED N2 = LAST DEGREE OF FREEDOM TO BE REMOVED	

8.4.5 EXIT COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

8.4.6 LOG MAGNITUDE COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC:	LG
HP-5451 KEYBOARD:	LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED	

8.4.7 LOGICAL LIST COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER	

8.4.8 ACCEPT COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT FREQUENCY/DAMPING ESTIMATES
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

8.4.9 PRINT COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL FREQUENCY AND DAMPING ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

8.4.10 RECTANGULAR COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN REAL/IMAG FORMAT
COMMAND MNEMONIC:	RT
HP-5451 KEYBOARD:	RECTANGULAR BUTTON (TR)
NO PARAMETERS REQUIRED	

8.4.11 STABILITY COMMAND

LSTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY STABILITY DIAGRAM
COMMAND MNEMONIC:	SD N1 N2
HP-5451 KEYBOARD:	NONE
N1 = FREQUENCY TOLERANCE (DEFAULT 1%) N2 = DAMPING TOLERANCE (DEFAULT 5%)	

8.4.12 OPERATIONAL EXAMPLE

```
**  PE

ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
          1)  MANUAL
          2)  CURSOR
          3)  LEAST SQUARES TIME DOMAIN
          4)  POLYREFERENCE TIME DOMAIN
          5)  POLYREFERENCE FREQ DOMAIN
          6)  ORTHOGONAL POLYNOMIAL
          7)  IBRAHIM POLYREFERENCE
          8)  MODIFIED IBRAHIM POLYREFERENCE
          9)  MULTI-MAC
          10) CURRENTLY SELECTED VALUES
          11) RETURN TO MONITOR

3

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION?  YES

DISK RECORD NUMBER OF TYPICAL DATA ?  1
```

```
MEASUREMENT INFORMATION:

REFERENCE POINT:                9
REFERENCE DIRECTION:            1
RESPONSE POINT:                 9
RESPONSE DIRECTION:            -1
ZOOM CODE:                     Z0
DATA TYPE CODE:                23
MEASUREMENT SOURCE:             3
FREQUENCY RESOLUTION:   1.953125
MINIMUM FREQUENCY:         0.000
MAXIMUM FREQUENCY:      1000.000
```

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

```
ENTER FREQUENCY BANDWIDTH (CHANNELS):
          64
          128
          256
          512

512

ENTER INITIAL CURSER CHANNEL NUMBER:  150

USE CURSER TO DENOTE FREQUENCY BANDWIDTH
```

At this point a plot of the Frequency Response Function is displayed.

```
P* OK

STARTING FREQUENCY:            0.0000
ENDING FREQUENCY:           1024.0000
CHANNEL SHIFT:                      0
CHANNEL BANDWIDTH:                512

FREQUENCY PARAMETERS ACCEPTABLE? YES

NUMBER OF VALID MEASUREMENTS:        10
NUMBER OF OVERLAPS PER MEASUREMENT:  20
```

The number of overlaps given is the approximate optimum number of overlaps for the algorithm. This optimum number should be entered below.

```
ENTER NUMBER OF OVERLAPS PER MEASUREMENT:  20

REFERENCE:  1   POINT:  XX   DIRECTION:  XX   RECORD:  XX
```

The processed data records are displayed.

```
DOF  1   ERROR =.705973E+00 ********************************
DOF  2   ERROR =.317572E+00 *******************************
DOF  3   ERROR =.462351E-01 ****************************
DOF  4   ERROR =.146795E-01 **************************
DOF  5   ERROR =.482038E-03 ********************
DOF  6   ERROR =.126725E-03 *****************
DOF  7   ERROR =.283145E-04 ***************
DOF  8   ERROR =.183009E-04 **************
DOF  9   ERROR =.802821E-05 *************
DOF 10   ERROR =.535214E-05 ************
DOF 11   ERROR =.310769E-05 ***********
DOF 12   ERROR =.293504E-05 ***********
DOF 13   ERROR =.224445E-05 **********
DOF 14   ERROR =.172650E-05 **********
DOF 15   ERROR =.155385E-05 **********
DOF 16   ERROR =.164017E-05 **********
DOF 17   ERROR =.112222E-05 *********
DOF 18   ERROR =.189915E-05 **********
DOF 19   ERROR =.431624E-06 ********
DOF 20   ERROR =.431624E-06 ********
```

The above error graph is used to determine the optimum number of degrees of freedom for a given set of measurements. An optimum number of degrees of freedom is the fewest degrees of freedom for which additional degrees result in only slight reductions of error. For our case, 8 looks like a good starting value.

P* DF 8

```
DOF   8   ERROR =     .183009E-04 *******************
MODE  FREQUENCY(HZ) DAMPING FACTOR(HZ)    ZETA (%)

  1       7.596             12.902        86.1724850
  2     272.166              3.210         1.1793180
  3     326.968            217.379        55.3641820
  4     495.077              3.202          .6466906
  5     738.875             12.756         1.7262189
  6     854.804              4.647          .5436792
  7     883.509              4.186          .4737393
  8    1024.000            140.495        13.5928940
```

P* DF 7

DOF 7 ERROR = .283145E-04 ********************

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA (%)
1	10.973	9.711	66.2752690
2	272.167	3.203	1.1766465
3	495.056	3.200	.6463064
4	734.508	36.367	4.9451218
5	854.201	4.374	.5120325
6	884.635	4.066	.4596449
7	1024.000	244.875	23.2578320

P* DF 6

DOF 6 ERROR = .126725E-03 **********************

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA (%)
1	272.215	3.214	1.1807768
2	495.066	3.164	.6391371
3	853.391	5.433	.6366818
4	884.041	4.255	.4812948
5	1024.000	275.370	25.9689900
6	1024.000	677.223	55.1626360

The optimum number of degrees of freedom is the lowest number for which the frequency and damping values of all structural poles have stabilized. That is, the smallest degree of freedom for which a higher degree of freedom causes only slight variance in frequencies and damping values for all structural poles. For this example 7 degrees of freedom will be selected. There are several computational poles found for 7 degrees of freedom. They may be deleted if a frequency domain modal vector estimation is used, otherwise, they may be kept as residual modes.

P* DF 7

DOF 7 ERROR = .283145E-04 ********************

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA (%)
1	10.973	9.711	66.2752690
2	272.167	3.203	1.1766465
3	495.056	3.200	.6463064
4	734.508	36.367	4.9451218
5	854.201	4.374	.5120325
6	884.635	4.066	.4596449
7	1024.000	244.875	23.2578320

P* OK

8.5 POLYREFERENCE TIME DOMAIN TECHNIQUE

8.5.1 OVERVIEW

The initialization process for this algorithm is identical to the Least Squares Time Domain algorithm. The only exception is, the option that allows the user to redefine which points of the impulse response function will be used for the pole calculation. By default the first 80 samples of the impulse response function are used.

After the data have been processed, the algorithm displays, simultaneously, an error chart and a rank estimate chart. The use of these two plots have been explained previously (Section 8.1.2). Upon execution of the Degree-of-Freedom Command, "DF", the program comes back with two tables, a temporary table (left) and a final table (right). The estimated pole values for the just entered degrees-of-freedom are displayed in the temporary table. These values can be placed in the final table by the MOve Command, "MO". This gives the user the flexibility to calculate the different poles with a different degree-of-freedom and store these values in the final table. The calculated poles are indicated by cursers superimposed on the accumulated power spectrum on the display unit. However, the cursors do not all have the same length. The computational poles will have, in general, a small cursor and the structural poles, a large cursor. This is an aid in distinguishing the computational poles from the structural poles. However, it should be obvious to the user that this is not an absolute criteria in the judgement if a pole is a structural or computational pole.

8.5.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

The following is a list of commands that are available from the Polyreference Time Domain Frequency and Damping Estimation Monitor :

SUMMARY OF PTD FREQUENCY/DAMPING ESTIMATION COMMANDS	
DF	SET NUMBER OF DEGREES OF FREEDOM
DL	DELETE DEGREES OF FREEDOM
EX	PROGRAM EXIT
IN	INTENSIFY TEMPORARY POLE
LG	DISPLAY IN LOG FORMAT
LL	LOGICAL LIST DEVICE
MO	MOVE ENTRY FROM TEMPORARY TO FINAL TABLE
OK	ACCEPT FREQUENCY/DAMPING ESTIMATES
PR	PRINT FREQUENCY/DAMPING ESTIMATES
RT	DISPLAY IN RECTANGULAR FORMAT
SD	DISPLAY STABILITY DIAGRAM
??	COMMAND SUMMARY

8.5.3 DEGREE OF FREEDOM COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	CHOOSE APPROXIMATE NUMBER OF DEGREES OF FREEDOM
COMMAND MNEMONIC:	DF
HP-5451 KEYBOARD:	POWER SPECTRUM BUTTON (SP)
N1 = NUMBER OF DEGREES OF FREEDOM	

8.5.4 DELETE COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DELETE A SPECIFIC DEGREE OF FREEDOM
COMMAND MNEMONIC:	DL
HP-5451 KEYBOARD:	DELETE BUTTON (/D)
N1 = FIRST DEGREE OF FREEDOM TO BE REMOVED N2 = LAST DEGREE OF FREEDOM TO BE REMOVED	

This command will only delete entries in the final table.

8.5.5 EXIT COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

8.5.6 INTENSIFY COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	INTENSIFY TEMPORARY POLE
COMMAND MNEMONIC:	IN
HP-5451 KEYBOARD:	NONE
N1 = TEMPORARY POLE NO.	

This command will only intensify entries in the temporary table.

8.5.7 LOG MAGNITUDE COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC:	LG
HP-5451 KEYBOARD:	LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED	

8.5.8 LOGICAL LIST COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER	

8.5.9 MOVE COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	MOVE ENTRY FROM THE TEMPORARY TABLE TO THE FINAL TABLE
COMMAND MNEMONIC:	MO N1 N2 N3
HP-5451 KEYBOARD:	NONE
N1 = ENTRY OF THE TEMPORARY TABLE N2 = POSITION IN THE FINAL TABLE N3 = REPETITION FACTOR (DEFAULT 1)	

This command allows the user to move the estimated pole values from the temporary table to the final table. There is an option for overwriting the final table, for the case when a pole estimate already resides in the position where a new estimate is to be entered. The modes in the final table do not have to be in increasing order, neither, do all the positions have to contain pole estimates. Upon exiting the program, the poles will be automatically ordered in increasing frequency and the zero entries will be deleted.

8.5.10 ACCEPT COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT FREQUENCY/DAMPING ESTIMATES
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

8.5.11 PRINT COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL FREQUENCY AND DAMPING ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

8.5.12 RECTANGULAR COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN REAL/IMAG FORMAT
COMMAND MNEMONIC:	RT
HP-5451 KEYBOARD:	RECTANGULAR BUTTON (TR)
NO PARAMETERS REQUIRED	

8.5.13 STABILITY DIAGRAM COMMAND

PTD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY STABILITY DIAGRAM
COMMAND MNEMONIC:	SD N1 N2
HP-5451 KEYBOARD:	NONE
N1 = FREQUENCY TOLERANCE (DEFAULT 1%) N2 = DAMPING TOLERANCE (DEFAULT 5%)	

8.5.14 OPERATIONAL EXAMPLE

```
** PE

ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
          1)  MANUAL
          2)  CURSOR
          3)  LEAST SQUARES TIME DOMAIN
          4)  POLYREFERENCE TIME DOMAIN
          5)  POLYREFERENCE FREQ DOMAIN
          6)  ORTHOGONAL POLYNOMIAL
          7)  IBRAHIM POLYREFERENCE
          8)  MODIFIED IBRAHIM POLYREFERENCE
          9)  MULTI-MAC
          10) CURRENTLY SELECTED VALUES
          11) RETURN TO MONITOR

4

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION ? YE

DISC RECORD NUMBER OF TYPICAL DATA? 3000

MEASUREMENT INFORMATION:

REFERENCE POINT:                  1
REFERENCE DIRECTION:             -2
RESPONSE POINT:                   1
RESPONSE DIRECTION:               2
ZOOM CODE:                       Z0
DATA TYPE CODE:                  23
MEASUREMENT SOURCE:               3
FREQUENCY RESOLUTION:      5.000000
MINIMUM FREQUENCY:            0.000
MAXIMUM FREQUENCY:         2560.000
```

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

```
ENTER FREQUENCY BANDWIDTH (SPECTRAL LINES ):
         64
         128
         256
         512

128

ENTER INITIAL CURSER SPECTRAL LINE NUMBER: 50

USE CURSER TO DENOTE FREQUENCY BANDWIDTH
```

At this point a plot of the Frequency Response Function is displayed.

```
P*  OK

 STARTING FREQUENCY:          250.0000
 ENDING FREQUENCY:            890.0000
 SPECTRAL LINE SHIFT:               50
 SPECTRAL LINE BANDWIDTH:          128

FREQUENCY PARAMETERS ACCEPTABLE ? YE

EXPONENTIAL WINDOW USED ON RESPONSE DATA? NO
```

If the bandwidth has been selected previously, the command, "PE 1 4 2", can be executed out of the Modal Monitor. The algorithm will immediately proceed to this point.

```
CURRENT REFERENCE INFORMATION:

REFERENCE      POINT NUMBER     DIRECTION

    1                1             -2
    2                6             -2
    3                8             -2
    4               12             -2
    5               17             -2
    6               22             -2

 SELECTED REFERENCES OK ? * YE
```

A subset of the references can be selected by answering NO.

```
 ENTER OPTION FOR MEASUREMENT SELECTION:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
4

 NUMBER OF VALID MEASUREMENTS:          216

 TIME SHIFT :    0
 NUMBER OF USED TIME SAMPLES :  80

 WISH TO MODIFY DEFAULT VALUES ?  NO
```

To redefine the part of the impulse response function that will be used in the calculations, answer YES.

```
 RECORD      FRF S TO GO      VALID # OF FRF S
```

```
3000            215                     216
```

The processed records are display here.

```
                ERROR CHART                          RANK ESTIMATE
DOF  3 @********************  |*                      |  1
DOF  3 @********************  |*                      |  2
DOF  3 @********************  |*                      |  3
DOF  6 @************          |*                      |  4
DOF  6 @************          |*                      |  5
DOF  6 @************          |*                      |  6
DOF  9 @********              |*                      |  7
DOF  9 @*******               |*                      |  8
DOF  9 @********              |*                      |  9
DOF 12 @******                |***********************| 10
DOF 12 @******                |*                      | 11
DOF 12 @******                |*                      | 12
DOF 15 @*****                 |*                      | 13
DOF 15 @*****                 |*                      | 14
DOF 15 @*****                 |*                      | 15
DOF 18 @****                  |*                      | 16
DOF 18 @****                  |*                      | 17
DOF 18 @****                  |*                      | 18
DOF 21 @***                   |*                      | 19
DOF 21 @***                   |*                      | 20
```

When a valid correlation matrix exists in memory, the command "PE 1 4 3", can be executed out of the Modal Monitor. The algorithm will immediately proceed to this point. After the error chart and rank estimate is displayed, the degree-of-freedom is selected by executing the "DF" command. Notice also, that on the left, the degree-of-freedom (DOF) numbers increase in increments of 3. This is a function of the number of references that are used and means that for this case, "DF 13", "DF 14" and "DF 15" will give the same estimated pole values.

```
P*  DF 10
```

	TEMPORARY TABLE			FINAL TABLE			
MODE	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	362.684	3.100	.85481	0.00	0.00	0.00	1
2	364.010	3.395	.93252	0.00	0.00	0.00	2
3	556.978	2.982	.53533	0.00	0.00	0.00	3
4	761.092	4.883	.64163	0.00	0.00	0.00	4
5	764.168	2.558	.33474	0.00	0.00	0.00	5
6	838.658	78.639	9.33579	0.00	0.00	0.00	6
7	877.692	168.365	18.83924	0.00	0.00	0.00	7

Notice that the structural poles can be easily distinguished from the computational poles by the estimated values of damping. Although 10 degrees of freedom are requested, only 7 modes are found. This is because nonphysical poles; poles with negative damping (unstable poles), or poles that are not complex conjugate roots, are automatically deleted.

P* DF 18

MODE	TEMPORARY TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FINAL TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	257.064	72.742	27.22817	0.00	0.00	0.00	1
2	357.325	76.540	20.94526	0.00	0.00	0.00	2
3	362.319	3.043	.83981	0.00	0.00	0.00	3
4	363.627	3.366	.92577	0.00	0.00	0.00	4
5	381.165	220.061	49.99918	0.00	0.00	0.00	5
6	557.052	2.928	.52562	0.00	0.00	0.00	6
7	659.006	309.507	42.51076	0.00	0.00	0.00	7
8	761.210	5.204	.68366	0.00	0.00	0.00	8
9	764.139	2.610	.34159	0.00	0.00	0.00	9
10	765.418	265.808	32.80534	0.00	0.00	0.00	10
11	778.424	17.779	2.28338	0.00	0.00	0.00	11
12	793.864	56.184	7.05958	0.00	0.00	0.00	12
13	834.918	78.955	9.41460	0.00	0.00	0.00	13

Assume that for "DF 18", acceptable estimates for the poles at 362 Hz, 363 Hz, 761 Hz and 764 Hz are obtained. While a better estimate can be obtained for the mode at 557 Hz, when a higher degree-of-freedom is used. The four acceptable estimates will be moved to the final table by executing the "MO" command.

P* MO 3 1 2

P* PR

MODE	TEMPORARY TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FINAL TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	257.064	72.742	27.22817	362.31	3.04	.83	1
2	357.325	76.540	20.94526	363.62	3.36	.92	2
3	362.319	3.043	.83981	0.00	0.00	0.00	3
4	363.627	3.366	.92577	0.00	0.00	0.00	4
5	381.165	220.061	49.99918	0.00	0.00	0.00	5
6	557.052	2.928	.52562	0.00	0.00	0.00	6
7	659.006	309.507	42.51076	0.00	0.00	0.00	7
8	761.210	5.204	.68366	0.00	0.00	0.00	8
9	764.139	2.610	.34159	0.00	0.00	0.00	9
10	765.418	265.808	2.80534	0.00	0.00	0.00	10
11	778.424	17.779	2.28338	0.00	0.00	0.00	11
12	793.864	56.184	7.05958	0.00	0.00	0.00	12
13	834.918	78.955	9.41460	0.00	0.00	0.00	13

P* MO 8 4 2

P* PR

MODE	TEMPORARY TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FINAL TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	257.064	72.742	27.22817	362.31	3.04	.83	1
2	357.325	76.540	20.94526	363.62	3.36	.92	2
3	362.319	3.043	.83981	0.00	0.00	0.00	3
4	363.627	3.366	.92577	761.21	5.20	.68	4
5	381.165	220.061	49.99918	764.13	2.61	.34	5
6	557.052	2.928	.52562	0.00	0.00	0.00	6
7	659.006	309.507	42.51076	0.00	0.00	0.00	7
8	761.210	5.204	.68366	0.00	0.00	0.00	8
9	764.139	2.610	.34159	0.00	0.00	0.00	9
10	765.418	265.808	32.80534	0.00	0.00	0.00	10
11	778.424	17.779	2.28338	0.00	0.00	0.00	11
12	793.864	56.184	7.05958	0.00	0.00	0.00	12
13	834.918	78.955	9.41460	0.00	0.00	0.00	13

P* DF 20

Request to estimate a new set of pole values, based on a different degree-of-freedom

MODE	TEMPORARY TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FINAL TABLE FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	303.280	499.851	85.49397	362.31	3.04	.839	1
2	339.426	143.774	39.00338	363.62	3.36	.925	2
3	358.296	25.090	6.98554	0.00	0.00	0.000	3
4	361.396	52.817	14.46114	761.21	5.20	.683	4
5	362.275	3.14	.86662	764.13	2.61	.341	5
6	363.613	3.407	.93704	0.00	0.00	0.000	6
7	441.673	346.068	61.67621	0.00	0.00	0.000	7
8	557.041	2.907	.52189	0.00	0.00	0.000	8
9	561.337	89.645	15.77005	0.00	0.00	0.000	9
10	623.397	293.533	42.59981	0.00	0.00	0.000	10
11	741.374	114.028	15.2019	0.00	0.00	0.000	11
12	761.143	5.065	.66543	0.00	0.00	0.000	12
13	764.138	2.576	.33712	0.00	0.00	0.000	13
14	767.988	15.946	2.07583	0.00	0.00	0.000	14
15	792.776	44.824	5.64503	0.00	0.00	0.000	15
16	825.876	268.751	30.94413	0.00	0.00	0.000	16

P* MO 8 3

P* PR

	TEMPORARY TABLE			FINAL TABLE			
MODE	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	303.280	499.851	85.49397	362.31	3.04	.83	1
2	339.426	143.774	39.00338	363.62	3.36	.92	2
3	358.296	25.090	6.98554	557.04	2.90	.52	3
4	361.396	52.817	14.46114	761.21	5.20	.68	4
5	362.275	3.140	.86662	764.13	2.61	.34	5
6	363.613	3.407	.93704	0.00	0.00	0.00	6
7	441.673	346.068	61.67621	0.00	0.00	0.00	7
8	557.041	2.907	.52189	0.00	0.00	0.00	8
9	561.337	89.645	15.77005	0.00	0.00	0.00	9
10	623.397	293.533	42.59981	0.00	0.00	0.00	10
11	741.374	114.028	15.20191	0.00	0.00	0.00	11
12	761.143	5.065	.66543	0.00	0.00	0.00	12
13	764.138	2.576	.33712	0.00	0.00	0.00	13
14	767.988	15.946	2.07583	0.00	0.00	0.00	14
15	792.776	44.824	5.64503	0.00	0.00	0.00	15
16	825.876	268.751	30.94413	0.00	0.00	0.00	16

P* OK

For each structural pole there is an entry in the final table. This concludes the frequency and damping estimation.

8.6 POLYREFERENCE FREQUENCY DOMAIN TECHNIQUE

8.6.1 OVERVIEW

For this method the initialization process is identical to the Least Squares Complex Exponential and Polyreference Time Domain techniques. The only difference is that there are no restrictions on the width of the frequency range of interest; it does not have to be an integer power of two, since this is a frequency domain method. The data set that will be used in the calculations MUST be identified by the Run Log 3 Command. (See Section 3.10 for Run Log 3 Command).

The algorithm is implemented in such a way that it needs an initial value of the poles in the selected frequency range. The algorithm automatically processes all measurements in the data set and calculates the accumulated power spectrum. The peaks in this function are taken as an initial value for the poles. This accumulated power function, together with cursors superimposed on it, is displayed. The initial values may be modified by by using the automatic peak search commands.

In order to speed up the algorithm and due to memory limitation, not all information at each spectral line in the frequency range of interest is used in the calculation. Since most of the information in a frequency response function is concentrated around the resonances, only this information is used by the algorithm. However, the user has the option to select how many spectral lines on each side of the resonance will be used. Due to memory restrictions the number of spectral lines that can be used around each pole is limited. This limitation will vary with the number of references, and poles, in the selected frequency range. For increasing numbers of references and poles, the number of spectral lines that can be used will decrease.

After these entries the algorithm starts the calculation of the system matrix and then the rank of this matrix. This information is given in the form of a rank estimate chart. The use of this chart is explained in the Parameter Estimation Frequency/Damping Overview (Section 8.1.2).

In some situations not all of the poles are found when the estimated rank is entered. This might happen when there are not enough measurements available to detect closely coupled poles. Another situation where this might occur, is when different poles have very similar modal vectors. When this happens, the optional "velocity term" can be used. In the absence of prior information it thus may be worthwhile to always redo the rank estimate using the "velocity term". If the rank estimate with the "velocity" term is higher than the initial estimate this may be an indication that two poles have similar modal vectors, one pole which was not detected in the initial rank estimate.

At this point, the pole information as well as the residue information is available. The remaining task is to write out the residues with respect to a certain reference, for the case of multiple inputs. The modal participation factors, in tabular form, are used as an aid in determining which reference to select. The rows of this table are associated with the poles, while the columns are associated with the references. Each entry tells how well that particular pole is excited by that particular reference. Each row is scaled to the maximum entry. This table shows which reference excites a certain mode the best. However, only one reference (one column) can be selected, and the residues will br written out with respect to this column. A general rule is to select the column with the highest average entry. However, when this column has a very small entry, less than 5, the estimate of the modal vector for that particular pole will be relatively poor.

The best way to obtain a good modal model, when each column shows a small entry for a particular pole, is to calculate the modal vectors for different columns, and then combine the resulting sets of modal vectors into one set. In this case, the columns must be selected in such a way that if one column has a small entry for a certain pole, the other column has a large value for the same pole.

After selecting the reference to which the residues have to be written out with respect to, all modal parameters are calculated. At this point, the modal model may be verified by synthesizing frequency response functions based on the estimated modal parameters. The synthesized functions are then displayed, superimposed on the measured frequency response function. This can be done for every measured point if desired. Another possibility for verification of the validity of the modal parameters, is the request for a table with the correlation coefficients. The correlation coefficient is a value between one and zero, that tells how well two functions match each other, with unity being a perfect match. This table shows how many points have a certain correlation coefficient. An option is provided to display all points that fall below a certain value of the correlation coefficient.

A DISADVANTAGE of this method, is that when a subset of the measurements in the data set is processed, the modal vectors are calculated ONLY for this subset. For example, if frequency response function measurements on only one component are used in the calculation the modal coefficients will only be calculated for these degrees of freedom and not for other degrees of freedom on the structure.

8.6.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth and for viewing the superimposed display of synthesized fit versus measured data. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

The following Automatic Peak Search Commands are available for the initial estimation of poles. Further explanation of these commands is in Section 8.10.

SUMMARY OF COMMANDS FOR AUTOMATIC PEAK SEARCH	
AD	ADd cursor
CL	CLear modes below level
CS	Choose modes according to Slope
DL	Delete cursor
EX	EXit the program
IN	INsert cursor
LG	Display Log amplitude
LL	Logical List device
MO	MOve cursor
OK	Accept frequency estimates
PR	Write or PRint cursor values
TR	Display rectangular
??	Help features

The following is a list of commands that are available from the Polyreference Frequency Domain Monitor :

SUMMARY OF PFD FREQUENCY/DAMPING ESTIMATION COMMANDS	
DL	DELETE DEGREES OF FREEDOM
EX	PROGRAM EXIT
LG	DISPLAY IN LOG FORMAT
LL	LOGICAL LIST DEVICE
OK	ACCEPT FREQUENCY/DAMPING ESTIMATES
PR	PRINT FREQUENCY/DAMPING ESTIMATES
RT	DISPLAY IN RECTANGULAR FORMAT
??	COMMAND SUMMARY

8.6.3 DELETE COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DELETE A SPECIFIC DEGREE OF FREEDOM
COMMAND MNEMONIC:	DL
HP-5451 KEYBOARD:	DELETE BUTTON (/D)
N1 = FIRST DEGREE OF FREEDOM TO BE REMOVED N2 = LAST DEGREE OF FREEDOM TO BE REMOVED	

8.6.4 EXIT COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

8.6.5 LOG MAGNITUDE COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC:	LG
HP-5451 KEYBOARD:	LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED	

8.6.6 LOGICAL LIST COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER	

8.6.7 ACCEPT COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT FREQUENCY/DAMPING ESTIMATES
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

8.6.8 PRINT COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL FREQUENCY AND DAMPING ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

8.6.9 RECTANGULAR COMMAND

PFD FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN REAL/IMAG FORMAT
COMMAND MNEMONIC:	RT
HP-5451 KEYBOARD:	RECTANGULAR BUTTON (TR)
NO PARAMETERS REQUIRED	

8.6.10 OPERATIONAL EXAMPLE 1

```
** PE

 ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
           1)  MANUAL
           2)  CURSOR
           3)  LEAST SQUARES TIME DOMAIN
           4)  POLYREFERENCE TIME DOMAIN
           5)  POLYREFERENCE FREQ DOMAIN
           6)  ORTHOGONAL POLYNOMIAL
           7)  IBRAHIM POLYREFERENCE
           8)  MODIFIED IBRAHIM POLYREFERENCE
           9)  MULTI-MAC
          10)  CURRENTLY SELECTED VALUES
          11)  RETURN TO MONITOR

5
```

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION ? YE

DISC RECORD NUMBER OF TYPICAL DATA? 3000

MEASUREMENT INFORMATION:

REFERENCE POINT:	1
REFERENCE DIRECTION:	-2
RESPONSE POINT:	1
RESPONSE DIRECTION:	2
ZOOM CODE:	Z0
DATA TYPE CODE:	23
MEASUREMENT SOURCE:	3
FREQUENCY RESOLUTION:	5.000000
MINIMUM FREQUENCY:	0.000
MAXIMUM FREQUENCY	2560.000

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

ENTER FREQUENCY BANDWIDTH (SPECTRAL LINES) : 147

ENTER INITIAL CURSER SPECTRAL LINE NUMBER: 45

USE CURSER TO DENOTE FREQUENCY BANDWIDTH

At this point a plot of the Frequency Response Function is displayed.

P* OK

STARTING FREQUENCY:	225.0000
ENDING FREQUENCY:	960.0000
SPECTRAL LINE SHIFT:	45
SPECTRAL LINE BANDWIDTH:	147

FREQUENCY PARAMETERS ACCEPTABLE ? YE

EXPONENTIAL WINDOW USED ON RESPONSE DATA? NO

CURRENT REFERENCE INFORMATION:

REFERENCE	POINT NUMBER	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4	12	-2
5	17	-2
6	22	-2

SELECTED REFERENCES OK ?* YE

A subset of the measurements defined by the Run Log 3 command can be selected with the following option.

```
ENTER OPTION FOR MEASUREMENT SELECTION:
         1) MEASUREMENT DIRECTION
         2) COMPONENTS
         3) POINT NUMBERS
         4) CONTINUE
         5) RETURN TO MONITOR
4
```

NUMBER OF VALID MEASUREMENTS: 216

SELECTED DOF= 36 SELECTED FRF=216

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

At this point the auto-power spectrum is calculated based on the measurements stored in the Run Log 3 table and modified by the above measurement selection option. Concurrently, an initial value is estimated for the poles in the frequency range of interest. The power spectrum is displayed with the initial poles superimposed.

P* PR

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA (%)
1	365.000	0.000	0.0000000
2	555.000	0.000	0.0000000
3	765.000	0.000	0.0000000

P* OK

INPUT BANDWIDTH (NO OF SPECTRAL LINES AROUND EACH PEAK) 10

SELECTED DATA NO.=33 TOTAL DATA LENGTH=198 MAX LENGTH=270

The total data length is calculated as :

(bandwidth + 1) * number of poles * number of references

```
ENTER OPTION FOR SOLUTION METHOD:
     1) REAL (NORMAL) MODAL COEFFICIENTS
     2) COMPLEX MODAL COEFFICIENTS
2
```

The processed record numbers are displayed.

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

NOW STORING DATA TO FILE

```
NOW CALCULATING SYSTEM MATRIX

NOW SOLVING EIGENVALUE OF SYSTEM MATRIX

***********************************
***    CRITERIA TO JUDGE RANK    ***
***********************************

NO.=  1  E.VAL=.308824E+05@*                                @
NO.=  2  E.VAL=.640855E+04@*                                @
NO.=  3  E.VAL=.531521E+04@*                                @
NO.=  4  E.VAL=.338147E+04@*                                @
NO.=  5  E.VAL=.256675E+04@*********************************@
NO.=  6  E.VAL=.200669E+02@*                                @
NO.=  7  E.VAL=.771906E+01@*                                @
NO.=  8  E.VAL=.610998E+01@*                                @
NO.=  9  E.VAL=.388094E+01@*                                @
NO.= 10  E.VAL=.263468E+01@*                                @
NO.= 11  E.VAL=.181340E+01@*                                @
NO.= 12  E.VAL=.614569E+00@*                                @
NO.= 13  E.VAL=.356587E+00@*                                @
NO.= 14  E.VAL=.129051E+00@*                                @
NO.= 15  E.VAL=.951674E-01@*                                @
NO.= 16  E.VAL=.705790E-01@*                                @
NO.= 17  E.VAL=.535207E-01@*                                @
NO.= 18  E.VAL=.479864E-01@*                                @
NO.= 19  E.VAL=.403115E-01@*                                @

ENTER RANK OF SYSTEM MATRIX  5
```

In general, entering a rank higher than the rank estimate, will not give better frequency and damping estimations. The "E.VAL" values are the singular eigenvalues of the system matrix.

```
SELECTED RANK OF SYSTEM MATRIX=    5
```

EIGENVALUE OF SYSTEM MATRIX

NO	JUDGE	FREQ.(HZ)	ZETA(%)
1	1	362.284	.843
2	1	363.489	.906
3	1	557.097	.560
4	1	761.304	.644
5	1	764.179	.326

```
P*  OK

SELECT
    1)  CHANGE RANK
```

2) ADD VELOCITY TERM
3) CONTINUE
4) RETURN TO MONITOR

3

MODAL PARTICIPATION MATRIX

MODE= 1	100.00	50.71	50.83	52.58	22.45	34.30
MODE= 2	10.41	93.78	100.00	92.64	40.91	3.41
MODE= 3	99.98	100.00	97.62	97.20	2.64	4.90
MODE= 4	100.0	.49	1.99	5.37	34.04	2.99
MODE= 5	2.03	100.00	99.53	98.49	1.68	28.19

REFERENCE INFORMATION

REFERENCE	POINT NO	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4	12	-2
5	17	-2
6	22	-2

SELECT REFERENCE TO WRITE THE RESIDUES OUT TO 4

INPUT POINT NO. AND DIRECTION TO CHECK 1,2

POINT 1 DIR 2 FRF REC.NO 3003

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .998080

P* OK

INPUT POINT NO. AND DIRECTION TO CHECK 0

DO YOU WANT TO CHECK THE RESULT? YES=1 NO=0

1

POINT 1	DIR 2	FRF REC NO 3003	CORR COEFF .9981
POINT 2	DIR 2	FRF REC NO 3010	CORR COEFF .9989
POINT 3	DIR 2	FRF REC NO 3017	CORR COEFF .9991
POINT 4	DIR 2	FRF REC NO 3024	CORR COEFF .9993
POINT 5	DIR 2	FRF REC NO 3031	CORR COEFF .9976
POINT 6	DIR 2	FRF REC NO 3038	CORR COEFF .9990
POINT 7	DIR 2	FRF REC NO 3045	CORR COEFF .9987
POINT 8	DIR 2	FRF REC NO 3052	CORR COEFF .9993
POINT 9	DIR 2	FRF REC NO 3059	CORR COEFF .9985
POINT 10	DIR 2	FRF REC NO 3066	CORR COEFF .9992
POINT 11	DIR 2	FRF REC NO 3073	CORR COEFF .9982

POINT	12	DIR	2	FRF	REC	NO	3080	CORR	COEFF	.9995
POINT	13	DIR	2	FRF	REC	NO	3087	CORR	COEFF	.9980
POINT	14	DIR	2	FRF	REC	NO	3094	CORR	COEFF	.9988
POINT	15	DIR	2	FRF	REC	NO	3101	CORR	COEFF	.9986
POINT	16	DIR	2	FRF	REC	NO	3108	CORR	COEFF	.9992
POINT	17	DIR	2	FRF	REC	NO	3115	CORR	COEFF	.9443
POINT	18	DIR	2	FRF	REC	NO	3122	CORR	COEFF	.9989
POINT	19	DIR	2	FRF	REC	NO	3129	CORR	COEFF	.9985
POINT	20	DIR	2	FRF	REC	NO	3136	CORR	COEFF	.9993
POINT	21	DIR	2	FRF	REC	NO	3143	CORR	COEFF	.9753
POINT	22	DIR	2	FRF	REC	NO	3150	CORR	COEFF	.9994
POINT	23	DIR	2	FRF	REC	NO	3157	CORR	COEFF	.9955
POINT	24	DIR	2	FRF	REC	NO	3164	CORR	COEFF	.9992
POINT	25	DIR	2	FRF	REC	NO	3171	CORR	COEFF	.9982
POINT	26	DIR	2	FRF	REC	NO	3178	CORR	COEFF	.9984
POINT	27	DIR	2	FRF	REC	NO	3185	CORR	COEFF	.9983
POINT	28	DIR	2	FRF	REC	NO	3192	CORR	COEFF	.9983
POINT	29	DIR	2	FRF	REC	NO	3199	CORR	COEFF	.9981
POINT	30	DIR	2	FRF	REC	NO	3206	CORR	COEFF	.9981
POINT	31	DIR	2	FRF	REC	NO	3213	CORR	COEFF	.9983
POINT	32	DIR	2	FRF	REC	NO	3227	CORR	COEFF	.9984
POINT	33	DIR	2	FRF	REC	NO	3234	CORR	COEFF	.9980
POINT	34	DIR	2	FRF	REC	NO	3241	CORR	COEFF	.9982
POINT	35	DIR	2	FRF	REC	NO	3248	CORR	COEFF	.9981
POINT	36	DIR	2	FRF	REC	NO	3255	CORR	COEFF	.9982

DISTRIBUTION OF CORRELATION COEFFICIENT

VAL RANGE	NO.	%
1.00 ~ 0.99	36	(100.00)
0.99 ~ 0.97	0	(0.00)
0.97 ~ 0.95	0	(0.00)
0.95 ~ 0.90	0	(0.00)
0.90 ~ 0.80	0	(0.00)
0.80 ~ 0.70	0	(0.00)
0.70 ~ 0.50	0	(0.00)
0.50 ~ 0.30	0	(0.00)
0.30 ~ 0.00	0	(0.00)

INPUT CRITERIA (0<X<1) TO PRINT MEASUREMENT INFORMATION .98

A list of all points that have a correlation below a certain value can be obtained by entering the value here.

DATA LIST WHOSE COEFF IS LOWER THAN .98

DO YOU WANT TO CHECK THE FRF? YES=1 NO=0 0

DO YOU WANT TO CHECK THE DIFFERENCE BETWEEN MEAS. & CAL. DATA
YES=1 NO=0
0

```
INPUT
  CHANGE RANK=1
  FINISH JOB =0
0
```

8.6.11 OPERATIONAL EXAMPLE 2

The next example will demonstrate the use of the optional "velocity term". The same measurement data set as in the previous example is used, but is reduced to a very small subset for this example. The pole calculation is over the same frequency range; therefore, the initialization process is not repeated for this example.

```
CURRENT REFERENCE INFORMATION:

REFERENCE      POINT NUMBER      DIRECTION

    1                1              -2
    2                6              -2
    3                8              -2
    4               12              -2
    5               17              -2
    6               22              -2

SELECTED REFERENCES OK ?* NO

  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 4
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 5
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 6
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 0

CURRENT REFERENCE INFORMATION:

REFERENCE      POINT NUMBER      DIRECTION

    1                1              -2
    2                6              -2
    3                8              -2
    4 *             12              -2
    5 *             17              -2
    6 *             22              -2

SELECTED REFERENCES OK ?* YE
```

The number of references that will be used during the calculations is reduced to 3.

```
ENTER OPTION FOR MEASUREMENT SELECTION:
            1) MEASUREMENT DIRECTION
            2) COMPONENTS
            3) POINT NUMBERS
            4) CONTINUE
            5) RETURN TO MONITOR
3
```

```
POINT NUMBER(S) ? 1,4

POINT NUMBER(S) ? 0
```

The number of measurement points that will be used in the pole calculation is reduced to 4, instead of 32. This is accomplished selecting the point numbers option (3) above, and by answering, "1,4". Only the points 1 through 4 will be included in the data subset.

```
ENTER OPTION OR MEASUREMENT SELECTION:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
4

NUMBER OF VALID MEASUREMENTS:          12


SELECTED DOF=  4    SELECTED FRF= 12

REFERENCE        POINT        DIRECTION       RECORD
    1              1              2            3000
    3              4              2            3023

P*  PR

MODE    FREQUENCY(HZ)  DAMPING FACTOR(HZ)    ZETA (%)

  1       365.000          0.000            0.0000000
  2       555.000          0.000            0.0000000
  3       765.000          0.000            0.0000000
```

Although the data set is drastically reduced, the initial values for all three peaks are still found.

```
P*  OK

INPUT BANDWIDTH (NO. OF SPECTRAL LINES AROUND EACH PEAK) 30

SELECTED DATA NO.= 93   TOTAL DATA LENGTH=279   MAX LENGTH=270


SOURCE DATA SPACE IS INSUFFICIENT. SELECT
          1)  REDUCE BANDWIDTH
          2)  REDUCE REF. POINT
1
```

The total data length can be reduced in two ways; decreasing the number of spectral lines around the peaks (bandwidth), or reducing the number of references used in the calculations.

```
INPUT BANDWIDTH (NO. OF SPECTRAL LINES AROUND EACH PEAK) 28
```

```
SELECTED DATA NO.=87   TOTAL DATA LENGTH=261   MAX LENGTH=270

ENTER OPTION FOR SOLUTION METHOD:
    1)  REAL (NORMAL) MODAL COEFFICIENTS
    2)  COMPLEX MODAL COEFFICIENTS
2

REFERENCE        POINT        DIRECTION        RECORD
    1              1              2              3000
    2              1              2              3001
    3              1              2              3002
    1              2              2              3007
    3              4              2              3023

NOW STORING DATA TO FILE

NOW CALCULATING SYSTEM MATRIX

NOW SOLVING EIGENVALUE OF SYSTEM MATRIX


**********************************
***   CRITERIA TO JUDGE RANK   ***
**********************************

NO.=  1  E.VAL=.667579E+04@****                                @
NO.=  2  E.VAL=.195262E+04@*                                   @
NO.=  3  E.VAL=.117506E+04@*********************************@
```

A rank of 3 is indicated by the rank estimate chart, while in the previous case a rank of 5 was estimated. A way to detect that not enough measurements are used to determine the correct rank of the system matrix, is the evaluation of singular eigenvalues. In this case the 3 singular eigenvalues are of the same order. From this information it is known that the rank of the system matrix is at least 3, but it can also be more. In order to verify the rank estimate of 3, more singular values have to be available.

```
ENTER RANK OF SYSTEM MATRIX  3

SELECTED RANK OF SYSTEM MATRIX=    3


          EIGENVALUE OF SYSTEM MATRIX
     NO     JUDE         FREQ.(HZ)      ZETA(%)

      1       1          520.945         .644
      2       1          659.826         .674
      3       1          751.542         .348

P*  OK
```

```
SELECT
     1)  CHANGE RANK
     2)  ADD VELOCITY TERM
     3)  CONTINUE
     4)  RETURN TO MONITOR
2
```

By entering a rank of 3, the algorithm was not able to distinguish the repeated roots. This is due to the fact that the algorithm did not have enough measurements in the data base to detect these repeated roots. By requesting the option "ADD VELOCITY TERM" the lack of information can be compensated for.

```
NOW STORING DATA TO FILE

NOW CALCULATING SYSTEM MATRIX

NOW SOLVING EIGENVALUE OF SYSTEM MATRIX

**********************************
***   CRITERIA TO JUDGE RANK   ***
**********************************

NO.=  1  E.VAL=.959707E+04@****                                @
NO.=  2  E.VAL=.239150E+04@*                                   @
NO.=  3  E.VAL=.130896E+04@*                                   @
NO.=  4  E.VAL=.109661E+04@***                                 @
NO.=  5  E.VAL=.310120E+03@************************************@
NO.=  6  E.VAL=.131655E+02@**************************          @
NO.=  7  E.VAL=.708482E+00@*                                   @
```

By using the option "ADD VELOCITY TERM" the dimension of the system matrix is increased and more information about the rank is available. Two drops in the singular eigenvalues can be noticed. This is the reason why the rank chart shows a possible rank of 5 or 6. However, when the option "ADD VELOCITY TERM" was not used for this reduced set, the rank chart estimate chart indicated that the rank was only 3, while effectively, the rank of the system matrix is higher.

```
ENTER RANK OF SYSTEM MATRIX  5

SELECTED RANK OF SYSTEM MATRIX=    5

          EIGENVALUE OF SYSTEM MATRIX
     NO    JUDGE        FREQ.(HZ)     ZETA(%)

      1      1          362.296        .958
      2      1          363.608        .935
      3      1          557.058        .553
      4      1          761.348        .670
      5      1          764.358        .329

P*  OK
```

By using the same amount of data, but asking for the "ADD VELOCITY TERM" option the algorithm is able to detect the repeated poles, which was not the case previously.

```
SELECT
     1)  CHANGE RANK
     2)  ADD VELOCITY TERM
     3)  CONTINUE
     4)  RETURN TO MONITOR
3

            MODAL PARTICIPATION MATRIX

MODE= 1    100.00     57.27     47.40
MODE= 2     11.40     91.23    100.00
MODE= 3     99.40    100.00     97.32
MODE= 4    100.00      4.11      3.36
MODE= 5      7.25    100.00     98.71

           REFERENCE INFORMATION

REFERENCE       POINT NO      DIRECTION

   1                1            -2
   2                6            -2
   3                8            -2
   4  *            12            -2
   5  *            17            -2
   6  *            22            -2

SELECT REFERENCE TO WRITE THE RESIDUES OUT TO 2

INPUT POINT NO. AND DIRECTION TO CHECK 1,2

POINT   1   DIR 2   FRF REC.NO 3001

PARAMETER ESTIMATION CORRELATION COEFFICIENT:   .994970

P*  OK

INPUT POINT NO. AND DIRECTION TO CHECK 0

DO YOU WANT TO CHECK THE RESULT ?  YES=1  NO=0   0

INPUT
  CHANGE RANK=1
  FINISH JOB =0
0
```

8.7 ORTHOGONAL POLYNOMIAL TECHNIQUE

8.7.1 OVERVIEW

This method calculates the frequency/damping values and residues for the system using the orthogonal polynomial algorithm. The selection of a frequency range of interest is the same as the other parameter estimation methods, except that there are no restrictions on the width. That is, the bandwidth does not have to be an integer power of two, since this is a frequency domain method. After selection of bandwidth, the algorithm will generate a Complex Mode Indication Function (CMIF) from the measurement directory, including modifications from the measurement selection option. This measurement directory MUST be identified by the Run Log 3 Command prior to invoking the algorithm. Repeated roots can be detected if multiple-reference measurements are included in the data set to be analyzed.

The peaks in the CMIF chart indicate existing modes. Thus, the order of the the polynomials is determined by the number of peaks found in the CMIF chart. Then, the order of the polynomials can be determined before the estimation process is begun. The number of peaks detected in CMIF is used as the number of degrees-of-freedom of the system, therefore, the order of the polynomials is determined as:

$$m * N_i \geq N$$

$$n \geq m + 2$$

where,

N is the degree-of-freedom of the system or the number of modes.
N_i is the number of references.
m is the order of matrix polynomial chosen in the Auto-Regressive (AR) or denominator part.
n is the order of matrix polynomial chosen in the Moving-Average (MA) or numerator part.

The algorithm will accept these default values as the order of the polynomials of the system, although higher orders may be chosen as well. In order to consider the effects of the residual terms the order of the MA part is chosen to be two larger than the order of the AR part.

The important modal information will exist in the neighborhood of the peaks detected in the CMIF. Therefore, the algorithm is designed to include only a few spectral lines on each side of the peaks. The default is to include five spectral lines on each side, or a total of 11 spectral lines at each peak.

The poles of the system will be calculated based upon the number of spectral lines included at each peak and the number of peaks in the CMIF. Upon review of the CMIF chart, peaks can be deleted, or added as desired.

There is also an option to add weighting to the least-squares formulation. Weighting with CMIF values will intensify the strong modes, while weighting with inverse of CMIF will intensify the weaker modes.

Some computational poles may be generated in the solution process. These computational poles may include nonphysical poles, that is; unstable poles, or poles with negative damping. The pole estimation results are given in two tables, a temporary table (left) and a final table (right). The temporary table contains all poles determined in the solution process, whereas, the nonphysical poles are omitted from the final table. The presence of nonphysical poles in the temporary table may indicate that the order of the polynomials in the solution process are too large. Upon review of the frequency/damping values, computational poles can be deleted from the final table with the delete option.

Once the frequency/damping values are estimated, the residues can be calculated either by orthogonal polynomial approach or by other residue algorithms.

8.7.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth and for viewing the superimposed display of synthesized fit versus measured data. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

8.7.3 OPERATIONAL EXAMPLE

```
**  PE

ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPINGS
          1)  MANUAL
          2)  CURSOR
          3)  LEAST SQUARES TIME DOMAIN
          4)  POLYREFERENCE TIME DOMAIN
          5)  POLYREFERENCE FREQ DOMAIN
          6)  ORTHOGONAL POLYNOMIAL
          7)  IBRAHIM POLYREFERENCE
          8)  MODIFIED IBRAHIM POLYREFERENCE
          9)  MULTI-MAC
          10) CURRENTLY SELECTED VALUES
          11) RETURN TO MONITOR
6
```

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION ? YE

DISC RECORD NUMBER OF TYPICAL DATA? 3000

MEASUREMENT INFORMATION:

REFERENCE POINT:	1
REFERENCE DIRECTION:	-2
RESPONSE POINT:	1
RESPONSE DIRECTION:	2
ZOOM CODE:	Z0
DATA TYPE CODE:	23
MEASUREMENT SOURCE:	3
FREQUENCY RESOLUTION:	5.000000
MINIMUM FREQUENCY:	0.000
MAXIMUM FREQUENCY:	2560.000

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

ENTER FREQUENCY BANDWIDTH (SPECTRAL LINES) : 150

ENTER INITIAL CURSOR SPECTRAL LINE NUMBER: 50

USE CURSER TO DENOTE FREQUENCY BANDWIDTH

At this point a plot of the Frequency Response Function is displayed.

P* OK

STARTING FREQUENCY:	250.0000
ENDING FREQUENCY:	1000.0000
SPECTRAL LINE SHIFT:	50
SPECTRAL LINE BANDWIDTH:	150

FREQUENCY PARAMETERS ACCEPTABLE ? YE

EXPONENTIAL WINDOW USED ON RESPONSE DATA? NO

CURRENT REFERENCE INFORMATION:

```
REFERENCE      POINT NUMBER      DIRECTION

    1                1             -2
    2                6             -2
    3                8             -2
    4               12             -2
    5               17             -2
    6               22             -2

SELECTED REFERENCES OK?* NO

  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 3
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 4
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 5
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 6
  ENTER REF. TO FLAG ( 0 TO TERMINATE )  * 0

SELECTED REFERENCES OK?* YE

CURRENT REFERENCE INFORMATION:

REFERENCE      POINT NUMBER      DIRECTION

    1                1             -2
    2                6             -2
    3 *              8             -2
    4 *             12             -2
    5 *             17             -2
    6 *             22             -2

SELECTED REFERENCES OK?* YE

ENTER OPTION FOR MEASUREMENT SELECTION:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
4
```

```
NUMBER OF VALID MEASUREMENTS:          72

       PEAK DETECTED IN CMIF CHART
         NO.    CHANNEL        FREQ.
          1         73         365.0
          2         73         365.0
          3        111         555.0
          4        152         760.0
          5        153         765.0


 SELECT
 1) DELETE PEAK NO. (From N1 to N2)
 2) ADD PEAK (Peak Channel No. between  51~200)
 3) CHANGE SPECTRAL LINES ON EACH SIDE OF PEAKS (Currently 5)
 4) CHANGE FRF INCLUDED IN CALCULATION
 5) CONTINUE
5
```

The CMIF chart is used to find the number of poles and in selecting the number of spectral lines to be included in the solution process. If repeated roots exist the data set must contain appropriate multiple reference data. In this circular plate example, at least two references must be included.

```
 SELECT WEIGHTING FUNCTION FOR LEAST SQUARE ALGORITHM
 0) UNIFORM WEIGHTING
 1) WEIGHTING WITH MAX. CMIF
 2) WEIGHTING WITH SUM OF CMIF (MATRIX TRACE)
 3) WEIGHTING WITH PRODUCT OF CMIF
 4) WEIGHTING WITH INVERSE OF MAX. CMIF
0
```

For most cases the uniform weighting function can be used for both strong and weak modes.

```
CHOOSE ORDERS OF POLYNOMIAL N,M
DENOMINATOR  N =   6    NUMERATOR  M =   8

6,8
```

Since the data used in this example is very clean, the default values for the orders of the polynomials are chosen. For noisy data, higher orders may be chosen in order to compensate for the noise, although higher orders will introduce more computational modes.

ORTHOGONAL POLYNOMIAL POLE ESTIMATION

ORDER OF DENOMINATOR= 6 ORDER OF NUMERATOR= 8 WEIGHTING= 0

	TEMPORARY TABLE			FINAL TABLE			
MODE	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	362.343	3.213	.886	362.343	3.213	.886	1
2	363.647	3.472	.954	363.647	3.472	.954	2
3	557.055	2.944	.528	557.055	2.944	.528	3
4	591.267	9.891	1.672	591.267	9.891	1.672	4
5	761.135	4.979	.654	761.135	4.979	.654	5
6	764.195	2.599	.340	764.195	2.599	.340	

SELECT
  0) RESTORE POLE TABLE
  1) DELETE MODES, FROM N1 TO N2
  2) PRINT OUT POLE TABLE
  3) FREQUENCY/DAMPING RECALCULATION
  4) MODAL VECTOR CALCULATION
  5) EXIT

1,4,4

The preceding table lists the estimated poles. All poles are included in the temporary table (l whereas, nonphysical poles are omitted from the final table (right). The CMIF indicates that mo in the final table is a computational mode. This mode is deleted from the final table with command, "1,4,4".

ORTHOGONAL POLYNOMIAL POLE ESTIMATION

ORDER OF DENOMINATOR= 6 ORDER OF NUMERATOR= 8 WEIGHTING= 0

	TEMPORARY TABLE			FINAL TABLE			
MODE	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	362.343	3.213	.886	362.343	3.213	.886	1
2	363.647	3.472	.954	363.647	3.472	.954	2
3	557.055	2.944	.528	557.055	2.944	.528	3
4	591.267	9.891	1.672	761.135	4.979	.654	4
5	761.135	4.979	.654	764.195	2.599	.340	5
6	764.195	2.599	.340				6

```
 SELECT
   0) RESTORE POLE TABLE
   1) DELETE MODES, FROM N1 TO N2
   2) PRINT OUT POLE TABLE
   3) FREQUENCY/DAMPING RECALCULATION
   4) MODAL VECTOR CALCULATION
   5) EXIT
4
```

This concludes the orthogonal polynomial frequency/damping estimation process. The remaining task is to estimate the modal vectors.

```
 SELECT THE METHOD FOR MODAL VECTOR ESTIMATION
   1) ORTHOGONAL POLYNOMIAL GLOBAL MODAL VECTOR
   2) LEAST SQUARE LOCAL MODAL VECTOR
   3) LEAST SQUARE GLOBAL MODAL VECTOR
1


         MODAL PARTICIPATION FACTOR

                   REFERENCE NO.

   MODE      1     2

     1      100.   50.
     2        8.  100.
     3      100.  100.
     4      100.    0.
     5        1.  100.


 CHOOSE REFERENCE FOR MODE SHAPE CALCULATION
1
```

The modal participation factor is a complex valued function. The magnitude of this function relates how well a mode is excited by a particular reference. The modal vectors are stored with respect to only one reference. Therefore, a general rule is to select the reference (column) with the highest average entry. However, when this column has a very small entry, the estimate of the modal vector for that particular mode will be relatively poor.

```
 REFERENCE: 1  POINT:    1  DIRECTION: 2  RECORD:  3000
 REFERENCE: 2  POINT:    1  DIRECTION: 2  RECORD:  3001

PARAMETER ESTIMATION CORRELATION COEFFICIENT:   .998853

P*  OK
```

```
REFERENCE: 1   POINT:    2  DIRECTION: 2   RECORD:   3007
REFERENCE: 2   POINT:    2  DIRECTION: 2   RECORD:   3008

PARAMETER ESTIMATION CORRELATION COEFFICIENT:    .993717

P*  GO
```

After reviewing a few synthesized results, the command, "GO", can be executed which puts the modal vector estimation in an automatic mode. When the modal vector estimation is completed, the pole tables are displayed again.

```
                    ORTHOGONAL POLYNOMIAL POLE ESTIMATION

ORDER OF DENOMINATOR= 6   ORDER OF NUMERATOR= 8   WEIGHTING= 0
```

	TEMPORARY TABLE			FINAL TABLE			
MODE	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	FREQ. (Hz)	DAMP. FACT. (Hz)	ZETA (%)	
1	362.343	3.213	.886	362.343	3.213	.886	1
2	363.647	3.472	.954	363.647	3.472	.954	2
3	557.055	2.944	.528	557.055	2.944	.528	3
4	591.267	9.891	1.672	761.135	4.979	.654	4
5	761.135	4.979	.654	764.195	2.599	.340	5
6	764.195	2.599	.340				6

```
 SELECT
   0) RESTORE POLE TABLE
   1) DELETE MODES, FROM N1 TO N2
   2) PRINT OUT POLE TABLE
   3) FREQUENCY/DAMPING RECALCULATION
   4) MODAL VECTOR CALCULATION
   5) EXIT
5

**
```

8.8 IBRAHIM/MODIFIED IBRAHIM POLYREFERENCE TECHNIQUES

8.8.1 OVERVIEW

The Ibrahim as well as the modified Ibrahim technique are time domain techniques based upon the superposition of damped exponentials. The Ibrahim methods work with a system that is of dimension equal to the number of measurements in the data set, whereas, the Polyreference time domain method reduces all measurements to a system of dimension equal to the number of references. This means the Ibrahim methods will require much more memory to process a given data set, which can be a disadvantage. However, the advantage of a larger system is that less computational modes will be computed when the order of the system is over-specified. This is an advantage of the Ibrahim techniques as compared to the Polyreference time domain technique.

The modified Ibrahim technique differs from the Ibrahim technique in that as a first [illegible] principal component reduction of the measurements is implemented for the modified Ibrahim technique. This feature reduces memory requirements and significantly improves the performance of the algorithm. The trade off is that more computational modes may be computed when the degree of freedom of the system is over-specified.

The initialization process for these algorithms are identical to the other time domain techniques. After selection of the frequency range of interest, reference and measurement selection options, the size of the system matrix is requested. The default value is a matrix of size 40 by 40. This might be reduced depending on the number of poles in the frequency range of interest. A minimum size of two to three times the number of poles in the frequency range is required, in order to get a good pole estimation. After entering the system matrix size, the number of time shifts must be entered. This value has to be larger than the time shift value shown when the system matrix size was specified. This number defines how many time samples of the impulse response function to use. The next question is the initial time shift, with a default value set to 5 time increments. This is to avoid truncation errors due to the inverse Fourier transform. The combination of the time shift value and the initial time shift allows the pole calculation to be based on different segments of the impulse response function. After these questions, the data is processed and a condition number chart is displayed together with a number of mode chart. The number of mode chart is equivalent with the rank estimate chart discussed previously. Since a time domain method is used, an optimal rank estimate to calculate the poles is 1.5 to 2 times the rank estimation. After entering the rank of the system matrix, the estimated frequency and damping values are displayed together with the magnitude and phase of the modal confidence factor. For clean data, the phase value should be smaller than 0.1 degree. This phase information can be very helpful in determining whether a pole is structural, or computational.

The original Ibrahim technique calculates the pole values as well as the modal vectors at the same time. This is still true for the Ibrahim Polyreference technique. Due to the principal component reduction, the modified Ibrahim Polyreference is not able to calculate the modal vectors at the same time as the poles. However, the algorithm provides all necessary information in order to run one of the Polyreference modal vector algorithms.

8.8.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

The following is a list of commands that are available for the Ibrahim Polyreference Frequency/Damping Estimation Monitor:

SUMMARY OF IBRAHIM F/D ESTIMATION COMMANDS	
DL	DELETE DEGREES OF FREEDOM
EX	PROGRAM EXIT
LG	DISPLAY IN LOG FORMAT
LL	LOGICAL LIST DEVICE
OK	ACCEPT FREQUENCY/DAMPING ESTIMATES
PR	PRINT FREQUENCY/DAMPING ESTIMATES
RT	DISPLAY IN RECTANGULAR FORMAT
??	COMMAND SUMMARY

8.8.3 DELETE COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DELETE A SPECIFIC DEGREE OF FREEDOM
COMMAND MNEMONIC:	DL
HP-5451 KEYBOARD:	DELETE BUTTON (/D)
N1 = FIRST DEGREE OF FREEDOM TO BE REMOVED N2 = LAST DEGREE OF FREEDOM TO BE REMOVED	

8.8.4 EXIT COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

8.8.5 LOG MAGNITUDE COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC:	LG
HP-5451 KEYBOARD:	LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED	

8.8.6 LOGICAL LIST COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER	

8.8.7 ACCEPT COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT FREQUENCY/DAMPING ESTIMATES
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

8.8.8 PRINT COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL FREQUENCY AND DAMPING ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

8.8.9 RECTANGULAR COMMAND

IBRAHIM FREQUENCY/DAMPING ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN REAL/IMAG FORMAT
COMMAND MNEMONIC:	RT
P-5451 KEYBOARD:	RECTANGULAR BUTTON (TR)
NO PARAMETERS REQUIRED	

8.8.10 OPERATIONAL EXAMPLE

The following is an example of the Modified Ibrahim Polyreference Technique. The use of the Ibrahim Polyreference closely parallels the Modified Ibrahim Polyreference. Therefore, one example is presented for the use of both techniques.

```
**  PE

ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
          1)  MANUAL
          2)  CURSOR
          3)  LEAST SQUARES TIME DOMAIN
          4)  POLYREFERENCE TIME DOMAIN
          5)  POLYREFERENCE FREQ DOMAIN
          6)  ORTHOGONAL POLYNOMIAL
          7)  IBRAHIM POLYREFERENCE
          8)  MODIFIED IBRAHIM POLYREFERENCE
          9)  MULTI-MAC
          10) CURRENTLY SELECTED VALUES
          11) RETURN TO MONITOR

8

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION ? YE

DISC RECORD NUMBER OF TYPICAL DATA? 3000
```

```
MEASUREMENT INFORMATION:

REFERENCE POINT:                 1
REFERENCE DIRECTION:            -2
RESPONSE POINT:                  1
RESPONSE DIRECTION:              2
ZOOM CODE:                      Z0
DATA TYPE CODE:                 23
MEASUREMENT SOURCE:              3
FREQUENCY RESOLUTION:     5.000000
MINIMUM FREQUENCY:           0.000
MAXIMUM FREQUENCY:        2560.000
```

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

```
ENTER FREQUENCY BANDWIDTH (SPECTRAL LINES ):
            64
           128
           256
           512
128

ENTER INITIAL CURSER SPECTRAL LINE NUMBER: 50

USE CURSER TO DENOTE FREQUENCY BANDWIDTH
```

At this point a plot of the Frequency Response Function is displayed.

```
P*  OK

STARTING FREQUENCY:       250.0000
ENDING FREQUENCY:         890.0000
SPECTRAL LINE SHIFT:            50
SPECTRAL LINE BANDWIDTH:       128

FREQUENCY PARAMETERS ACCEPTABLE ? YE

EXPONENTIAL WINDOW USED ON RESPONSE DATA? NO


ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
          1)  MULTIPLE-REFERENCE IBRAHIM TIME DOMAIN
          2)  MODIFIED MULTIPLE-REFERENCE IBRAHIM TIME DOMAIN

2
```

CURRENT REFERENCE INFORMATION:

REFERENCE	POINT NUMBER	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4	12	-2
5	17	-2
6	22	-2

SELECTED REFERENCES OK?* NO

ENTER REF. TO FLAG (0 TO TERMINATE) * 4
ENTER REF. TO FLAG (0 TO TERMINATE) * 5
ENTER REF. TO FLAG (0 TO TERMINATE) * 6
ENTER REF. TO FLAG (0 TO TERMINATE) * 0

CURRENT REFERENCE INFORMATION:

REFERENCE	POINT NUMBER	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4 *	12	-2
5 *	17	-2
6 *	22	-2

SELECTED REFERENCES OK?* OK

Three references are arbitrarily chosen for this example.

ENTER OPTION FOR MEASUREMENT SELECTION:
1) MEASUREMENT DIRECTION
2) COMPONENTS
3) POINT NUMBERS
4) CONTINUE
5) RETURN TO MONITOR

3

POINT NUMBER(S) ? 1,10

POINT NUMBER(S) ? 0

The number of measurement points is reduced to the first 10 points.

```
ENTER OPTION FOR MEASUREMENT SELECTION:
          1) MEASUREMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RETURN TO MONITOR
4
```

NUMBER OF VALID MEASUREMENTS & REFERENCES: 30 3

```
SELECT SYSTEM MATRIX SIZE [DEFAULT 40 * 40 ]
 1.   [10*10]   3  TIME SHIFTS
 2.   [20*20]   6  TIME SHIFTS
 3.   [30*30]   9  TIME SHIFTS
 4.   [40*40]  12  TIME SHIFTS
 5.   MANUAL INPUT

2
```

The current maximum size of the system matrix is 40x40. The system matrix should be chosen such that it is one to three times the number of modes in the frequency range of interest. Otherwise, the estimation of the poles will be poor. A large system matrix will produce fewer computational modes but requires a longer solution time.

```
 SELECTED SYSTEM MATRIX SIZE [      20*      20]

 ENTER TIME SHIFTS : DEFAULT =  20
```

The default values can be entered by hitting a carriage return.

```
 20  TIME SHIFTS WERE SELECTED

 ENTER INITIAL TIME SHIFTS >=0 : DEFAULT =        5
```

The default values can be entered by hitting a carriage return. The advantage of taking an initial time shift in the impulse response function is that the distortion, due to an inverse Fourier transform, that occurs in the beginning and at the end of the data block is avoided.

```
      5  INITIAL TIME SHIFTS WERE SELECTED
```

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

The processed data records are displayed.

```
*******************************************
***    CONDITION NUMBER AND RANK CHART   ***
*******************************************

                   CONDITION NUMBER    NUMBER OF MODES
 1 S=.1000E+01 @***************** @*                  @ 1
 2 S=.7371E+00 @****************  @*                  @ 2
 3 S=.3353E+00 @**************    @*                  @ 2
 4 S=.2494E+00 @***************   @*                  @ 2
 5 S=.1643E+00 @***************   @*                  @ 3
 6 S=.1386E+00 @***************   @*                  @ 3
 7 S=.1151E+00 @***************   @*                  @ 4
 8 S=.9708E-01 @**************    @*                  @ 4
 9 S=.8622E-01 @**************    @*                  @ 5
10 S=.7742E-01 @**************    @*******************@ 5
11 S=.4844E-04 @*******           @*                  @ 6
12 S=.2513E-04 @*******           @*                  @ 6
13 S=.2014E-04 @*******           @*                  @ 7
14 S=.1714E-04 @*******           @*                  @ 7
15 S=.2460E-05 @*****             @*                  @ 8
16 S=.1626E-05 @*****             @*                  @ 8
17 S=.1355E-05 @*****             @*                  @ 9
18 S=.1050E-05 @*****             @*                  @ 9

ENTER RANK OF SYSTEM : DEFAULT = 10
```

The numbers on the left hand side of the previous chart are different from those displayed on the right hand side. The numbers on the left are related to the number-of-degrees of freedom, while the numbers on the right hand side are the number of poles that will be found for each particular degree of freedom.

```
SELECTED RANK OF SYSTEM   10

MODE  FREQUENCY   DAMPING             MAGNITUDE     PHASE(DEG.)
  1    362.223    .90279   TOTAL MCF    .9996      .0273
  2    363.513    .95930   TOTAL MCF    .9991      .0343
  3    557.102    .51529   TOTAL MCF    .9996      .0105
  4    761.234    .70284   TOTAL MCF    .9711      .4061
  5    764.233    .35437   TOTAL MCF    .9991      .1057

 0)  PROCEED
 1)  SELECT  5 MODES
 2)  CHANGE NUMBER OF MODES TO BE SELECTED
 3)  CHANGE RANK.
 4)  CHANGE MATRIX SIZE
 5)  PRINT OUT PARAMETERS WITH ALL MCF
 6)  DISPLAY PARAMETERS WITH TOTAL MCF
 7)  DISPLAY PARAMETERS WITH ALL MCF
```

Option 1 allows the modification of the number of modes that are selected. This selection is based on the modal confidence factor (MCF). The computational poles (when there are some) can also be eliminated by selecting option 0 (proceed) and then deleting the computational poles with the Static Display Monitor.

```
P*  OK

    SELECT
      1)   CHANGE RANK
      2)   CONTINUE
2
```

8.9 MULTI-MAC TECHNIQUE

8.9.1 OVERVIEW

This multiple reference frequency domain technique will determine frequency and modal vector information. Initially a frequency bandwidth must be selected to analyze. This bandwidth selection process is identical to the other techniques.

After selection of bandwidth there are several options available to choose a subset of measurements from the data set previously identified by the Run Log 3 Command. The algorithm will process the chosen measurements and compute a summation of the power spectrum of the quadrature responses. This power spectrum is used to compute the initial values of the poles. The summation of the power spectrums is displayed with the initial pole values superimposed.

The quadrature part of the frequency response function is used as an estimate of the residue for each initial pole value. In addition, one or two spectral lines on either side of the peak can be included. A principal component analysis is computed on these estimated residues. This analysis results in a rank estimate chart that portrays the number of independent residue vectors found at that frequency. For rank greater than one, there are that many independent vectors that make up the residue vectors at that frequency. The use of the rank chart is explained previously (Section 8.1.2).

The residue vectors are then transformed using unity weighting to yield the orthogonal modes at that frequency. These transformed residues are used to compute an enhanced frequency response function which can be fit for estimates of frequency and damping.

8.9.2 COMMAND SUMMARY

The following data display commands are available for the selection of the frequency bandwidth and in viewing the enhanced frequency response function. Further explanation of these commands is in Section 2.7.

SUMMARY OF HP-13XX DISPLAY COMMANDS	
A	ARGAND DISPLAY
B	BANDWIDTH EXPAND
C	CURSOR (ABSOLUTE POSITION)
E	EXPAND ABOUT CURSOR
I	IMAGINARY DISPLAY
LG	LOG MAGNITUDE DISPLAY
M	CURSOR (RELATIVE POSITION)
MA	MAGNITUDE DISPLAY
OK	ACCEPT
P	PRINT CURSOR POSITION
PH	PHASE DISPLAY
R	REAL DISPLAY
S	VERTICAL SCALING
U	UNEXPAND
X	EXIT

The following is a list of commands that are available from the Automatic Peak Search Monitor. Further explanation of these commands is in Section 8.10.

SUMMARY OF COMMANDS FOR AUTOMATIC PEAK SEARCH	
AD	ADd cursor
CL	CLear modes below level
CS	Choose modes according to Slope
DL	Delete cursor
EX	EXit the program
IN	INsert cursor
LG	Display Log amplitude
LL	Logical List device
MO	MOve cursor
OK	Accept frequency estimates
PR	Write or PRint cursor values
TR	Display rectangular
??	Help features

8.9.3 OPERATIONAL EXAMPLE

```
** PE

 ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
               1)  MANUAL
               2)  CURSOR
               3)  LEAST SQUARES TIME DOMAIN
               4)  POLYREFERENCE TIME DOMAIN
               5)  POLYREFERENCE FREQ DOMAIN
               6)  ORTHOGONAL POLYNOMIAL
               7)  IBRAHIM POLYREFERENCE
               8)  MODIFIED IBRAHIM POLYREFERENCE
               9)  MULTI-MAC
               10) CURRENTLY SELECTED VALUES
               11) RETURN TO MONITOR

9

 CLEAR CURRENT FREQUENCY/DAMPING INFORMATION ? YE

 DISC RECORD NUMBER OF TYPICAL DATA? 3000

 MEASUREMENT INFORMATION:

 REFERENCE POINT:                   1
 REFERENCE DIRECTION:              -2
 RESPONSE POINT:                    1
 RESPONSE DIRECTION:                2
 ZOOM CODE:                        Z0
 DATA TYPE CODE:                   23
 MEASUREMENT SOURCE:                3
 FREQUENCY RESOLUTION:       5.000000
 MINIMUM FREQUENCY:             0.000
 MAXIMUM FREQUENCY:          2560.000
```

For Zoom Code Zn, zoom power equals 2 to the power n. Data Type Code are listed in Appendix F. Measurement Source Code is explained in the Measurement Header Command.

```
 ENTER FREQUENCY BANDWIDTH (SPECTRAL LINES) : 145

 ENTER INITIAL CURSER SPECTRAL LINE NUMBER: 45

 USE CURSE TO DENOTE FREQUENCY BANDWIDTH

P*  OK

 STARTING FREQUENCY:         225.0000
 ENDING FREQUENCY:           950.0000
 SPECTRAL LINE SHIFT:              45
 SPECTRAL LINE BANDWIDTH:         145

 FREQUENCY PARAMETERS ACCEPTABLE ? YE
```

EXPONENTIAL WINDOW USED ON RESPONSE DATA? NO

CURRENT REFERENCE INFORMATION:

REFERENCE	POINT NUMBER	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4	12	-2
5	17	-2
6	22	-2

SELECTED REFERENCES OK?* YE

ENTER OPTION FOR MEASUREMENT SELECTION:
1) MEASUREMENT DIRECTION
2) COMPONENTS
3) POINT NUMBERS
4) CONTINUE
5) RETURN TO MONITOR

4

NUMBER OF VALID MEASUREMENTS: 216

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

The processed records are displayed and the autopower spectrum plus initial values of the poles are calculated.

P* PR

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA (%)
1	365.000	0.000	0.0000000
2	555.000	0.000	0.0000000
3	765.000	0.000	0.0000000

P* OK

NO	FREQUENCY
1	365.000
2	555.000
3	765.000

INPUT MODE NO. TO CALCULATE 1

In the current implementation, only one particular pole at a time can be used in the calculation process.

```
INPUT NUMBER OF SPECTRAL LINES ON BOTH
SIDES OF PEAK TO BE USED
```
2

By using spectral lines on both sides of the peak, more estimates of the mode shape are used in the calculation. If the modes are lightly damped, the lines adjacent to the peak will be less effected by leakage and may have less biased estimates of the mode shapes.

```
ENTER OPTION FOR SOLUTION METHOD:
     1)  REAL (NORMAL) MODAL COEFFICIENTS
     2)  COMPLEX MODAL COEFFICIENTS
```
1

At this point a quadrature peak picking will commence, on each of the measurements in the previously defined data set, as an estimate of the modes.

```
REFERENCE        POINT        DIRECTION       RECORD
    1              1              2             3000
```

The processed records are displayed.

```
*********************************
***   CRITERIA TO JUDGE RANK   ***
*********************************
```

```
NO.=  1  E.VAL=.171710E+04@*                                      @
NO.=  2  E.VAL=.122335E+04@***************************************@
NO.=  3  E.VAL=.139691E+00@*                                      @
NO.=  4  E.VAL=.108188E+00@*                                      @
NO.=  5  E.VAL=.157510E-01@*                                      @
NO.=  6  E.VAL=.104319E-01@*                                      @
NO.=  7  E.VAL=.738069E-02@*                                      @
NO.=  8  E.VAL=.519491E-02@*                                      @
NO.=  9  E.VAL=.394510E-02@*                                      @
NO.= 10  E.VAL=.251465E-02@*                                      @
NO.= 11  E.VAL=.178288E-02@*                                      @
NO.= 12  E.VAL=.121690E-02@*                                      @
NO.= 13  E.VAL=.708494E-03@*                                      @
NO.= 14  E.VAL=.499717E-03@*                                      @
NO.= 15  E.VAL=.350255E-03@*                                      @
NO.= 16  E.VAL=.331177E-03@*                                      @
NO.= 17  E.VAL=.191156E-03@*                                      @
NO.= 18  E.VAL=.150529E-03@*                                      @
NO.= 19  E.VAL=.763199E-04@*                                      @
NO.= 20  E.VAL=.675850E-04@*                                      @
```

For this rank chart, 2 independent vectors have been found at this frequency, indicating either a repeated root or heavely coupled modes. The transformation will find the orthogonal modes, using unity weighting, that are summed together at this frequency.

```
ENTER RANK OF SYSTEM MATRIX  2

SELECTED RANK OF SYSTEM MATRIX=    2


TRANSFORMING MODE SHAPES
USING IDENTITY WEIGHTING MATRIX


INPUT NO.OF MODE TO ENHANCE  1

NOW CALCULATING ENHANCED FRF OF MODE  1

P*  OK

SAVE ENHANCED FREQUENCY RESPONSE FUNCTION? NO

CALCULATE ANOTHER ENHANCEMENT F.R.F ?YES=1  NO=0

0
```

At this point the two modal vectors as well as their frequency are available and can be displayed by using the Animation Module out of the Modal Monitor.

8.10 COMMAND SUMMARY FOR AUTOMATIC PEAK SEARCH

The following is a list of commands that are available from the Automatic Peak Search Monitor :

SUMMARY OF COMMANDS FOR AUTOMATIC PEAK SEARCH	
AD	ADd cursor
CL	CLear modes below level
CS	Choose modes according to Slope
DL	Delete cursor
EX	EXit the program
IN	INsert cursor
LG	Display Log amplitude
LL	Logical List device
MO	MOve cursor
OK	Accept frequency estimates
PR	Write or PRint cursor values
TR	Display rectangular
??	Help features

8.10.1 ADD CURSOR COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	ADd cursor
COMMAND MNEMONIC:	AD IPAR1
Parameter IPAR1 spectral line	

8.10.2 CLEAR MODE COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	CLear modes below level
COMMAND MNEMONIC:	CL IPAR1
Parameter IPAR1 level value in % of max. peak	

8.10.3 SLOPE SELECTION COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	Choose modes according to slope
COMMAND MNEMONIC:	CS IPAR1
Parameter	IPAR1 number of points around the peak to compare with. (default IPAR1 = 5)

8.10.4 DELETE COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	Delete cursor
COMMAND MNEMONIC:	DL IPAR1 IPAR2
Parameters :	Delete cursor from IPAR1 to IPAR2

8.10.5 EXIT COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	EXit program
COMMAND MNEMONIC:	EX
NO PARAMETERS REQUIRED	

8.10.6 INSERT COMMAND

AUTOMATIC PEAK SEARCH COMMAND
COMMAND FUNCTION: INsert cursor
COMMAND MNEMONIC: IN IPAR1
Parameter IPAR1 spectral line

8.10.7 LOG AMPLITUDE COMMAND

AUTOMATIC PEAK SEARCH COMMAND
COMMAND FUNCTION: Log amplitude
COMMAND MNEMONIC: LG
NO PARAMETERS REQUIRED

8.10.8 LOGICAL LIST COMMAND

AUTOMATIC PEAK SEARCH COMMAND
COMMAND FUNCTION: Logical List device
COMMAND MNEMONIC: LL IPAR1
Parameter IPAR1 LU - number

8.10.9 MOVE CURSOR COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	MOve last (added) cursor
COMMAND MNEMONIC:	MO IPAR1
Parameter IPAR1 number of spectral lines to move	

8.10.10 ACCEPT COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	Accept frequency estimates
COMMAND MNEMONIC:	OK
NO PARAMETERS REQUIRED	

8.10.11 PRINT COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	PRint cursor values
COMMAND MNEMONIC:	PR
NO PARAMETERS REQUIRED	

8.10.12 RECTANGULAR DISPLAY COMMAND

AUTOMATIC PEAK SEARCH COMMAND	
COMMAND FUNCTION:	Rectangular display
COMMAND MNEMONIC:	TR
NO PARAMETERS REQUIRED	

9. MODAL VECTOR ESTIMATION

9.1 OVERVIEW

The task of estimating modal coefficients can be performed by one of the following methods:

- Complex Magnitude
- Real Part of Frequency Response Function
- Imaginary Part of Frequency Response Function
- Real Circle Fit
- Complex Circle Fit
- Least-Squares Frequency Domain
- Polyreference Time Domain
- Polyreference Frequency Domain

The first five methods, complex magnitude, real part, imaginary part, real circle fit and complex circle fit, are single degree-of-freedom methods. The Least-Squares frequency domain method is a multiple degree-of-freedom method, but similar to the first five methods, does not estimate global modal vectors. The two polyreference methods are multiple degree-of-freedom, multiple reference methods and estimate global modal vectors.

At the present time, the RTE Modal Program is capable of estimating complex modal coefficients using a floating point word for the real part and a floating point word for the imaginary part. The modal vectors are actually stored, regardless of the method used to estimate the modal coefficients, as the diameter of the complex circle that can be used to describe the single degree of freedom and with the units of the data from which the modal vectors were estimated. Within the RTE Modal Program, if the modal vectors are rescaled, the actual values of the modal vectors are never altered; a complex scale factor is altered from unity to account for any scaling required. All values that are output from the RTE Modal Program include this complex scale factor in a transparent manner.

The ability to animate the modal vectors is possible in any of four formats. The possibilities allow the user to view the modal vectors in complex or one of three real formats. Options are available in the real formats to view the complex magnitude, real component, or imaginary component so that all data types (D/F,V/F,A/F,D/D,V/V,A/A) can be used to determine modal vectors. This also gives the user the possibility to view the out-of-phase portion of the modal vector to determine whether a complex modal vector is a function of reasonable structure characteristics or a function of poor excitation energy distribution.

9.1.1 MEASUREMENT DIRECTORY

The data set (ie. data records) to be used in the Modal Vector Estimation is identified by the Run Log 3 Command, Section 3.10. For Modal Vector Estimation to proceed, the Measurement Directory MUST first be formulated by the Run Log 3 Command.

9.2 COMPLEX MAGNITUDE

The magnitude and phase of a given frequency is recorded. The frequency can be chosen manually, with the cursor, or with any of the other frequency/damping algorithms.

9.3 IMAGINARY COMPONENT

The value of the quadrature, or imaginary component of the data, at a specific frequency is recorded as the magnitude and the angle is assumed to be 90 degrees. The frequency can be chosen manually, with the cursor, or with any of the other frequency/damping algorithms.

9.4 REAL COMPONENT

The value of the co-incident, or real, component of the data at a specific frequency is recorded as the magnitude and the angle is assumed to be 90 degrees. The frequency can be chosen manually, with the cursor, or with any of the other frequency/damping algorithms. This method is used when using mobility type data (V/F,F/V) or when ratioing responses (D/D,V/V,A/A) where the in-phase component of the ratio is an estimate of the modal coefficient.

9.5 CIRCLE FIT ALGORITHM

9.5.1 OVERVIEW

The RTE Modal Program identifies modal coefficients from measured frequency response data by fitting circles in the complex frequency (or Argand plane) display. The data points at the damped natural frequency and a number of data points on either side of the damped natural frequency are used to estimate the best least squares circle that will fit the data.

The magnitude is determined from the diameter of the fitted circle but the phase is determined differently depending upon whether a real or complex circle fit has been chosen. If a real circle fit is chosen, the phase will be determined in a similar manner as the approach used in the imaginary component method but a displaced origin is utilized to reduce effects of other modes. The frequency can again be chosen manually, with the cursor, or with any of the other frequency/damping algorithms. For the complex circle fit method, the phase is determined again taking into account the displaced origin but the actual rotation of the circle (phase angle) is used as the phase angle of the modal coefficient.

After a circle fit is computed for a mode, the system displays the following waveforms on the display unit:

- The computed circle fit for the present mode (for HP-5451C this is only displayed with the MODE switch in the COMPLEX position.
- The frequency response data in the neighborhood of the damped natural frequency (approximately 30 data points centered around the damped natural frequency).
- The frequency response data that was used to calculate the least squares circle fit is intensified.
- Bandwidth markers to show what data was actually used to compute the circle fit.
- A line from the displaced origin to the damped natural frequency to outline these to points and to show the phase angle that will be returned if a complex circle fit is chosen.

The data points may not exist for the display. For example, if the damped natural frequency of a mode was at spectral line 5 and the bandwidth was 2. In this case, the display of (2) above would extend from data spectral line 0 to spectral line 22. If the mode center spectral line is near either end of a data block, the system will use as many points as possible up to the normal limit to calculate the circle fit and display the results.

The circle fit display is used to judge the acceptability of the circle fit and, hence, the accuracy of the modal coefficient determined from it. In general, the data points should lie near or on the circle. Due to the finite resolution, the points may not be evenly spaced on the circle, especially for very lightly damped modes. A "typical" circle fit display (for Bandwidth = 2) is shown in Figure 9-1.

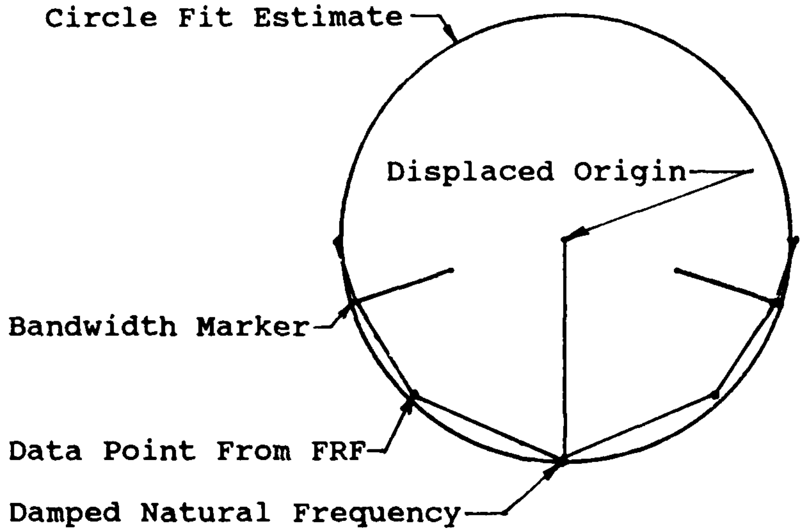

Circle Fit Estimate
Displaced Origin
Bandwidth Marker
Data Point From FRF
Damped Natural Frequency

FIGURE 9-1

9.5.2 COMMAND SUMMARY

The following is a list of commands that are available from the Circle Fit Modal Vector Estimation Monitor:

SUMMARY OF CIRCLE FIT MODAL VECTOR ESTIMATION COMMANDS	
BW	CHANGE BANDWIDTH
OK	ACCEPT MODAL VECTOR ESTIMATES
GO	ESTIMATE MODAL COEFFICIENTS (NO RECONSTRUCTION)
MF	MOVE FREQUENCY
IM	SET MODAL COEFFICIENT TO IMAGINARY PART
RS	RESET FREQUENCY
CL	CLEAR MODAL COEFFICIENT
RP	REPLACE FREQUENCY/DAMPING VALUES
EX	PROGRAM EXIT
??	COMMAND SUMMARY

The Circle Fit Monitor allows the user to interactively change the circle fit or the coefficient when the monitor character is printed.

The values of center spectral line and bandwidth are considered permanent values. When the user first fits a mode using the command, these permanent values are assigned to temporary or working values from which the circle fit is calculated. The circle fit is always calculated from these temporary values of center spectral line and bandwidth.

The Circle Fit Monitor commands allow the temporary center spectral line and bandwidth to be varied in order that the circle fit for a mode may be improved. Whenever a new circle fit is calculated, a new modal coefficient is found. When the user judges the fit or the coefficient to be acceptable, the coefficient may be saved. In addition, the new temporary center spectral line and bandwidth may be saved as the permanent values in the table, so that they will be used as the temporary values for this mode in later measurements.

HP-5451-C System Considerations

```
Switch  15        Abort Point Print
Switch  14        Abort Parameter Estimation
Switch   0        Automatic Circle Fit
```

Automatic Circle Fit

If switch register bit 0 is on when the algorithm is entered, the coefficients from the modal circle fits will be automatically accepted with no circle fit displays or user interaction.

9.5.3 BANDWIDTH COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	CHOOSE NUMBER OF POINTS IN LEAST SQUARES CIRCLE FIT
COMMAND MNEMONIC:	BW
HP-5451 KEYBOARD:	POSITIVE NUMBER
NO PARAMETERS REQUIRED	

Assign the value of N1 ($1<N1<30$) to the temporary bandwidth for the current mode, and recalculate the circle fit using this new bandwidth value. N1 = 0 uses the quadrature response and proceeds. $N1<0$ accepts the current circle fit.

9.5.4 ACCEPT FIT COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT CURRENT CIRCLE FIT
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

9.5.5 GO COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	AUTOMATIC ACCEPT OF MODAL VECTOR ESTIMATES WITHOUT RECONSTRUCTION
COMMAND MNEMONIC:	GO
HP-5451 KEYBOARD:	NONE
N1 = NUMBER OF MEASUREMENTS TO CONTINUE WITHOUT RECONSTRUCTION	

This command allows the user, after viewing several reconstructions, to put the algorithm in an automatic configuration. In this operational mode, the modal parameter estimation proceeds for the number of measurements given without reconstruction and then begins to require user interaction once again. Note that this feature can be interrupted and returned to the interactive process at any time by using the 'BR' command from the RTE system monitor.

9.5.6 MOVE FREQUENCY COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	SHIFT THE APPARENT MODAL FREQUENCY
COMMAND MNEMONIC:	MF
HP-5451 KEYBOARD:	SHIFT BUTTON (__b)
NO PARAMETERS REQUIRED	

Increment the current temporary center spectral line value by N1 (+ or -) and recalculate the circle fit.

9.5.7 IMAGINARY COMPONENT COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	SET MODAL COEFFICIENT TO IMAGINARY PART OF FRF AT THE DAMPED NATURAL FREQUENCY
COMMAND MNEMONIC:	IM
HP-5451 KEYBOARD:	NONE
NO PARAMETER REQUIRED	

9.5.8 RESET FREQUENCY COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET THE MODAL FREQUENCY
COMMAND MNEMONIC:	RS
HP-5451 KEYBOARD:	SUBTRACT BUTTON (A-)
NO PARAMETERS REQUIRED	

Assign the center spectral line value from the table to the temporary center spectral line, print the value, and recalculate the circle fit.

9.5.9 CLEAR COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	CLEAR MODAL COEFFICIENT
COMMAND MNEMONIC:	CL
HP-5451 KEYBOARD:	CLEAR BUTTON (CL)
NO PARAMETERS REQUIRED	

Sets the modal coefficient to zero and proceeds.

9.5.10 REPLACE COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	REPLACE MODAL FREQUENCY AND DAMPING VALUES
COMMAND MNEMONIC:	RP
HP-5451 KEYBOARD:	REPLACE BUTTON (/R)
NO PARAMETERS REQUIRED	

Save the temporary values of center spectral line, bandwidth, and damping into the table, thereby making them the "permanent" values for the current mode.

9.5.11 EXIT COMMAND

CIRCLE FIT MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT TO CONTROL OF MODAL SYSTEM MONITOR
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN BUTTON (<b)
NO PARAMETERS REQUIRED	

9.6 LEAST SQUARES FREQUENCY DOMAIN

9.6.1 OVERVIEW

The RTE Modal Program executes a least squares error estimation of the data within a 64/128/256/512 data spectral line range based upon a frequency domain model of a multiple degree of freedom system. The process is linear since the values of frequency and damping are not allowed to change from measurement to measurement. The results are the complex residues for the measurement or real residues for the measurement, based on the selection of real versus complex modal vectors that has been made. The residues are then used to directly determine the modal coefficients. The model is based on a partial fraction expansion of the transfer function. Details concerning the algorithms used can be found in SAE Paper Number 790221.

9.6.2 COMMAND SUMMARY

The following is a list of commands that are available from the LSFD Modal Vector Estimation Monitor:

```
|-----------------------------------------------------------------|
|   SUMMARY OF LSFD MODAL VECTOR ESTIMATION COMMANDS              |
|-----------------------------------------------------------------|
|   A       ARGAND DISPLAY                                        |
|   DI      DISPLAY DATA AND RECONSTRUCTION                       |
|   EX      PROGRAM EXIT                                          |
|   GO      ESTIMATE MODAL COEFFICIENTS (NO RECONSTRUCTION)       |
|   I       IMAGINARY DISPLAY                                     |
|   LG      DISPLAY IN LOG FORMAT                                 |
|   LL      LOGICAL LIST                                          |
|   MA      MAGNITUDE DISPLAY                                     |
|   OK      ACCEPT MODAL VECTOR ESTIMATES                         |
|   PH      PHASE DISPLAY                                         |
|   PR      PRINT MODAL VECTOR ESTIMATES                          |
|   R       REAL DISPLAY                                          |
|   RS      RESTART MODAL VECTOR ESTIMATE                         |
|   ??      COMMAND SUMMARY                                       |
-------------------------------------------------------------------
```

9.6.3 ARGAND DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY DATA IN ARGAND FORMAT
COMMAND MNEMONIC:	A
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.6.4 CLEAR COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	CLEAR MODAL COEFFICIENT
COMMAND MNEMONIC:	CL
HP-5451 KEYBOARD:	CLEAR BUTTON (CL)
NO PARAMETERS REQUIRED	

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY DATA AND RECONSTRUCTION
COMMAND MNEMONIC:	DI
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

The reconstruction of the frequency response function is normally computed using all of the frequency/damping values stored in the RUN LOG table. If the user would like to see a reconstruction based upon only one of the frequency/damping values, the N1 parameter can be entered and refers to the numbered list of frequency/damping values obtained from the Print Command.

9.6.5 EXIT COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

9.6.6 GO COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	AUTOMATIC ACCEPT OF MODAL VECTOR ESTIMATES WITHOUT RECONSTRUCTION
COMMAND MNEMONIC:	GO
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

This command allows the user, after viewing several reconstructions, to put the algorithm in an automatic configuration. In this operational mode, the modal parameter estimation proceeds for the number of measurements given without reconstruction and then begins to require user interaction once again. Note that this feature can be interrupted and returned to the interactive process at any time by using the 'BR' command from the RTE system monitor.

9.6.7 IMAGINARY DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IMAGINARY PART OF DATA
COMMAND MNEMONIC:	I
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.6.8 LOG MAGNITUDE DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND
COMMAND FUNCTION: DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC: LG
HP-5451 KEYBOARD: LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED

9.6.9 LOGICAL LIST COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND
COMMAND FUNCTION: RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC: LL
HP-5451 KEYBOARD: LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER

9.6.10 MAGNITUDE DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND
COMMAND FUNCTION: DISPLAY MAGNITUDE OF DATA
COMMAND MNEMONIC: MA
HP-5451 KEYBOARD: NONE
NO PARAMETERS REQUIRED

9.6.11 ACCEPT COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT CURRENT LSFD FIT
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

9.6.12 PHASE DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY PHASE PART OF DATA
COMMAND MNEMONIC:	PH
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.6.13 PRINT COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL VECTOR ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

9.6.14 REAL DISPLAY COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY REAL PART OF DATA
COMMAND MNEMONIC:	R
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.6.15 RESTART COMMAND

LSFD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	RESTART MODAL VECTOR ESTIMATES
COMMAND MNEMONIC:	RS
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

The restart command allows the user to restart the program without actually leaving the program.

9.7 POLYREFERENCE TIME/FREQUENCY DOMAIN

The Polyreference modal vector algorithm allows the calculation of modal vectors in the time, or the frequency domain as real, or complex quantities. The algorithms can be invoked with single, or multiple references. In the case of multiple references, the residues are determined with respect to all references included in the data set. This means, that the residue estimation is a global fit. The Least Squares frequency domain method (described previously) uses only one measurement to calculate the residues. At times it may appear that the Least Squares frequency domain method is producing better results than the Polyreference time domain method based on the reconstruction and measured data on the display. This difference is mainly due to the fact that the Polyreference time domain is a global estimator, whereas, the Least Squares frequency domain is not. The Polyreference frequency domain method will, essentially, reduce to a Least-Squares frequency domain algorithm if single reference measurements are used to estimate the modal vectors.

The time domain part of the algorithm is restricted to bandwidths of 64/128/256/512 spectral lines. The reason for this is that the algorithm uses the impulse response function in order to determine the modal vectors. The time domain is favorable to the frequency domain when the poles have high damping values. However, a big disadvantage of a time domain algorithm is that the effects of the poles outside the frequency range of interest cannot be compensated for with residual terms. Due to this restriction, the frequency domain algorithm will give better results, since the influence of modes outside the frequency range can be compensated by including residuals in the estimation process.

Whereas, the time domain method is restricted to certain frequency bandwidths, the frequency domain algorithm can be used on any arbitrary bandwidth and even on frequency response functions with variable frequency spacing. Due to memory limitations the maximum bandwidth that can be selected in the frequency domain is 256 spectral lines, or 512 spectral lines when the complex modal vector option is chosen. This part of the program is basically an extension to multiple references of the Least Squares frequency domain method.

After the selection of time, or frequency domain, and real, or complex modal vector options, both techniques display the modal participation matrix, when there are multiple reference measurements available. The residues have to be written out with respect to one of the references and the modal participation factors, in tabular form, are used as an aid in determining which reference to select. The rows of this table are associated with the poles, while the columns are associated with the references. In other words, this table shows which reference excites a certain mode the best. Each row is scaled to the maximum entry. However, only one reference (one column) can be selected, and the residues will be written out with respect to this reference (column). A general rule is to select the column with the highest average entry. When this column has a very small entry, less than 5, the estimate of the modal vector for that particular pole will be relatively poor. The best way to obtain a good modal model, when each column shows a small entry for a pole, is to calculate the modal vectors for different columns, and then combine the resulting sets of modal vectors into one set. In this case, the columns must be selected in such a way that if one column has a small entry for a certain pole, the other column has a large value for the same pole.

Using the "IP" command (go to specified point), residues can be determined for various measurement locations of specific interest. In this way a few points can be fit, and the reconstruction visually checked for quality, before using the automatic accept mode. After checking selected measurement locations the "IP" command should be invoked again. This time the lowest numbered measurement point and direction is entered, followed by the "GO" command. This will start the residue calculation at the first point in the data set and continue sequentially through all data points.

9.7.1 COMMAND SUMMARY

The following is a list of commands that are available from the PTD Modal Vector Estimation Monitor:

SUMMARY OF PTD MODAL VECTOR ESTIMATION COMMANDS	
A	ARGAND DISPLAY
DI	DISPLAY DATA AND RECONSTRUCTION
EX	PROGRAM EXIT
GO	ESTIMATE MODAL COEFFICIENTS (NO RECONSTRUCTION)
I	IMAGINARY DISPLAY
IP	GO TO SPECIFIED POINT
LG	DISPLAY IN LOG FORMAT
LL	LOGICAL LIST
MA	DISPLAY MAGNITUDE
OK	ACCEPT MODAL VECTOR ESTIMATES
PH	PHASE DISPLAY
PR	PRINT MODAL VECTOR ESTIMATES
R	REAL DISPLAY
RE	RESET THE RESIDUALS FOR ACTUAL POINT
RS	RESTART MODAL VECTOR ESTIMATION
??	COMMAND SUMMARY

9.7.2 ARGAND PLOT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY DATA IN ARGAND FORMAT
COMMAND MNEMONIC:	A
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.7.3 DISPLAY COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY DATA AND RECONSTRUCTION
COMMAND MNEMONIC:	DI
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

The reconstruction of the frequency response function is normally computed using all of the frequency/damping values stored in the frequency and damping table. If the user would like to see a reconstruction based upon only one of the frequency/damping values, the N1 parameter can be entered and refers to the numbered list of frequency/damping values obtained from the Print Command.

9.7.4 EXIT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	EXIT
COMMAND MNEMONIC:	EX
HP-5451 KEYBOARD:	SUBRETURN (<b)
NO PARAMETERS REQUIRED	

9.7.5 GO COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	AUTOMATIC ACCEPT OF MODAL VECTOR ESTIMATES WITHOUT RECONSTRUCTION
COMMAND MNEMONIC:	GO
HP-5451 KEYBOARD:	NONE
N1 = NUMBER OF MEASUREMENTS TO CONTINUE WITHOUT RECONSTRUCTION	

This comand allows the user, after viewing several reconstructions, to put the algorithm in an automatic configuration. In this operational mode, the modal parameter estimation proceeds for the number of measurements given without reconstruction and them begins to require user interaction once again. Note that this feature can be interrupted and returned to the interactive process at any time by using the 'BR' command from the RTE system monitor.

9.7.6 IMAGINARY FORMAT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IMAGINARY PART OF DATA
COMMAND MNEMONIC:	I
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.7.7 POINT SELECT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	GO TO SPECIFIED POINT
COMMAND MNEMONIC:	IP
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

This command allows the user to estimate modal coefficients and reconstruct any arbitrary measured point on the structure to evaluate the pole estimation. If the entered point and direction does not exist the next point is processed. If the user issued the "GO" command, after using the "IP" command, only the points with a higher point number will be automatically processed. Therefore a safe way to use this feature is to check if the estimated modal coefficients for different points on the structure are acceptable. If this is the case, go back to point number one and issue the "GO" Command.

9.7.8 LOG MAGNITUDE COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY IN LOG MAGNITUDE FORMAT
COMMAND MNEMONIC:	LG
HP-5451 KEYBOARD:	LOG MAGNITUDE BUTTON (TL)
NO PARAMETERS REQUIRED	

9.7.9 LOGICAL LIST COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET LOGICAL LIST DEVICE LU
COMMAND MNEMONIC:	LL
HP-5451 KEYBOARD:	LIST BUTTON (/L)
N1 = LIST LOGICAL UNIT NUMBER = 1 TERMINAL = 6 PRINTER	

9.7.10 MAGNITUDE FORMAT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY MAGNITUDE OF DATA
COMMAND MNEMONIC:	MA
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.7.11 ACCEPT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	ACCEPT CURRENT LSFD FIT
COMMAND MNEMONIC:	OK
HP-5451 KEYBOARD:	NEGATIVE NUMBER
NO PARAMETERS REQUIRED	

9.7.12 PHASE DISPLAY COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY PHASE PART OF DATA
COMMAND MNEMONIC:	PH
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.7.13 PRINT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	PRINT CURRENT MODAL VECTOR ESTIMATES
COMMAND MNEMONIC:	PR
HP-5451 KEYBOARD:	PRINT BUTTON (Wb)
NO PARAMETERS REQUIRED	

9.7.14 REAL FORMAT COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	DISPLAY REAL PART OF DATA
COMMAND MNEMONIC:	R
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

9.7.15 RESET COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	RESET THE RESIDUALS FOR ACTUAL POINT
COMMAND MNEMONIC:	RE
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

This command allows the user to recalculate the residues for the actual point after changing the residuals. However, it should be noted that the change in residuals will be in effect for the rest of the measurements, unless changed again by this command.

9.7.16 RESTART COMMAND

PTD MODAL VECTOR ESTIMATION COMMAND	
COMMAND FUNCTION:	RESTART MODAL VECTOR ESTIMATES
COMMAND MNEMONIC:	RS
HP-5451 KEYBOARD:	NONE
NO PARAMETERS REQUIRED	

This command allows the user to restart the program from the pole selection option, without leaving the program. The delete pole, or computational pole flags can be toggled at this point to improve the estimation.

9.7.17 OPERATIONAL EXAMPLE

** PE 2

```
ENTER OPTION TO BE USED TO DETERMINE MODAL VECTORS:
             1)   COMPLEX MAGNITUDE
             2)   REAL PART
             3)   IMAGINARY PART
             4)   REAL CIRCLE FIT
             5)   COMPLEX CIRCLE FIT
             6)   LEAST-SQUARES FREQUENCY DOMAIN
             7)   POLYREFERENCE TIME DOMAIN
             8)   POLYREFERENCE FREQUENCY DOMAIN
             9)   RETURN TO MONITOR
8

CLEAR CURRENT MODAL VECTORS ? YE

   1 ) COMPLEX MODAL VECTORS
   2 ) REAL MODAL VECTORS
1
```

MODE	FREQUENCY(HZ)	DAMPING FACTOR(HZ)	ZETA(%)
1	362.223	3.270	.90279
2	363.513	3.487	.95930
3	557.102	2.871	.51529
4	761.234	5.350	.70284
5	764.233	2.708	.35437

```
SELECTED POLES OK?* YE
```

If "NO" is entered there are two options available for selecting the poles to be included in the residue calculation. The first option is to delete poles from the frequency/damping table. The deleted poles are given a flag of two asterisks (**) and are not used in the residue calculation. The second option is to identify poles as computational. The poles identified as computational are given a flag of one asterisk (*) . For both options, the poles are assigned the appropriate flag, but remain in the frequency/damping table until exiting the modal vector estimation monitor. At that time the deleted poles are removed from the frequency/damping table.

After review of the reconstruction and measured data superimposed on the display, the fit may be deemed unacceptable. Upon execution of the Restart Command, "RS", the algorithm returns to the selection of the poles option. The flags can be toggled off with the second issuance of the delete pole, or computational pole option.

```
ENTER OPTION FOR RESIDUAL TERMS TO BE INCLUDED:
             1) NO RESIDUALS
             2) RESIDUAL MASS ONLY
             3) RESIDUAL FLEXIBILITY ONLY
             4) RESIDUAL MASS AND FLEXIBILITY
1
```

No residuals are included in the fit.

MODAL PARTICIPATION FACTORS (%)

MODE	REFERENCES					
1	100.00	51.03	50.17	0.00	0.00	0.00
2	6.25	97.10	100.00	0.00	0.00	0.00
3	99.86	100.00	97.59	0.00	0.00	0.00
4	100.00	.28	2.23	0.00	0.00	0.00
5	1.33	100.00	99.38	0.00	0.00	0.00

REFERENCE	POINT NUMBER	DIRECTION
1	1	-2
2	6	-2
3	8	-2
4 *	12	-2
5 *	17	-2
6 *	22	-2

ENTER REFERENCE TO USE FOR WRITING
OUT MODE SHAPE COEFFICIENTS: * 3

References one, two, and three are included in the data set. Reference three is chosen for writing out the modal vectors. Note that mode four is not well-excited by the third reference. This means the modal vector estimation will be relatively po(· for this mode.

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .997183

P* RE

ENTER OPTION FOR RESIDUAL TERMS TO BE INCLUDED:
1) NO RESIDUALS
2) RESIDUAL MASS ONLY
3) RESIDUAL FLEXIBILITY ONLY
4) RESIDUAL MASS AND FLEXIBILITY

4

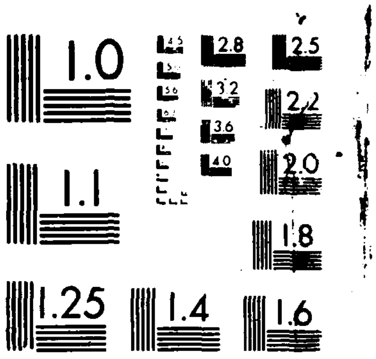
The fit is of unacceptable quality. Residual mass and flexibility are added to improve the fit.

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .999244

P* PR

AD-A195 140 EXPERIMENTAL MODAL ANALYSIS AND DYNAMIC COMPONENT 3/4
SYNTHESIS VOLUME 6 SOFT..(U) CINCINNATI UNIV OH DEPT OF
MECHANICAL AND INDUSTRIAL ENGINEER..
UNCLASSIFIED R J ALLEMANG ET AL. DEC 87 F/G 13/13 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963

RESIDUE INFORMATION

MODE	FREQ.	ZETA(%)	MAGNI.	PHASE	REAL	IMAGINARY
1	362.22	.90279	.000	96.768	-.2427E-05	.2045E-04
2	363.51	.95930	.000	179.684	.2075E-05	-.1144E-07
3	557.10	.51529	.000	89.707	.5123E-07	.1002E-04
4	761.23	.70284	.000	41.023	.3810E-06	.335E-06
5	764.23	.35437	.000	132.245	-.2318E-06	.2552E-06

RESIDUAL MASS = .74896E-01
RESIDUAL FLEXIBILITY = .24739E-08

P* IP

POINT NUMBER TO BE REFIT 5
DIRECTION 2

Calculate residues and reconstruction for point 5, direction 2, skip intermediate points. If point 5, direction 2, does not exist, the next available direction, or point number will be used.

REFERENCE	POINT	DIRECTION	RECORD
1	5	2	3028

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .999477

P* GO 2

Continue calculating residues for two points before calculating reconstruction.

REFERENCE	POINT	DIRECTION	RECORD
1	6	2	3035
REFERENCE	POINT	DIRECTION	RECORD
1	7	2	3042
REFERENCE	POINT	DIRECTION	RECORD
1	8	2	3049

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .999111

P* IP

POINT NUMBER TO BE REFIT 1
DIRECTION 2

Recalculate residues and reconstruction for point 1, direction 2.

REFERENCE	POINT	DIRECTION	RECORD
1	1	2	3000

PARAMETER ESTIMATION CORRELATION COEFFICIENT: .999244

P* GO

Start automatic mode.

10. MODAL MODIFICATION

10.1 OVERVIEW

When a vibration problem occurs in a mechanical structure, the structure can often be modified to solve this problem. Modal Modification deals with the ways to optimize the dynamics of a mechanical structure through modification. If the modal model or the mass, stiffness and damping distributions (M-K-C model) are known, it is possible to modify the model and to analyze the effect of any modification on its dynamic behavior. Assuming the linearity of the model with respect to those distributions, the modifications can be described as additional mass, stiffness and damping distributions.

The modifications can be divided into three different main classes, each having a well defined purpose and result. These classes are:

a) Hardware Modifications :

Hardware Modification refers to stiffness, damping or mass addition (removal). The purpose usually is a shift of frequency and/or a reduction of the modal displacement at certain nodal points.

b) Structural Assembly :

The modifications are, in this case, called connections. These connections remain modifications from the mathematical modeling viewpoint. The structure may be described using modal parameters and/or in terms of their mass, stiffness and damping distributions. The MKC model allows finite element model data to be used as well. The purpose of Structural Assembly is a modal model of the assembled structure for vibration isolation or force transmission problems.

c) Structural Decomposition :

Structural Decomposition is in fact the inverse operation of structural assembly using hardware modifications within one structure. One of the major difficulties of this method is an accurate model of the connections between two structures. Structural Decomposition is an interesting technique as it allows the study of separate components and allows the isolation of vibrating components.

Modal modification can utilize either a real normal mode data base or a complex mode data base with or without damping. A complex mode data base may occur when non-proportional damping is encountered. However, errors introduced during measurement and parameter estimation phases or errors caused by invalid assumptions such as linearity and time invariance of the system may cause normal modes to appear complex. Hence, it is advisable to verify the modal data by using the concept of "Mode Overcomplexity" to check whether data is valid or not. If the modal data is too complex to have originated from a realistic system, then a normalization procedure which changes complex modes to real modes may be utilized to improve the modal data (see Section 13).

The modal modification program is referred to as the Dynamic Optimization Package (DYNOP) which originated at the University of Leuven, Belgium. This software has been altered to be compatible with the RTE Modal Program. The Dynamic Optimization Package is actually a combination of two independent modules, Modal Synthesis Modification and Sensitivity Modification, and two auxiliary programs, Modification File generation program and validating program, Mode Overcomplexity.

Modal Synthesis Modification is characterized by its compact formulation and by the fact that an eigenvalue problem has to be solved. The method will solve the matrix equations of motion of the modified system in modal coordinates rather than in physical coordinates, which gives model its compactness. The fact that the equations are solved using only the modal coordinates is also its weakest point because only a limited number of modes are included. A remedy to this drawback exists and consists of using the MKC model matrices, when available, to include more degrees of freedom.

Sensitivity Modification is in fact an approximation method using a truncated Taylor series expansion to compute the inverse of the transfer function matrix. Since the method requires less computation time, it is easier to gain a general feel for the effects of the modification at different locations on the structure. Due to the nature of the sensitivity modification, the predicted mode shapes are accurate only for small modifications.

Physical units play an important role when modification is being conducted. Care must be taken during the conversion of units, when generating a modification file that defines the modifications to the structure. Scaling of the mode shapes MUST be done BEFORE the dynamic optimization package is called. The DYNOP program requires that the modal vectors be scaled such that the product of the scaled modal coefficients for each mode of a specific frequency response function is equal to the residue (Unity Scaling Coefficient $Q_r = 1.0$).

The scaling utility can be called within the RTE Modal Program as follows :

```
** SC
```

The Dynamic Optimization Package can be called within the RTE Modal Program as follows :

```
** DY
```

When DY has been entered, the Modal Modification Monitor prompt (*DO*) will display on the terminal. There are four options to choose from within the Dynamic Optimization Package. The options are :

```
MO (Mode Overcomplexity Verification)
MF (Modification File Generator)
SM (Sensitivity Modification)
MS (Modal Synthesis Modification)
```

10.2 MODE OVERCOMPLEXITY

This method qualifies each mode by a number called the Mode Overcomplexity Value (M.O.V.) and the global Modal Model by the Mode Overcomplexity Ratio (M.O.R.). The basic idea of the Mode Overcomplexity test is that, for good modal models with complex modes, the frequency sensitivity for an added mass change should be negative. If it happens that the sensitivity is positive, it is caused by either an incorrect scale factor (modal mass) or by the fact that the phase angle of the complex modes compared to the normal mode phase angle exceeds a certain limit; in other words, it is due to an overcomplexity of the mode shape.

The MOV is defined as the ratio of the number of positive frequency sensitivities over the number of all the frequency sensitivities for a particular mode. To give more weight to points with a high modal displacement compared to points with a small modal displacement, a weighted sum is introduced to give a more general evaluation of the modal model. The value of MOV is between 1 and 0, the bigger the value is, the modal model is more overcomplex.

The MOR is defined as the ratio of $\sum_{i=1}^{m} MOV_i$ over (1 - $\sum_{i=1}^{m} MOV_i$) which gives a one figure assessment of the modal model with respect to its overcomplexity. The MOR ranges from zero to infinity. A low MOR value indicates good modal data, while a large MOR indicates a scale factor problem or a overcomplexity problem.

10.2.1 COMMAND

```
 ------------------------------------------------------------
|    DYNAMIC OPTIMIZATION COMMAND                            |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   VERIFY THE VALIDATION OF THE MODE   |
|                        SHAPE BEING MODIFIED                |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   MO                                  |
|------------------------------------------------------------|
|    NO PARAMETERS REQUIRED                                  |
 ------------------------------------------------------------
```

10.2.2 EXAMPLE

```
**   LO

ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):
CPLT

TEST IDENTIFICATION.........  WCPLT
TEST DATE...................    85 0 08

**   SC

ENTER MODAL VECTOR SCALING OPTION:

      0)  CLEAR PREVIOUS SCALING
      1)  MULTIPLY BY (jw)
      2)  MULTIPLY BY (jw)**2
      3)  MULTIPLY BY COMPLEX CONSTANT
      4)  DIVIDE BY (jw)
      5)  DIVIDE BY (jw)**2
      6)  DIVIDE BY COMPLEX CONSTANT
      7)  UNITY SPECIFIC MODAL VECTOR COMPONENT
      8)  UNITY LARGEST MODAL VECTOR COMPONENT
      9)  UNITY MODAL VECTOR LENGTH
     10)  UNITY MODAL MASS
     11)  RESIDUES (MEASUREMENT UNITS)
     12)  UNITY SCALING COEFFICIENT (Q)
     13)  UPDATE MODAL FILE 5 WITH SCALED MODAL VECTORS
     14)  RETURN TO MONITOR

12
```

MODE	FREQUENCY	ZETA(%)	MASS	STIFFNESS
1	360.9092	.5387	.19611E-06	.10085E+01
2	361.2104	.5374	.41502E-07	.21378E+00
3	556.5631	.3689	.60479E-07	.73961E+00
4	764.3735	.2577	.68561E-07	.15814E+01
5	765.1104	.2567	.10839E-08	.25049E-01
6	1223.4053	.2430	.11196E-07	.66157E+00
7	1224.5400	.2170	.14430E-07	.85426E+00
8	1328.9158	.1557	.17361E-07	.12104E+01
9	1329.4912	.1543	.25249E-07	.17619E+01

** DY

DO MO

****

MODE OVERCOMPLEXITY

****

CHOOSE THE OUTPUT FORMAT
1) FULL LISTING
2) OVERCOMPLEXITY VALUE ONLY
1

1) NORMAL SUM
2) WEIGHTED SUM
2

TEST ID : WCPLT
TEST DATE: 85-05-08

SIGN OF FREQUENCY SENSITIVITY FOR A MASS CHANGE
EXPECTED SIGN = NEGATIVE!

PT	DIR	MODE 1	2	3	4	5	6	7	8	9
1	2	-	-	-	-	+	-	-	-	-
2	2	-	-	-	-	+	-	-	-	-
3	2	-	-	-	-	+	-	-	-	-
4	2	-	-	-	-	+	-	-	-	-
5	2	-	-	-	-	+	-	-	-	-
6	2	-	-	-	-	+	-	-	-	-
7	2	-	-	-	-	+	-	-	-	-
8	2	-	-	-	-	-	-	-	-	-
9	2	-	-	-	-	+	-	-	-	-
10	2	-	-	-	-	+	-	-	-	-
11	2	-	-	-	-	+	-	-	-	-
12	2	-	-	-	-	+	-	-	-	-
13	2	-	-	-	-	+	-	-	-	-
14	2	-	-	-	-	+	-	-	-	-

15	2	-	-	-	-	+	-	-	-	-
16	2	-	-	-	-	+	-	-	-	-
17	2	-	-	-	-	+	-	-	-	-
18	2	-	-	-	-	+	-	-	-	+
19	2	-	-	-	-	+	-	-	-	-
20	2	-	-	-	-	+	-	-	-	-
21	2	-	-	-	-	+	-	-	-	-
22	2	-	-	-	-	+	-	-	-	-
23	2	-	-	-	-	+	-	-	-	-
24	2	-	-	-	-	+	-	-	-	-
25	2	-	-	-	-	+	-	-	-	-
26	2	-	-	-	-	+	-	-	-	-
27	2	-	-	-	+	+	-	-	-	-
28	2	-	-	-	-	+	-	-	-	-
29	2	-	-	-	-	+	-	-	-	-
30	2	-	-	-	-	-	-	-	-	-
31	2	-	-	-	-	+	-	-	-	-
32	2	-	-	-	-	+	-	-	-	-
33	2	-	-	-	-	+	-	-	-	+
34	2	-	-	-	-	+	-	-	-	-
35	2	-	-	-	-	+	-	-	-	-
36	2	-	-	-	-	+	-	-	-	-

MODE OVERCOMPLEXITY VALUES
NORMAL(1); WEIGHTED(2) : 1

MODE	1	2	3	4	5	6	7	8	9
%	0	0	0	2	94	0	0	0	5

MODE OVERCOMPLEXITY RATIO = .13

Note:
Mode 5 is overcomplex due to the positive frequency shifts, which makes MOV for mode 5 to be 0.94.

10.3 MODIFICATION FILE

The Modification File generates a file defining how the current structure is to be modified. Mass, stiffness and damping modifications can be defined related to hardware modification and must be set up before Sensitivity Modification or Modal Synthesis Modification is applied to the structure. The units of added mass, stiffness or damping are a function of the units of the measurements. The table below shows the relation between units conversion. It should be noted that BEFORE generating a modification file, the modal model to be modified MUST be loaded into the RTE Modal Program so the units can be consistent.

MEASUREMENT UNITS	ADDED MASS	ADDED STIFFNESS	ADDED DAMPING
ENGLISH UNITS	Slug	Lb/in Lb/ft	Lb-Sec/in Lb-Sec/ft
METRIC UNITS	Kg	N/Cm N/M	N-Sec/Cm N-Sec/M

10.3.1 COMMAND SUMMARY

The following is a list of commands available in the modification file generator:

```
 ------------------------------------------------------------
|    SUMMARY OF MODIFICATION FILE                            |
|------------------------------------------------------------|
|    A      ADD MODIFICATION ITEM TO FILE                    |
|    C      CHANGE MODIFICATION ITEM                         |
|    D      DELETE MODIFICATION ITEM                         |
|    L      LIST THE MODIFICATION FILE                       |
|    P      PURGE THE MODIFICATION FILE                      |
|    R      READ EXISTING MODIFICATION FILE                  |
|    S      STORE THE MODIFICATION FILE                      |
|    ?      HELP COMMAND                                     |
|    /      PROGRAM EXIT                                     |
 ------------------------------------------------------------
```

10.3.1.1 ADD COMMAND

```
 ------------------------------------------------------------
|    MODIFICATION FILE COMMAND                               |
|------------------------------------------------------------|
|    COMMAND FUNCTION:   ADD MASS (OR DAMPING, STIFFNESS)    |
|------------------------------------------------------------|
|    COMMAND MNEMONIC:   A                                   |
|------------------------------------------------------------|
|    N1 =  Mass (Damping, Stiffness)                         |
 ------------------------------------------------------------
```

When making a mass addition, the x, y and z directions of the added mass at a single location are included in the formulation of the modified model. On the other hand, direction (positive) should be included when specifying the connection locations of the added stiffness or damping (e.g. 2y, 4z).

10.3.1.2 CHANGE COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	CHANGE LOCATION AND/OR AMOUNT OF ADDED MASS (OR DAMPING, STIFFNESS)
COMMAND MNEMONIC:	C
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.1.3 DELETE COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	DELETE CERTAIN MODIFICATION ITEM
COMMAND MNEMONIC:	D
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.1.4 LIST COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	LIST THE MODIFICATION FILE
COMMAND MNEMONIC:	L
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.1.5 PURGE COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	PURGE AN EXISTING MODIFICATION FILE
COMMAND MNEMONIC:	P
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.1.6 READ COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	LOAD AN EXISTING MODIFICATION FILE
COMMAND MNEMONIC:	R
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.1.7 STORE COMMAND

MODIFICATION FILE COMMAND	
COMMAND FUNCTION:	STORE THE MODIFICATION FILE BEING EDITED
COMMAND MNEMONIC:	S
NO PARAMETERS REQUIRED	

This command is menu-driven, thus no further parameters are required.

10.3.2 EXAMPLE

```
**    DY

*DO*    MF
```

```
*MF* R
 MODIFICATION FILE NAME ? ONELB.DAT

*MF* L

    #  TYPE           LOCATION        AMOUNT

    1  MASS          1                 .45

*MF* A M

LOCATION ? 12

AMOUNT ?
IN ORDER TO BE CONSISTENT IN UNITS WITH THE ORIGINAL
MODAL MODEL, ENTER AMOUNT IN UNITS AS FOLLOWS :

            MASS        ... Kg
            STIFFNESS   ... N/Cm
            DAMPING     ... N-Sec/Cm

*MF* A S

LOCATION ? 1Y

LOCATION ? 2Y

AMOUNT ?
IN ORDER TO BE CONSISTENT IN UNITS WITH THE ORIGINAL
MODAL MODEL, ENTER AMOUNT IN UNITS AS FOLLOWS :

            MASS        ... Kg
            STIFFNESS   ... N/Cm
            DAMPING     ... N-Sec/Cm

*MF* L

    #  TYPE           LOCATION        AMOUNT

    1  MASS           1                 .45
    2  MASS          12                 .45
    3  STIFFNESS     1Y+     2Y+        .54

*MF* /

*DO* EX
```

10.4 SENSITIVITY MODIFICATION

The use of the Sensitivity Analysis (SS command) allows the test and/or design engineer to choose, quickly and easily, the location and type of hardware modifications that yield the most efficient change in system parameters. Sensitivity Modification uses the sensitivities computed by that procedure to estimate the actual change in modal parameters based on a specific hardware modification.

First (differential) and second (difference) order sensitivities are derived during the Taylor series expansion of the flexibility matrix (inverse of the transfer function matrix). The differential or first order sensitivities are relatively easy to compute, but are only valid for small changes in mass, stiffness, and/or damping parameters. The differential sensitivities are in fact a linear approximation of the effect of the modification and thus only give the direction to which the observed parameter will shift. On the other hand, the difference or second order sensitivities use a quadratic approximation which should be more accurate than the linear one and the difference sensitivities are also valid in a larger range of modification. The major drawback to the use of difference sensitivities is the required computation time - for one modification of one parameter, the computation time of the second order term will take approximately two times the number of modes than that of the first order sensitivity.

10.4.1 SENSITIVITY MODIFICATION COMMAND

```
 ---------------------------------------------------------------
|    DYNAMIC OPTIMIZATION COMMAND                               |
|---------------------------------------------------------------|
|    COMMAND FUNCTION:   OPERATE THE SENSITIVITY MODIFICATION   |
|---------------------------------------------------------------|
|    COMMAND MNEMONIC:   SM                                     |
|---------------------------------------------------------------|
|    NO PARAMETERS REQUIRED                                     |
 ---------------------------------------------------------------
```

10.4.2 EXAMPLE

```
**  LO

ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):
CPLT

TEST IDENTIFICATION.........  WCPLT
TEST DATE...................    85 0 08

**  SC

ENTER MODAL VECTOR SCALING OPTION:

      0)  CLEAR PREVIOUS SCALING
      1)  MULTIPLY BY (jw)
      2)  MULTIPLY BY (jw)**2
      3)  MULTIPLY BY COMPLEX CONSTANT
      4)  DIVIDE BY (jw)
      5)  DIVIDE BY (jw)**2
      6)  DIVIDE BY COMPLEX CONSTANT
      7)  UNITY SPECIFIC MODAL VECTOR COMPONENT
      8)  UNITY LARGEST MODAL VECTOR COMPONENT
      9)  UNITY MODAL VECTOR LENGTH
     10)  UNITY MODAL MASS
     11)  RESIDUES (MEASUREMENT UNITS)
     12)  UNITY SCALING COEFFICIENT (Q)
```

13) UPDATE MODAL FILE 5 WITH SCALED MODAL VECTORS
14) RETURN TO MONITOR

12

MODE	FREQUENCY	ZETA(%)	MASS	STIFFNESS
1	360.9092	.5387	.19611E-06	.10085E+01
2	361.2104	.5374	.41502E-07	.21378E+00
3	556.5631	.3689	.60479E-07	.73961E+00
4	764.3735	.2577	.68561E-07	.15814E+01
5	765.1104	.2567	.10839E-08	.25049E-01
6	1223.4053	.2430	.11196E-07	.66157E+00
7	1224.5400	.2170	.14430E-07	.85426E+00
8	1328.9158	.1557	.17361E-07	.12104E+01
9	1329.4912	.1543	.25249E-07	.17619E+01

** DY

DO SM
MODIFICATION FILE NAME ? ONELB.DAT

OPTION:

(1) DIFFERENTIAL SENSITIVITIES.
(2) DIFFERENCE SENSITIVITIES.
ENTER 1 OR 2
1

MODIFICATION WITH SENSITIVITY METHOD

	FREQUENCY				DAMPING ZETA			
MODE	ORIG	MOD	SHIFT	%	ORIG	MOD	SHIFT	%
1	360.90	350.35	-10.55	-2.92	.53	.53	-.00	-.38
2	361.21	345.79	-15.41	-4.26	.53	.46	-.07	-13.22
3	556.56	542.25	-14.31	-2.57	.36	.26	-.10	-2.54
4	764.37	764.36	-.01	-.00	.25	.25	.00	.32
5	765.11	771.70	6.63	.86	.25	.43	.15	60.72
6	1223.40	1200.27	-23.12	-1.89	.24	.13	-.08	-32.95
7	1224.54	1195.84	-28.69	-2.34	.21	.28	.07	33.10
8	1328.91	1292.69	-36.22	-2.72	.15	.13	-.02	-13.69
9	1329.49	1254.18	-75.30	-5.66	.15	.12	-.03	-21.24

DO YOU WANT THE MODIFIED MODAL COEFFICIENTS
WRITTEN TO THE WORK TRACK ?
1) YES
2) NO

1

DO EX

10.5 MODAL SYNTHESIS MODIFICATION

The Modal Synthesis is another modification method using modal coordinates. The use of modal coordinates for modification purpose allows a drastic reduction of the number of degrees of freedom (DOF) compared to finite element modification techniques or impedence modeling techniques. A secondary effect of this reduced size is the increase in computational speed. In fact, the reduction in the number of DOF is possible only because a limited number of modes are analyzed. Lower and higher frequencies are not included in the modal synthesis and may, in some cases, cause poor results, if not enough care is taken.

The three major modification types are allowed with the modal synthesis technique: hardware modification, structural assembly and structural decomposition. The most obvious is the hardware modification and actually the other two types can be considered as special cases of the hardware modification. Two sources of modal data may be available, measured data and analytically generated data. The data generated with finite element codes usually contains real normal modes and no damping. In order to use analytical data, a damping value for each mode may be estimated. However, in the case of measured data, most parameter estimation techniques in RTE Modal Program are based on the assumption of general viscous damping which may yield complex modes.

10.5.1 MODAL SYNTHESIS MODIFICATION COMMAND

```
 ------------------------------------------------------------
|     DYNAMIC OPTIMIZATION COMMAND                           |
|------------------------------------------------------------|
|     COMMAND FUNCTION:    OPERATE THE MODAL SYNTHESIS       |
|                          MODIFICATION                      |
|------------------------------------------------------------|
|     COMMAND MNEMONIC:    MS                                |
|------------------------------------------------------------|
|     NO PARAMETERS REQUIRED                                 |
 ------------------------------------------------------------
```

10.5.2 EXAMPLE

```
**   LO

ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):
CPLT

TEST IDENTIFICATION.........  WCPLT
TEST DATE...................    85 05 08

**   SC

ENTER MODAL VECTOR SCALING OPTION:

     0)   CLEAR PREVIOUS SCALING
     1)   MULTIPLY Y (jw)
     2)   MULTIPLY BY (jw)**2
     3)   MULTIPLY BY COMPLEX CONSTANT
     4)   DIVIDE BY (jw)
     5)   DIVIDE BY (jw)**2
     6)   DIVIDE BY COMPLEX CONSTANT
```

7) UNITY SPECIFIC MODAL VECTOR COMPONENT
8) UNITY LARGEST MODAL VECTOR COMPONENT
9) UNITY MODAL VECTOR LENGTH
10) UNITY MODAL MASS
11) RESIDUES (MEASUREMENT UNITS)
12) UNITY SCALING COEFFICIENT (Q)
13) UPDATE MODAL FILE 5 WITH SCALED MODAL VECTORS
14) RETURN TO MONITOR

12

MODE	FREQUENCY	ZETA(%)	MASS	STIFFNESS
1	360.9092	.5387	.19611E-06	.10085E+01
2	361.2104	.5374	.41502E-07	.21378E+00
3	556.5631	.3689	.60479E-07	.73961E+00
4	764.3735	.2577	.68561E-07	.15814E+0
5	765.1104	.2567	.10839E-08	.2549E-01
6	1223.4053	.243	.11196E-07	.66157E+00
7	224.5400	.2170	.14430E-07	.85426E+00
8	1328.9158	.1557	.17361E-07	.12104E+01
9	1329.4912	.1543	.25249E-07	.17619E+01

** DY

DO MS
MODIFICATION FILE NAME ? ONELB.DAT
START --- MATRIX SETUP --- FINISH

EIGENPROBLEM SOLVING --- DONE

MODAL SYNTHESIS MODIFICATION

	FREQUENCY				DAMPING ZETA			
MODE	ORIG	MOD	SHIFT	%	ORIG	MOD	SHIFT	%
1	360.90	336.64	-24.26	-6.72	.53	.47	-.06	-12.68
2	361.21	361.03	-.17	-.04	.53	.53	.00	.06
3	556.56	545.18	-11.38	-2.04	.36	.29	-.07	-19.65
4	764.37	764.37	.00	.00	.25	.25	.00	.03
5	765.11	77.93	5.82	.76	.25	.39	.13	52.88
6	1223.40	1154.36	-69.04	-5.64	.24	.18	-.06	-25.49
7	1224.54	1223.92	-.61	-.05	.21	.23	.01	7.35
8	1328.91	1280.72	-48.19	-3.62	.15	.16	.00	2.59
9	1329.49	1329.11	-.37	-.02	.15	.15	.00	.59

DO YOU WANT THE MODIFIED MODAL COEFFICIENTS
WRITTEN TO THE WORK TRACK ?
1) YES
2) NO
1

STORING QUADRATURE RESPONSE BACK AT POINT : 36

DO EX

11. NORMALIZATION OF MEASURED COMPLEX MODES

11.1 OVERVIEW

When experimentally derived modal vectors are used to predict dynamics of a modified system or response due to applied forces, it may be desirable to normalize the measured complex modal vectors such that the vectors are real, normal modes.

The task of normalizing a set of measured complex modes can be performed one of four ways:

```
1)   Real Part
2)   Imaginary Part
3)   Magnitude
4)   Time Domain Method using PRA (Principal Response Analysis)
```

The Real-Normalization module can be called within the RTE Modal Monitor as follows:

** RN

When RN has been entered, the user will be asked whether to continue with normalization program due to the fact that the modal vectors stored in the project area will be overridden by the normalized modal vectors at the end of the execution. If the answer is positive, then the modal coefficients in Modal File 5 will be read, and the complexity of the measured complex modes will then be computed using linear regression analysis. The output of the linear regression analysis will show four quantities: (1) absolute sum of the real part, (2) absolute sum of the imaginary part, (3) phase angle from a straight line curvefit, (4) least-square errors, of the measured modal vectors. Note that the least square percent error could become very large if the phase angle of the straight line fit is approaching + or - 90 degrees due to the nature of the algorithm.

11.2 MEASURED COMPLEX MODES

The data set (i.e., modal vectors) to be used in the modal vector normalization are either stored in the project file or a separate Modal File 5 (such as file : MF0501) which can be loaded into the project area. Scaling of the modal vectors is not required for the first three methods mentioned above. The last method, Principal Response Analysis, requires all the measured modal vectors to be properly scaled so that the largest modal coefficient for each mode is unity using the RTE Modal Scaling Module (option number 8).

11.3 NORMALIZATION USING REAL PART OF THE MODAL COEFFICIENT

With this method, the real part of each complex modal coefficient in a set of measured modal vectors is used to represent the normalized modal coefficient of the original complex modal data. These normal modal vectors are then scaled to match the Euclidian norm (length) of the original modal vectors for each mode existing in the modal data set. The length of a modal vector is defined as the square root of the sum of squares of all modal coefficients (in the sense of its magnitude) existing in a modal vector. This scaling is done to preserve the absolute scaling of each modal vector with respect to modal mass.

11.4 NORMALIZATION USING IMAGINARY PART OF THE MODAL COEFFICIENT

With this method, the imaginary part of each complex modal coefficient in a set of measured modal vectors is used to represent the normalized modal coefficient of the original complex modal data. These normal modal vectors are then scaled to match the length of these two sets of modal vectors for each mode existing in the modal data set.

11.5 NORMALIZATION USING MAGNITUDE OF THE MODAL COEFFICIENT

With this method, the magnitude of each complex modal coefficient in a set of measured modal vectors is used to represent the normalized modal modal vector. The phase of the normalized modal coefficient will be $\pm 90^o$ which is dependent on the orientation of the complex modal coefficient. Similar to the previous methods, the normalized real modal vectors are also scaled to keep the length of the original complex modal vector.

11.6 NORMALIZATION USING A PRA TIME DOMAIN TECHNIQUE

A time domain technique described in Section 2.8.6 of the Volume of System Modeling Technique, Final Technical Report, is used to normalize a set of measured complex modes. From the given modal parameters , free decay responses are formed using properly scaled modal vectors. Real eigenvalues and eigenvectors are solved for the $[M]^{-1}[K]$ matrix in the principal response coordinates (which has the same number of degrees of freedom as the number of modes included in the data set). The set of normal modes in the principal coordinates are then transformed back to the physical coordinates to obtain a set of undamped modes. Similar to the previous method, the normalized real modal vectors are also scaled to keep the length of the original complex modal vectors.

11.7 COMPUTATION OF MAC

At the end of the normalization program, MAC (Modal Assurance Criteria) values are computed between the original modal vectors and the normalized modal vectors. These values can then be examined to evaluate the validity of the normalized modal vectors. If the MAC value has changed dramatically before and after the normalization process, then this may indicate the computed normal modes are invalid due to either an erroneous data base or some numerical problem existing in the computer program.

11.8 EXAMPLE

An example of using this normalization program is listed below. Project File TPLATE is loaded. The first six modes are used and then scaled to the unity largest modal coefficient for each mode. The

PRA time domain method is chosen to real-normalize the measured complex modes.

** LO

ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):
TPLATE

TEST IDENTIFICATION......... TPLATE
TEST DATE................... 86 06 30

** W 5 1 (review the first complex mode)

ENTER MODAL VECTOR FORMAT:
1) MAGNITUDE-PHASE
2) REAL-IMAGINARY
1

MODE	POINT	X,Y,Z DEFORMATIONS			X,Y,Z PHASE ANGLES		
1	1	.000E+00	.000E+00	95.4	0.00	0.00	104.05
1	2	.000E+00	.000E+00	99.0	0.00	0.00	104.61
1	3	.000E+00	.000E+00	97.0	0.00	0.00	104.61
1	4	.000E+00	.000E+00	44.2	0.00	0.00	104.63
1	5	.000E+00	.000E+00	44.4	0.00	0.00	105.61
1	6	.000E+00	.000E+00	44.4	0.00	0.00	105.64
1	7	.000E+00	.000E+00	7.98	0.00	0.00	106.10
1	8	.000E+00	.000E+00	8.60	0.00	0.00	108.42
1	9	.000E+00	.000E+00	5.36	0.00	0.00	107.32
1	10	.000E+00	.000E+00	49.2	0.00	0.00	-76.68
1	11	.000E+00	.000E+00	50.0	0.00	0.00	-73.46
1	12	.000E+00	.000E+00	49.2	0.00	0.00	-73.61
1	13	.000E+00	.000E+00	106.	0.00	0.00	-75.78
1	14	.000E+00	.000E+00	101.	0.00	0.00	-75.43
1	15	.000E+00	.000E+00	97.1	0.00	0.00	-73.79
1	16	27.4	.000E+00	.000E+00	105.75	0.00	0.00
1	17	23.5	.000E+00	.000E+00	106.65	0.00	0.00
1	18	26.9	.000E+00	.000E+00	106.15	0.00	0.00
1	19	24.6	.000E+00	.000E+00	-72.56	0.00	0.00
1	20	27.2	.000E+00	.000E+00	-73.82	0.00	0.00
1	21	24.3	.000E+00	.000E+00	-73.60	0.00	0.00
1	22	98.9	.000E+00	.000E+00	-73.88	0.00	0.00
1	23	101.	.000E+00	.000E+00	73.86	0.00	0.00
1	24	98.5	.000E+00	.000E+00	-74.35	0.00	0.00

** RS,4,6

** SC

ENTER MODAL VECTOR SCALING OPTION:

```
         0)   CLEAR PREVIOUS SCALING
         1)   MULTIPLY BY (jw)
         2)   MULTIPLY BY (jw)**2
         3)   MULTIPLY BY COMPLEX CONSTANT
         4)   DIVIDE BY (jw)
         5)   DIVIDE BY (jw)**2
         6)   DIVIDE BY COMPLEX CONSTANT
         7)   UNITY SPECIFIC MODAL VECTOR COMPONENT
         8)   UNITY LARGEST MODAL VECTOR COMPONENT
         9)   UNITY MODAL VECTOR LENGTH
        10)   UNITY MODAL MASS
        11)   RESIDUES (MEASUREMENT UNITS)
        12)   UNITY SCALING COEFFICIENT (Q)
        13)   UPDATE MODAL FILE 5 WITH SCALED MODAL VECTORS
        14)   RETURN TO MONITOR

8
```

MODE	FREQUENCY	ZETA(%)	MASS	STIFFNESS
1	178.3403	.3823	.11175E+01	.14032E+07
2	335.4455	.1244	.61848E+00	.27475E+07
3	412.4849	.1316	.55859E+00	.37521E+07
4	582.5028	.1199	.10744E+01	.14392E+08
5	596.7325	.1776	.31471E+00	.44242E+07
6	742.5321	.2234	.30905E+00	.67270E+07

```
**   RN

   THIS PROGRAM WILL OVERRIDE WORK AREA MODAL VECTORS!
      CONTINUE   (YE/NO) ?
YE

      ** READ MODAL COEFFICIENT FROM MODAL FILE 5 !
```

			SUM-REAL	SUM-IMAG	PHASE	ERROR(%)
MODE :	1	X	125.478	434.216	106.018	.041
MODE :	1	Z	232.048	867.687	104.821	.355
MODE :	1	TOTAL	357.526	1301.903	105.199	.256
MODE :	2	X	175.064	293.284	120.709	.015
MODE :	2	Z	47.456	76.953	120.921	.471
MODE :	2	TOTAL	222.520	370.238	120.717	.032
MODE :	3	X	28.962	102.978	105.988	18.530
MODE :	3	Z	951.447	4521.583	101.651	.145
MODE :	3	TOTAL	980.410	4624.562	101.654	.156
MODE :	4	X	219.497	842.454	75.301	.078
MODE :	4	Z	94.617	375.002	75.650	.103
MODE :	4	TOTAL	314.115	1217.456	75.361	.082
MODE :	5	X	141.016	575.807	103.732	.126
MODE :	5	Z	761.116	3501.192	102.010	.320
MODE :	5	TOTAL	902.132	4077.000	102.081	.312
MODE :	6	X	9.613	93.368	89.014	2359.778
MODE :	6	Z	69.328	3451.960	88.973	11.121

MODE : 6   TOTAL   78.940   3545.328   88.973   13.394

SELECT RE-NORMALIZATION METHOD
1) REAL PART
2) IMAGINARY PART
3) MAGNITUDE
4) TIME DOMAIN METHOD (USING PRA)
5) BACK TO MONITOR

4

HAVE YOU SCALED THE MODAL VECTORS TO UNITY LARGEST
MODAL VECTOR COMPONENT (METHOD 8 IN SCALING PROGRAM) ?(YE/NO)

YE

** NOW READING RESIDUE DATA FROM MODAL FILE 5 !

NOW CALCULATING TRANSFORMATION MATRIX USING PRA

NEW EIGENVALUE

1	178.34	0.00000E+00
2	335.44	0.00000E+00
3	412.49	0.00000E+00
4	582.53	0.00000E+00
5	596.73	0.00000E+00
6	742.50	0.00000E+00

NEW EIGEN VECTOR (in the principal coordinates)

REAL PART

.998	-.009	.040	-.163	.011	-.037
-.033	-.008	1.021	-.150	-.017	.133
.076	-.016	.136	1.028	-.014	-.065
-.006	-.145	.024	-.050	-.609	-.573
-.021	.010	.077	-.043	.321	-.890
.003	1.240	.007	.004	-.054	-.043

IMAGINARY PART

0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000

MAC OF ORIGINAL MODE SHAPE

	1	2	3	4	5	6
1	1.00	.00	.00	.01	.00	.00
2	.00	1.00	.00	.00	.00	.00
3	.00	.00	1.00	.00	.00	.00
4	.01	.00	.00	1.00	.00	.00
5	.00	.00	.00	.00	1.00	.01
6	.00	.00	.00	.00	.01	1.00

MAC OF REAL-NORMALIZED MODE SHAPE

	1	2	3	4	5	6
1	1.00	.00	.00	.01	.00	.00
2	.00	1.00	.00	.00	.00	.00
3	.00	.00	1.00	.00	.00	.00
4	.01	.00	.00	1.00	.00	.00
5	.00	.00	.00	.00	1.00	.01
6	.00	.00	.00	.00	.01	1.00

MAC BETWEEN ORIGINAL AND NORMALIZED MODE SHAPE

	1	2	3	4	5	6
1	1.00	.00	.00	.01	.00	.00
2	.00	1.00	.00	.00	.00	.00
3	.00	.00	1.00	.00	.00	.00
4	.01	.00	.00	1.00	.00	.00
5	.00	.00	.00	.00	1.00	.01
6	.00	.00	.00	.00	.01	1.00

```
** W 5 1

  ENTER MODAL VECTOR FORMAT:
      1)  MAGNITUDE-PHASE
      2)  REAL-IMAGINARY
1
```

MODE	POINT	X,Y,Z DEFORMATIONS			X,Y,Z PHASE ANGLES		
1	1	.000E+00	.000E+00	95.4	0.00	0.00	90.0
1	2	.000E+00	.000E+00	99.0	0.00	0.00	90.0
1	3	.000E+00	.000E+00	97.0	0.00	0.00	90.0
1	4	.000E+00	.000E+00	44.2	0.00	0.00	90.0
1	5	.000E+00	.000E+00	44.4	0.00	0.00	90.0
1	6	.000E+00	.000E+00	44.4	0.00	0.00	90.0
1	7	.000E+00	.000E+00	7.98	0.00	0.00	90.0
1	8	.000E+00	.000E+00	8.60	0.00	0.00	90.0
1	9	.000E+00	.000E+00	5.36	0.00	0.00	90.0
1	10	.000E+00	.000E+00	49.2	0.00	0.00	-90.0
1	11	.000E+00	.000E+00	50.0	0.00	0.00	-90.0
1	12	.000E+00	.000E+00	49.2	0.00	0.00	-90.0
1	13	.000E+00	.000E+00	106.	0.00	0.00	-90.0
1	14	.000E+00	.000E+00	101.	0.00	0.00	-90.0
1	15	.000E+00	.000E+00	97.1	0.00	0.00	-90.0
1	16	27.4	.000E+00	.000E+00	90.0	0.00	0.00
1	17	23.5	.000E+00	.000E+00	90.0	0.00	0.00
1	18	26.9	.000E+00	.000E+00	90.0	0.00	0.00
1	19	24.6	.000E+00	.000E+00	-90.0	0.00	0.00
1	20	27.2	.000E+00	.000E+00	-90.0	0.00	0.00
1	21	24.3	.000E+00	.000E+00	-90.0	0.00	0.00
1	22	98.9	.000E+00	.000E+00	-90.0	0.00	0.00
1	23	101.	.000E+00	.000E+00	-90.0	0.00	0.00
1	24	98.5	.000E+00	.000E+00	-90.0	0.00	0.00

12. FOURIER SYSTEM USER PROGRAMS

12.1 OVERVIEW

In order to provide frequency response data to the RTE Modal Program, a number of User Programs have been written for an HP-5451-B/C Fourier System which provides a method of storing test information with each data record as it is stored to the Fourier system disc. This information is stored in the File Nine record portion of every data record as the data record is stored to the disc by User Program 88 or 888. The information in the File Nine record is formulated based upon general test data stored into a File Seven record by User Program 91 or 889. This information is available to the RTE Modal Program by way of EXEC calls from within the RTE system. Once the test informaton has been stored with the data, the RTE Modal Program will be able to recognize modal data and distinguish between different modal data sets.

12.2 USER PROGRAM Y0080 - Y0083 (HP-5451-C)

DATA TRANSFER FROM HP-542X to HP-5451C

These programs were originally supplied by Hewlett-Packard. They have been changed by U.C. such that they now store the entire HP-542X data header to the header area on the HP-5451-C Fourier disc in addition to the system information. User programs 80 and 81 work in conjunction with the 5423, while User Programs 82 and 83 are for the 5420. Four programs are needed in an overlay in the HP-5451-C system. The sources for these programs are named: &5423W, &FORCC, $RW9C, and &BCNV.

Also, for this program to work, the revised D.37 (A8524D) driver that picks up the CLEAR E REG fix and the fix for a zero length record must be in the system.

To run the program one needs to first set the HP-542X to the addressable mode and then issue a "RESET" on the HP-542X, to clear any pending service requests. The program will read any data type generated by the HP-542X and stored on the HP-542X data cartridge. The program will read file one record XX on the HP-542X data tape and store this data in the HP-5451-C block 0, with the correct coordinate code and scale factors. To accomplish this the coordinate code for all data types will be 99 (denoting that the data was zoom). In this way the correct parameters for delta F, delta time, or delta voltage will be sent as zoom center freq. and delta freq. in the header words 9 thru 12. This makes the curser routine work independent of what the data was.

To make a transfer, issue the following commands:

User Program 80 N1 (User Program 82 for HP-5423)

N1 = Tape cartridge record number be read in file 1.

User Program 81 0 (User Program 83 for HP-5420)

Once Y 80 has been called, multiple calls to Y 81 0 will read the next record on the tape.

To include this in your system one needs to regenerate the system to include the new driver D.37 and an appropriate PCS table that has the 59310 card in the proper IO slot. Also another entry has to be made to include SUB CHANNEL 4.

12.3 USER PROGRAM Y0088 (HP-5451B)

MODAL DATA ANNOTATION

This program is called within the data acquisition keyboard program in order to put the proper test information into the data block header area when the data is stored to the disk.

The following command format must be used:

User Program 88 N1 N2 N3 N4

N1 = 1, 2 or 3; Stores data blocks 1 through N1 to the disk.

N2 = Point number increment value, (N2 default value = 1). If the parameter N2 is less than or equal to zero, the point number is not incremented and the data is stored with the current point number and transducer orientation.

N3 = Zoom range parameter (N3 = 0-9) (N3 default value = 0 i.e. Baseband) N3 is an integer from 0 to 9 which specifies a parameter of Z0 to Z9 respectively. The zoom range parameter provides an easy key on which other programs can search when looking for a specific frequency range.

N4 = File 7 record number where data acquisition set-up is stored. The data acquisition set-up is read in from File Seven, record N4, before the current data is stored on the disk. After the data has been stored, the test set-up is restored to File Seven, record N4. This way the test set-up always contains the last point number and transducer orientations used. Before the set-up is read, the Mass Storage File 1 (Data File) pointer is recorded so that after reading or writing the set-up, the data file pointer is returned to its original location.

Upon issuing the Y88 N1 N2 N3 N4 command the program will respond with a prompt character "D" at the terminal. The user must then enter point number and transducer orientation as such:

N (IX) (IY) (IZ), where

N = Point number associated with current measurements.

IX = Local transducer orientation associated with data in ADC channel B.

IY = Local transducer orientation associated with data in ADC channel C.

IZ = Local transducer orientation associated with data in ADC channel D.

Local transducer orientations are expressed as plus or minus 1, 2, or 3 corresponding to local coordinate directions of plus or minus X, Y, or Z respectively. The correct orientation entry is that which describes the local direction in which the transducer is pointing.

The direction of the transducer can be imagined by drawing a vector from the base of the transducer through the top of it. As an example, if the transducer associated with the data in ADC channel B is pointing in the positive local Y direction then IX = 2.

12.3.1 Automatic Point Number Increment

If successive measurements have the same transducer orientation, then switch register bit 1 may be turned on to have automatic incrementing of the point number. If switch register bit 0 is off then the point number is increased by N2. If bit 0 is on then the point number is decreased by N2.

12.3.2 Reset Data File Pointer

If switch register bit 9 is on, the disk data file pointer will be reset to record 1.

12.3.3 Override Uncleared Protection

If switch register bit 12 is on, the disk data records need not have been previously cleared. Data will be stored in the next disk data record.

12.3.4 Error Messages

E0 - Insufficient number of parameters.
E1 - First parameter out of range (1-3).
E2 - Invalid point number
E3 - Third parameter out of range (0-9).
E4 - Fourth parameter out of range (1-79).
E5 - Data storage start record out of range (1-600).

12.4 USER PROGRAM Y0888 (HP-5451-C (CINCINNATI))

MODAL DATA ANNOTATION

This program is called within the data acquisition keyboard program in order to put the proper test information into the data block header area when the data is stored to the disk.

The following command format must be used:

User Program 888 N1 N2 N3 N4 N5

N1 = 1-24; Stores blocks 1 through N1 to the disk.

-25<N1<0 N1 separate point number and direction prompts are issued. This stores up to 24 measurements with 24 different point number, direction pairs.

0<N1<4 N1 data blocks are stored with a single point number and direction(s) prompt.

5<N1<25 Stores N1/3 sets of tri-axial measurements, (N1 must be a multiple of 3). Only N1/3 point number and direction(s) prompts are issued.

N2 = Point number increment value. With bit 0 on, the current point number is automatically incremented/decremented by N2 (depending on the sign of N2). If N2=0, the current point number and direction(s) is used. Bit 0 need not be lit to use current point number feature. In all cases, if a current point number and/or direction(s) does not exist, a prompt will be issued. Current point number and direction(s) are retained only if no overlay swapping occurs between Y 888 calls.

N3 = Zoom range parameter (N3 = 0-9) (0 = Baseband) N3 is an integer from 0 to 9 which specifies the parameter Z0 to Z9 respectively. The zoom range parameter provides an easy key on which other programs can search when looking for a specific frequency range.

N4 = Excitation configuration number. This entry designates which of the six possible inputs, that can be defined in the File 7 set-up, is currently being used to estimate the frequency rsponse functions in blocks 1 - N1.

N5 = File 7 record number where data acquisition set-up is stored. The data acquisition set-up is read in from File Seven, record N5, before the current data is stored on the disk. After the data has been stored, the test set-up is restored to File Seven, record N5. Before the set-up is read, the Mass Storage File 1 (Data File) pointer is recorded so that after reading or writing the set-up, the data file pointer is returned to its original location.

Upon issuing the Y 888 N1 N2 N3 N4 N5 command the program will respond with a prompt message at the terminal. The user must then enter point number and transducer orientation as such:

N (IX) (IY) (IZ), where

N = Point number associated with current measurements.

IX = Local transducer orientation associated with data in ADC channel B.

IY = Local transducer orientation associated with data in ADC channel C.

IZ = Local transducer orientation associated with data in ADC channel D.

Local transducer orientations are expressed as plus or minus 1, 2, or 3 corresponding to local coordinate directions of plus or minus X, Y, or Z respectively. The correct orientation entry is that which describes the local direction in which the transducer is pointing.

The direction of the transducer can be imagined by drawing a vector from the base of the transducer through the top of it. As an example, if the transducer associated with the data in ADC channel B is pointing in the positive local Y direction then IX = 2.

12.4.1 Automatic Point Number Increment

If successive measurements have the same transducer orientation, then switch register bit 0 may be turned on to have automatic incrementing/decrementing of the point number. For details refer to the description of N2.

12.4.2 Reset Data File Pointer

If switch register bit 9 is on, the disk data file pointer will be reset to record 1. Bit 9 will be cleared upon exit.

12.4.3 Override Uncleared Protection

If switch register bit 12 is on, the disk data records need not have been previously cleared. Data will be stored in the next disk data record.

12.4.4 Data Format

Data must be stored in a rectangular, linear frequency format. If data is log mag, linear frequency, Y 888 will convert it before storing to disc. Otherwise, an error message will be issued and the program aborted, displaying the faulty data block.

12.5 USER PROGRAM Y0889 (HP-5451-C (CINCINNATI))

MODAL DATA SETUP

User Program 889 is used to input and edit the test information stored in a File Seven record of the Fourier system disc. This information is accessed by an appropriate call to User Program 888. This information is used to define the header of the data record as it is stored to the File Nine area of the Fourier system disc. All input to this program follows an interactive format once the User program has been called. Before exiting a read/input/edit mode, a prompt is made for a range of records to be cleared. In addition to clearing the specified data records, the first record number entered is stored with the rest of the set-up information as a starting search record for data storage. If the user does not wish to change the current starting search record, a -1 may be entered for the range to be cleared.

12.6 USER PROGRAM Y0890 (HP-5451-C (CINCINNATI))

MODAL DATA RUN LOG

User Program 890 is used to create a listing of the modal data available on a Fourier system disc. Three parameters may be entered to control the run log listing. These parameters are as follows:

IPAR1 = FIRST RECORD NUMBER (DEFAULT=1)
IPAR2 = SECOND RECORD NUMBER (DEFAULT=819)
IPAR3 = HEADER FORMAT CODE
= 2 HP-5451-B
= 3 HP-5451-C (CINCINNATI) DEFAULT
= 4 HP-5451-C (LEUVEN)

12.7 USER PROGRAM Y0891 (HP-5451-C (CINCINNATI))

MODAL DATA (FILE NINE) LIST

User Program 891 is used to output the contents of a specific data header (File Nine) to the terminal or line printer. The File Nine information consists of 128 binary words of information. The output display can be in terms of octal or integer/ASCII/real data formats. If all parameters are defaulted, the program will run interactively. Two parameters may be entered to control operation as follows:

IPAR1 = HEADER RECORD TO BE LISTED
IPAR2 = HEADER FORMAT CODE
= 2 HP-5451-B
= 3 HP-5451-C (CINCINNATI) DEFAULT
= 4 HP-5451-C (LEUVEN)

12.8 USER PROGRAM Y0892 (HP-5451-C (CINCINNATI))

MODAL DATA (FILE NINE) EDIT

If errors exist in the header due to incorrect input via User Program 888 or User Program 889, the header can be modified by User Program 892. User Program 892 can be called from the interactive mode of User Program 891, or it can be called directly. If no parameters are input, this User program will run via interactive inputs. Parameters may be entered to control the operation as follows:

IPAR1 = HEADER WORD NUMBER (1-128)
IPAR2 = STARTING RECORD NUMBER
IPAR3 = ENDING RECORD NUMBER (DEFAULT = IPAR2)
IPAR4 = HEADER FORMAT CODE

= 2 HP-5451-B
= 3 HP-5451-C (CINCINNATI) DEFAULT
= 4 HP-5451-C (LEUVEN)

13. RTE LOADING INFORMATION

13.1 OVERVIEW

Each module of the RTE Modal Program is loaded as a stand alone program within the RTE operating environment. Since most of the programs require some part of the unlabeled common to operate, the individual programs are not operational unless called in a prescribed order. This order is determined from within the RTE Modal Program in response to a monitor request.

Most of the programs are currently loaded as temporary, large background programs without access to system common. The programs required to drive the displays are currently loaded as permanent, large background programs without access to system common area. The unlabeled common used in each program is buffered to work tracks so that in the session environment, no conflicts between the users will exist. This is required since the RTE Operating System has only one shared system common area.

13.2 INITIALIZATION CHANGES

All system and device initialization occurs within the subprogram INIT. As a system is loaded for a specific hardware or test configuration, some changes may be required in disc or plotter hardware or in the number of work tracks required to store the modal vectors. If this is the case, some changes must be made in the FTN4 source (&INIT), the source recompiled, and the recompiled result stored into the relocatable file (%INIT).

13.3 FRF DATA DISC FORMAT

The RTE Modal Program accesses HP-5451-B/C by way of the FMTXX subroutine used in the BCS generation of the appropriate Fourier system. Therefore, the specific FMTXX file used must be stored into a file called FMTXXX. As the RTE Modal Program is loaded, this relocatable file is attached to the 'INIT' subprogram and the required data map information placed in the common area.

13.4 FILE MANAGER CONTROL FILES

There is a File Manager control file to do the actual loading and purging of all RTE Modal Program modules. The file which loads the basic set of RTE Modal Modules excluding the Display Modules is '*BLD'. Then, the appropriate file must be used to load the Display Modules for the vector display unit being used. For the HP-5460-A Display Unit this file is '*BLD1'. For the HP-1351-A Vector Grahics Generator, this file is '*BLD2'. If a new copy of the RTE Modal Program is to be loaded, all RTE Modal Modules can be purged from the system disc by the control file '*PU'. If a listing of the source of all programs and subroutines is required, the file '*LIST' can be used. In all cases, the file is exercised by the following File Manager command sequence: "TR,*XXXXX"/

13.5 LOADR CONTROL FILES

Each subprogram has a separate LOADR control file which has the form of _#XXXXX. This LOADR control file can be used to reload a subprogram by using the following command: 'RU,LOADR,_#XXXXX,,1,LBNCTE'.

The File Manager control file '*BLD' is a collection of these commands which will load all RTE Modal Program Modules. On RTE systems with minimal memory or disc configurations, all Program Modules that are not needed should be eliminated from this transfer file before execution.

14. PROGRAM PROBLEMS AND ERRORS

14.1 WARRANTY

This software carries absolutely no warranty or guarantee. The University does not have the personnel to provide support and does not advise that anyone outside of the University or another academic research oriented facility use this software due to the self supporting nature of the program.

14.2 BUG REPORTS

If you have chosen to ignore the warranty, all reports of problems or possible errors should be forwarded in writing to the following address:

Randall J. Allemang, PhD
Mail Location #72
University of Cincinnati
Cincinnati, Ohio 45221

Any suggestions for changes, improvements, etc are also welcome.

APPENDIX A: SOFTWARE LIBRARY INFORMATION

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INFORMATION FILE: RTE MODAL SYSTEM LIBRARY

****

FILE CONVENTIONS:		
	SOURCE FILES	&XXXXX
	RELOCATABLE FILES	%XXXXX
	FMGR CONTROL FILES	*XXXXX
	LOADR CONTROL FILES	#XXXXX
	TEXT FILES	"XXXXX

****

REVISION DATE: MARCH 5, 1987
NOTE: AS THE UC MODAL PROGRAM IS CONTINUALLY BEING REVISED AND UPGRADED, THIS LIST IS CURRENT AS OF THE REVISION DATE.

****

FILE NAME	DESCRIPTION
&ADSP1	ANIMATED DISPLAY OUTPUT PROGRAM (HP-5460-A)
&ADSP2	ANIMATED DISPLAY OUTPUT PROGRAM (HP-1351-A)
&ADSP3	ANIMATED DISPLAY OUTPUT PROGRAM (HP-1347-A)
&AMPP	AUTO POWER SPECTRUM PEAK SEARCH
&ANCG	ALPHA-NUMERIC CHARACTER GENERATOR
&ANIM2	ENHANCED ANIMATED DISPLAY OUTPUT PROGRAM (HP-1351-A)
&ANIM3	ENHANCED ANIMATED DISPLAY OUTPUT PROGRAM (HP-1347-A)
&APLOT	CREATES AND PLOTS ANIMATION DISPLAY TO HPIB PLOT DEVICE
&ASD	ADD SUBTRACT FOURIER DATA RECORDS
&ASCT1	ASCII TEXT TO HP-5460-A DISPLAY UNIT
&ASDMP	DUMP ASCII FILE TO LOGICAL UNIT
&BALA1	EISPAC ROUTINE
&BALAN	EISPAC ROUTINE
&BALB1	EISPAC ROUTINE
&BALBA	EISPAC ROUTINE
&BCOEF	PTD - CALCULATES MATRIX COEFFICIENTS
&BLDF	PFD, OTHOG. POLY. - CREATES MEASUREMENT TABLE
&BLDIF	ITD - CREATES MEASUREMENT TABLE
&BLDKF	ITD POLYREF - CREATES MEASUREMENT TABLE
&BLDQD	MULTI MAC - CALCULATES QUADRATURE
&BLDQM	FRF AUTO POWER SUMMATION
&BLDSM	PFD - BUILDS DATA ARRAY
&BYT	SPLIT 16 BIT WORD INTO TWO BYTES
&CAEKF	PFD - CALCULATES MODAL PARAMETERS
&CALAM	PFD - FORMULATES SYSTEM MATRIX
&CALEG	PFD - CALCULATES EVECTORS & EVALUES OF SYSTEM MATRIX
&CALKF	BUILDS SYSTEM MATRIX
&CALM2	SOLVES LEAST SQUARES
&CALMO	SOLVES LEAST SQUARES
&CALPA	CALCULATES PARTICIPATION FACTOR
&CALR1	SEGMENT PROGRAM TO LOAD SETPT
&CALR2	SEGMENT PROGRAM TO LOAD SETDF
&CALR3	SEGMENT PROGRAM TO LOAD GELS
&CALRO	ROTATIONAL FRF CALCULATION
&CCMPL	CALCULATES COMPLEXITY OF A MODE
&CDSP1	CIRCLE DISPLAY OUTPUT PROGRAM (HP-5460-A)

&CDSP2	CIRCLE DISPLAY OUTPUT PROGRAM (HP-1351-A)
&CDSP3	CIRLCE DISPLAY OUTPUT PROGRAM (HP-1347-A)
&CF1	PTD RESIDUE CALCULATION INFO REQUEST (COMPLEX MODES)
&CF2	PTD RESIDUE CALCULATION INFO REQUEST (REAL MODES)
&CF3	PFD RESIDUE CALCULATION INFO REQUEST (COMPLEX MODES)
&CF4	PFD RESIDUE CALCULATION INFO REQUEST (REAL MODES)
&CHANG	PTD - EXCHANGES TWO ROWS IN MATRIX
&CRCL	LEAST SQUARES CIRCLE FIT ALGORITHM
&D5451	CREATE HP-5451-A/B/C DATA RECORD FROM DATA ARRAY
&DFT	DISCRETE FAST FOURIER TRANSFORM ALGORITHM
&DISP	COMPUTE DISPLAY BUFFER REQUIRED BY DVM72 FOR THE HP-5460-A
&DLTF	DECODE HP-5451-B/C FREQUENCY CODE
&DRCTN	DECODE MEASUREMENT DIRECTION FROM ASCII TO INTEGER
&DSPL	DISPLAY HP-5451-A/B/C DATA RECORD FROM RTE
&EBAL	EISPAC ROUTINE
&EBBK2	EISPAC ROUTINE
&EFRF	COMPUTE ENHANCED FREQUENCY RESPONSE FUNCTION
&EIGN3	EISPAC ROUTINE
&ELMH1	EISPAC ROUTINE
&ELMHE	EISPAC ROUTINE
&ELTR1	EISPAC ROUTINE
&ELTRA	EISPAC ROUTINE
&EMQR2	EISPAC ROUTINE
&EORTH	EISPAC ROUTINE
&EQL2	EISPAC ROUTINE
&EQLRT	EISPAC ROUTINE
&ERED1	EISPAC ROUTINE
&ETRIB	EISPAC ROUTINE
&ETRID	EISPAC ROUTINE
&FD1	IDENTIFY DAMPED NATURAL FREQUENCIES (SDOF METHODS)
&FD2A	IDENTIFY BANDWIDTH (LEAST SQUARES LINEAR MDOF METHOD)
&FD2B	DATA ACQUISITION (LEAST SQUARES LINEAR MDOF METHOD)
&FD2C	COMPUTE FREQUENCY/DAMPING VALUES FROM &FD2A AND &FD2B
&FD3B	PTD - SETS UP MEASUREMENT TABLE AND SYSTEM MATRIX
&FD3B1	PTD - SETS UP MEASUREMENT TABLE AND SYSTEM MATRIX
&FD3B2	PTD - SETS UP MEASUREMENT TABLE AND SYSTEM MATRIX
&FD3C	PTD - ROOTS AND ERROR CHARTS
&FD3C1	PTD - ROOTS AND ERROR CHARTS
&FD3C2	PTD - ROOTS AND ERROR CHARTS
&FD6B	ORTHOGONAL POLYNOMIAL
&FDF01	PFD - LOAD SEGMENT
&FDF02	PFD - LOAD SEGMENT
&FDF03	PFD - LOAD SEGMENT
&FDF04	PFD - LOAD SEGMENT
&FDF05	PFD - LOAD SEGMENT
&FDF06	PFD - LOAD SEGMENT
&FDF07	PFD - LOAD SEGMENT
&FDF08	PFD - LOAD SEGMENT
&FDFA	PFD - DETERMINE FIT BANDWITH
&FDFR	PFD - CALCULATE MODAL PARAMETERS
&FDFRC	POLYREFERENCE FREQUENCY DOMAIN
&FDFRD	POLYREFERENCE FREQUENCY DOMAIN
&FDFRE	POLYREFERENCE FREQUENCY DOMAIN
&FDFRF	POLYREFERENCE FREQUENCY DOMAIN
&FDFRK	POLYREFERENCE FREQUENCY DOMAIN

&FIX	ADD VALID Y888 HEADER TO EXISTING FRF DATA
&FLIO	MODAL FILE INPUT OUT
&FMT0A	FMTXX FILE FOR HP-7900 DISC U.C. REVISION
&FMT5A	FMTXX FILE FOR HP-7925 DISC U.C. REVISION
&FMT6A	FMTXX FILE FOR HP-7906 DISC U.C. REVISION
&GATMR	GENERATE FRF
&GAUS	PTD - GAUSS ELIMINATION
&GAUSB	COMPLEX GAUSS ELIMINATION, RIGHT SIDE UNKNOWN
&GDATA	POLYREF - RESIDUE CALCULATION
&GDIFF	DISPLAY TWO AUTO POWER SPECTRUMS
&GELS	GAUSS ELIMINATION SOLUTION SUBROUTINE
&GUIL	ITD - GAUSS ELIMINATION
&HDR51	DECODE 128 WORD HEADER ARRAY (HP-5451-A/B/C INFORMATION)
&HLBRT	HILBERT TRANSFORM
&HLP	MODAL HELP FILE SUBROUTINE
&HPDOT	DOTTED LINE ROUTINE FOR HP-7210 PLOTTER
&HPPLT	LINE ROUTINE FOR HP-7210 PLOTTER
&HPPOS	POSITION ROUTINE FOR HP-7210 PLOTTER
&HQR2	EISPAC ROUTINE
&IMPL	CALCULATES IMPULSE RESPONSE
&INDIS	INITIALIZES DISPLAY - BRINGS UP UC PLOT
&INIT	INITIALIZE MODAL PROGRAM
&INPT3	INPUT DISPLAY SEQUENCE FILE INFORMATION FROM TERMINAL
&INVER	MATRIX INVERSION - COMPLEX VALUED MATRIX ELEMENTS
&INVRS	SQUARE MATRIX INVERSION AND DETERMINANT CALCULATION
&IPOSE	TRANSPOSE BINARY WORD TO EVALUATE RELOC FILE CODE
&ISWR	SET OR CLEAR PORTIONS OF THE SWITCH REGISTER
&ITD	IBRAHIM TIME DOMAIN
&ITD1	IBRAHIM TIME DOMAIN
&ITD2	IBRAHIM TIME DOMAIN
&ITD3	IBRAHIM TIME DOMAIN
&ITD4	IBRAHIM TIME DOMAIN
&ITD5	IBRAHIM TIME DOMAIN
&ITDB	IBRAHIM TIME DOMAIN
&ITDC	IBRAHIM TIME DOMAIN
&ITDE	IBRAHIM TIME DOMAIN
&ITDM	IBRAHIM TIME DOMAIN
&ITDP	IBRAHIM TIME DOMAIN
&ITDR	IBRAHIM TIME DOMAIN
&LINE	PTD - DISPLAY MONITOR
&LSFRF	LISTS FRFS - HP-5451-C FOURIER SYSTEM
&LSMF	LOAD/STORE MODAL FILES
&LSPF	LOAD/STORE PROJECT FILES
&LSTD	SINGLE REFERENC LEAST SQUARES TIME DOMAIN
&LSTD1	SINGLE REFERENC LEAST SQUARES TIME DOMAIN
&LSTD2	SINGLE REFERENC LEAST SQUARES TIME DOMAIN
&LSTD3	SINGLE REFERENC LEAST SQUARES TIME DOMAIN
&MAC	COMPUTE MODAL ASSURANCE CRITERION
&MCF1	PTD - COMPLEX RESIDUE CALCULATION
&MCF2	PTD - REAL RESIDUE CALCULATION
&MCF3	PTD - COMPLEX RESIDUE CALCULATION
&MCF4	PTD - REAL RESIDUE CALCULATION
&MDF1A	COMPUTE COMPLEX RESIDUES (LEAST SQUARES LINEAR MDOF METHOD)
&MDF1B	COMPUTE COMPLEX RESIDUES (LEAST SQUARES LINEAR MDOF METHOD)
&MDSP	RTE MODAL ANIMATION DISPLAY PROGRAM

&MDSP1	MDOF DISPLAY OUTPUT PROGRAM (HP-5460-A)
&MDSP2	MDOF DISPLAY OUTPUT PROGRAM (HP-1351-A)
&MDSPL	MODAL VECTOR DISPLAY
&MFMT	MEASUREMENT FORMAT DEFINATION
&MHDR	DECODE MODAL HEADER INFORMATION
&MHLP	POLYREF RESIDUE CALC -CALLS HELP FEATURE
&&MITD	MODIFIED IBRAHIM TIME DOMAIN
&MITD1	MODIFIED IBRAHIM TIME DOMAIN
&MITD2	MODIFIED IBRAHIM TIME DOMAIN
&MITD3	MODIFIED IBRAHIM TIME DOMAIN
&MITD4	MODIFIED IBRAHIM TIME DOMAIN
&MITD5	MODIFIED IBRAHIM TIME DOMAIN
&MITDA	MODIFIED IBRAHIM TIME DOMAIN
&MITDB	MODIFIED IBRAHIM TIME DOMAIN
&MITDC	MODIFIED IBRAHIM TIME DOMAIN
&MITDE	MODIFIED IBRAHIM TIME DOMAIN
&MITDM	MODIFIED IBRAHIM TIME DOMAIN
&MITDP	MODIFIED IBRAHIM TIME DOMAIN
&MITDR	MODIFIED IBRAHIM TIME DOMAIN
&MITDW	MODIFIED IBRAHIM TIME DOMAIN
&MKC	CALCULATES MODAL PARAMETERS FROM MKC MATRICES
&MLMC	MULTI MAC USING PRINCIPAL COMPONENT RESPONSE
&MODAL	PRIMARY MONITOR FOR RTE MODAL PROGRAM
&MOD4	LOADS STORES SMS MODAL 4.0 FILES
&MPE	MODAL PARAMETER ESTIMATION CONTROL PROGRAM
&MSCL	MODAL VECTOR SCALING
&MSRC	MEASUREMENT SOURCE FUNCTIONS
&MTBLF	PFD - SETS UP MEASUREMENT TABLE
&MTDB	CONVERT FEM DATA BASE TO/FROM RTE MODAL FILES
&NIXT	OUTPUT INTEGER TO HP-5460-A DISPLAY UNIT NIXIE TUBES
&NRRT	NEWTON-RAPHSON METHOD FOR POLYNOMIAL COMPLEX ROOT SOLUTION
&PCRFF	CALCULATES TRANSFER MATRIX FOR PRINC COMP RES(PCR)
&PCRKF	PCR FOR IBRAHIM
&PCRMM	REDUCED MODE SHAPE USING PCR METHOD (MULTI MAC)
&PLT06	MODAL VECTOR PLOT (TEKTRONIX DEVICE)
&PLT10	MODAL VECTOR PLOT (HP-7210 PLOTTER)
&PLT37	MODAL VECTOR PLOT (HP-IB DEVICE)
&PREF	POYREF - RESIDUE CALCULATION
&PREF1	POYREF - RESIDUE CALCULATION
&PREF2	POYREF - RESIDUE CALCULATION
&PREF3	POYREF - RESIDUE CALCULATION
&PROPT	MATERIAL PROPERTY DEFINATION - MODAL MODIFICATION
&RDAT1	READS AND SCALES FRF DATA
&RDAT2	INVERSE FFT RDATA ARRAY INTO TIME DOMAIN
&RDAT3	POLYREF RESIDUE CALC - READS AND SCALES FRF DATA
&RDAT4	POLYREF RESIDUE CALC - READS AND SCALES FRF DATA
&RDATF	PFD, MM - READS AND SCALES FRF DATA
&RDFEM	STORES BEAM FEM RESULTS (EIGN3) TO MODAL PROJECT FILE
&RDFFS	READS DIFS TABLE TO FTN4 PROGRAM
&RDFS	READ DIFS TABLE
&RDHLP	READ MODAL HELP FILE ^CMND GENERATED BY UCHLP
&RDIFS	READ ONE EIGHT-WORD DIFS TABLE ENTRY FROM AN FMTXX FILE
&RDKF	READS AND SCALES FRF DATA
&REQR	EISPAC ROUTINE
&RGAUB	GAUSS ELIMINATION - REAL COEFF, RIGHT SIDE UNKNOWN

&RGAUS	GAUSS ELIMINATION - REAL COEFFICIENTS
&RIGID	CALCULATES RIGID BODY CORRELATION (LEAST SQUARES)
&RNIB	RNORM MODES FROM COMPLEX MODES USING IBRAHIM TECHNIQUE
&RNLG	PRINT RUN LOG OF HP-5451-A/B/C DISC (USER PROGRAM 88 INFO)
&RNMP	CALCULATES REDUCED MODE SHAPE USING PCR METHOD
&RNORM	CALCULATES REAL NORMAL MODES FROM COMPLEX MODES
&RPACL	A900/RTE6VM CLONING PROGRAM
&RUNPG	USES RP6CL TO RECALL, CLONE, RUN & OFF A PROGRAM IN RTE
&RPOF	RUN/OFF PROGRAM ROUTINE
&RW7B	BCS SUBROUTINE TO ACCESS FILE SEVEN AREA (COMMON) HP-5451-B
&RW7C	BCS SUBROUTINE TO ACCESS FILE SEVEN AREA (COMMON) HP-5451-C
&RW9B	BCS SUBROUTINE TO ACCESS FILE NINE AREA (HEADER) HP-5451-B
&RW9C	BCS SUBROUTINE TO ACCESS FILE NINE AREA (HEADER) HP-5451-C
&RWB	READ/WRITE TO PART OF PROJECT AREA
&RWBLK	READ/WRITE TO SPECIFIC BLOCKS OF PROJECT AREA
&RWD	READ/WRITE TO WORK TRACKS A SPECIFIC NUMBER OF WORDS
&RWD00	READ/WRITE COMMON TO WORK TRACK
&RWD01	READ/WRITE COMPONENT INFORMATION TO WORK TRACK
&RWD02	READ/WRITE GEOMETRY INFORMATION TO WORK TRACK
&RWD03	READ/WRITE CONNECTIVITY INFORMATION TO WORK TRACK
&RWD04	READ/WRITE FREQUENCY/DAMPING INFORMATION TO WORK TRACK
&RWD05	READ/WRITE MODAL COEFFICIENT TO WORK TRACK
&RWDMC	READ/WRITE MODAL COEFFICIENTS TO WORK TRACK
&RWDMV	READ/WRITE MODAL VECTOR TO WORK TRACK
&RWERR	DECODE AND PRINT FMG ERROR CODES
&RWF01	READ/WRITE COMPONENT INFORMATION TO ASCII RTE FILE
&RWF02	READ/WRITE GEOMETRY INFORMATION TO ASCII RTE FILE
&RWF03	READ/WRITE CONNECTIVITY INFORMATION TO ASCII RTE FILE
&RWF04	READ/WRITE FREQUENCY/DAMPING INFORMATION TO ASCII RTE FILE
&RWF05	READ/WRITE MODAL VECTOR TO ASCII RTE FILE
&RWFF	READ/WRITE OF FOURIER FILE
&RWMTD	READ/WRITE DATA TO/FROM A FOURIER DISC IN ASCII FORMAT
&RWUF	READ/WRITE TO UNIVERSAL FILE
&SDOF1	COMPUTE MODAL COEFFICIENTS (AMPLITUDE,REAL,IMAG,REAL+IMAG)
&SDOF2	COMPUTE MODAL COEFFICIENTS (CIRCLE FIT)
&SDSP1	STATIC DISPLAY OUTPUT PROGRAM (HP-5460-A)
&SDSP2	STATIC DISPLAY OUTPUT PROGRAM (HP-1351-A)
&SENAN	SENSITIVITY ANALYSIS
&SETDF	SEGMENT PROGRAM WHICH SETS DEGREE OF FREEDOM
&SETPT	SETS POINT IN CALRO PROGRAM
&SMS01	FMTXX FILE FOR HP-7900 DISC FOR SMS MODAL 4.0
&SMS61	FMTXX FILE FOR HP-7906 DISC FOR SMS MODAL 4.0
&SROOT	PTD - CALCULATES POLES
&STABL	PTD - STABILITY DIAGRAM
&SWTCH	READ HP-5460-A DISPLAY UNIT SWITCHES
&SYNTH	SYNTHESIZE MEASUREMENTS FROM CURRENT MODAL DATA
&TINPT	MONITOR INPUT DECODE SUBROUTINE
&TKDOT	TEKTRONIX DOTTED LINE ROUTINE
&TKPLT	TEKTRONIX PLOT SUBROUTINE
&TKPOS	TEKTRONIX POSITION SUBROUTINE
&TRED1	EISPAC ROUTINE
&U888	RTE PROGRAM TO PERFORM USER PROGRAM 888 FUNCTION
&U889	RTE PROGRAM TO PERFORM USER PROGRAM 889 FUNCTION
&U891	RTE PROGRAM TO PERFORM USER PROGRAM 891 FUNCTION
&U892	RTE PROGRAM TO PERFORM USER PROGRAM 892 FUNCTION

&U893	RTE PROGRAM TO PERFORM HEADER MODIFICATION
&U894	RTE PROGRAM TO PERFORM USER PROGRAM 894 FUNCTION
&U895	CONVERTS MEASUREMENT HEADER TO UC FORMAT
&UCHDR	U895 SUBROUTINE
&UCHLP	UC HELP FILE GENERATION PROGRAM
&UNVFL	READ/WRITE TO UNIVERSAL FILE
&USR9	READ/WRITE OF USER PROGRAM 9 MODAL DATA STRUCTURE
*BLD	CALL TO LOADR FOR MAIN MODAL PROGRAMS
*BLD1	CALL TO LOADR FOR MODAL DISPLAY PROGRAMS (HP-5460-A)
*BLD2	CALL TO LOADR FOR MODAL DISPLAY PROGRAMS (HP-1351-A)
*LIST	LIST OF ALL MODAL SYSTEM SOURCE PROGRAMS
*PU	PURGES ALL MODAL PROGRAMS

****

#$UNVF	LOADR CONTROL FILE
#ADSP1	LOADR CONTROL FILE
#ADSP2	LOADR CONTROL FILE
#ADSP3	LOADR CONTROL FILE
#AMPP	LOADR CONTROL FILE
#ANIM	LOADR CONTROL FILE
#ANIM2	LOADR CONTROL FILE
#ANIM3	LOADR CONTROL FILE
#APLOT	LOADR CONTROL FILE
#ASD	LOADR CONTROL FILE
#ASCT1	LOADR CONTROL FILE
#CALRO	LOADR CONTROL FILE
#CDSP1	LOADR CONTROL FILE
#CDSP2	LOADR CONTROL FILE
#CDSP3	LOADR CONTROL FILE
#CMM4	LOADR CONTROL FILE
#DSPL	LOADR CONTROL FILE
#EFRF	LOADR CONTROL FILE
#EIGN3	LOADR CONTROL FILE
#FCOOR	LOADR CONTROL FILE
#FD1	LOADR CONTROL FILE
#FD2A	LOADR CONTROL FILE
#FD2B	LOADR CONTROL FILE
#FD2C	LOADR CONTROL FILE
#FD3B	LOADR CONTROL FILE
#FD3C	LOADR CONTROL FILE
#FD5B	LOADR CONTROL FILE
#FD8B	LOADR CONTROL FILE
#FDFA	LOADR CONTROL FILE
#FDFR	LOADR CONTROL FILE
#FDFRC	LOADR CONTROL FILE
#FDFRD	LOADR CONTROL FILE
#FDFRF	LOADR CONTROL FILE
#FDFRK	LOADR CONTROL FILE
#FDI1	LOADR CONTROL FILE
#FDI2	LOADR CONTROL FILE
#FDIB	LOADR CONTROL FILE
#FLIO	LOADR CONTROL FILE
#FTN7X	LOADR CONTROL FILE
#GATMR	LOADR CONTROL FILE
#HLBRT	LOADR CONTROL FILE
#INDIS	LOADR CONTROL FILE

#FMODE	LOADR CONTROL FILE
#INIT	LOADR CONTROL FILE
#ITD	LOADR CONTROL FILE
#LSFRF	LOADR CONTROL FILE
#LSMF	LOADR CONTROL FILE
#LSPF	LOADR CONTROL FILE
#LSTD	LOADR CONTROL FILE
#MAC	LOADR CONTROL FILE
#MDF1A	LOADR CONTROL FILE
#MDF1B	LOADR CONTROL FILE
#MDMD	LOADR CONTROL FILE
#MDSP	LOADR CONTROL FILE
#MDSP1	LOADR CONTROL FILE
#MDSP2	LOADR CONTROL FILE
#MDSPL	LOADR CONTROL FILE
#MHLP	LOADR CONTROL FILE
#MITD	LOADR CONTROL FILE
#MITDA	LOADR CONTROL FILE
#MKC	LOADR CONTROL FILE
#MLMC	LOADR CONTROL FILE
#MODAL	LOADR CONTROL FILE
#MOD4	LOADR CONTROL FILE
#MPE	LOADR CONTROL FILE
#MSCL	LOADR CONTROL FILE
#MTDB	LOADR CONTROL FILE
#PLT06	LOADR CONTROL FILE
#PLT10	LOADR CONTROL FILE
#PLT37	LOADR CONTROL FILE
#PREF	LOADR CONTROL FILE
#RDFEM	LOADR CONTROL FILE
#RIGID	LOADR CONTROL FILE
#RNIB	LOADR CONTROL FILE
#RNLG	LOADR CONTROL FILE
#RNMW	LOADR CONTROL FILE
#RNORM	LOADR CONTROL FILE
#RP6CL	LOADR CONTROL FILE
#RWMTD	LOADR CONTROL FILE
#SDOF1	LOADR CONTROL FILE
#SDOF2	LOADR CONTROL FILE
#SDSP1	LOADR CONTROL FILE
#SDSP2	LOADR CONTROL FILE
#SENAN	LOADR CONTROL FILE
#STT	LOADR CONTROL FILE
#SYNTH	LOADR CONTROL FILE
#TT9	LOADR CONTROL FILE
#U8XX	LOADR CONTROL FILE
#UCHLP	LOADR CONTROL FILE
#UNVFL	LOADR CONTROL FILE
#USR9	LOADR CONTROL FILE

****

!CMND	HELP FILE FOR MODAL SYSTEM COMMANDS (UCHLP OUTPUT)
"CMND	HELP FILE FOR MODAL SYSTEM COMMANDS (UCHLP INPUT)

APPENDIX B: MODAL PROGRAM COMMON

The following is an example of the common declaration used in most of the RTE modal program modules.

```
COMMON IFLAG(100),ITRAK,NUMTRK,LUTERM,LUPRNT
*,LUSYS,LUFILE,LUDATA(10),LUPLOT(5),LUDISP,LUHPIB
*,INAM(3),IBELL,IPAGE,ICR,MAXFL1,MAXFL7
*,IL,IPAR1,IPAR2,IPAR3,IPAR4,IPAR5,IPAR6
*,MAXCM,MAXPT,MAXCN,MAXMOD,NCOM,NPT,NCON,NMODE
*,IDENT(10),IDATE(3),IZOOM,IDCODE,MDVA,BETA
*,MAXBS,MAXREF,NREF,FMIN,DF,IBS,NSHFT,JBS
*,FRQ(30),ZETA(30),SCL(30,2),GNMSS(30),MCODE(30)
*,IXPNT(30),IXDIR(30),RMV(30,3),IMV(30,3),IXP(6),IXD(6)
*,LSHFT,IDFLG(17),METH(30,4),IDAMP(30)
*,IUNITS(30,2),ITEMP(100),RTEMP(100)
*,NDIFS,IDIFS(25,8),ILVN(200),ICNN(200)
```

Each program has access to this unlabelled common information by way of the project area assigned to the program. This project area location is passed to each program as it is executed by way of the parameter list in the exec call. The unlabeled common information resides within the first 16 blocks (2048 words) of the project area. At present only the first 1975 words are used.

```
IFLAG   = ARRAY OF CONTROL FLAGS
              (1) VALID COMMON FLAG
              (2) NUMBER OF WORDS IN COMMON
              (3) MEASUREMENT SOURCE FLAG
                  (3) = 1    HP-5423-A
                  (3) = 2    HP-5451-B
                  (3) = 3    HP-5451-C (CINCINNATI)
                  (3) = 4    HP-5451-C (LEUVEN)
                  (3) = 5    HP-5451-C (SMS MODAL 4.0)
                  (3) = 6    F-MONITOR (SK-LMS SYSTEM)
              (4) PROJECT FILE MODAL VECTOR FLAG
                  (4) = 0    NO MODAL VECTORS STORED
                  (4) = 1    MODAL VECTORS STORED
              (5) FREQ/DAMPING METHOD
              (6) MODAL VECTOR METHOD
              (7) REVISION CODE YEAR
              (8) REVISION CODE MONTH
              (9) REVISION CODE DAY
             (10) PARAMETER ESTIMATION FLAG
             (11) DISPLAY UNIT FLAG
                  (11) = 0    NO DISPLAY UNIT
                  (11) = 5460 HP-5460-A
                  (11) = 1345 HP-1345-A
                  (11) = 1347 HP-1347-A
                  (11) = 1351 HP-1351-A
             (12) OPERATING SYSTEM FLAG
                  (12) = 1  HP-5451-C
                  (12) = 2  HP-1000-E
                  (12) = 3  HP-1000-F
                  (12) = 4  HP-1000-A-900
             (13) DISC UNIT FLAG
```

```
          (13) = 1  HP-7900-A
          (13) = 2  HP-7905-A
          (13) = 3  HP-7906-A
          (13) = 4  HP-7920-A
          (13) = 5  HP-7925-A
          (13) = 6  HP CS-80
     (14) NUMBER OF SECTORS/TRACK
     (15) DATA FORMAT FLAG
          (15) = 1  HP FMTXX STRUCTURE
          (15) = 2  SK-LMS STRUCTURE
          (15) = 3  SMS FMTXX STRUCTURE
     (16) NUMBER OF DEGREES OF FREEDOM/POINT
          (16) = 0  3 DOF/POINT
          (16) = 1  6 DOF/POINT
     (20) NUMBER OF REFERENCES USED
     (21) REFERENCE FLAG
     (22)    "       "
     (23)    "       "
     (24)    "       "
     (25)    "       "
     (26)    "       "
     (30) MODAL VECTOR ERROR CHECK

INAM   = SCHEDULED PROGRAM NAME
LUTERM = LOGICAL UNIT OF RTE TERMINAL
LUPRNT = LOGICAL UNIT OF RTE PRINTER
LUDATA = LOGICAL UNITS OF FOURIER DATA
         EACH OF UP TO TEN LOGICAL UNITS MAY BE DEFINED
         CORRESPONDING TO HEAD/SUBCHANNEL (0-9)
         DEFINITION IN THE "FMTXX' MAP
LUFILE = LOGICAL UNIT OF MODAL FILE AREA
LUDISP = LOGICAL UNIT OF DISPLAY UNIT
LUPLOT = LOGICAL UNIT OF PLOTTER
         (1)  TEKTRONIX SCREEN
         (2)  HP-7210 PLOTTER
         (3)  HP-9872/7225 PLOTTERS (HP-IB)
         (4)  HP-264X GRAPHICS TERMINALS
         (5)  NOT ASSIGNED
LUHPIB = LOGICAL UNIT OF HP-IB SUBCHANNEL OF HP-5420
         AND/OR HP-5423
IBELL  = OCTAL CODE FOR BELL RING
IPAGE  = OCTAL CODE FOR FORM FEED
ICR    = OCTAL CODE FOR CARRIAGE RETURN
MAXFL1 = MAXIMUM FILE ONE RECORD NUMBER
MAXFL7 = MAXIMUM FILE SEVEN RECORD NUMBER
IL     = TWO CHARACTER COMMAND
IPAR1  = COMMAND PARAMETER ONE
IPAR2  = COMMAND PARAMETER TWO
IPAR3  = COMMAND PARAMETER THREE
IPAR4  = COMMAND PARAMETER FOUR
IPAR5  = COMMAND PARAMETER FIVE
IPAR6  = COMMAND PARAMETER SIX
MAXCM  = MAXIMUM NUMBER OF COMPONENTS
MAXPT  = MAXIMUM NUMBER OF POINTS
MAXCN  = MAXIMUM NUMBER OF DISPLAY CONNECTIONS
```

```
MAXMOD = MAXIMUM NUMBER OF MODES
NCOM   = LARGEST COMPONENT NUMBER
NPT    = LARGEST POINT NUMBER
NMODE  = LARGEST MODE NUMBER
IDENT  = TEST IDENTIFICATION
IDATE  = TEST DATE
IZOOM  = ZOOM CODE
IDCODE = DATA TYPE CODE
MDVA   = CODE FOR RESPONSE TYPE
       = 0   DISPLACEMENT
       = 1   VELOCITY
       = 2   ACCELERATION
BETA   = AMOUNT OF ADDED DAMPING
MAXBS  = MAXIMUM DATA BLOCK SIZE
MAXREF = MAXIMUM NUMBER OF REFERENCE POSITIONS
NREF   = NUMBER OF REFERENCE POSITIONS USED IN
         CURRENT DATA SET
FMIN   = MINIMUM FREQUENCY OF FRF
DF     = FREQUENCY INCREMENT OF FRF
IBS    = CURRENT DATA BLOCK SIZE
NSHFT  = NUMBER OF FREQUENCY INCREMENTS TO BE IGNORED
         AT THE START OF THE FRF
JBS    = REDUCED BLOCK SIZE TO BE USED FOR MODAL
         PARAMETER ESTIMATION
FRQ    = DAMPED NATURAL FREQUENCIES
ZETA   = CRITICAL DAMPING FACTOR
SCL    = MODAL SCALE FACTOR
         SCL(I,1) = REAL PART
         SCL(I,2) = IMAG PART
GNMSS  = GENERALIZED MASS
MCODE  = DATA TYPE OF MODAL VECTOR
METH   = METHOD USED TO DETERMINE MODAL PARAMETERS.

         METH(I,1) IS THE CODE FOR THE METHOD THAT HAS
         BEEN USED TO DETERMINE THE FREQUENCY AND DAMPING
         INFORMATION FOR MODE I

           METH(I,1) = 1   MANUAL
           METH(I,1) = 2   CURSER
           METH(I,1) = 3   LEAST SQUARES TIME DOMAIN
           METH(I,1) = 4   POLY REFERENCE TIME DOMAIN
           METH(I,1) = 8   IBRAHIM
           METH(I,1) = 9   REDUCED M-K-C

         METH(I,2) IS THE CODE FOR THE METHOD THAT HAS
         BEEN USED TO DETERMINE THE MODAL VECTOR
         INFORMATION FOR MODE I

           METH(I,2) = 1   COMPLEX MAGNITUDE
           METH(I,2) = 2   IMAGINARY PART
           METH(I,2) = 3   REAL PART
           METH(I,2) = 4   REAL CIRCLE FIT
           METH(I,2) = 5   COMPLEX CIRCLE FIT
           METH(I,2) = 6   LEAST SQUARES FREQUENCY DOMAIN
           METH(I,2) = 7   POLY REFERENCE TIME DOMAIN
```

```
          METH(I,2) = 8   IBRAHIM
          METH(I,2) = 9   REDUCED M-K-C

        METH(I,3) IS THE CODE FOR THE TYPE OF SCALING
        THAT HAS BEEN ADDED TO THE MODAL VECTOR

          METH(I,3) = 0 NO SCALING HAS BEEN ADDED
          METH(I,3) > 0 SCALING HAS BEEN ADDED
                        USE SCL(I,1) AS REAL SCALE FACTOR
                        USE SCL(I,2) AS IMAG SCALE FACTOR

        METH(I,4) IS AN OPTIONAL PARAMETER NOT
        YET DEFINED.

IDAMP  = CODE FOR DAMPING MODEL
IXPNT  = EXCITATION POINT(S) FOR EACH MODAL VECTOR
IXDIR  = EXCITATION DIRECTION(S) FOR EACH MODAL VECTOR
IXP    = REFERENCE POINTS FOR UP TO SIX REFERENCES OF
         THE MEASUREMENT DIRECTORY
IXD    = REFERENCE DIRECTIONS FOR UP TO SIX REFERENCES
         OF THE MEASUREMENT DIRECTORY
RMV    = TEMPORARY BUFFER FOR MODAL VECTOR PARAMETERS
         (REALS)
IMV    = TEMPORARY BUFFER FOR MODAL VECTOR PARAMETERS
         (INTEGERS)
LSHFT  = OFFSET OF USEABLE 1024 BUFFER FROM START OF
         MEASUREMENT. USED FOR BLOCK SIZES GREATER
         THAN 1024
IDFLG  = DISPLAY FLAGS
IUNITS = UNITS CODE FOR INPUT AND RESPONSE
           IUNITS(I,1) = INPUT UNITS CODE
           IUNITS(I,2) = RESPONSE UNITS CODE
ITEMP  = ARRAY FOR TEMPORARY STORAGE OF INTEGER NUMBERS
RTEMP  = ARRAY FOR TEMPORARY STORAGE OF REAL NUMBERS
NDIFS  = NUMBER OF DIFS TABLE ENTRIES(FILES 1,7,9)
IDIFS  = EIGHT WORD DIFS TABLE ENTRIES
ILVN   = TEMPORARY ARRAY FOR LEUVEN DEVELOPMENT
ICNN   = TEMPORARY ARRAY FOR CINCINNATI DEVELOPMENT
```

APPENDIX C: PROJECT FILE STRUCTURE

The project file is a Type One File Manager file with fixed length records of 128 words. This file is an image of the project area used by the RTE Modal Program. The project area consists of a number of blocks where each block consists of 128 words. If no modal vectors are present only 48 blocks of information is loaded or stored. If modal vectors are present, the complete project area is loaded or stored. This includes 24 blocks for every modal vector plus 96 blocks which are used to store arrays used for parameter estimation, measurement directory, or plotting. The total number of blocks required for the modal data base, therefore, is a function of the maximum number of modal vectors. The actual number of blocks stored in the project file is dependent on the number of modal vectors in the data base when the project file is created. This means that the project file can be of variable length depending on the number of modal vectors found. The calculation of the maximum number of blocks required by the modal program is as follows:

NUMBER OF BLOCKS = NB = 48 + (MAXMOD/2 + 1) x 48 + 96

The project area is accessed relative to the block offset from the start of the project area. Note that the variable NB in the above equation is used to locate parts of the database in the following example structure of the project area. The format of the project area and therefore the project file is briefly described by the following:

FIRST BLOCK	LAST BLOCK	DESCRIPTION
0	15	COMMON
16	17	COMPONENT INFORMATION
18	33	COORDINATE INFORMATION
34	39	DISPLAY SEQUENCE INFORMATION
40	47	AVAILABLE
48	71	RESIDUAL MASS/FLEXIBILITY
72	95	MODAL VECTOR ONE
96	119	MODAL VECTOR TWO
120	143	MODAL VECTOR THREE
144	167	MODAL VECTOR FOUR
168	191	MODAL VECTOR FIVE
192	215	MODAL VECTOR SIX
216	239	MODAL VECTOR SEVEN
240	263	MODAL VECTOR EIGHT
264	287	MODAL VECTOR NINE
288	311	MODAL VECTOR TEN
---	---	----------------
---	---	----------------
---	---	----------------
---	---	----------------
---	---	----------------
---	---	----------------
---	---	----------------
---	---	----------------
(NB-96)	(NB-61)	MEASUREMENT DIRECTORY
(NB-60)	(NB-49)	AVAILABLE
(NB-48)	(NB-25)	LSTD FREQUENCY/DAMPING ARRAYS
(NB-24)	(NB-120	DISPLAY/PLOT ARRAYS
(NB- 8)	(NB- 1)	AVAILABLE

APPENDIX D: MODAL FILE STRUCTURES

The Modal Files are Type Two File Manager files with fixed length records of 16 words per record. Each Modal File contains some prologue information followed by information which can be used to calculate how many records will follow. The file name of the Modal File is constructed by the program to be MFXXYY, where XX is the file number (01-05) and YY is the record number (01-99). The format of each Modal File is described briefly in the following:

MODAL FILE ONE: COMPONENTS

RECORD ONE

WORD	DESCRIPTION
1	TEST IDENTIFICATION
2	TEST IDENTIFICATION
3	TEST IDENTIFICATION
4	TEST IDENTIFICATION
5	TEST IDENTIFICATION
6	TEST IDENTIFICATION
7	TEST IDENTIFICATION
8	TEST IDENTIFICATION
9	TEST IDENTIFICATION
10	TEST IDENTIFICATION
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD TWO

WORD	DESCRIPTION
1	TEST DATE - YEAR
2	TEST DATE - MONTH
3	TEST DATE - DAY
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD THREE

WORD	DESCRIPTION
1	MAXIMUM COMPONENT NUMBER
2	AVAILABLE
3	AVAILABLE
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FOUR (TYPICAL FOR EACH COMPONENT)

WORD	DESCRIPTION
1	X ORIGIN
2	
3	Y ORIGIN
4	
5	Z ORIGIN
6	
7	X AXIS ORIENTATION
8	Y AXIS ORIENTATION
9	Z AXIS ORIENTATION
10	COMPONENT COORDINATE CODE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

MODAL FILE TWO: COORDINATES

RECORD ONE

WORD	DESCRIPTION
1	TEST IDENTIFICATION
2	TEST IDENTIFICATION
3	TEST IDENTIFICATION
4	TEST IDENTIFICATION
5	TEST IDENTIFICATION
6	TEST IDENTIFICATION
7	TEST IDENTIFICATION
8	TEST IDENTIFICATION
9	TEST IDENTIFICATION
10	TEST IDENTIFICATION
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD TWO

WORD	DESCRIPTION
1	TEST DATE - YEAR
2	TEST DATE - MONTH
3	TEST DATE - DAY
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD THREE

WORD	DESCRIPTION
1	MAXIMUM POINT NUMBER
2	AVAILABLE
3	AVAILABLE
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FOUR (TYPICAL FOR EACH POINT)

WORD	DESCRIPTION
1	X COORDINATE
2	
3	Y COORDINATE
4	
5	Z COORDINATE
6	
7	COMPONENT NUMBER
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

MODAL FILE THREE: DISPLAY SEQUENCE

RECORD ONE

WORD	DESCRIPTION
1	TEST IDENTIFICATION
2	TEST IDENTIFICATION
3	TEST IDENTIFICATION
4	TEST IDENTIFICATION
5	TEST IDENTIFICATION
6	TEST IDENTIFICATION
7	TEST IDENTIFICATION
8	TEST IDENTIFICATION
9	TEST IDENTIFICATION
10	TEST IDENTIFICATION
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD TWO

WORD	DESCRIPTION
1	TEST DATE - YEAR
2	TEST DATE - MONTH
3	TEST DATE - DAY
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD THREE

WORD	DESCRIPTION
1	MAXIMUM DISPLAY SEQUENCE ENTRY NUMBER
2	AVAILABLE
3	AVAILABLE
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FOUR (TYPICAL FOR EACH DISPLAY SEQUENCE ENTRY)

WORD	DESCRIPTION
1	DISPLAY SEQUENCE ENTRY
2	AVAILABLE
3	AVAILABLE
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

MODAL FILE FOUR: FREQUENCY/DAMPING

RECORD ONE

WORD	DESCRIPTION
1	TEST IDENTIFICATION
2	TEST IDENTIFICATION
3	TEST IDENTIFICATION
4	TEST IDENTIFICATION
5	TEST IDENTIFICATION
6	TEST IDENTIFICATION
7	TEST IDENTIFICATION
8	TEST IDENTIFICATION
9	TEST IDENTIFICATION
10	TEST IDENTIFICATION
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD TWO

WORD	DESCRIPTION
1	TEST DATE - YEAR
2	TEST DATE - MONTH
3	TEST DATE - DAY
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD THREE

WORD	DESCRIPTION
1	MAXIMUM MODAL VECTOR NUMBER
2	MINIMUM FREQUENCY
3	MINIMUM FREQUENCY
4	FREQUENCY RESOLUTION
5	FREQUENCY RESOLUTION
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FOUR (TYPICAL FOR EACH MODAL VECTOR)

WORD	DESCRIPTION
1	FREQUENCY
2	
3	ZETA
4	
5	MODAL VECTOR SCALE FACTOR (REAL)
6	
7	MODAL VECTOR SCALE FACTOR (IMAG)
8	
9	GENERALIZED MASS
10	
11	FREQUENCY DAMPING METHOD
12	MODAL VECTOR METHOD
13	SCALING METHOD
14	METHOD (NOT DEFINED YET)
15	DATA TYPE OF MODAL VECTOR (0,1,2)
16	DAMPING MODEL CODE

RECORD FIVE (TYPICAL FOR EACH MODAL VECTOR)

WORD	DESCRIPTION
1	INPUT POINT NUMBER 1
2	INPUT POINT NUMBER 2
3	INPUT POINT NUMBER 3
4	INPUT POINT NUMBER 4
5	INPUT POINT NUMBER 5
6	INPUT POINT NUMBER 6
7	INPUT DIRECTION 1
8	INPUT DIRECTION 2
9	INPUT DIRECTION 3
10	INPUT DIRECTION 4
11	INPUT DIRECTION 5
12	INPUT DIRECTION 6
13	INPUT TRANSDUCER UNITS CODE
14	RESPONSE TRANSDUCER UNITS CODE
15	AVAILABLE
16	AVAILABLE

MODAL FILE FIVE: MODAL VECTORS

RECORD ONE

WORD	DESCRIPTION
1	TEST IDENTIFICATION
2	TEST IDENTIFICATION
3	TEST IDENTIFICATION
4	TEST IDENTIFICATION
5	TEST IDENTIFICATION
6	TEST IDENTIFICATION
7	TEST IDENTIFICATION
8	TEST IDENTIFICATION
9	TEST IDENTIFICATION
10	TEST IDENTIFICATION
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD TWO

WORD	DESCRIPTION
1	TEST DATE - YEAR
2	TEST DATE - MONTH
3	TEST DATE - DAY
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD THREE

WORD	DESCRIPTION
1	MAXIMUM POINT NUMBER
2	AVAILABLE
3	AVAILABLE
4	AVAILABLE
5	AVAILABLE
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FOUR

WORD	DESCRIPTION
1	MAXIMUM MODAL VECTOR NUMBER
2	MINIMUM FREQUENCY
3	MINIMUM FREQUENCY
4	FREQUENCY RESOLUTION
5	FREQUENCY RESOLUTION
6	AVAILABLE
7	AVAILABLE
8	AVAILABLE
9	AVAILABLE
10	AVAILABLE
11	AVAILABLE
12	AVAILABLE
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

RECORD FIVE (TYPICAL FOR EACH MODAL VECTOR)

WORD	DESCRIPTION
1	FREQUENCY
2	
3	ZETA
4	
5	MODAL VECTOR SCALE FACTOR (REAL)
6	
7	MODAL VECTOR SCALE FACTOR (IMAG)
8	
9	GENERALIZED MASS
10	
11	FREQUENCY DAMPING METHOD
12	MODAL VECTOR METHOD
13	SCALING METHOD
14	METHOD (NOT DEFINED YET)
15	DATA TYPE OF MODAL VECTOR (0,1,2)
16	DAMPING MODEL CODE

RECORD SIX (TYPICAL FOR EACH MODAL VECTOR)

WORD	DESCRIPTION
1	INPUT POINT NUMBER 1
2	INPUT POINT NUMBER 2
3	INPUT POINT NUMBER 3
4	INPUT POINT NUMBER 4
5	INPUT POINT NUMBER 5
6	INPUT POINT NUMBER 6
7	INPUT DIRECTION 1
8	INPUT DIRECTION 2
9	INPUT DIRECTION 3
10	INPUT DIRECTION 4
11	INPUT DIRECTION 5
12	INPUT DIRECTION 6
13	INPUT TRANSDUCER UNITS CODE
14	RESPONSE TRANSDUCER UNITS CODE
15	AVAILABLE
16	AVAILABLE

RECORD SEVEN (TYPICAL FOR EACH POINT)

WORD	DESCRIPTION
1	X MODAL COEFFICIENT - REAL
2	
3	X MODAL COEFFICIENT - IMAGINARY
4	
5	Y MODAL COEFFICIENT - REAL
6	
7	Y MODAL COEFFICIENT - IMAGINARY
8	
9	Z MODAL COEFFICIENT - REAL
10	
11	Z MODAL COEFFICIENT - IMAGINARY
12	
13	AVAILABLE
14	AVAILABLE
15	AVAILABLE
16	AVAILABLE

FILE SEVEN INFORMATION (USER PROGRAM 88)

WORD	
1	TEST IDENTIFICATION
.	....
5	TEST IDENTIFICATION
6	TEST DATE-YEAR
7	TEST DATE-MONTH
8	TEST DATE-DAY
9	INPUT POINT (INTEGER)
10	INPUT DIRECTION (ASCII)
11	INPUT TRANSDUCER MODEL NUMBER
12	INPUT TRANSDUCER SERIAL NUMBER
13	NUMBER OF RESPONSES (1-3)
14	RESPONSE NUMBER 1 TRANSDUCER MODEL NUMBER
15	RESPONSE NUMBER 1 TRANSDUCER SERIAL NUMBER
16	RESPONSE NUMBER 2 TRANSDUCER MODEL NUMBER
17	RESPONSE NUMBER 2 TRANSDUCER SERIAL NUMBER
18	RESPONSE NUMBER 3 TRANSDUCER MODEL NUMBER
19	RESPONSE NUMBER 3 TRANSDUCER SERIAL NUMBER
20	DATA TYPE CODE (ASCII)
21	TEST (EXCITATION) TYPE CODE (ASCII)
22	FIRST CLEARED DISC RECORD NUMBER
23	AVAILABLE
..	....
40	AVAILABLE
41	CALIBRATION CONSTANT FOR TRANSDUCER PAIR ONE
42	CALIBRATION CONSTANT FOR TRANSDUCER PAIR ONE
43	CALIBRATION CONSTANT FOR TRANSDUCER PAIR TWO
44	CALIBRATION CONSTANT FOR TRANSDUCER PAIR TWO
45	CALIBRATION CONSTANT FOR TRANSDUCER PAIR THREE
46	CALIBRATION CONSTANT FOR TRANSDUCER PAIR THREE
47	AVAILABLE
..	....
128	AVAILABLE

FILE NINE INFORMATION (USER PROGRAM 88)

WORD	
6	MODAL DATA CODE (52525B OR 12345)
9	LENGTH OF ASCII SEARCH AREA (70)
10	TEST IDENTIFICATION (ASCII)
..	....
14	TEST IDENTIFICATION (ASCII)
15	DELIMITER
16	RESPONSE POINT NUMBER (ASCII)
17	RESPONSE POINT NUMBER (ASCII)
18	DELIMITER
19	RESPONSE DIRECTION (ASCII)
20	DELIMITER
21	INPUT POINT NUMBER (ASCII)
22	INPUT POINT NUMBER (ASCII)
23	DELIMITER
24	INPUT DIRECTION (ASCII)
25	DELIMITER
26	DATE - YEAR (ASCII)
27	DATE - MONTH (ASCII)
28	DATE - DAY (ASCII)
29	DELIMITER
30	TIME (ASCII)
31	TIME (ASCII)
32	TIME (ASCII)
33	DELIMITER
34	DATA TYPE CODE (ASCII)
35	DELIMETER
36	ZOOM RANGE (ASCII)
37	DELIMITER
45	RESPONSE POINT NUMBER
46	INPUT POINT NUMBER
47	RESPONSE TRANSDUCER MODEL NUMBER
48	RESPONSE TRANSDUCER SERIAL NUMBER
49	INPUT TRANSDUCER MODEL NUMBER
50	INPUT TRANSDUCER SERIAL NUMBER
51	ADC INPUT NUMBER
76	MINIMUM FREQUENCY
77	
78	FREQUENCY RESOLUTION
79	
80	DATA CALIBRATION VALUE
81	

FILE SEVEN INFORMATION (USER PROGRAM 888)

WORD	
1	TEST IDENTIFICATION (ASCII)
..	....
10	TEST IDENTIFICATION (ASCII)
11	TEST DATE - YEAR (ASCII)
12	TEST DATE - MONTH (ASCII)
13	TEST DATE - DAY (ASCII)
14	DATA TYPE CODE (ASCII)
15	TEST TYPE CODE (ASCII)
16	INPUT TRANSDUCER UNITS CODE
17	RESPONSE TRANSDUCER UNITS CODE
18	NUMBER OF INPUTS
19	NUMBER OF RESPONSES
20	STARTING SEARCH RECORD
21	INPUT POINT NUMBER 1
..	....
26	INPUT POINT NUMBER 6
27	INPUT DIRECTION NUMBER 1
..	....
32	INPUT DIRECTION NUMBER 6
33	INPUT TRANSDUCER NUMBER 1 SERIAL NUMBER
..	....
38	INPUT TRANSDUCER NUMBER 6 SERIAL NUMBER
39	RESPONSE TRANSDUCER NUMBER 1 SERIAL NUMBER
..	....
62	RESPONSE TRANSDUCER NUMBER 24 SERIAL NUMBER
63	MAXIMUM FILE ONE RECORD NUMBER
64	MAXIMUM FILE SEVEN RECORD NUMBER
65	INPUT TRANSDUCER NUMBER 1 CALIBRATION (UNITS/VOLT)
66	INPUT TRANSDUCER NUMBER 1 CALIBRATION (UNITS/VOLT)
..	....
..	....
75	INPUT TRANSDUCER NUMBER 6 CALIBRATION (UNITS/VOLT)
76	INPUT TRANSDUCER NUMBER 6 CALIBRATION (UNITS/VOLT)
77	RESPONSE TRANSDUCER NUMBER 1 CALIBRATION (UNITS/VOLT)
78	RESPONSE TRANSDUCER NUMBER 1 CALIBRATION (UNITS/VOLT)
..	....
..	....
123	RESPONSE TRANSDUCER NUMBER 24 CALIBRATION (UNITS/VOLT)
124	RESPONSE TRANSDUCER NUMBER 24 CALIBRATION (UNITS/VOLT)
125	CURRENT RESPONSE POINT NUMBER
126	CURRENT RESPONSE DIRECTION - BLOCK 1
127	CURRENT RESPONSE DIRECTION - BLOCK 2
128	CURRENT RESPONSE DIRECTION - BLOCK 3

FILE NINE INFORMATION (USER PROGRAM 888)

WORD	
4	FREQUENCY CODE
6	MODAL DATA CODE (52525B OR 12345)
9	BSFA CENTER FREQUENCY
10	
11	FREQUENCY RESOLUTION
12	
13	AVAILABLE
..	....
39	AVAILABLE
40	NUMBER OF INPUTS
41	NUMBER OF RESPONSES
42	INPUT POINT NUMBERS
43	RESPONSE POINT NUMBER
44	INPUT TRANSDUCER SERIAL NUMBER
45	RESPONSE TRANSDUCER SERIAL NUMBER
46	DATA BLOCK NUMBER
47	DATA CALIBRATION RECORD
48	INPUT TRANSDUCER UNITS CODE
49	RESPONSE TRANSDUCER UNITS CODE
50	AVAILABLE
..	....
59	AVAILABLE
60	INPUT TRANSDUCER CALIBRATION
61	INPUT TRANSDUCER CALIBRATION
62	RESPONSE TRANDUCER CALIBRATION
63	RESPONSE TRANSDUCER CALIBRATION
64	AVAILABLE
..	....
80	AVAILABLE
81	LENGTH OF ASCII SEARCH AREA (70)
82	TEST IDENTIFICATION (ASCII)
..	....
91	TEST IDENTIFICATION (ASCII)
92	DELIMITER
93	RESPONSE POINT NUMBER (ASCII)
94	RESPONSE POINT NUMBER (ASCII)
95	DELIMITER
96	RESPONSE DIRECTION (ASCII)
97	DELIMITER
98	INPUT POINT NUMBER (ASCII)
99	INPUT POINT NUMBER (ASCII)
100	DELIMITER
101	INPUT DIRECTION (ASCII)
102	DELIMITER
103	TEST DATE - YEAR (ASCII)
104	TEST DATE - MONTH (ASCII)
105	TEST DATE - DAY (ASCII)
106	DELIMITER
107	DATA TYPE CODE (ASCII)
108	DELIMITER

109	TEST TYPE CODE (ASCII)
110	DELIMITER
111	ZOOM RANGE (ASCII)
112	AVAILABLE
...	....
116	AVAILABLE

FILE NINE INFORMATION (USER PROGRAM 80/81 (HP-5423 DATA))

WORD	
14	TRACE FLAG
15	STARTING ADDRESS OF DATA BLOCK
16	NUMBER OF 16 BIT DATA WORDS IN BLOCK
17	POWER OF TWO EXPONENT (FOR INTEGER DATA)
18	DATA TYPE CODE
19	NEW DATA FLAG
20	DATA SOURCE CHANNEL FLAG
21	PEAK AVERAGE FLAG
22	SAVED FILE NUMBER AND FUNCTION TYPE
23	NUMBER OF AVERAGES
24	TIME DOMAIN SAMPLE SPACING
25	
26	MINIMUM FREQUENCY
27	
28	FREQUENCY RESOLUTION
29	
30	TIME OFFSET OF BLOCK ORIGIN
31	
32	SIGNAL TYPE
33	X-AXIS LABEL FLAG
34	MEASUREMENT ID - TIME
35	MEASUREMENT ID - DAY
36	MEASUREMENT ID - YEAR
37	INPUT POINT NUMBER
38	INPUT DIRECTION
39	INPUT TRANSDUCER UNITS CODE
40	RESPONSE POINT NUMBER
41	RESPONSE DIRECTION
42	RESPONSE TRANSDUCER UNITS CODE
43	INPUT CHANNEL RANGE CODE
44	RESPONSE CHANNEL RANGE CODE
45	INPUT CHANNEL COUPLING CODE
46	RESPONSE CHANNEL COUPLING
47	INPUT CHANNEL DELAY
48	
49	RESPONSE CHANNEL DELAY
50	
51	INPUT CHANNEL CALIBRATION
52	

53	RESPONSE CHANNEL CALIBRATION
54	
55	AMOUNT OF DAMPING ADDED BY EXPONENTIAL WINDOW
56	
57	DUMMY VARIABLE
58	
59	INPUT TRANSDUCER SERIAL NUMBER
60	RESPONSE TRANSDUCER SERIAL NUMBER
61	INPUT TRANSDUCER MODEL NUMBER (ASCII)
62	
63	
64	RESPONSE TRANSDUCER MODEL NUMBER (ASCII)
65	
66	
67	MEASUREMENT TITLE (ASCII)
..	....
76	MEASUREMENT TITLE (ASCII)

APPENDIX F: DATA TYPE CODES

10	Time
11	Correlation
20	Frequency
21	Frequency Response (D/F)
22	Frequency Response (V/F)
23	Frequency Response (A/F)
25	Power Spectrum
29	Coherence
30	Modal Enhancement
31	Enhanced FRF
32	Weighted Summation
40	Curve Fit Data
60	Synthesized Data
70	Set-up
71	Modal Set-up
72	Modal Coefficients
80	Data Windows
81	Force Window
82	Exponential Window

APPENDIX G: TEST TYPE CODES

10	Deterministic: Periodic
11	Swept Sine
12	Pseudo Random
13	Periodic Chirp
14	Step Sine
20	Deterministic: Non-Periodic
21	Impulse
22	Unit Step
23	Chirp
30	Random: Non-Deterministic
31	Pure Random
32	Periodic Random
33	Random Transient

APPENDIX H: TRANSDUCER UNITS CODES

1X	English Units
11	Pounds
12	Inches
13	Inches/Second
14	Inches/(Second**2)
15	G's
16	Feet
17	Feet/Second
18	Feet/(Second**2)
2X	Metric Units
21	Newtons
22	Centimeters
23	Centimeters/Second
24	Centimeters/(Second**2)
25	G's
26	Meters
27	Meters/Second
28	Meters/(Second**2)

APPENDIX I: UNIVERSAL FILE FORMATS

A Universal File is a physical file, card deck, mag tape, paper tape, etc. containing symbolic data in physical records with a maximum record length of 80 characters.

On the physical file data is contained in logical data sets with the following characteristics:

a. The first record of the data set contains "-1" right justified in columns 1 through 6. Columns 7 through 80 of the physical record are blanks.

b. The second record of the data set contains the data type number, numeric range 1 through 32767, right justified in columns 1 through 6. Columns 7 through 80 of this physical record are blanks.

c. The last record of the data set contains "-1" right justified in columns 1 through 6. Columns 7 through 80 of the physical record are blanks.

d. The specification of data on the remaining records of the data set are totally dependent on the data set type.

For example:

```
    -1
   xxx
    .
    .
  (data pertaining to the data set type)
    .
    .
    -1
```

1. Data Set Type 15 - Grid Points

Dataset Type: 15

Description: Grid Points

Record 1: FORMAT(4I10,3E13.5)

Field 1 - node tag number (location label)
Field 2 - definition coordinate system (>=0)
Field 3 - displacement coordinate system (>=0)
Field 4 - color
Field 5-7 - 3-dimensional coordinates of node

Record 1 is repeated for each grid point in the model.

For example:

```
    -1
    15
         1         0         0         8  0.00000E+00  0.00000E+00  0.00000E+00
         2         0         0         8  5.00000E-01  0.00000E+00 -5.00000E-02
         .
         .
         .
       100         0         0         8  1.20000E+01  1.20000E+01 -4.50000E+00
    -1
```

Notes:

1. Any non-zero coordinate system must exist in the SDRC SYSTAN database before this dataset can be read. A value of 0 refers to the entity definition coordinate system.

2. Data Set Type 55 - Analysis Data at Nodes

Dataset Type: 55

Description: Analysis Data at Nodes

Record 1: FORMAT(80A1)

Field 1 - ID Line 1

Record 2: FORMAT(80A1)

Field 1 - ID Line 2

Record 3: FORMAT(80A1)

Field 1 - ID Line 3

Record 4: FORMAT(80A1)

Field 1 - ID Line 4

Record 5: FORMAT(80A1)

Field 1 - ID Line 5

Record 6: FORMAT(6I10)

Data Definition Parameters

```
Field 1 - Model Type
          0 :Unknown
          1 :Structural
          2 :Heat Transfer
          3 :Fluid Flow

Field 2 - Analysis Type
          0 :Unknown
          1 :Static
          2 :Normal Mode
          3 :Complex Eigenvalue, first order
         -3:Complex Eigenvalue, first order (conjugate pairs
          4 :Transient Response
          5 :Frequency Response
          6 :Buckling
          7 :Complex Eigenvalue, second order
```

Field 3 - Data Characteristics
- 0 :Unknown
- 1 :Scalar
- 2 :3 DOF Global Translation Vector
- 3 :6 DOF Global Translation and Rotation Vector
- 4 :Symmetric Global Tensor
- 5 :General Global Tensor

Field 4 - Specific Data Type
- 0 :Unknown
- 1 :General
- 2 :Stress
- 3 :Strain
- 4 :Elemental Force
- 5 :Temperature
- 6 :Heat Flux
- 7 :Strain Energy
- 8 :Displacement
- 9 :Reaction Force
- 10:Kinetic Energy
- 11:Velocity
- 12:Acceleration

Field 5 - Data Type
- 2 :Real
- 5 :Complex

Field 6 - Number of data values per node (NDV)

Records 7 and 8 are analysis type specific.

General Form

Record 7: FORMAT(8I10)

Field 1 - Number of integer data values
1 < or = NINT < or = 10
Field 2 - Number of Real data values
1 < or = NRVAL < or = 12
Fields 3-N-Type specific integer parameters

Record 8: FORMAT(6E13.5)

Fields 1-N-Type specific real parameters

For Analysis Type = 0, Unknown

Record 7:
    Field 1 - 1
    Field 2 - 1
    Field 3 - ID Number

Record 8:
    Field 1 - 0.0

For Analysis Type = 1, Static

Record 7:
    Field 1 - 1
    Field 2 - 1
    Field 3 - Load Case Number

Record 8:
    Field 1 - 0.0

For Analysis Type = 2, Normal Mode

Record 7:
    Field 1 - 2
    Field 2 - 4
    Field 3 - Load Case Number
    Field 4 - Mode Number

Record 8:
    Field 1 - Frequency (Hertz)
    Field 2 - Modal Mass (see note 17)
    Field 3 - Modal Viscous Damping Ratio
    Field 4 - Modal Hysteretic Damping Ratio

For Analysis Type = 3, Complex Eigenvalue, first order

Record 7:
- Field 1 - 2
- Field 2 - 6
- Field 3 - Load Case Number
- Field 4 - Mode Number

Record 8:
- Field 1 - Real Part of Eigenvalue
- Field 2 - Imaginary Part of Eigenvalue
- Field 3 - Real Part of Modal A (see note 18)
- Field 4 - Imaginary Part of Modal A
- Field 5 - Real Part of Modal B (see note 18)
- Field 6 - Imaginary Part of Modal B

For Analysis Type = 4, Transient Response

Record 7:
- Field 1 - 2
- Field 2 - 1
- Field 3 - Load Case Number
- Field 4 - Time Step Number

Record 8:
- Field 1 - Time (seconds)

For Analysis Type = 5, Frequency Response

Record 7:
- Field 1 - 2
- Field 2 - 1
- Field 3 - Load Case Number
- Field 4 - Frequency Step Number

Record 8:
- Field 1 - Frequency (Hertz)

For Analysis Type = 6, Buckling

Record 7:
- Field 1 - 1
- Field 2 - 1
- Field 3 - Load Case Number

Record 8:
- Field 1 - Eigenvalue

For Analysis Type = 7, Complex Eigenvalue, second order

Record 7:
    Field 1 - 2
    Field 2 - 6
    Field 3 - Load Case Number
    Field 4 - Mode Number

Record 8:
    Field 1 - Real Part of Eigenvalue
    Field 2 - Imaginary Part of Eigenvalue
    Field 3 - Real Part of Modal A (see note 18)
    Field 4 - Imaginary Part of Modal A
    Field 5 - Real Part of Modal B (see note 18)
    Field 6 - Imaginary Part of Modal B

Record 9: FORMAT(I10)
Field 1 - Node Number

Record 10: FORMAT(6E13.5)
Fields 1-N - Data at this Node
(NDV Real or Complex Values)

Records 9 and 10 are repeated for each node.
Notes:

1. ID Lines may not be blank. If no information is required, the word "NONE" must appear in columns 1 through 4.

2. For complex data there will be 2*NDV data items at each node. The order is real part for VALUE 1, imaginary part for VALUE 1, real part for VALUE 2, imaginary part for VALUE 2, etc.

3. The order of values for various data characteristics is:

3 DOF GLOBAL VECTOR:	X, Y, Z
6 DOF GLOBAL VECTOR:	X, Y, Z, RX, RY, RZ
SYMMETRIC GLOBAL TENSOR:	SXX, SXY, SYY, SXZ, SYZ, SZZ
GENERAL GLOBAL TENSOR:	SXX, SYX, SZX, SXY, SYY, SZY, SXZ, SYZ, SZZ

4. ID Line 1 always appears on plots in OUTPUT DISPLAY.

5. If specific data type is "UNKNOWN", ID Line 2 is displayed as data type in OUTPUT DISPLAY.

6. Typical FORTRAN I/O statements for the data section are:

```
      READ (LUN,1000) NUM
      WRITE
1000  FORMAT (I10)
      READ (LUN,1010) (VAL(I),I=1,NDV)
      WRITE
1010  FORMAT (6E13.5)
```

where: NUM is node number

VAL is real or complex data array
NDV is number of data values per node

7. Data characteristic values imply the following values of NDV:

   3 DOF GLOBAL VECTOR: 3
   6 DOF GLOBAL VECTOR: 6
   SYMMETRIC GLOBAL TENSOR: 6
   GENERAL GLOBAL TENSOR: 9

8. Data associated with SDRC MODAL-PLUS and SDRC MODALX has the following special form of ID Line 5.

   FORMAT (4I10)

   Field 1 : Reference Coordinate Label (1-8000)

```
Field 2 : Reference Coordinate Direction
          1 :+X Direction
          2 :-X Direction
          3 :+Y Direction
          4 :-Y Direction
          5 :+Z Direction
          6 :-Z Direction

Field 3 : Numerator Signal Code
          0 :unknown
          2 :stress
          3 :strain
          5 :temperature
          8 :displacement
          11:velocity
          12:acceleration
          13:excitation force
          15:pressure

Field 4 : Denominator Signal Code
          0 :unknown
          2 :stress
          3 :strain
          5 :temperature
          8 :displacement
          11:velocity
          12:acceleration
          13:excitation force
          15:pressure
```

9. ID Line 5 for SDRC MODAL-PLUS and SDRC MODALX, and the information included in record 6 is provided only to inform the user. The data is not used to alter the modal parameters on record 8. The modal parameters on record 8 are accepted exactly as entered.

10. Any record with all 0.0 data entries need not, but may appear.

11. A direct result of the previous note is that if no records 9 and 10 appear, all data for the data set is 0.0.

12. When new analysis types are added, record 7 fields 1 and 2 are always > or = 1 with dummy integer and real data if data is not required. If complex data is needed, it is treated as two real numbers, real part followed imaginary point.

13. Data loaders use the following ID line convention:

    1. (80A1) Model Indentification
    2. (80A1) Run Identification
    3. (80A1) Run Date/Time
    4. (80A1) Load Case Name

    For Static:

    5. (17H LOAD CASE NUMBER;, I10)

    For normal mode:

    5. (10H mode same, I10, 10H frequency, E13.5)

14. Maximum value for NDV is 9.

15. Typical FORTRAN I/O statements for processing records 7 and 8 are:

```
      READ (LUN,1000) NINT,NRVAL,(IPAR(I),I=1,NINT)
1000  FORMAT (8I10)
      READ (LUN,1010) (RPAV(I),I=1,NRVAL)
1010  FORMAT (6E13.5)
```

16. For situations with reduced number DOF, use 3 DOF translations or 6 DOF tranlation and rotation with unused values equal to 0.0.

17. Record 8 for real mode shapes contains the resonance frequency, modal mass, and modal viscous damping ratio. The modal mass is calculated based on the following relations for each data type. The data type is taken from the modal parameter data set, not the mode shape data set.

$$m_r = \frac{X_1 * X_2}{2 * A * \Omega_r * \sqrt{1-\varsigma^2}} \quad \text{for D/F}$$

$$m_r = \frac{X_1 * X_2}{2 * A * \sqrt{1-\varsigma^2}} \quad \text{for V/F}$$

$$m_r = \frac{\Omega_r * X_1 * X_2}{2 * A * \sqrt{1-\varsigma^2}} \quad \text{for A/F}$$

where :

m_r = modal mass for mode r
X_1 = mode shape coefficient of reference coordinate
X_2 = mode shape coefficient of response coordinate
Ω_r = undamped natural frequency in rad/sec
A = residue amplitude, or modal amplitude
ς = modal viscous damping ratio

18. Record 8 for complex mode shapes contains the complex eigenvalue, the complex Modal A value, and the complex Modal B value. The complex eigenvalue is calculated through the following relation.

$$s = -\varsigma * \Omega_r + j * \Omega_r * \sqrt{1-\varsigma^2}$$

where :

s = complex eigenvalue

Ω_r = undamped natural frequency in rad/sec

ζ = modal viscous damping ratio

The complex Modal A value is calculated based on the following relations for each data type. The data type is taken from the modal parameter data set, not the mode shape data set.

$$MA_r = \frac{X_1 * X_2}{A} \qquad \text{for D/F}$$

$$MA_r = \frac{j * \Omega_r * X_1 * X_2}{A} \qquad \text{for V/F}$$

$$MA_r = \frac{-\Omega_r^2 * X_1 * X_2}{A} \qquad \text{for A/F}$$

where :

MA_r = complex Modal A value for mode r

X_1 = complex mode shape coefficient of reference coordinate

X_2 = complex mode shape coefficient of response coordinate

Ω_r = undamped natural frequency in rad/sec

A = complex residue (residue amplitude and phase)

The complex Modal B value is the product of the complex eigenvalue and the complex Modal A value.

3. Data Set Type 58 - Function at Nodal DOF

Dataset Type: 58

Description: Function at Nodal DOF

Record 1: FORMAT(80A1)

Field 1 - ID Line 1
NOTE:
ID Line 1 is generally used for the function description

Record 2: FORMAT(80A1)

Field 1 - ID Line 2

Record 3: FORMAT(80A1)

Field 1 - ID Line 3
NOTE:
ID Line 3 is generally used to identify when the function was created. The date is in the form DD-MMM-YY, and the time is in the form HH:MM:SS, with a general FORMAT(9A1,1X,8A1).

Record 4: FORMAT(80A1)

Field 1 - ID Line 4

Record 5: FORMAT(80A1)

Field 1 - ID Line 5

Record 6: FORMAT(2(I5,I10),2(1X,10A1,I10,I4))

DOF Identification

```
Field 1 - Function Type
          0 :General or Unknown
          1 :Time Response
          2 :Auto Spectrum
          3 :Cross Spectrum
          4 :Frequency Response Function
          5 :Transmissibility
          6 :Coherence
          7 :Auto Correlation
          8 :Cross Correlation
          9 :Power Spectral Density (PSD)
          10:Energy Spectral Density (ESD)
          11:Probability Density Function
          12:Spectrum
```

Field 2 - Function Identification Number

Field 3 - Version Number, or sequence number

Field 4 - Load Case Identification Number
0 : Single Point Excitation

Field 5 - Response Entity Name ("NONE" if unused)

Field 6 - Response Node

Field 7 - Response Direction
```
0 :Scalar
1 :+X Translation 4:+X Rotation
-1:-X Translation -4:-X Rotation
2 :+Y Translation 5:+Y Rotation
-2:-Y Translation -5:-Y Rotation
3 :+Z Translation 6:+Z Rotation
-3:-Z Translation -6:-Z Rotation
```

Field 8 - Reference Entity Name ("NONE" if unused)

Field 9 - Reference Node

Field 10 - Reference Direction (same as field 7)
NOTE:
Fields 8, 9, and 10 are only reievant if field 4 is zero.

Record 7: FORMAT(3I10,3E13.5)

Data Form

Field 1 - Ordinate Data Type
```
2 :real, single precision
4 :real, double precision
5 :complex, single precision
6 :complex, double precision
```

Field 2 - Number of data pairs for uneven abscissa spacing, or number of data values for even abscissa spacing

Field 3 - Abscissa Spacing
0 : uneven
1 : even (no abscissa values stored)

Field 4 - Abscissa minimum (0.0 if spacing uneven)

Field 5 - Abscissa increment (0.0 if spacing uneven)

Field 6 - Z-axis value (0.0 if unused)

Record 8: FORMAT(I10,3I5,2(1X,20A1))

Abscissa Data Characteristics

```
Field 1 - Specific Data Type
          0 :unknown
          1 :general
          2 :stress
          3 :strain
          5 :temperature
          6 :heat flux
          8 :displacement
          9 :reaction force
          11:velocity
          12:acceleration
          13:excitation force
          15:pressure
          16:mass
          17:time
          18:frequency
          19:rpm
```

Field 2 - Length units exponent

Field 3 - Force units exponent

Field 4 - Temperature units exponent
NOTE:
Fields 2, 3 and 4 are relevant only if the Specific Data Type is General, or in the case of ordinates, the response/reference direction is a scalar. See Addendum 'A' for the units exponent table.

Field 5 - Axis label ("NONE" if not used)

Field 6 - Axis units label ("NONE" if not used)
NOTE:
If fields 5 and 6 are supplied, they take precendence over program generated labels and units.

Record 9: FORMAT(I10,3I5,2(1X,20A1))

Ordinate (or ordinate numerator) Data Characteristics

Record 10: FORMAT(I10,3I5,2(1X,20A1))

Ordinate Denominator Data Characteristics

Record 11: FORMAT(I10,3I5,2(1X,20A1))

Z-axis Data Characteristics

NOTE:
Records 9, 10, and 11 are always included and have fields the same as record 8. If records 10 and 11 are not used, set field 1 to zero.

Record 12:

Case	Data Values Ordinate Type	Precision	Abscissa Spacing	FORMAT
1	real	single	even	6E13.5
2	real	single	uneven	6E13.5
3	complex	single	even	6E13.5
4	complex	single	uneven	6E13.5
5	real	double	even	4E20.12
6	real	double	uneven	2(E13.5,E20.12)
7	complex	double	even	4E20.12
8	complex	double	uneven	E13.5,2E20.12

NOTE: See Addendum 'B' for typical FORTRAN READ/WRITE statements for each case.

General Notes:

1. ID lines may not be blank. If no information is required, the word "NONE" must appear in columns 1 through 4.
2. ID line 1 appears on plots in OUTPUT DISPLAY.
3. Dataloaders use the following ID line conventions
   ID Line 1 - Model Identification
   ID Line 2 - Run Identification
   ID Line 3 - Run Date and Time
   ID Line 4 - Load Case Name
4. Coordinates codes from SDRC MODAL-PLUS and SDRC MODALX are decoded into node (grid point) and direction.
5. Entity names used in SDRC SYSTAN have a 4 character maximum.

Addendum A

In order to correctly perform units conversion, length, force, and temperature exponents must be supplied for a specific data type of General; that is, Record 8 Field 1 = 1. For example, if the function has the physical dimensionality of Energy (Force * Length), then the required exponents would be as follows:

Length = 1
Force = 1 Energy = L * F
Temperature = 0

Units exponents for the remaining specific data types should not be supplied. The following exponents will automatically be used.

Table - Unit Exponents

Specific Data Type	Direction: Translational Length	Translational Force	Translational Temp	Rotational Length	Rotational Force	Rotational Temp
0	0	0	0	0	0	0
1	(requires input to fields 2,3,4)					
2	-2	1	0	-1	1	0
3	0	0	0	0	0	0
5	0	0	1	0	0	1
6	1	1	0	1	1	0
8	1	0	0	0	0	0
9	0	1	0	1	1	0
13	0	1	0	1	1	0
15	-2	1	0	-1	1	0
16	-1	1	0	1	1	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0

NOTE: Units exponents for scalar points are defined within SDRC SYSTAN prior to reading this dataset.

Addendum B

There are 8 distinct combinations of parameters which affect the details of READ/WRITE operations. The parameters involved are Ordinate Data Type, Ordinate Data Precision, and Abscissa Spacing. Each combination is documented in the examples below. In all cases, the number of data values (for even abscissa spacing) or data pairs (for uneven abscissa spacing) is NVAL. The abcissa is always real single precision. Complex double precision is handled by two real double precision variables (real part followed by imaginary part) because most systems do not directly support complex double precision.

CASE 1

REAL
SINGLE PRECISION
EVEN SPACING

Order of data in file

```
Y1  Y2  Y3  Y4  Y5  Y6
Y7  Y8  Y9  Y10 Y11 Y12
.
.
.
```

Input

```
      REAL Y(6)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR=  ,END=  )(Y(I),I=1,6)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+6
      .
      .   code to process these six values
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

Output

```
      REAL Y(6)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .   code to set up these six values
      .
      WRITE(LUN,1000,ERR=  )(Y(I),I=1,6)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+6
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

CASE 2

REAL
SINGLE PRECISION
UNEVEN SPACING

Order of data in file

```
X1  Y1  X2  Y2  X3  Y3
X4  Y4  X5  Y5  X6  Y6
.
.
.
```

Input

```
     REAL X(3),Y(3)
     .
     .
     .
     NPRO=0
  10 READ(LUN,1000,ERR=  ,END=  )(X(I),Y(I),I=1,3)
1000 FORMAT(6E13.5)
     NPRO=NPRO+3
     .
     .  code to process these three values
     .
     IF(NPRO.LT.NVAL)GO TO 10
     .
     .  continued processing
     .
```

Output

```
     REAL X(3),Y(3)
     .
     .
     .
     NPRO=0
  10 CONTINUE
     .
     .  code to set up these three values
     .
     WRITE(LUN,1000,ERR=  )(X(I),Y(I),I=1,3)
1000 FORMAT(6E13.5)
     NPRO=NPRO+3
     IF(NPRO.LT.NVAL)GO TO 10
     .
     .  continued processing
     .
```

CASE 3

COMPLEX
SINGLE PRECISION
EVEN SPACING

Order of data in file

```
RY1 IY1 RY2 IY2 RY3 IY3
RY4 IY4 RY5 IY5 RY6 IY6
.
.
.
```

Input

```
      COMPLEX Y(3)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR= ,END= )(Y(I),I=1,3)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+3
      .
      .  code to process these six values
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

Output

```
      COMPLEX Y(3)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .  code to set up these three values
      .
      WRITE(LUN,1000,ERR= )(Y(I),I=1,3)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+3
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

CASE 4

COMPLEX
SINGLE PRECISION
UNEVEN SPACING

Order of data in file

```
X1  RY1 IY1 X2 RY2 IY2
X3  RY3 IY3 X4 RY4 IY4
.
.
.
```

Input

```
      REAL X(2)
      COMPLEX Y(2)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR= ,END= )(X(I),Y(I),I=1,2)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+2
      .
      .  code to process these two values
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

Output

```
      REAL X(2)
      COMPLEX Y(2)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .  code to set up these two values
      .
      WRITE(LUN,1000,ERR= )(X(I),Y(I),I=1,2)
 1000 FORMAT(6E13.5)
      NPRO=NPRO+2
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

CASE 5

REAL
DOUBLE PRECISION
EVEN SPACING

Order of data in file Y1 Y2 Y3 Y4
Y5 Y6 Y7 Y8
.
.
.

Input

```
      DOUBLE PRECISION Y(4)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR=  ,END=  )(Y(I),I=1,4)
 1000 FORMAT(4E20.12)
      NPRO=NPRO+4
      .
      .   code to process these four values
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

Output

```
      DOUBLE PRECISION Y(4)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .   code to set up these four values
      .
      WRITE(LUN,1000,ERR=  )(Y(I),I=1,4)
 1000 FORMAT(4E20.12)
      NPRO=NPRO+4
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

CASE 6

REAL
DOUBLE PRECISION
UNEVEN SPACING

Order of data in file

```
X1  Y1   X2  Y2
X3  Y3   X4  Y4
.
.
.
```

Input

```
      REAL X(2)
      DOUBLE PRECISION Y(2)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR=  ,END=  )(X(I),Y(I),I=1,2)
 1000 FORMAT(2(E13.5,E20.12))
      NPRO=NPRO+2
      .
      .  code to process these two values
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

Output

```
      REAL X(2)
      DOUBLE PRECISION Y(2)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .  code to set up these two values
      .
      WRITE(LUN,1000,ERR=  )(X(I),Y(I),I=1,2)
 1000 FORMAT(2(E13.5,E20.12))
      NPRO=NPRO+2
      IF(NPRO.LT.NVAL)GO TO 10
      .
      . continued processing
      .
```

CASE 7

COMPLEX
DOUBLE PRECISION
EVEN SPACING

Order of data in file

```
RY1   IY1   RY2   IY2
RY3   IY3   RY4   IY4
.
.
.
```

Input

```
        DOUBLE PRECISION Y(2,2)
        .
        .
        .
        NPRO=0
   10   READ(LUN,1000,ERR=  ,END=  )((Y(I,J),I=1,2),J=1,2)
 1000   FORMAT(4E20.12)
        NPRO=NPRO+2
        .
        .  code to process these two values
        .
        IF(NPRO.LT.NVAL)GO TO 10
        .
        . continued processing
        .
```

Output

```
        DOUBLE PRECISION Y(2,2)
        .
        .
        .
        NPRO=0
   10   CONTINUE
        .
        .  code to set up these two values
        .
        WRITE(LUN,1000,ERR=  )((Y(I,J),I=1,2),J=1,2)
 1000   FORMAT(4E20.12)
        NPRO=NPRO+2
        IF(NPRO.LT.NVAL)GO TO 10
        .
        . continued processing
        .
```

CASE 8

COMPLEX
DOUBLE PRECISION
UNEVEN SPACING

Order of data in file

```
X1  RY1  IY1
X2  RY2  IY2
.
.
.
```

Input

```
      REAL X
      DOUBLE PRECISION Y(2)
      .
      .
      .
      NPRO=0
   10 READ(LUN,1000,ERR=  ,END=  )(X,Y(I),I=1,2)
 1000 FORMAT(E13.5,2E20.12)
      NPRO=NPRO+1
      .
      .   code to process this value
      .
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

Output

```
      REAL X
      DOUBLE PRECISION Y(2)
      .
      .
      .
      NPRO=0
   10 CONTINUE
      .
      .   code to set up this value
      .
      WRITE(LUN,1000,ERR=  )(X,Y(I),I=1,2)
 1000 FORMAT(E13.5,2E20.12)
      NPRO=NPRO+1
      IF(NPRO.LT.NVAL)GO TO 10
      .
      .  continued processing
      .
```

4. Data Set Type 82 - Trace Lines

Dataset Type: 82

Description: Trace Lines

Record 1: FORMAT(3I10)

Field 1 - Trace Line number
Field 2 - Number of entries defining trace
Field 3 - Color

Record 2: FORMAT(80A1)

Field 1 - Identification Line

Record 3: FORMAT(8I10)

Fields 1-N - Entries defining trace

Notes:

1. A non-zero trace line entry means to draw a line to the grid point. A zero trace line entry means to move to the grid point without a draw. A move to the first grid point is implied.
2. The maximum number of entries defining a trace must not exceed 250.
3. SDRC MODAL-PLUS and SDRC MODALX grid point numbers must not exceed 8000.
4. The identification line must not be blank. If no information is required, the word "NONE" must appears in columns 1 through 4.
5. SDRC SYSTAN only uses the first 60 characters of the identification text.
6. SDRC SYSTAN does not process color on a trace line by trace line basis. Each trace line is displayed using the color of the component to which each belongs.
7. SDRC MODAL-PLUS and SDRC MODALX do not support trace lines longer than 125 grid points.

5. Data Set Type 83 - Coordinate Trace

Dataset Type: 83

Description: Coordinate Trace

Record 1: FORMAT(3I10)

Field 1 - Coordinate Trace number
Field 2 - Number of entries defining trace
Field 3 - Color

Record 2: FORMAT(80A1)

Field 1 - Identification Line

Record 3: FORMAT(6(I10,2A1))

Field 1 - Grid point number portion of the coordinate specification
Field 2 - Direction identification character (must be "X", "Y", or "Z")
Field 3 - Sense identification character (must be "+" or "-")

Fields 1 through 3 are repeated for each coordinate.

Notes:

1. A coordinate must contain all three fields.
2. The maximum number of entries defining a trace must not exceed 125.
3. SDRC MODAL-PLUS and SDRC MODALX grid point numbers must not exceed 8000.
4. The identification line must not be blank. If no information is required, the word "NONE" must appears in columns 1 through 4.

6. Data Set Type 151 - Header File

Dataset Type: 151

Description: Header File

Record 1: FORMAT(80A1)

Field 1 - Model file name

Record 2: FORMAT(80A1)

Field 1 - Model file description

Record 3: FORMAT(80A1)

Field 1 - Program which created DB

Record 4: FORMAT(10A1,10A1)

Field 1 - Date database created (DD-MMM-YY)
Field 2 - Time database created (HH:MM:SS)

Record 5: FORMAT(10A1,10A1)

Field 1 - Date database last saved (DD-MMM-YY)
Field 2 - Time database last saved (HH:MM:SS)

Record 6: FORMAT(80A1)

Field 1 - Program which created universal file

Record 7: FORMAT(10A1,10A1)

Field 1 - Date universal file written (DD-MMM-YY)
Field 2 - Time universal file written (HH:MM:SS)

7. Data Set Type 156 - Units File

Dataset Type: 156

Description: Units File

Record 1: FORMAT(I10,20A1)

Field 1 - Units code
1 : SI - METRIC_ABS_(SI)
2 : BG - BRITISH_GRAV
3 : MG - METRIC_GRAV
4 : BA - BRITISH_ABS
5 : MM - MODIFIED_SI_(MM)
6 : CM - MODIFIED_SI_(CM)
7 : IN - BRITISH_GRAV_(MOD)
8 : GM - METRIC_GRAV_(MOD)
9 : US - USER_DEFINED

Field 2 - Units description (used for documentation only)

Record 2: FORMAT(3E13.5)

Field 1 - Length
Field 2 - Force
Field 3 - Temperature

NOTE:
Unit factor for converting universal file units to SI. To convert from universal file units to SI divide by the appropriate factor listed above.

8. Data Set Type 241 - Component Header Data

Dataset Type: 241

Description: Component Header Data

Record 1: FORMAT(I6)

Field 1 - Component Kind
6 - General Matrix

Record 2: FORMAT(2A2)

Field 1 - Component Name (4 character max)

Record 3: FORMAT(40A2)

Field 1 - Component Description (80 character max)

Record 4: FORMAT(5A2)

Field 1 - Analysis Date (dd-mmm-yy)

Record 5: FORMAT(2I6)

Field 1 - Analysis Machine
1 - VAX
2 - CDC
3 - IBM

Field 2 - Analysis Program
1 - NASTRAN
2 - SUPERB
3 - DAGS
4 - FSI
5 - ANSYS

9. Data Set Type 250 - Entry Definition Matrix

Dataset Type: 250

Description: Entry Definition Matrix

Record 1: FORMAT(I10)

Field 1 - Matrix Identifier (IMAT) - Refer to Table I-1

Record 2: FORMAT(5I10)

Field 1 - Matrix Data Type (MDTYPE)
- 1 - Integer
- 2 - Real
- 4 - Double Precision
- 5 - Complex
- 6 - Complex Double Precision

Field 2 - Matrix Form (MFORM)
- 3 - General Rectangular

Field 3 - No. of Rows (NROWS)

Field 4 - No. of Cols (NCOLS)

Field 5 - Storage Key (MKEY)
- 1 - Row
- 2 - Column (suggested)

Record 3: FORMAT(6I10)

Field 1 - Starting Row for Submatrix (ISR)

Field 2 - Starting Column for Submatrix (ISC)

Field 3 - No. of Rows in Submatrix (NR)

Field 4 - No. of Columns in Submatrix (NC)

Field 5 - Submatrix Form (MFORMS)
- 3 - General Rectangular
- 5 - Diagonal

Field 6 - Submatrix Storage Key (MKEYS)
- 1 - Row
- 2 - Column (suggested)

Record 4: Matrix Data

FORMAT(8I10)	INTEGER
FORMAT(4E20.12)	REAL
FORMAT(4D20.12)	DOUBLE PRECISION
FORMAT(2(2E20.12))	COMPLEX
FORMAT(2(2D20.12))	COMPLEX DOUBLE PRECISION

(Record 4 repeated as necessary to fulfill requirements of record 3)

(Records 3 and 4, as a group, are repeated as necessary to define all non-zero submatrices)

Notes:

1. Submatrix data is added to current components.

2. Submatrix data not present is assumed equal to zero. If records 3 and 4 are not present, a zero matrix is created.

3. Matrix 148 will have its diagonal overwritten with the identity matrix [I]. The independent-independent portion of matrix 31 will be overwritten with [I].

Table I-1. Valid Matrices for SDRC SYSTAN Components.

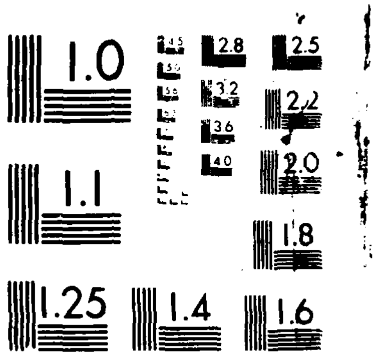
IMAT	Description	Component					
		FM	FS	E	S	R	G
6	Mass		•		•		
7	Viscous		•		•		
8	Histeretic		•		•		
9	Stiffness		•		•		
11	Modal Displacement	•		•			
13	Modal Mass	•		•			
14	Modal Viscous	•		•			
15	Modal Hysteretic	•		•			
16	Modal Stiffness	•		•			
31	Rigid Body Constraint					•	
32	Rigid Body Mass					•	
131	Mass (I-I)						•
132	Mass (I-D)						•
133	Mass (D-I)						•
134	Mass (D-D)						•
135	Viscous (I-I)						•
136	Viscous (I-D)						•
137	Viscous (D-I)						•
138	Viscous (D-D)						•
139	Stiffness (I-I)						•
140	Stiffness (I-D)						•
141	Stiffness (D-I)						•
142	Stiffness (D-D)						•
143	Hysteretic (I-I)						•
144	Hysteretic (I-D)						•
145	Hysteretic (D-I)						•
146	Hysteretic (D-D)						•
147	Constraint (D-I)						•
148	Constraint (D-D)						•

Key

I	-	Independent	E	-	Experimental modal synthesis
D	-	Dependent	S	-	SDRC SYSTAN finite element
FM	-	Finite element modal synthesis	R	-	Rigid body
FS	-	Finite element substructure	G	-	General matrix

AD-A195 148 EXPERIMENTAL MODAL ANALYSIS AND DYNAMIC COMPONENT SYNTHESIS VOLUME 6 SOFT..(U) CINCINNATI UNIV OH DEPT OF MECHANICAL AND INDUSTRIAL ENGINEER.. R J ALLEMANG ET AL. DEC 87 4/4

UNCLASSIFIED F/G 13/13 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963

APPENDIX J: EXAMPLE MODAL TEST

The purpose of this example test is to illustrate both the general procedures involved in a modal test, as well as some of the specific features of the University of Cincinnati RTE Modal Program. To help accomplish this, comments have been added to the raw listing to give additional insight into what is being accomplished. Comments consist of upper and lower case letters, whereas the prompts and responses of the program are all upper case. In general, comments start in column 40 however, when a single phrase or two are not explanation enough, full lines are used, in which case "*" characters are used to set them off. User responses are underlined. All user responses were entered through the terminal keyboard, except where noted. This example test was performed on a T-plate structure. The Frequency Response Function estimates were made utilizing impact testing techniques using an HP 5451C Fourier Analyzer.

```
*****************************************************************
LOADING RTE MODAL FROM THE DISK
*****************************************************************
```

In order to use the RTE Modal Program, one must realize that it only operates on HP-5451-C Fourier Systems, (not HP-5451-B Systems). The RTE Modal system operates from the lower (fixed) disc. If a copy of the RTE Modal Program already exists on the lower disc, skip to PROJECT SET-UP. To copy the RTE Modal Program to the lower disc use the standard HP User Program Y 999 to copy the RTE Modal System to the lower disc.

```
*****************************************************************
PROJECT SET UP
*****************************************************************


  - Boot the lower (fixed) disc:

  * For HP-7900 disc : Enter 101700(octal) to S register, "RUN"
  * For HP-7906 disc : Enter 111702(octal) to S register, "RUN"

SET TIME
*****************************************************************
     RTE SYSTEM:          RTE-IV B
     REVISION CODE:       2140
     GENERATION CODE:     830830 RJA
     SYSTEM USAGE:        RTE MODAL PROGRAM
     SYSTEM OWNER:        R. J. ALLEMANG
*****************************************************************
:MODAL

   UNIVERSITY OF CINCINNATI MODAL ANALYSIS SYSTEM
        REVISION CODE: 830830


**  IN 0                          Enter test identification
                                  (Section 4.3)
ENTER TEST ID-20 CHARACTERS
TPLATE

TEST ID IS    TPLATE

ENTER DATE - 6 DIGITS(YYMMDD)
831201
```

```
**  IN 1                                Enter component information
                                        (Section 4.4)
ENTER: COMPONENT NUMBER, X, Y, Z, IX, IY, IZ, IC
     IX,IY,IZ ARE THE COMPONENT AXIS ORIENTATIONS
     (PLUS/MINUS 1,2,3) IN THE GLOBAL X,Y,Z DIRECTIONS

1 0 0 0 1 2 3 1
2 0 0 0 1 2 3 1
0

**  IN 2                                Enter coordinate information
                                        (Section 4.5)
ENTER: POINT NUMBER, X,Y,Z COORDINATES, "COMPONENT NUMBER"
1 0 0 0 1
2 0 0 2 1
3 2 0 0 1
4 2 0 2 1
5 4 0 0 1
6 4 0 2 1
7 2 2 0 2
8 2 2 2 2
9 2 3 0 2
10 2 3 2 2
0

**  IN 3                                Enter display sequence
                                        information (Section 4.6)
CONNECTIVITY MONITOR

C* IN

1
2
4
6
5
3
4
-3
7
9
10
8
4
-3
0

C*  PR

 LINE NUMBER  DISPLAY POINT
```

1	1
2	2
3	4
4	6
5	5
6	3
7	4
8	-3
9	7
10	9
11	10
12	8
13	4
14	-3

C* /I 0 — An example of inserting an entry Insert "-3" before line 0

-3
0

C* PR

LINE NUMBER	DISPLAY POINT
1	-3
2	1
3	2
4	4
5	6
6	5
7	3
8	4
9	-3
10	7
11	9
12	10
13	8
14	4
15	-3

C* EX

** MD — Display undeformed structure (Section 5.2.4)

D* D 0

D* IN 1 — An example of identifying a point, Intensify point #1

D* EX

** PR 0 — To verify information is correct, Print test identification

TEST IDENTIFICATION......... TPLATE
TEST DATE................... 83 12 01

** PR 1 — Print component information

COMPONENT	X	Y	Z	IX	IY	IZ	IC
1	0.0000	0.0000	0.0000	1	2	3	1
2	0.0000	0.0000	0.0000	1	2	3	1

** PR 2 — Print coordinate information

TEST I.D. TPLATE

POINT	X	Y	Z	COMPCNENT
1	0.00	0.00	0.00	1
2	0.00	0.00	2.00	1
3	2.00	0.00	0.00	1
4	2.00	0.00	2.00	1
5	4.00	0.00	0.00	1
6	4.00	0.00	2.00	1
7	2.00	2.00	0.00	2
8	2.00	2.00	2.00	2
9	2.00	3.00	0.00	2
10	2.00	3.00	2.00	2

** PR 3 — Print display sequence information

LINE NUMBER	DISPLAY POINT
1	-3
2	1
3	2
4	4
5	6
6	5
7	3
8	4
9	-3
10	7
11	9
12	10
13	8
14	4
15	-3

** ST

* If the system is an HP-7900 drive only system insure when

```
*   storing or loading modal information a "library" disc
*   is in the upper drive to store or load the information -
*   DO NOT write modal files to the data disc!!!    The
*   system can possibly write over data.  After the information
*   has been stored or loaded, the data disc can be placed back
*   into the upper disc to continue.
*
*   If the system is an HP-7906 drive or multiple HP-7900 drive
*   system, project and modal files are generally stored on
*   disc area that is available without needing to change disc.


                                -security code
                                -cartridge reference number
ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):

TPLATE::-9                      Store information on upper disc
                                without a security code.
**  DS                          Enter data acquisition set-up


ENTER DATA SETUP OPTION:
          1)  USER 888 OPERATION (DATA ANNOTATION)
          2)  USER 889 OPERATION (DATA SETUP-FILE SEVEN)
          3)  USER 891 OPERATION (DATA LIST-FILE NINE)
          4)  USER 892 OPERATION (DATA EDIT-FILE NINE)
          5)  USER 893 OPERATION (DATA EDIT-FILE NINE)
          6)  USER 894 OPERATION (DATA COMPARISON-FILE ONE)
2

ENTER OPTION FOR TEST SET-UP:
   1)  CLEAR DISK RECORDS FOR MODAL TEST
   2)  READ SET-UP FROM FILE SEVEN AREA
   3)  INPUT TEST SET-UP INFORMATION
   4)  WRITE SET-UP TO FILE SEVEN AREA
   5)  PRINT SET-UP INFORMATION
   6)  EDIT SET-UP INFORMATION
   7)  RETURN TO MONITOR

3

ENTER TEST IDENTIFICATION (20 CHARACTERS):
TPLATE

ENTER TEST DATE (YYMMDD):
821018

ENTER NUMBER OF INPUTS:
1

ENTER INFORMATION FOR INPUT NUMBER  1

ENTER INPUT POSITION:
9
```

ENTER INPUT DIRECTION:
1

ENTER SERIAL NUMBER AND CALIBRATION (E.U./VOLT):
1723,1

ENTER NUMBER OF RESPONSES PER MEASUREMENT CYCLE
1

ENTER SERIAL NUMBER AND CALIBRATION FOR EACH TRANSDUCER
(E.U./VOLT)

RESPONSE NUMBER 1
2508,1

ENTER DATA TYPE CODE (2 CHARACTERS):
23

For code types refer to Modal Manual Appendix F and G

ENTER TEST TYPE CODE
21

ENTER CODE FOR INPUT TRANSDUCER UNITS
11

ENTER CODE FOR RESPONSE TRANSDUCER UNITS
13

ENTER RANGE OF DISK RECORDS TO BE CLEARED:
(-1 TO NOT CLEAR)
1,20

ENTER OPTION FOR TEST SET-UP:
1) CLEAR DISK RECORDS FOR MODAL TEST
2) READ SET-UP FROM FILE SEVEN AREA
3) INPUT TEST SET-UP INFORMATION
4) WRITE SET-UP TO FILE SEVEN AREA
5) PRINT SET-UP INFORMATION
6) EDIT SET-UP INFORMATION
7) RETURN TO MONITOR

4

ENTER DESTINATION FILE SEVEN RECORD:
15

Stores the setup in record 15 in Fourier Disc file 7

ENTER OPTION FOR TEST SET-UP:
1) CLEAR DISK RECORDS FOR MODAL TEST
2) READ SET-UP FROM FILE SEVEN AREA
3) INPUT TEST SET-UP INFORMATION
4) WRITE SET-UP TO FILE SEVEN AREA
5) PRINT SET-UP INFORMATION
6) EDIT SET-UP INFORMATION
7) RETURN TO MONITOR

7

```
**
*************************************************************
DATA ACQUISITION
*************************************************************

- Boot the upper (removable) disc:
 * For HP-7900 disc: Enter 101701(octal) to S register
   "RUN"(3 times)
 * For HP-7906 disc: Enter 111700(octal) to S register
   "RUN"(3 times)

BLOCKS ##/   SIZE #/  SPACE   printout on terminal
       7 /   4096  /  28672

-------------------
CREATE FORCE WINDOW
-------------------
BS1024

CL0
K 0 0 1024
K -4 0
10000
H1                               Repeat 20 times
 0 507                           This command is the SHIFT
                                 Button 0 SPACE 507
CL 0 512 1024
K 0 0 10
K -4 0
10000
MS31 710                         Store window to disc
MS21                             File 1, Record 710
D
-------------------------
CREATE EXPONENTIAL WINDOW
-------------------------


/R0                              Enter keyboard program
L 10
X<2
* 1
: 0 0
X>2
A+3
X>3
# 10 18
/
```

```
/L
        1 L    10
        5 X<    2
        9 *     1
       13 :     0     0
       18 X>    2
       22 A+    3
       26 X>    3
       30 #    10    18     0
       36 .
```

```
CL0
```

Create a data blk to input to above keyboard program.

```
CL1
K 0 0 1024
K -4 0
10000
X>2
X>3
K 1 1 1024
K -5 0
-225 0
$ 1
J 10
MS31 711
MS21
```

Store window to disc File 1, Record 711

```
----------------
DATA ACQUISITION
----------------
```

```
/R0
L 0
MS34 5
MS14
Y R 101
L 1
BS1024
CL 2
CL 3
CL 4
CL 5
MS31 710
MS11 6
MS11 7
MS34 15
MS14
D 1
L 2
MS34 20
MS14
RA
```

Enter keyboard program that calculates frequency response from single impact & single response.

```
Y 5 0 -4
* 6
X 1
* 7
X 1
F 0 1
CL 0 0 3
CL 1 0 3
SP 0 2 2
# 2 101D 0
CH 0 2 2
D 0
X 1
D 0
Y 888 1 1 0 1 15
J 1
/
```

```
MS33 10          Store keyboard program
MS23             File 3, Record 10
```

```
/L                                   List data acquisition program
      1 L      0                     to check for correctness.
      5 MS    34    5
     10 MS    14
     14 Y R 101
     18 L      1
     22 BS  1024
     26 CL     2
     30 CL     3
     34 CL     4
     38 CL     5
     42 MS    31  710
     47 MS    11    6
     52 MS    11    7
     57 MS    34   15
     62 MS    14
     66 D      1
     70 L      2
     74 MS    34   20
     79 MS    14
     83 RA
     86 Y      5    0     -4
     92 *      6
     96 X      1
    100 *      7
    104 X      1
    108 F      0    1
    113 CL     0    0      3
    119 CL     1    0      3
    125 SP     0    2      2
```

```
131  _#      2   101D    0
137 CH     0    2      2
143 D      0
147 X      1
151 D      0
155 Y     888   1      1      0      1       15
164 J      1
168 .
```

```
* Input Ascii Text files to be used in this data acquisition*
* keyboard program                                          *

MS 34 5
MS24
Enter: # of Averages
/*
MS34 15
MS 24
PRESS: "CONTINUE" FOR NEXT MEASUREMENT (cntl G)
/*

MS34 20
MS24
IMPACT AGAIN (cntl G)
/*


*  Slide switch from "SINGLE" to "REPEAT" mode              *
*  to set-up the ADC's.                                     *


RA                              Set-up ADC's


*  Slide switch back to "SINGLE" mode when ready to take data


J 0                             Start keyboard program
Enter: # of Averages
10                              Enter 10 averages
PRESS "CONTINUE" FOR NEXT MEASUREMENT


IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
```

ENTER POINT NUMBER AND DIRECTION(S):

A question from Y 888
Enter point number and
local orientation

9 -1

9 -1

PRESS "CONTINUE" FOR NEXT MEASUREMENT

IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN

ENTER POINT NUMBER AND DIRECTION(S):

1 -2

1 -2

PRESS "CONTINUE" FOR NEXT MEASUREMENT

IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN

ENTER POINT NUMBER AND DIRECTION(S):

2 -2

2 -2

PRESS "CONTINUE" FOR NEXT MEASUREMENT

IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN

```
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN

ENTER POINT NUMBER AND DIRECTION(S):

3 -2

   3  -2

PRESS "CONTINUE" FOR NEXT MEASUREMENT
```

* Repeat for the remaining points

```
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN
IMPACT AGAIN

ENTER POINT NUMBER AND DIRECTION(S):

10 -1

  10  -1

PRESS "CONTINUE" FOR NEXT MEASUREMENT
```

Press "RESTART" to exit the keyboard program

```
*************************************************************
RUN RTE MODAL
*************************************************************
```

-Boot the lower (fixed) disc

```
SET TIME
*************************************************************
     RTE SYSTEM:       RTE-IV B
```

```
     REVISION CODE:      2140
     GENERATION CODE:    830830 RJA
     SYSTEM USAGE:       RTE MODAL PROGRAM
     SYSTEM OWNER:       R. J. ALLEMANG
*************************************************************
:MODAL

    UNIVERSITY OF CINCINNATI MODAL ANALYSIS SYSTEM
          REVISION CODE: 830830

**

--------------------
QUADRATURE CURVE-FIT
(Section 8.3)
--------------------


** LO

ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):

TPLATE::-9

TEST IDENTIFICATION.........  TPLATE
TEST DATE...................  83 12 01

** RL,3

ENTER DIRECTORY OPTION:
     1)  READ CURRENT DIRECTORY
     2)  WRITE CURRENT DIRECTORY
     3)  CREATE NEW DIRECTORY
     4)  PRINT CURRENT DIRECTORY
     5)  EXIT TO MONITOR
3

CURRENT TEST IDENTIFICATION IS:    TPLATE

WISH TO CHANGE?
NO

ENTER NUMBER OF CHARACTERS REQUIRED FOR MATCH:
4

ENTER ZOOM RANGE OF DATA:
Z0

ENTER NUMBER OF REFERENCES (INPUTS):
1

INPUT NUMBER:   1   POINT NUMBER:
9
```

```
INPUT NUMBER:  1  POINT DIRECTION:
1

ENTER RANGE OF DISC RECORDS FOR CURRENT DIRECTORY:(N1,N2)
          N1 = STARTING RECORD
          N2 = ENDING RECORD
1,15

ENTER OPTION FOR MEASURMENT SELECTION:
          1) MEASURMENT DIRECTION
          2) COMPONENTS
          3) POINT NUMBERS
          4) CONTINUE
          5) RESTART DIRECTORY DEFINITION
          6) RETURN TO MONITOR
4

RECORD NUMBER:  1
RECORD NUMBER:  2
RECORD NUMBER:  3
RECORD NUMBER:  4
RECORD NUMBER:  5
RECORD NUMBER:  6
RECORD NUMBER:  7
RECORD NUMBER:  8
RECORD NUMBER:  9
RECORD NUMBER: 10
RECORD NUMBER: 11
RECORD NUMBER: 12
RECORD NUMBER: 13
RECORD NUMBER: 14
RECORD NUMBER: 15

ENTER DIRECTORY OPTION:
     1)  READ CURRENT DIRECTORY
     2)  WRITE CURRENT DIRECTORY
     3)  CREATE NEW DIRECTORY
     4)  PRINT CURRENT DIRECTORY
     5)  EXIT TO MONITOR

2
ENTER DIRECTORY OPTION:
     1)  READ CURRENT DIRECTORY
     2)  WRITE CURRENT DIRECTORY
     3)  CREATE NEW DIRECTORY
     4)  PRINT CURRENT DIRECTORY
     5)  EXIT TO MONITOR

4

POINT:   1   DIRECTION:  1    -1   -1   -1   -1   -1   -1
POINT:   1   DIRECTION:  2     2   -1   -1   -1   -1   -1
POINT:   1   DIRECTION:  3    -1   -1   -1   -1   -1   -1
POINT:   2   DIRECTION:  1    -1   -1   -1   -1   -1   -1
```

```
POINT:   2   DIRECTION:  2    3   -1   -1   -1   -1   -1
POINT:   2   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   3   DIRECTION:  1   -1   -1   -1   -1   -1   -1
POINT:   3   DIRECTION:  2    4   -1   -1   -1   -1   -1
POINT:   3   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   4   DIRECTION:  1   -1   -1   -1   -1   -1   -1
POINT:   4   DIRECTION:  2    5   -1   -1   -1   -1   -1
POINT:   4   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   5   DIRECTION:  1   -1   -1   -1   -1   -1   -1
POINT:   5   DIRECTION:  2    6   -1   -1   -1   -1   -1
POINT:   5   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   6   DIRECTION:  1   -1   -1   -1   -1   -1   -1
POINT:   6   DIRECTION:  2    7   -1   -1   -1   -1   -1
POINT:   6   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   7   DIRECTION:  1    8   -1   -1   -1   -1   -1
POINT:   7   DIRECTION:  2   -1   -1   -1   -1   -1   -1
POINT:   7   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   8   DIRECTION:  1    9   -1   -1   -1   -1   -1
POINT:   8   DIRECTION:  2   -1   -1   -1   -1   -1   -1
POINT:   8   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:   9   DIRECTION:  1    1   -1   -1   -1   -1   -1
POINT:   9   DIRECTION:  2   -1   -1   -1   -1   -1   -1
POINT:   9   DIRECTION:  3   -1   -1   -1   -1   -1   -1
POINT:  10   DIRECTION:  1   10   -1   -1   -1   -1   -1
POINT:  10   DIRECTION:  2   -1   -1   -1   -1   -1   -1
POINT:  10   DIRECTION:  3   -1   -1   -1   -1   -1   -1

ENTER DIRECTORY OPTION:
        1)  READ CURRENT DIRECTORY
        2)  WRITE CURRENT DIRECTORY
        3)  CREATE NEW DIRECTORY
        4)  PRINT CURRENT DIRECTORY
        5)  EXIT TO MONITOR
5

**  PE

ENTER OPTION TO BE USED TO DETERMINE FREQUENCIES AND DAMPING
     1) MANUAL
     2) CURSOR
     3) LEAST SQUARES TIME DOMAIN
     4) POLY-REFERENCE TIME DOMAIN
     5) POLY-REFERENCE FREQ DOMAIN
     6) ORTHOGONAL POLYNOMIAL
     7) IBRAHIM POLY-REFERENCE
     8) MODIFIED IBRANIM POLY-REFERENCE
     9) MULTI-MAC
    10) CURRENTLY SELECTED VALUES
    11) RETURN TO MONITOR

2

CLEAR CURRENT FREQUENCY/DAMPING INFORMATION?
```

YES

DISK RECORD NUMBER OF TYPICAL DATA?

1 Driving point measurement

MEASUREMENT INFORMATION:

REFERENCE POINT:	9
REFERENCE DIRECTION:	1
RESPONSE POINT:	9
RESPONSE DIRECTION:	-1
ZOOM CODE:	Z0
DATA TYPE CODE:	23
MEASUREMENT SOURCE:	3
FREQUENCY RESOLUTION:	1.953125
MINIMUM FREQUENCY:	0.000
MAXIMUM FREQUENCY:	1000.000

MODE NUMBER AND ZETA(%)?

1 0

* Set the "MODE" switch on the 5460A Disply to IMAG
* - refer to Section 2.7.1 for movement of the cursor.

FREQUENCY (HERTZ) 272.0000
CHANNEL NUMBER............... 136

MODE NUMBER AND ZETA(%)?

2 0

FREQUENCY (HERTZ) 496.0000
CHANNEL NUMBER............... 248

MODE NUMBER AND ZETA(%)?

3 0

FREQUENCY (HERTZ) 854.0000
CHANNEL NUMBER............... 427

MODE NUMBER AND ZETA(%)?

4 0

FREQUENCY (HERTZ) 884.0000
CHANNEL NUMBER............... 442

MODE NUMBER AND ZETA(%)?

0

ENTER OPTION TO BE USED TO DETERMINE MODAL VECTORS:
1) COMPLEX MAGNITUDE
2) IMAGINARY PART
3) REAL PART
4) REAL CIRCLE FIT
5) COMPLEX CIRCLE FIT
6) LEAST-SQUARES FREQUENCY DOMAIN
7) POLY-REFERENCE TIME DOMAIN
8) POLY-REFERENCE FREQUENCY DOMAIN
9) RETURN TO MONITOR

2

CLEAR CURRENT MODAL VECTORS?

YES

REFERENCE: 1 POINT: 9 DIRECTION: -1 RECORD: 1

** PR 4 Print frequency damping information

MODE	FREQUENCY	ZETA(%)	CHANNEL	BAND	METHOD	METHOD
1	272.000	0.0000000	136	2	2	2
2	496.000	0.0000000	248	2	2	2
3	854.000	0.0000000	427	2	2	2
4	884.000	0.0000000	442	2	2	2

** MD Display mode shapes

D* D 1

272.0000 HERTZ ****

D* D 2

496.0000 HERTZ ****

D* D 3

854.0000 HERTZ ****

```
D*  D 4

    884.0000 HERTZ    ****

D*  VW 0 0 1                              Change view of
                                          the structure

    884.0000 HERTZ    ****

D*  EX
                                          Store project file
                                          to disc
**  ST
ENTER PROJECT FILE NAME (XXXXXX:SC:CRN):

TPLATE::-9
WARNING-FILE CURRENTLY EXISTS

WISH TO OVERWRITE CURRENT FILE ?

YES

**  EX
SYSTEM PROJECT AREA TO BE RELEASED
DO YOU WISH TO EXIT ?

YES
```

END

DATE

FILMED

8-88

DTIC