



Experimental Modal Parameter Estimation Master Test Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To determine the natural frequencies and corresponding mode shapes of a test object.

1.2 Applicability. This test procedure is appropriate for the evaluation of vehicle level, vehicle subsystems and components.

The testing standards defined in this document are intended to pertain only to standard work being done for the corporate database and validation. Other testing methods and interpretations are useful and valid, and shall continue to be used for normal vehicle development work where appropriate.

1.3 Remarks. Data from modal surveys is often used as a means of describing the structural performance of GM and competitive structures.

This procedure utilizes existing Frequency Response Functions (FRF), developed using one of the acquisition procedures listed in 2.2, for the parameter estimation process.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14181 GMW14228

2.3 Additional References. None.

3 Resources

3.1 Facilities. Not applicable.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Processing Equipment. PC or Workstation-based software with the capability to perform the modal parameter estimation process described in 5.1.

3.3 Test Vehicle/Test Piece. Not applicable

3.4 Test Time.

Calendar time: 0.5 to 1.0 day

Test time: 0 hours

Coordination time: 4 to 8 hours

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3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. To complete this analysis, at least one (1) technician and/or one (1) engineer skilled in vibration data acquisition, modal analysis, equipment use, and test setup is required.

Note: To correctly estimate modal parameters, an understanding of experimental FRF acquisition as well as the modal parameter estimation process is required.

4 Procedure

This procedure focuses on modal parameter extraction from FRF obtained in the Shaker FRF Acquisition Master Test Procedure (GMW14228) or Impact FRF Acquisition Master Test Procedure (GMW14181).

4.1 Preparation. Not applicable.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions. Not applicable.

5 Data

5.1 Calculations. The data (FRFs and geometry set) for this section are acquired using the Shaker FRF Acquisition Master Test Procedure (GMW14228) or Impact FRF Acquisition Master Test Procedure (GMW14181).

Data acquisition is made using either of these two (2) procedures.

5.1.1 Create Geometry. Recall the record of transducer locations and generate the geometric representation of these locations.

5.1.2 Measurement Sums (SUM) and Mode Indicator Functions (MIF). Compute and store a sum (straight sum, imaginary squared sum, etc.) of the measurements and, if applicable, MIFs.

To develop an understanding of subsystems and the interaction between local and global modes; it is useful to examine sums for individual components.

Note: To correctly estimate modal parameters, an understanding of experimental FRF acquisition as well as the modal parameter estimation process is required.

5.1.3 Parameter Estimation. Use a global multiple degree-of-freedom modal parameter estimation technique (time or frequency domain) to estimate the natural frequencies and corresponding mode shapes. Typically, time domain based modal parameter estimation works well for lightly damped modes and low modal density. While frequency domain based modal parameter estimation works well for more heavily damped modes and higher modal density. Local modal parameter estimation may be used if global is not available or if it improved the modal parameter estimates. Do not specify **normal/real modes**; i.e., specify complex modes. For evaluating convertibles, it is useful to add modal mass to the parameters.

5.1.3.1 For correlation of math models to experimental data, estimation of the modal parameters may require repeating 5.1.3 specifying normal/real modes.

5.1.4 Compare estimates of the natural frequencies to the sum and the individual measurements to ensure accuracy of the results. For additional data processing guidelines, see Appendix A. Store the natural frequency and mode shape information.

5.1.5 Use the estimated modal parameters to re-synthesize all of the measurements used during modal parameter estimation. Compute and store the sum and MIFs using these measurements. Be sure that the amplitude of the synthesized sum is within 10% of the amplitude of the data sum. Use sum and MIF comparison as a guide to improve modal parameter estimates.

5.1.6 Individually view each estimated mode shape. Note the natural frequency and damping estimates. Label each mode shape by first indicating, by name, the portion (or component) of the structure with the maximum relative deflection and describe the nature of its motion (e.g., pitch, bending). Note the relative amplitude and phase in the description as appropriate for further clarity (e.g., bending, in-phase).

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Note: If this procedure does not result in accurate definition of these significant modes then a separate test shall be performed. Repeat for the portion of the structure with the next largest relative deflection until all aspects of the mode shape are described.

5.2 Interpretation of Results. Refer to referencing procedure(s).

5.3 Test Documentation. All test documentation shall contain: contact name, number and organization; date; data type; component or subsystem description, correct axis labels (where appropriate); data storage path and/or archive location and project name.

5.3.1 Data presentation is usually in the form of a summary table with natural frequencies and mode shape descriptions determined in 5.1.6. An example summary table is shown in Appendix B, Table B1.

5.3.2 Animated mode shapes are also commonly presented in databases, memos and presentations. For example, many software packages can generate Audio Video Interleave (AVI) or Graphic Interchange Format (GIF) files that can be animated in Microsoft products.

5.3.3 Overlay plots featuring the sum of the actual measurements, the sum of the synthesized measurements, and the amplitude weighted assessment function may be included. Also, the measured and synthesized MIF may be plotted.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Audio Video Interleave (AVI): A multimedia container format.

Frequency Response Function (FRF): An output/input relationship of a system as a function of frequency. Unless otherwise stated, FRF in the context of this document implies an accelerance. However, input and response units can represent any output/input mathematical relationship.

Graphics Interchange Format (GIF): A bitmap image format.

7.2 Acronyms, Abbreviations, and Symbols.

AVI	Audio Video Interleave (file type)
DOF	Degrees of Freedom
FRF	Frequency Response Mode
GIF	Graphic Interchange Format (file type)
IDSR	Integration Driven Subsystem Requirements
MAC	Modal Assurance Criterion
MIF	Mode Indicator Function
MPC	Modal Phase Collinearity
N&V	Noise and Vibration
SDOF	Single Degree of Freedom
SUM	Measurement Sum
VPO	Vehicle Performance Owner

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14229

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