



Assembled Steering Column Drive Point A/F FRF to Ground Evaluation Procedure

1 Introduction

The Transducer Calibration Master Test Procedure, GMW14172 and the Hand Held Force Input Frequency Response Function (FRF) Acquisition Master Test Procedure, GMW14181, shall be referenced for more detailed information corresponding to the following procedure.

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. Determination of the dynamic behavior in the low frequency range of the steering system to ground supporting the objective to have a good tactile vibration performance in the vehicle.

1.2 Applicability. This test procedure is appropriate for benchmarking competitive and GM steering columns to ground boundary condition. The procedure is valid for use with a program intent steering wheel and airbag or universal steering wheel and airbag test mass.

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

1.3 Remarks. In road-induced and powertrain-induced load conditions, vibrations of the steering column and wheel can be perceived by the driver as unacceptable tactile vibration and thus lower perceived quality and refinement. The purpose of this Test Procedure is to establish the conformity to standards when validating targets and for benchmark purposes. Additional testing may be desirable for development work.

Measured steering column to ground drive point FRFs could be used to validate the respective Computer Aided Engineering (CAE) model not only regarding the eigenfrequency, but also regarding the steering column sensitivity increasing the CAE capability level.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14172 GMW14181

2.3 Additional References.

- PCB Piezotronics, Inc., 3425 Walden Avenue, Depew, NY 14043-2495 USA.
- Siemens PLM Software - Global Headquarters, 5800 Granite Parkway, Suite 600, Plano, TX 75024.
- Steering Column Subsystem Technical Specification (SSTS) Appendix C1 and C2.

3 Resources

3.1 Facilities. All measurements are performed in a test room that is equipped for vibration measurements and free of extraneous vibration (per GMW14181). The test setup shall include a qualified test fixture for component mounting to ensure the static and dynamic requirements as defined in 3.7 are met. See Appendix A, Figure A2 for an example of setup.

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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 Test Equipment.

- Two (2) triaxial acceleration transducers (PCB 356A02 or PCB 356A15 with Integrated Circuit Piezoelectric (ICP) signal amplifiers, available from PCB Piezotronics, Inc.)
- Modally tuned impulse hammer (e.g., PCB-086D05 with PCB-084A51 Adaptor and hammer tips range from 084A50 to 086C05, the super soft tip (Grey 084A50) is recommended and available from PCB Piezotronics, Inc.)
- Hot glue or light weight mounting clamps are used for positioning the accelerometer transducers on the rim of the steering wheel or the universal steering wheel and airbag test mass, as documented in Steering Column Subsystem Technical Specification (SSTS), Appendix C1 and C2. It shall be ensured that no relative motion between the accelerometer and rim is possible.
- Multi-channel spectrum analyzer front end with Analog/Digital converter, computer and software for measurement and analysis (e.g., LMS SCADAS Front End and LMS Test Lab software, available from Siemens PLM Software, Siemens Industry, Inc.). A multi-channel Data Acquisition System (DAS) is required to receive all signals simultaneously.

Note: See GMW14181, Appendix A, Transducer Examples for transducer key characteristics.

3.3 Test Vehicle/Test Piece. Test objects are completed with a steering wheel and airbag (or universal test mass as documented in Steering Column SSTS, Appendix C1 and C2) and fully dressed steering column or a structural steering column to ground.

3.4 Test Time.

Calendar time:	2 days
Test time:	4 hours
Test Summary time:	1 hour
Coordination time:	2 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Engineer and/or technician skilled in vibration data acquisition and analysis, and operation of the equipment.

3.7 Component Test Fixture/Component Boundary Condition. The test fixture to ground boundary condition must meet the following static and dynamic specifications:

- Lowest Fixture Mode Natural Frequency: 500 Hz.
- Minimal Static Stiffness: 375 000 N/mm (all attachment points and directions).

To achieve these requirements the steering column should be fixed as close as possible to the clamping plate. Appendix A, Figures A2 and A3 show the preferred fixture. The steering column is directly clamped to a rigid bedplate fixed directly to ground with overhanging steering wheel and airbag (or universal test mass). Only if that fixture could not be realized, an alternative as shown in Appendix A, Figure A4 should be used.

4 Procedure

4.1 Preparation. The steering wheel is in straight-ahead (12 o'clock) position and not locked. When the column is adjustable, middle positions are to be chosen for all settings.

4.1.1 Positions and Leveling. The drive point accelerometer mounting positions are 12 o'clock and 3 o'clock (see Appendix A, Figures A2 and A3). The acceleration transducers shall be fixed with respect to the local coordinate system of the steering wheel. It is recommended to use a digital level to ensure that an accurate mounting of the accelerometers to the local coordinate system is verified to within 5 degrees.

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4.2 Conditions.

4.2.1 Environmental Conditions. When no other specifications are defined explicitly, the test shall be performed at $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

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.

4.3.1 Setup for Measurement System.

- Frequency range: 0 Hz to 128 Hz.
- Resolution: 0.25 Hz.
- Trigger mode: Hammer Input channel.
- Time windows: Uniform Window. If event cannot be completely observed, use Force/Exponential Windows.
- Trigger level: 10% to 50% slope channel. Sign of the slope may vary depending on transducer type and DAS.
- 1% (of time block) trigger delay (pre-trigger) for all channels.
- Alternating Current (AC) Coupled (1 Hz high pass filter).
- Enable overload detection.
- Measuring function: Frequency Response Function (FRF) with force as reference.
- Number of average: Five (5) minimum.
- Force level input: Select hammer tip to achieve an approximate 12 dB roll off 5 Hz to 100 Hz. Typical time domain input 40 N peak level (approximately 1 N to 1.2 N Root Mean Square (RMS) from 5 Hz to 100 Hz). Check if it is necessary to add mass to impact hammer to achieve the force level input.

4.3.2 Measurement. During the acquisition time, impact the wheel with the modally tuned impulse hammer near one (1) transducer position. Conduct this measurement three (3) times for repeatability comparison. Perform the following drive point FRF measurements: 12 o'clock vertical, 12 o'clock fore/aft (only with a steering wheel and inert airbag), 3 o'clock fore/aft (only with a steering wheel and inert airbag) and 3 o'clock lateral (see Appendix A, Figures A2 and A3). Carefully document all locations, directions and corresponding measured response accelerations (see Appendix A, Table A1 for an example).

4.3.3 Saving the Data. Save the FRFs of all response points for each applied force direction for further comparisons. Additionally the results of the test fixture check (stiffness of the attachments and natural frequency) should be saved.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Compare different tests, it shall be ascertained, whether plotted differences are significant for arrangements or are caused by measurement variances.

5.3 Test Documentation. In addition to the necessary specifications of the vehicle and the steering system, the record shall give the resonance frequencies that are taken from drive point Acceleration over Force (A/F) FRF. An example is shown in Appendix A, Table A1.

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.

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