



HVAC Blower, Stepper and DC Motor Noise and Vibration Evaluation 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 define the process for quantifying subsystem level noise measurements of Heating, Ventilation, Air Conditioning (HVAC) blowers and actuator motors that are used in front HVAC modules. This procedure is used to gain knowledge of the Noise and Vibration (N&V) behavior of a blower module at the subsystem level before prototype vehicles are available. The measurements made on bare blower modules are comparable to in-car HVAC system measurements except for the effect of cavity resonances on the absolute noise level when measured in vehicle.

The free acceleration response of an energized component is one of the factors affecting structure-borne noise. This quantity, with others, can be used to calculate forces into the body or be combined to predict noise levels in the vehicle passenger compartment.

1.2 Applicability. This procedure is appropriate for blowers on front HVAC modules. It is also applicable for all kinds of flap adjustment noises such as: recirculation flaps, temperature flaps, ventilation flaps, heater flaps, defrost flaps, or rear vent flaps whether they are driven by a Local Interconnect Network (LIN) or unipolar stepper motor.

1.3 Remarks. The noise emission of the HVAC module subsystem must be recorded to apply the objective methods for Sound Quality Metric evaluation. This subsystem has multiple modes of operation. Each mode of operation must be recorded independently for analysis. This procedure describes the operating conditions of the HVAC module subsystem, the appropriate sound recording methods for those operating conditions, and the analysis methods necessary for objective Sound Quality Metric evaluation.

Because blower noise emission is dependent on blower airflow rate, airflow measurements are a necessary part of an objective assessment of blower noise. Airflow rate is especially important when evaluating multiple blowers. Blower noise levels from multiple blowers can be compared by relating blower noise levels to airflow rates.

2 References

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

2.1 External Standards/Specifications.

DIN 45631/A1 2010 IEC 61672-1:2003

2.2 GM Standards/Specifications.

GMW14172 GMW17625

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 1 of 17

2.3 Additional References.

- ArtemiS suite software solution available at www.head-acoustics.de/eng/nvh_artemis_suite.
- Local Interconnect Network (LIN) Controller available at <https://www.xilinx.com/products/intellectual-property/1-8dyf-2943.html>.
- Subsystem Technical Specification (SSTS).
- Unipolar Stepper Motor available at <http://www.orientalmotor.com/stepper-motors/technology/unipolar-bipolar-connections.html>.
- Vehicle Technical Specification (VTS).

3 Resources

3.1 Facilities. All measurements shall be performed in a semi-anechoic test room free from interfering noises. Background noise levels must be less than 30 dB(A) unless otherwise specified. Background noise is considered to include test room ambient noise and test equipment noise.

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 Microphones. Three (3) free field measurement microphones (12.7 mm diameter) meeting Class 1 accuracy corresponding to IEC 61672-1:2003 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$). Microphone preamplifier, connecting cables, power supply (if the function is not already provided by the digital sound recording system) and calibrator.

3.2.2 Microphone Stands. Microphone floor stands or equivalent method for supporting the microphones.

3.2.3 Data Acquisition System (DAS). Data acquisition hardware capable of calculating frequency domain results between 22 Hz and 11 200 Hz with a minimum of 80 dB dynamic range. This hardware shall meet Class 1 accuracy corresponding to IEC 61672-1:2003 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.2.4 Accelerometers (optional). Small accelerometers (weighing less than 0.006 kg), transducer cabling and signal conditioning.

3.2.5 Digital Voltmeter (optional). Digital voltmeter for monitoring voltage of the blower motor at the terminal connector to the blower motor.

3.2.6 Current Meter (optional). Current meter for monitoring current of the blower motor.

3.2.7 Variable DC Power Supply. Variable DC power supply with sufficient capacity to provide at least 15 V at 50 A.

3.2.8 Pulse Width Modulation (PWM) Controller. A device capable of variable frequency and duty cycle. Digital control of PWM signal to the blower motor is required for blower motors that use PWM control.

3.2.9 Tachometer. Optical or inductive sensor capable of accurately measuring the blower speed in revolutions per minute (rpm).

3.2.10 Data Analysis System. ArtemiS sound quality analysis program by HEAD Acoustics or an equivalent analysis program.

3.2.11 Elastomeric Cords. Elastomeric cords for mounting the HVAC blower module in vehicle orientation.

3.2.12 Air Intake Throttle Box or Flow Bench. An air flow throttle box or flow bench that is calibrated and can be adjusted to different restriction values (see Appendix A, Figure A1).

3.2.13 LIN controller. A LIN controller must be used for LIN stepper motors. The HVAC module supplier should be prepared to provide such controller to GM if testing will occur at GM facilities.

3.3 Test Vehicle/Test Piece. A complete HVAC module, including blower motor and electrically driven actuators, if applicable, that represents the current part release status is required. Deviations shall be eliminated.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 2 of 17

Documents
Document Sharing Hub

3.3.1 For validation, the blower motor assembly should be built to the maximum allowable unbalance tolerance. The main blower system characteristics and design features shall be recorded including the part numbers, number of blower blades, number of motor pole pairs, blower wheel diameter and width, unbalance levels, and any other design features important for noise and vibration (such as closed fan hub, or number of hub struts or spokes).

3.3.2 A representative HVAC or heater module that the blower and actuators will attach to is required.

3.3.3 For all module blower noise measurements, a suitable control panel is needed to measure the blower noise on the bare module at the defined speed stages.

3.3.4 For all modules, where applicable, the use of the production released climate control remote electric control unit (ECU) and control panel is desired to measure actuator motor noise.

If the production climate control unit and control panel is not available, the actuator motors shall be tested at 13 V.

3.4 Test Time.

Calendar time: 1 to 2 days

Test time: 4 to 8 hours for VTS validation portion if appropriate cabling is available, more if root cause is performed

Coordination time: 4 to 8 hours

3.5 Test Required Information.

The airflow rates at the restriction values included in GMW17625 should be measured or known.

If the production control panel and control unit are not available, mode/door positions on the cam(s) must be known. For unipolar steppers, use calibration values for door positions. For LIN steppers, position requests need to be used based on the Integration table for actuator call file definition.

3.6 Personnel/Skills. One (1) or more engineer or technician with basic knowledge of acoustic data acquisition and sound quality analysis are required to run this test.

4 Procedure

4.1 Preparation. Ensure that the test part meets the requirements outlined in 3.3.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient air temperature shall be between 15 °C and 25 °C.

All interfering noise emissions from test stand devices must be eliminated.

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.

4.2.3 Standard Test Conditions. Ensure that the production climate control remote ECU and control panel are controlling the HVAC module correctly. Involve the electrical release engineers to assist with the setup if needed. Use the Control front panel or Cable control panel for cable driven system to select each operating condition listed in Table 1 and Table 2. If the production climate control remote ECU and control panel are not available, set the modes using manual methods.

Table 1: Steady-State Test Air Settings

Vent mode	100%	Cold	OSA
Heater mode	100%	Hot	OSA
Defrost	100%	Hot	OSA
Vent mode	100%	Cold	REC

Note: OSA = Outside Air Mode, REC = Recirculation Mode.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 3 of 17

Documents
Document Sharing Hub

Table 2: Sweep Test Air Settings

Vent mode	Cold	OSA
Heater mode	Hot	OSA
Bi-level	Cold	OSA
Bi-level	Hot	OSA
Hi-level	Cold	OSA
Hi-level	Hot	OSA
Tri-level	Cold	OSA
Tri-level	Hot	OSA
Defog	Hot	OSA
Defrost	Hot	OSA
Vent mode	Cold	REC

Note: OSA = Outside Air Mode, REC = Recirculation Mode.

4.2.4 HVAC Module Blower and Blower Motor Noise Tests.

4.2.4.1 Steady-State Tests for Broadband Noise. HVAC module blower noise and blower motor noise should be measured using microphones in positions M1, M2 and M3 (see Appendix A, Figures A3 and A4) for the same outside air mode settings included in Table 1. For each condition in Table 1, test at the blower motor speed that provides the correct airflow and restriction combination from SSTs.

4.2.4.2 Sweep Test. Sweep the blower motor speed by incrementing the blower motor connector voltage from 3 V to 15 V over 1 minute using the same settings included in Table 2.

For PWM systems, perform PWM duty cycle sweeps from 1000 rpm to the maximum duty cycle for high blower setting at the appropriate PWM signal frequency and operating voltage as defined by the supplier or design engineer for each condition in Table 2.

4.2.5 HVAC Module Power Operated Flap Adjustment Noise Tests. Position microphone M2, 0.1 m from power actuator motor as shown in Appendix A, Figure A2.

4.2.5.1 Actuator Motor Driven Recirculation Flap Test. With the HVAC control panel supplied with 13 V from either the controller or an external power source, cycle the recirculation button on the HVAC control panel on and off repeating the following sequence three (3) times:

- Wait 2 s.
- Press the recirculation button.
- After the recirculation flap has reached its end position in recirculation mode, wait 5 s.
- Press the recirculation button.
- After the recirculation flap has reached its original position in outside air mode, wait 2 s.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 4 of 17

4.2.5.2 Actuator Motor Driven Air Distribution Flap Test. Potential air distribution flap movement may include the following:

- Temperature Flap moves from full cold to full hot and from full hot to full cold.
- Ventilation and/or Defrost Flap moves from ventilation to defrost and from defrost to ventilation.
- Defrost and/or Heater Flap moves from defrost to heater and from heater to defrost.
- With the HVAC control panel supplied with 13 V from either the controller or an external power source, cycle the appropriate air distribution knob/button on the HVAC control panel on and off repeating the following sequence three (3) times:
 - a. Wait 2 s.
 - b. Press the appropriate air distribution knob/button.
 - c. After the air distribution flap has reached its end position, wait 5 s.
 - d. Press the appropriate air distribution knob/button.
 - e. After the air distribution flap has reached its original position, wait 2 s.

4.3 Instructions.

4.3.1 Installation. Mount the HVAC blower to the program specific HVAC module. Support the complete HVAC module, as it is oriented in the vehicle using elastomeric cords to approximate free-free boundary conditions. Adjust the vertical height of the vent outlet(s) centerline to be 1 m above the floor.

Note: Do not overly constrain the test part.

For all blower and blower motor noise measurements in outside air mode, mount an air intake throttle on the suction side of the module. An example is shown in Appendix A, Figure A1. Air resistance values are listed in the program specific sourcing requirements.

For all HVAC blower and blower motor noise measurements in recirculation mode, the air intake throttle box on the suction side of the HVAC module has to be removed. Prepare the HVAC module for noise testing as follows:

- Close /cover/tape over all air outlets for radio cooling, glove box cooling and rear ventilation as required.
- Plug all unintended holes and leaks (Thermostatic Expansion Valve (TVX) seal, drain tubes, etc.)
- Install a new program specific air filter, if applicable.

4.3.2 Calibration Verification. Check equipment for valid calibration date. Replace out-of-date equipment. Perform transducer calibration verification (see GMW14172).

Document the equipment settings and transducer sensitivities in the test log as necessary.

4.3.3 Install Instrumentation.

4.3.3.1 Speed Sensor. Install optical or inductive speed sensor to accurately measure blower motor speed tachometer signal, in rpm, without disturbing the air flow or generating disturbing noises.

4.3.3.2 Fan External Power Supply. Connect an adjustable external DC power supply and control cable to the blower motor terminal connector. The power supply will be used to adjust the voltage at the blower connector(s), the current and blower speed to the levels defined in 3.5 and 4.2.4. For PWM blower motors, set power supply voltage and PWM controller for appropriate PWM signal frequency and duty cycle as required for the test condition.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 5 of 17



Documents

Document Sharing Hub

4.3.3.3 Microphones. Install measurement instrumentation using the following microphone positions:

- Position microphone M1, 1.60 m in the vertical direction from the floor and 1 m in the horizontal direction from the centerline (cross-car) of the middle of the HVAC module vent outlet(s).
- For blower motor noise measurements, position microphone M2, 0.1 m below the blower motor along the centerline of the blower motor axis.
- Position microphone M3, 1.60 m in the vertical direction from the floor and 1 m in the horizontal direction from the centerline of the air inlet on the passenger-facing side of the module.
- Position all microphones so that they are pointing at the measured noise source (i.e., M1 toward the center of the vent outlet, M2 toward the blower motor, M3 toward the center of the air inlet). Use wind screens for microphones M1 and M3.

4.3.3.4 Accelerometers (optional). Install accelerometers to monitor triaxial acceleration responses at each of the HVAC module vehicle attachment locations and at the blower motor housing. Accelerometer data should be acquired for root cause purposes as needed. There are no requirements for module attachment acceleration.

4.3.4 Data Acquisition. Set up the DAS as defined in Section 5 when data acquisition and processing are done simultaneously.

4.3.4.1 HVAC Module Blower and Blower Motor Noise Data Acquisition.

4.3.4.1.1 Steady-State Data Acquisition. Set up the data acquisition system to acquire narrowband, A-weighted Sound Pressure Level (SPL) spectra using the following parameters:

- Frequency range: 22 Hz to 11.2 kHz for SPL.
- Frequency resolution: 1 Hz.
- Window: Hanning, Energy Correction.
- Amplitude: Root Mean Square (RMS).
- Averaging: Two (2) Averages per second, 50% Overlap.
- Acquire data for each Steady-State condition, as required. Record at least 20 s of data for each required Steady-State condition.

4.3.4.1.2 Steady-State Acceleration Data Acquisition (optional). Set up the DAS to acquire narrow band, linear acceleration spectra in the units of m/s^2 using the following parameters:

- Frequency range: 0 Hz to 800 Hz.
- Frequency resolution: 1 Hz.
- Window: Hanning, Energy Correction.
- Amplitude: RMS.
- Averaging: Two (2) Averages per second, 50% Overlap.

Identify the blower speed (in rpm) and HVAC operating mode that result in the highest acceleration levels. Acquire triaxial acceleration data at each vehicle attachment location at the identified.

4.3.4.1.3 Sweep Data Acquisition. Sweep the blower speed by incrementing the blower connector voltage from 3 V to 15 V over 1 minute. For PWM systems, perform PWM duty cycle sweeps from 1000 rpm to the maximum duty cycle for high blower setting at the appropriate PWM signal frequency and operating voltage as defined by the supplier or design engineer.

Set up the DAS to acquire blower speed based data capable of providing the following:

- Overall A-Weighted SPL.
- A-Weighted SPL order cuts at prominent blower orders.

Time data and waterfall data are required for post processing.

Additional narrow band steady state operation data may be required based on 5.1.2.2.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

November 2017

Page 6 of 17

Documents
Document Sharing Hub