A/C Compressor Electronic Control Valve Noise 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 method for measuring air conditioning (A/C) compressor electronic control valve (ECV) noise at the component, subsystem and vehicle levels.

1.2 Applicability. This test procedure is applicable for ECVs that are used on external variable displacement A/C compressors.

1.3 Remarks. This test is used to assess ECV noise resulting from the pulse-width modulation (PWM) signal frequency excitation.

2 References

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

2.1 External Standards/Specifications.

ANSI/ASA S1.4 Part 1

2.2 GM Standards/Specifications.

GMW14172 GMW14264 GMW14477

2.3 Additional References.

- Component Technical Specification (CTS)
- Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. All measurements shall be performed in a hemi-anechoic test room free from interfering noises or outdoors in a free-field area.

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 Microphone. One (1) free-field microphone is preferred for ECV component level, compressor level, or subsystem level measurements. Three (3) Free-field microphones are preferred for vehicle exterior locations. Random-incidence microphones may be used for component measurements or vehicle exterior locations if free-field microphones are not available.

Two (2) random incidence microphones are preferred for vehicle interior locations. Free-field microphones may be used for interior locations if random incidence microphones are not available.

3.2.2 Data Acquisition System. Multi-channel data acquisition hardware capable of calculating both frequency domain and order domain results between 0 Hz and 11.2 kHz with a minimum of 80 dB dynamic range. This

© Copyright 2015 General Motors Company All Rights Reserved

Documents Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GM GMW16376 2015

hardware shall meet class 1 accuracy corresponding to ANSI/ASA S1.4 Part 1 or be equivalent for the application (precision ± 0.7 dB or ± 8%).

3.2.3 Compressor PWM Controller. A device capable of variable frequency and duty cycle digital control of PWM signal to the A/C compressor such as the Model 205 PWM Controller from Applied Processor and Measurement, Inc. is required.

3.2.4 Power Supply. A 12 V DC power supply (or other appropriate voltage range per PWM controller specifications) is required for powering the PWM controller.

3.2.5 Current Measurement Device. Use an inductive current clamp to measure current output of the PWM controller. Use a current clamp with minimum 1 A range and a tolerance ± 2%.

3.2.6 Vehicle Network Interface (Optional). For a vehicle-level measurement, the ECV and other vehicle functions can be controlled via a suitable vehicle network interface such as the NeoVI with Vehicle Spy software from Intrepid Control Systems, Inc.

3.2.7 A/C Load Cart (Optional). A device capable of controlling the A/C system load applied to the compressor in a compressor-level component test.

3.3 Test Vehicle/Test Piece. A representative ECV component, a representative A/C compressor with ECV or a complete A/C subsystem or vehicle with variable compressor containing an ECV is required. Test component and vehicle content should represent the current part release status.

3.4 Test Time.

Calendar time:	1 d
Test hours:	2 h
Coordination hours:	2 h

3.5 Test Required Information. Compressor PWM control signal frequency is required. The supplier specific compressor operating range (compressor minimum and maximum control valve current and approximate corresponding PWM duty cycle values) is also required.

3.6 Personnel/Skills. One qualified engineer or technician trained in the use of acoustic data acquisition and PWM compressor control is required.

4 Procedure

4.1 Preparation. Verify that test component or vehicle meets the requirements of 3.3. Document the status of all hardware relative to the current part release status in the test project documentation.

4.1.1 PWM Controller Setup. Electrical attachments to PWM controller are shown in Figure 1 and are detailed in 4.1.1.1 thru 4.1.1.4.

4.1.1.1 Attach 12 V power supply to the “Input” side of the PWM controller at the left side.

4.1.1.2 Connect the red (positive) post on the input side to the red (positive) post on the output side using a jumper wire.

4.1.1.3 Connect the two leads on the output side of the PWM controller to the two sides of the ECV on the compressor. ECV polarity is not important, which is to say the red (positive) and black (negative) leads from the PWM controller can be attached to either side of the ECV.

4.1.1.4 Clamp the current probe around one of the two leads from the PWM controller to the ECV. Attach current probe’s output to acquisition device. Turn on the current probe and adjust the probe’s output to zero before the PWM signal is applied. Note: If the current probe is attached to the wrong lead or in the wrong direction, it will produce negative values during normal testing.

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GM GMW16376 2015

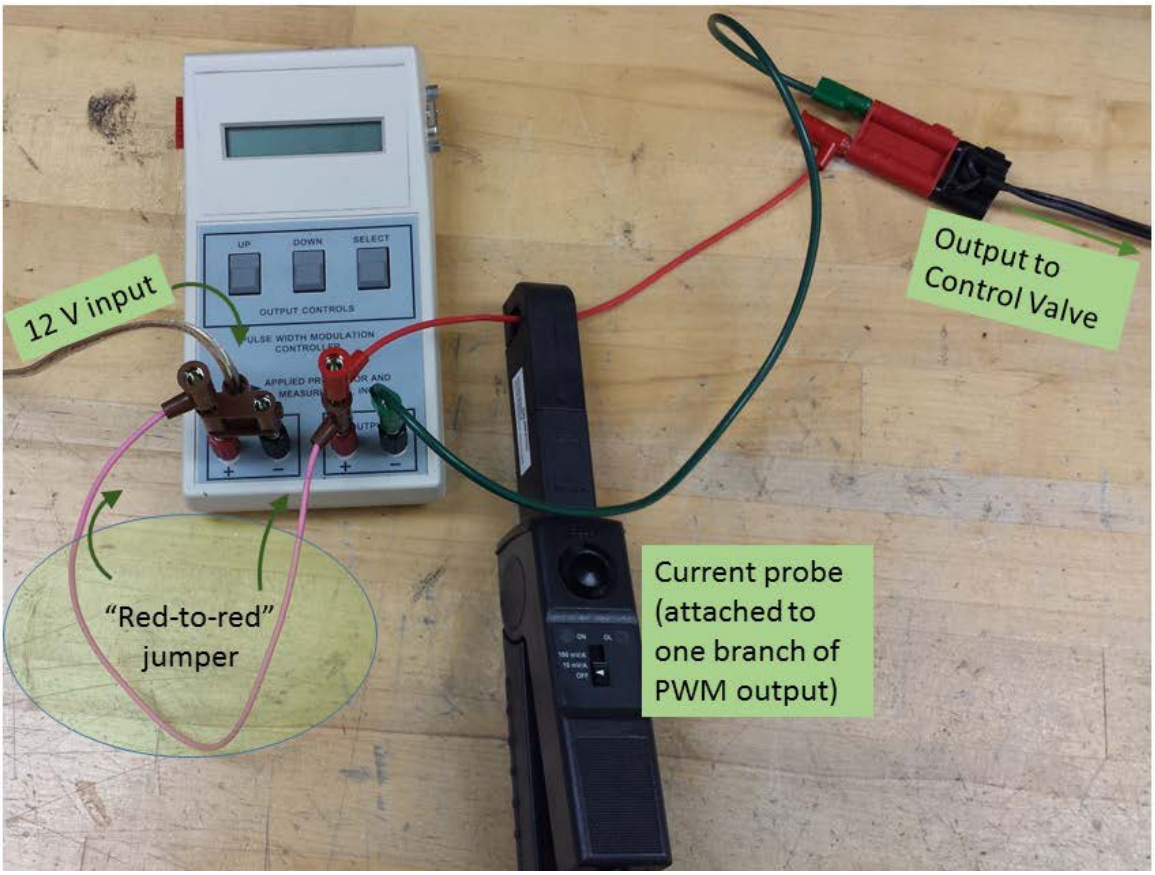

Figure 1: PWM Controller Setup

4.2 Conditions.

4.2.1 Environmental Conditions. The test shall be performed with the ambient air temperature between 10 °C and 40 °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.

4.2.2.1 Standard Test Conditions.

4.2.2.1.1 Steady State with PWM Signal Excitation Tests. ECV noise performance due to the applied PWM control signal without the compressor operating (and without the engine operating for vehicle level tests) is measured at nominal PWM control signal frequency per 3.5 with 5% PWM duty cycle increments from maximum to minimum control valve current (e.g., 400 Hz PWM signal frequency at maximum PWM duty cycle, 75%, 70%, 65%, 60%, 55%, 50%, 45%, 40%, 35%, 30%, 25%, and minimum PWM duty cycle).

4.2.2.1.2 PWM Duty Cycle Sweep. ECV noise without the compressor operating is measured at nominal PWM control signal frequency during PWM duty cycle sweep from maximum to minimum control valve current over a span of approximately 60 s, and from minimum to maximum current, also during a span of approximately 60 s.

4.2.2.1.3 Steady State with PWM Signal Excitation and Operating Compressor Tests. For compressor-level, subsystem-level, or vehicle-level test, measurements are repeated with A/C compressor operating at engine idle speed to assess ECV noise with compressor load and vehicle masking noise (for vehicle-level measurement) both subjectively and objectively. Set PWM control for measurements at nominal PWM control signal frequency per 3.5 with 5% PWM duty cycle increments from maximum to minimum control valve current (e.g., 400 Hz PWM signal frequency at maximum PWM duty cycle, 75%, 70%, 65%, 60%, 55%, 50%, 45%, 40%, 35%, 30%, 25%, and minimum PWM duty cycle) while maintaining compressor discharge pressure at 1500 kPa.

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub
Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GM GMW16376 2015

4.2.2.1.4 PWM Duty Cycle Sweep with Operating Compressor. For compressor-level, subsystem-level, or vehicle-level test, PWM duty cycle is swept from maximum to minimum ECV current, and from minimum to maximum, while maintaining steady operating speed at idle and compressor discharge pressure at 1500 kPa.

4.3 Instructions.

4.3.1 Test Setup. Set up the vehicle or test component per the appropriate instructions below for component, subsystem, or vehicle level tests.

4.3.1.1 ECV Component Test Setup. Using elastomeric cords, suspend the test piece as oriented in the vehicle to approximate free-free boundary conditions. Do not overly constrain the test piece. Elastomeric cord stiffness should be as low as possible. Adjust vertical height of ECV centerline to be 1.0 m above the floor. Reference test setup schematic Figure A1 in Appendix A.

4.3.1.2 A/C Compressor Component Test Setup. Attach compressor to test stand, and charge the refrigerant system as described in GMW14477, Section 4.1.

4.3.1.3 A/C Subsystem Test Setup. Using appropriate fixtures, mount the entire A/C subsystem to a bedplate, set up electrical controls for all components, and complete appropriate refrigerant charging procedures.

4.3.1.4 Vehicle Level Test Setup. For ECV testing at the vehicle level, set up the vehicle in the test room. Environmentally controlled test chamber is recommended.

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

4.3.3 Install Instrumentation.

4.3.3.1 PWM Control. Install PWM controller with power supply. Set PWM frequency as required for compressor control and duty cycle as required for test condition.

4.3.3.2 Microphones. Set up the microphones per the appropriate instructions below for component or vehicle level testing.

4.3.3.2.1 ECV Component Microphone Setup. Locate microphone at a distance of 10 cm from the ECV and 1.0 m from the floor. Reference Figure A1 in Appendix A. Orient microphone toward the control valve.

4.3.3.2.2 A/C Compressor Component Microphone Setup. Locate microphone at a distance of 50 cm above the compressor ECV. Orient microphone toward the compressor control valve. Reference Figure A2 in Appendix A.

4.3.3.2.3 A/C Subsystem Microphone Setup. Locate microphone at a distance of 50 cm above the compressor ECV. Orient microphone toward the compressor control valve. Reference Figure A2 in Appendix A.

4.3.3.2.4 Vehicle Level Test Microphone Setup. Install vehicle interior microphones in positions specified in Appendix B, B1 (Figure B1 and Figure B2). Standard positions are the left front seat (LF) and the right front seat (RF). Use center of seat location unless the seat is occupied. Position seats according to Appendix C.

Position vehicle exterior microphones at the global exterior microphone locations M_{G1}, M_{G2} and M_{G3} detailed in Appendix B, B2 (Figure B3 and Figure B4). The microphones shall be positioned 1.0 m from the vehicle and 1.6 m from the ground. Position microphone M_{G1} on the front center line of the vehicle and microphones M_{G2} and M_{G3} in line with the center of the front wheels of the vehicle. Orient all exterior microphones so that they are directed towards the vehicle.

4.3.4 Data Acquisition.

4.3.4.1 Steady State with PWM Signal Excitation Tests. Set up the data acquisition system to acquire A-weighted sound pressure level spectra in dB relative to 20 μPa. Also acquire control valve current (PWM controller output) as a data channel.

Set the PWM control signal frequency to the appropriate nominal value from 3.5. Set the PWM duty cycle to achieve the maximum compressor specific ECV current. Acquire 20 s to 30 s of data.

Repeat for all PWM duty cycle increments of 5% and for minimum PWM duty cycle.

4.3.4.2 PWM Duty Cycle Sweep. Set up the data acquisition system to acquire A-weighted sound pressure level spectra in dB relative to 20 μPa. Also acquire control valve current (PWM controller output) as a data channel.

Set the PWM control signal frequency to the appropriate nominal value from 3.5. Set the PWM duty cycle to achieve the maximum compressor specific ECV current. Acquire sound data and control valve current during a

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GM GMW16376 2015