The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SAE/USCAR-17

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PERFORMANCE SPECIFICATION FOR AUTOMOTIVE RF CONNECTOR SYTEMS

SUMMARY OF CONTENTS

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1. SCOPE

Procedures included within this specification are intended to cover performance testing at all phases of development, production, and field analysis of electrical terminals, connectors and components for coaxial cable connection systems (hereafter referred to as RF connectors) in road vehicle applications. The intent of this specification is to qualify RF connectors that operate at frequencies greater than 200 MHz. This specification does not apply to single conductor wire or twisted pair connection systems. The RF connection system will be qualified for specific coaxial cable; the qualified coaxial cable and frequency range of interest must be listed on the connector drawing. Changing coaxial cable necessitates re-qualification.

This specification is a supplement to the SAE/USCAR-2 Performance Standard for Automotive Electrical Connector Systems and all requirements herein must be met in addition to all requirements of SAE/USCAR-2, unless otherwise specified. Only RF connector related additions and/or subtractions to the SAE/USCAR-2 specification are contained in this document.

2. REFERENCES

SAE/USCAR-2 Performance Specification for Automotive Electrical Connector Systems
400 Commonwealth Dr
Warrendale, PA 15096-0001
USA
http://www.sae.org

3. GENERAL REQUIREMENTS

3.1 Sample Size

A minimum of 15 terminal pairs (5 terminal pairs for Isolation Resistance/Contact Resistance measurements and 10 terminal pairs for VSWR/Insertion Loss measurements) are required for each segment of SAE/USCAR-2 environmental testing. See the respective procedures to determine how to prepare the samples. All other sample sizes are the same as required by SAE/USCAR-2.

The total number of test samples needed for sequential tests should be determined by starting from the bottom of each flow chart and working back through the parallel paths. The same set of samples CAN be used for parallel test paths, however the Acceptance Criteria remains the same.

3.2 Equipment

In addition to the equipment listed in the SAE/USCAR-2 Performance Standard, the equipment listed in Table 3.2.1 is required.

Item	Description	Requirements
1	High Voltage Source	800V AC
2	Network Analyzer	3GHz Minimum S Parameter

TABLE 3.2.1: RF Conn. Additional Equipment

4. TEST & ACCEPTANCE REQUIREMENTS

4.1 General

Refer to the SAE/USCAR-2 Performance Standard for the majority of RF connector test and acceptance requirements. The exceptions to those tests are listed in the following sections. The Maximum Test Current Capability test is optional.

4.2 Connector Mechanical Tests

4.2.1 Mechanical Pull Test

4.2.1.1 Purpose

This test verifies that the connector latch, terminal retention system, and cable attachment will maintain continuity when subjected to mechanical stress.

For RF connectors, this Mechanical Pull test is in addition to the mechanical connector tests in SAE/USCAR-2 Performance Standard.

Note: This test is a destructive design validation test and shall not be used as a production acceptance or quality control test.

4.2.1.2 Procedure

Prepare 10 samples of production intent male and female terminals and connectors. Terminals are to be attached to the largest size cable for which they are designed.

Number each sample pair of connectors.

Attach a continuity tester so as to check continuity through both the center contact and shield of the mated connector pair.

For board mount connectors, mount the male connectors firmly to a suitable fixture. Grip the cable on the female connector approximately 100mm behind the connector. For in-line connectors, grip the cables approximately 100mm behind the male and female connectors.

Subject the connection system to a direct 80N pull force parallel with the axis of the connectors by gripping and pulling on the cable(s). Increase the pull force at a uniform rate until the full test force is achieved and then hold the force for one minute while monitoring for continuity.

Disassemble each sample and visually check for damage that could affect the performance of the connection system.

4.2.1.3 Acceptance Criteria

There shall be no interruptions in continuity on any sample during the test.

There shall be no visual damage to any part of the connection system including connector body, metal terminals or cable attachment.

4.3 Terminal Electrical Tests

4.3.1 Contact Resistance

4.3.1.1 Purpose

This test determines the electrical resistance of both the outer conductor crimps and corresponding contact interface and the inner conductor crimps and corresponding contact interface under low energy conditions.

For RF connectors, this Contact Resistance test replaces the Dry Circuit Resistance testing in the SAE/USCAR-2 Performance Standard.

4.3.1.2 Procedure

Follow the Dry Circuit Resistance procedure in the latest SAE/USCAR Performance Standard. Since gaining access to the inner conductor may damage the outer conductor, the millivolt lead locations need not follow the SAE/USCAR-2 Performance Standard. Subtract the cable resistance portion from the measured value.

4.3.1.3 Acceptance Criteria

The total connection resistance of the inner conductor must not exceed 40 mΩ. Likewise, the total connection resistance of the outer conductor must not exceed 40 mΩ.

4.3.2 Dielectric Withstanding Voltage

4.3.2.1 Purpose

The dielectric withstanding voltage test is used to prove that the connection can withstand momentary overpotentials due to switching, surges, and other similar phenomena. It serves to determine whether insulating materials and spacings in the connector are adequate.

For RF connectors, this Dielectric Withstanding Voltage test replaces the Current Cycle testing in the SAE/USCAR-2 Performance Standard.

4.3.2.2 Procedure

With the connector engaged, apply 800 volts of commercial frequency alternating voltage between the internal and external conductor terminals for 60 seconds. The test voltage shall be raised from 0 to the 800V (rms) as uniformly as possible.

4.3.2.3 Acceptance Criteria

There must be no dielectric breakdowns.

4.4 Connector Electrical Tests

4.4.1 Isolation Resistance

4.4.1.1 Purpose

This test verifies that the electrical resistance between the center contact and the outer contact will prevent detrimental electrical conductivity.

For RF connectors, this Isolation Resistance test replaces the Isolation Resistance testing in the SAE/USCAR-2 Performance Standard.

4.4.1.2 Procedure

Follow the Isolation Resistance procedure in the latest SAE/USCAR-2 Performance Standard as it pertains to the center conductor and outer conductor of the RF connector.

4.4.1.3 Acceptance Criteria

The center contact to outer contact resistance shall be $\geq$100 MΩ.

4.4.2 Voltage Standing Wave Ratio and Insertion Loss

4.4.2.1 Purpose

This test measures both the mismatch loss between the connector and the cable and the insertion loss through the cable test assembly at the frequencies of interest. The VSWR is equal to 1 when the cable impedance is perfectly matched to the connector. The insertion loss for an ideal connection system with no loss is 0 dB. Only the VSWR will be measured for board mount connectors, however, the Insertion Loss of the corresponding in-line must also meet specification to release the board mount connector in question.

For RF connectors, Voltage Standing Wave Ratio/Insertion Loss testing replace the Nominal Current Resistance (Voltage Drop) test in the SAE/USCAR-2 Performance Standard.

4.4.2.2 Procedure

The following minimum sample sets should be prepared for each segment of environmental testing per SAE/USCAR-2.

1. In-Line Connectors:
   a. Prepare 10 samples with SMA connectors so the overall length is 95 mm to 100 mm when the connectors under test are engaged (Figure 4.4.2.2, 1a.).
   b. Prepare one cable only sample (with SMA connectors on the end) the same length as 1a. above (reference assembly, Figure 4.4.2.2, 1b.).

   Board Mount Connectors:
   c. Prepare 10 samples with SMA connectors such that the overall length is sufficient to distinguish the S_{11} TDR gate span of the CUT (typically greater than 200mm) (Figure 4.4.2.2, 1c.).
2. Perform a full 2 port Time Domain Calibration (low pass step response recommended).
3. For in-lines only, prepare one additional sample with the overall length roughly 200mm long when the CUT is engaged. Determine the "electrical length" of this CUT sample using the S_{11} TDR plot, creating a gate span in picoseconds.
4. Place the gate center in the "electrical middle" of each CUT sample. Measure the S_{11} (reflected power) for all samples and S_{21} (transmitted power) on in-lines only over the frequency range listed in Tables 4.4.1. and 4.4.2. The S_{11} measured is the CUT VSWR.
5. For in-lines only, measure the gated S_{21} parameter of the reference assembly (1b.) and subtract from the S_{21} measurements taken in 4. This is the net Insertion Loss of each CUT.
6. Completely mate and unmate each sample a total of 10 times and then mate them again.
7. Repeat steps 4 and 5.

Note: The SMA connectors should be protected during environmental exposure with a mating connector or plug.

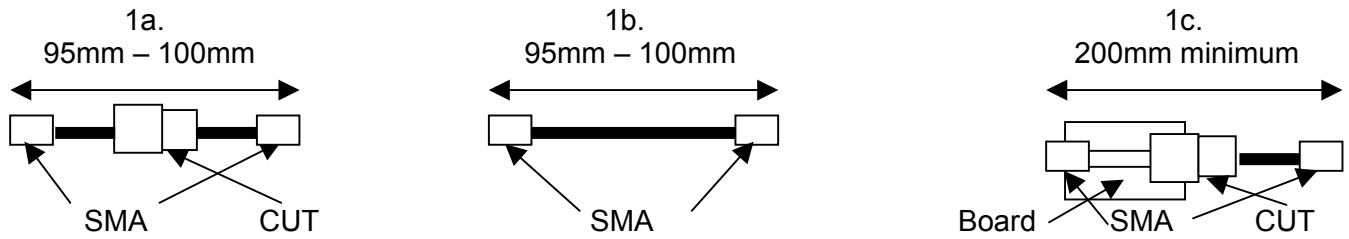

FIGURE 4.4.2.2: VSWR Test Sample

4.4.2.3 Acceptance Criteria

The RF connector VSWR and insertion loss values must be equal to or less than those listed in Tables 4.4.1 and 4.4.2.

RF Connector Type	Max. VSWR [freq.]
Square Outer Conductor, EWCAP	1.35 [0 - 1 GHz] 1.60 [1 - 2 GHz]
SMB 3GHz, FAKRA	1.40 [0 - 2 GHz] 1.50 [2 - 3 GHz]
SMB 0.5GHz	1.35 [0 - 0.5 GHz]

TABLE 4.4.1: Maximum VSWR Values

RF Connector Type	Max. Insertion Loss [freq.]
Square Outer Conductor, EWCAP	0.2 [0 - 1 GHz] 0.4 [1 - 2 GHz]
SMB 3GHz FAKRA	0.3 [<= 3 GHz]
SMB 0.5GHz	0.25 [<= 0.5 GHz]

TABLE 4.4.2: Maximum Insertion loss Values (In-line Connectors only)

4.5 Test Sequence

Follow the Test Sequence paragraph specified in the SAE/USCAR-2 Performance Specification, replacing all occurrences of those tests listed in Table 4.5.

RF Connector Spec.	SAE/USCAR-2
Section 4.3.1, Contact Resistance	Dry Circuit Resistance
Section 4.3.2, Dielectric Withstanding Voltage	Current Cycling
Section 4.4.1, Isolation Resistance	Isolation Resistance
Section 4.4.2, VSWR and Insertion Loss	Nom. Current Resistance (Voltage Drop)

TABLE 4.5: Test Sequence Replacements

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EWCAP (ELECTRICAL WIRING COMPONENTS APPLICATION PARTNERSHIP)