

## PERFORMANCE SPECIFICATION FOR AUTOMOTIVE RF CONNECTOR SYSTEMS

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**PERFORMANCE SPECIFICATION FOR AUTOMOTIVE RF CONNECTOR SYSTEMS****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 a 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 the most recent revision 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. 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. All other minimum sample sizes are the same as required by SAE/USCAR-2 and superseded by this specification.

Number each sample pair of connectors and record crimp heights and widths for each. Document cable information such as type, supplier and supplier part number. All test data, including swept VSWR and IL, must be maintained by the supplier for possible review. The test samples must also be kept by the supplier such that each new customer can visually inspect the samples or confirm VSWR and IL.

### 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 Terminal – Mechanical Tests of SAE/USCAR-2 are not required for RF connector qualification.

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. This is a stand-alone test and requires a minimum of 10 samples for each cable type qualified.

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 a minimum of 10 Connector Under Test (CUT) assemblies for each cable being qualified per Procedure 4.4.2.2, Steps 1 through 7.

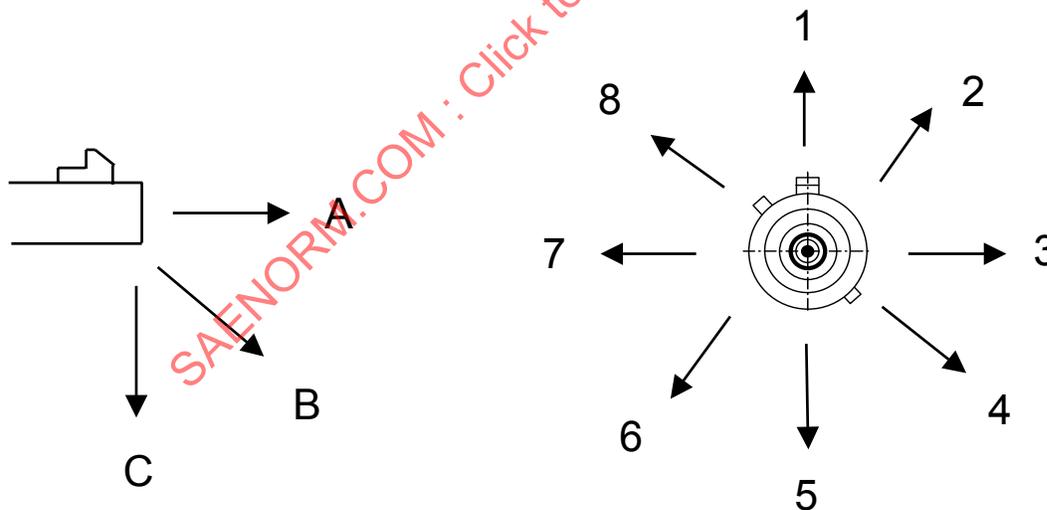
Attach a continuity tester so as to check continuity through both the center contact and shield of the mated connector pair.

In-lines and Board Mount connectors:

Subject the connection system to a direct pull force parallel with the axis of the connectors (direction A of Figure 4.2.1.2) by gripping on the SMA connectors (or by attaching a mating SMA connector to the assembly and gripping on that). Board mount connectors may have the circuit board end firmly attached to a suitable fixture. Increase the pull force at a uniform rate until the full test force is achieved and then hold the force for 5 seconds while monitoring for continuity. Subject SMB connection systems to 110N force; subject Square Outer Conductor connection systems to 80N force. OEM Pull Test requirements for Square Outer Conductor connector systems may be higher depending on cable size. Prior to conducting this test, always consult with the responsible OEM engineering department for the required pull force.

Additional Board Mount only testing:

Again by gripping on the cable side SMA connector, subject the board mount connection system to at least the following directional forces, all at 75N: 1C, 3C, 5B, 7B, 8C (per Figure 4.2.1.2.)



**FIGURE 4.2.1.2: Board Mount Mechanical Pull**

Measure VSWR and I.L. per Procedure 4.4.2.2, Steps 4, 6, and 7.

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

**Note:**

Optionally, to account for SMA crimp degradation and the corresponding increased insertion loss, a minimum of 10 SMA connector assemblies (same crimp process and length as CUT assembly) may be subjected to this test (statistical evaluation).

**4.2.1.3 Acceptance Criteria**

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

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.

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

**4.2.2 Connector Mating/Unmating Force****4.2.2.1 Purpose**

This test determines the mating/unmating forces associated with RF connectors.

**4.2.2.2 Procedure**

Follow the procedure of SAE/USCAR-2.

**4.2.2.3 Acceptance Criteria**

For single contact connectors, the mating force must be less than or equal to 40N; the unmating force must be less than or equal to 35N with the primary connector lock completely disengaged/disabled.

For multiple contact connectors, SAE/USCAR-2 acceptance criteria apply.

**4.2.3 Polarization Feature Effectiveness****4.2.3.1 Purpose**

This test prevents mating of a connector housing with any unintended mate.

**4.2.3.2 Procedure**

Follow the procedure of SAE/USCAR-2 "Polarization Feature Effectiveness".

#### 4.2.3.3 Acceptance Criteria

For single contact SMB connection systems, the minimum mismatching force to achieve center contact electrical continuity is 80N. For multiple contact SMB connection systems, the minimum mismatching force to achieve center contact electrical continuity is 100N.

For Square Outer Conductor connection systems, SAE/USCAR-2 acceptance criteria apply.

### 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  $\geq 100 \text{ M}\Omega$ .

#### 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 qualify 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

1. The following minimum sample sets should be prepared for each segment of environmental testing per SAE/USCAR-2.
  - In-Line Connectors:  
Prepare a minimum of 10 samples with SMA connectors to the preferred length, as shown in Figure 4.4.2.2, 1a. To facilitate sample assembly, the overall sample length may be as long as 130mm, however, all samples should be the same length (within 5 mm).
  - Board Mount Connectors:  
Prepare a minimum of 10 samples with SMA connectors to the preferred length as shown in 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, measure/record the  $S_{21}$  parameter (transmitted power) of each SMA connector assembly (1a.) over the frequency range listed in Table 4.4.2. Affix a CUT in the middle of each of these assemblies, maintaining the original length within 5mm (Figure 4.4.2.2, 1b. shows the preferred length).
4. For in-lines only, measure the  $S_{21}$  parameter of the CUT assembly and subtract the corresponding SMA connector assembly's  $S_{21}$  value. This is the net Insertion Loss of each CUT.
5. For in-lines only, prepare one additional sample with the overall length roughly 500mm long when the CUT is engaged. Determine the start gate and stop gate of just the CUT within this additional sample using the  $S_{11}$  TDR plot, creating a gate span in picoseconds.
6. For in-lines only, place the gate center in the "electrical middle" of each CUT sample. Measure the  $S_{11}$  (reflected power) for all samples over the frequency range listed in Table 4.4.1. The  $S_{11}$  measured is the CUT VSWR.
7. For board mount connectors, measure the gated  $S_{11}$  (reflected power) of just the CUT for all samples over the frequency range listed in Table 4.4.1. The  $S_{11}$  measured is the CUT VSWR.
8. Completely unmate and mate each sample a total of 10 times and leave them mated.
9. Repeat steps 4, 6 and 7.

#### Notes:

- A. The SMA connectors should be protected during environmental exposure with a mating connector or plug.
- B. Optionally, to account for SMA insertion loss degradation due to environmental exposure, a minimum of 10 SMA connector assemblies (same crimp process and length as CUT assembly) must be prepared for each segment of environmental exposure (statistical evaluation). The statistical data from these assemblies is to be used as reference for determining the net Insertion Loss of each CUT.
- C. Optional in-line VSWR samples: Rather than use the same CUT assemblies for both VSWR and IL testing, a minimum of 10 additional samples may be used solely for VSWR measurements. Prepare these samples per 4.4.2.2, Step 5. The  $S_{11}$  measured is the CUT VSWR.

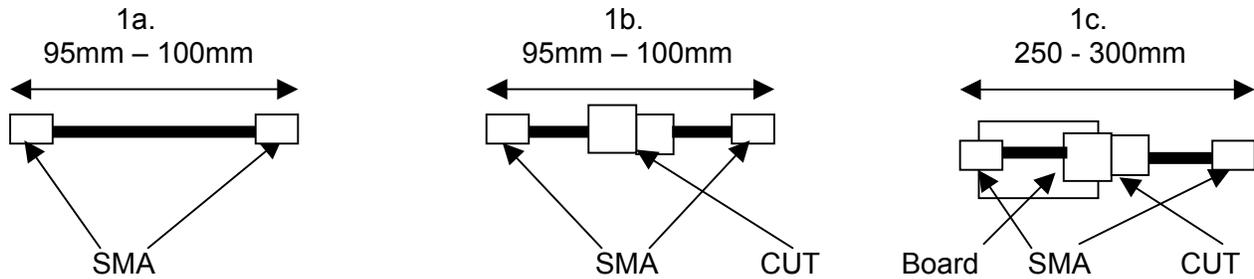


FIGURE 4.4.2.2: VSWR Test Sample

4.4.2.3 Acceptance Criteria

The RF connector maximum VSWR and insertion loss values are shown in Tables 4.4.1 and 4.4.2. Actual test data must be available for OEM evaluation against system requirements.

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)