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

SURFACE VEHICLE STANDARD

Submitted for recognition as an American National Standard

SAE J1113-3

ISSUED NOV95

Issued 1995-11

CONDUCTED IMMUNITY, 250 KHZ TO 500 MHZ, DIRECT INJECTION OF RADIO FREQUENCY (RF) POWER

Foreword**—**This SAE Standard expands on the method documented in SAE J1113 AUG87 to increase the frequency range of the test from the original 50 kHz to 100 MHz to the new 250 kHz to 500 MHz range. It also harmonizes the test with ISO 11452–7.

TABLE OF CONTENTS

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-8512 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER; (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS http://www.sae.org

Printed in U.S.A.

1. ***Scope*—**This part of SAE J1113 specifies the direct RF power injection test method and procedure for testing electromagnetic immunity of electronic components for passenger cars and commercial vehicles. The electromagnetic disturbances considered in this part of SAE J1113 are limited to continuous, narrowband conducted RF energy.

This test method is applicable to all DUT leads except ground. The test provides differential mode excitation to the DUT.

Immunity measurements of complete vehicles are generally only possible by the vehicle manufacturer. The reasons, for example, are high costs of a large absorber-lined chamber, preserving the secrecy of prototypes or the large number of different vehicle models. Therefore, for research, development, and quality control, a laboratory measuring method for components shall be applied by the manufacturer. This method is suitable over the frequency range of 250 kHz to 500 MHz.

2. *References*

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113/1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) (60 Hz to 18 GHz)—Part 1: General and Definitions

2.1.2 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 7637-2—Road vehicles—Electrical disturbance by conduction and coupling

3. ***Definitions*—**See SAE J1113/1.

4. ***Test Conditions*—**See SAE J1113/1 for standard test temperature, test voltage, modulation, dwell time, and frequency step considerations.

4.1 Frequency Range—The upper frequency limit of the test is limited by resonances and parasitic capacitances to ground in the Broadband Artificial Network (BAN) and the leads from the BAN to the DUT. By using an appropriate BAN, a useful frequency range of 0.25 MHz to 500 MHz can readily be achieved. See Appendix A for more information on the construction of BANs.

4.2 Test Severity Level—The user should specify the test levels over the frequency range. Suggested test severity levels are included in Appendix B of this document.

These test severity levels are expressed in terms of equivalent root-mean-square (RMS) value of an unmodulated wave.

The power level is calibrated at the output of the DC blocking capacitor (Item 6 of Figure 1). The RF sampling device is used to control the RF power during the test. Mismatch between the 50 Ω coaxial transmission line and the load consisting of the BAN and the DUT lead is disregarded.

NOTE—The maximum input is equivalent to the level into the 50 Ω load. If the impedance of the DUT lead under test is very low, excessive power will not be injected into the lead.

5. Test Facility Description and Specifications

5.1 Power Injection System—Direct RF power injection is a technique which exposes the operating DUT to quantifiable RF power, while eliminating variables related to wiring harness length and routing, loads, and measuring equipment. RF is coupled into the DUT directly at its connector's pins.

The DUT is connected in the test set-up to perform its designated functions with only the necessary connections made through broadband artificial networks (BANs). The BAN is a device that presents a controlled impedance to isolate the DUT from sensors/loads over a specified frequency range while allowing the DUT to be interfaced to its sensors and loads.

NOTE—The series impedance of the BAN may affect some input signal waveforms. In cases where distortion occurs, document the characteristics of the distortion in the test report.

The procedure can be used to predict the compatibility of components in the vehicle environment with respect to radiated and conducted RF energy, including conducted transient RF energy. The technique is especially useful as a means of isolating the susceptible circuits within a component and evaluating potential solutions.

5.2 Instrumentation—Figure 1 shows an example set-up of the direct RF power injection measurement system.

The spectrum analyzer or power meter shall be capable of measuring levels at the sampling device with a tolerance of ±1.5 dB.

If necessary, this test shall be performed in a shielded room.

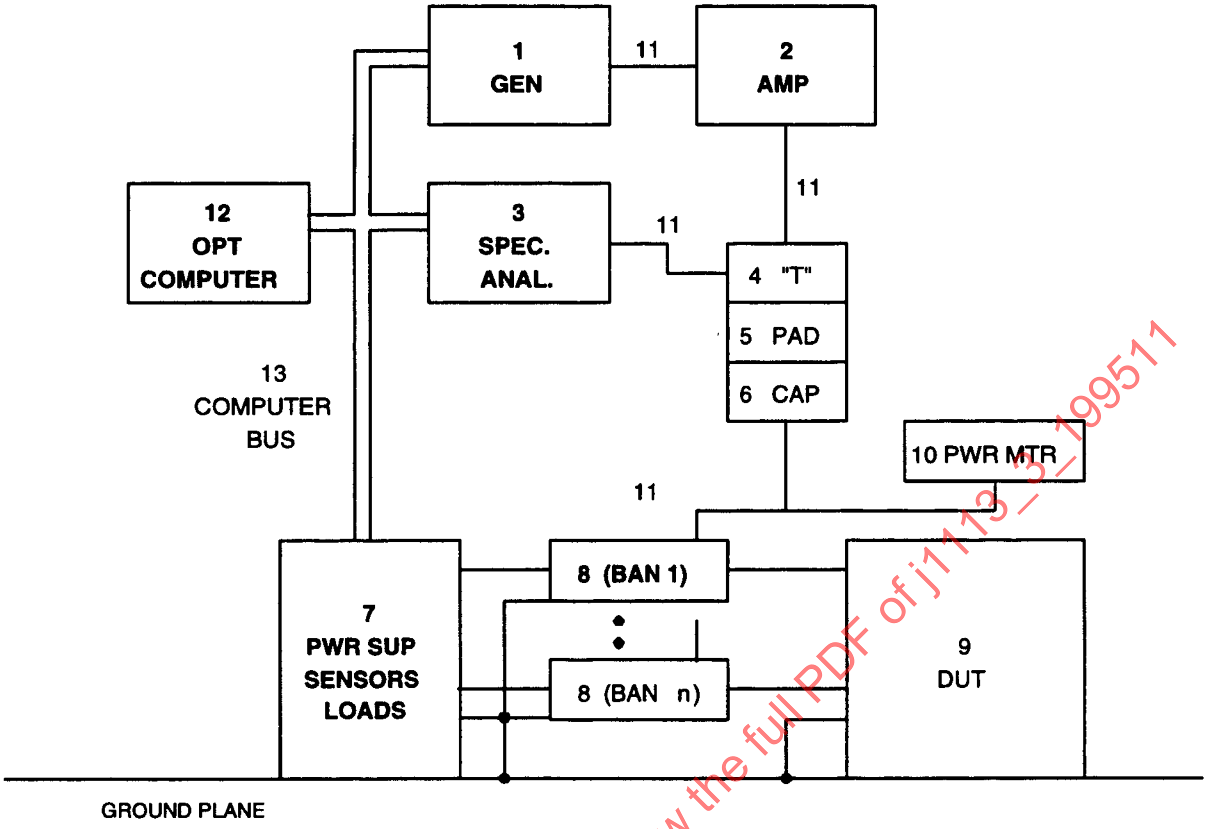
NOTE—A fuse device or a fixed attenuator (typically 10 dB) may be used to protect the spectrum analyzer input from a failure of the RF sampling device in a shorted mode. Any additional attenuation shall be factored into the calibration process.

5.3 Test Set-Up—At the high frequencies within the range of this test, it is necessary to keep the leads as short as possible. The maximum length of lead from the DUT to the BAN shall be 150 mm. Lengths over 120 mm can begin to affect the test results at higher frequencies and therefore should be avoided. When lengths over 120 mm are used, their lengths and positioning shall be documented in the test report. Care should be taken to separate the DUT leads from the loads and measuring instrument leads.

The RF power is delivered to the DUT through a 50 Ω, 10 dB attenuator in order to minimize RF sampling device measurement error caused by reflections at the injection point. A DC blocking capacitor is inserted at the injection point to prevent damage to the test equipment from the DC voltage on the DUT lead being tested.

The preferred construction of the BAN includes an RF connector, such as a "BNC". This provides a controlled ground connection and a short exposed center conductor. An alternate method of connection is the use of test clips and individual wires not to exceed 50 mm length. The length of coaxial transmission line between the blocking capacitor and the BAN shall be 250 mm maximum.

NOTE—Experience has shown that a separation of 25 mm between BANs provides sufficient isolation to allow constructing a fixture with multiple BANs to efficiently test a module.



1	RF signal generator
2	RF amplifier(s) (10 to 25 Ω, typical)
3	Spectrum analyzer or RF power meter
4	RF sampling device ("T"), 50 Ω, 25 W power rating, 30 dB isolation
5	Attenuator (Pad)—50 Ω, 10 dB
6	DC blocking capacitor (impedance less than 5 Ω over the entire test frequency range with a voltage rating at least twice the DUT DC voltage at the line under test)
7	Sensors, loads, and performance measuring equipment
8	BANs—One in series with each lead except RF reference ground
9	DUT
10	RF power meter (for calibration)
11	50 Ω Coaxial transmission line (double shielded or equivalent preferred)
12	Optional data acquisition equipment and programmable controller
13	Optional computer bus

FIGURE 1—EQUIPMENT BLOCK DIAGRAM

6. Test Procedure

CAUTION—HAZARDOUS VOLTAGES AND FIELDS MAY EXIST WITHIN THE TEST AREA. CARE SHOULD BE TAKEN TO ENSURE THAT THE REQUIREMENTS FOR LIMITING THE EXPOSURE OF HUMANS TO RF ENERGY ARE MET AND THAT INTERFERENCE TO COMMERCIAL EQUIPMENT IS AVOIDED WHEN A SHIELDED ENCLOSURE IS NOT USED.

6.1 Test Plan—Prior to performing the tests, a test plan shall be generated which specifies the frequencies, power levels, modulation, dwell time and the leads to be tested. Every DUT shall be verified under the most significant situations, i.e., at least in stand-by and in a mode where all the functions can be excited.

6.2 Test Method

a. Before each test, calibrate the test set-up (see Appendix C). The sampling tee is susceptible to overload which may affect the calibration of the test set-up. Compare the level at the sampling tee output with the level at the injection line (DC block) output. If the test level (power output of the 10 dB attenuator) minus the calibration value (power output from the 30 dB "tee") varies from 20 dB by more than ±3 dB, the test set-up shall receive maintenance.
b. All DUT terminals except RF reference ground are injected with RF power individually; otherwise, the BAN RF connector is left open circuited. The performance requirements of the DUT are determined by the test plan. The RF power into the 10 dB attenuator shall be incremented in steps of 0.1 dB, or as defined in the test plan, from a level of 10 mW or less.
c. While the injected RF power is being maintained at the specified test level, exercise the DUT to operate it in all modes specified in the test plan.
d. Record the injection point, frequency, RF power and the nature of any interactions that occur during the test.
e. Increment the frequency and repeat until the entire frequency range has been tested. (See Section 4.)

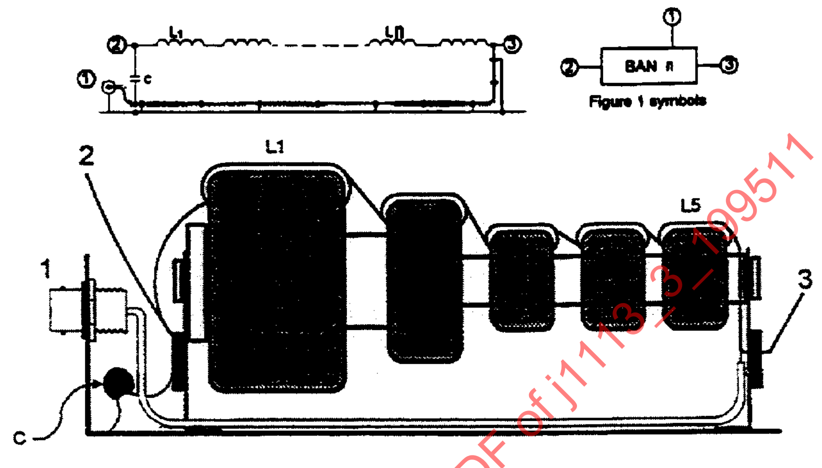
6.3 Test Report—When required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test set-up, systems tested, frequencies, power levels, system interactions, and any other relevant information regarding the test such as deviations, if any, from the original test plan and an explanation of why they occurred.

DEVELOPED BY THE SAE EMI STANDARDS COMMITTEE

APPENDIX A

BROADBAND ARTIFICIAL NETWORK (BAN) DESIGN REQUIREMENTS[1]

Preface—An example schematic and assembly drawing is shown in Figure A1.



1 BNC or similar RF connector
2 Connection to DUT supply/load/support circuitry
3 Connection to DUT

Suggested optimum bypass capacitor is 0.047 µF.

FIGURE A1—EXAMPLE SCHEMATIC AND ASSEMBLY DRAWING OF THE BAN

A.1 BAN Series Impedance Requirements

a.	0.25 MHz to 0.50 MHz	200 Ω min.
b.	0.50 MHz to 300 MHz	500 Ω min.
c.	300 MHz to 500 MHz	200 Ω min.

A.2 BAN Bypassing—The supply/load/support circuitry end of the BAN shall be bypassed to ground. This requires an optimum value capacitor or multiple capacitors to provide a sufficiently low impedance across the frequency range utilized for the test. Minimum lead length is to be used.

A.3 Current Capacity—Current handling capacity shall be included in the parameters of the BAN design. The saturation characteristics of ferrite or powered iron cores, if used, are a significant factor in the current handling capability of a BAN.

A.4 Suggested design for a 1/2 A BAN is given in Table A1, a 2 A BAN in Table A2, and a 30 A BAN in Table A3.

---

[1] Chrysler Corporation holds a patent (#4,763,062) and a patent pending on a BAN design which is anticipated to be available commercially in the near future.

TABLE A1—COIL WINDING INFORMATION—1/2 A BAN

Coil	Core Type	Number of turns	L (µH)	f_c (MHz)	H (Oe)
L1	FT82-77	12	180	3	1.43
L2	FT50-61	4	1	72	0.83
L3	FT50-67	4	0.6	100	0.83
L4	FT50-68	4	0.2	150	0.83
L5	FT50-68	4	0.2	200	0.83

Wire is approximately 0.40 mm diameter (#26 AWG or #26 B&S) approximately 1 m long.

Core Material—Ferrite (Amadon part numbers shown, equivalent parts are acceptable).

TABLE A2—COIL WINDING INFORMATION—2 A BAN

Coil	Core Type	Number of turns	L (µH)	f_c (MHz)	H (Oe)
L1	FT114A-77	8	86	2	2.72
L2	FT82-43	6	20	50	2.88
L3	FT50-67	6	1	100	4.98
L4	FT50-68	4	0.2	150	3.32
L5	FT50-68	4	0.2	225	3.32

Wire is approximately 0.64 mm diameter (#22 AWG or #22 B&S) approximately 1.3 m long.

Core Material—Ferrite (Amadon part numbers shown, equivalent parts are acceptable). L is measured at 10 kHz for L1, calculated for L2 – L5.

TABLE A3—COIL WINDING INFORMATION—30 A BAN

Coil	Core	Turns	L(µH)
L1	T184-26	15	38
L2	T157-26	12	15
L3	T130-26	5	2.4

Wire is approximately 1.61 mm diameter (#14 AWG or #14 B&S) approximately 1.5 m long. Core Material—Powdered iron (Amadon part numbers shown, equivalent parts are acceptable).

NOTE—The recommended technique for winding the assembly utilizes one continuous piece of wire. Leave sufficient wire for the termination on the capacitor end of L1 then wind the turns close-spaced on the toroid for L1. At this point, hold the toroid for L2 approximately 6 mm from L1 and wind the turns for L2 close-spaced in the opposite direction so that the windings are parallel to those of L1. Continue in this manner with L3 through L5 with the windings zig-zagging from L1 to L5. Figure A2 shows the arrangement. The remaining wire should be cut off allowing enough to connect L5 to its terminal lug.

Install the assembly on the dowel, then assemble the dowel to the support lugs (with the close-spaced windings away from the ground plane) with nonmetallic screws. Use minimum lead length for all connections.

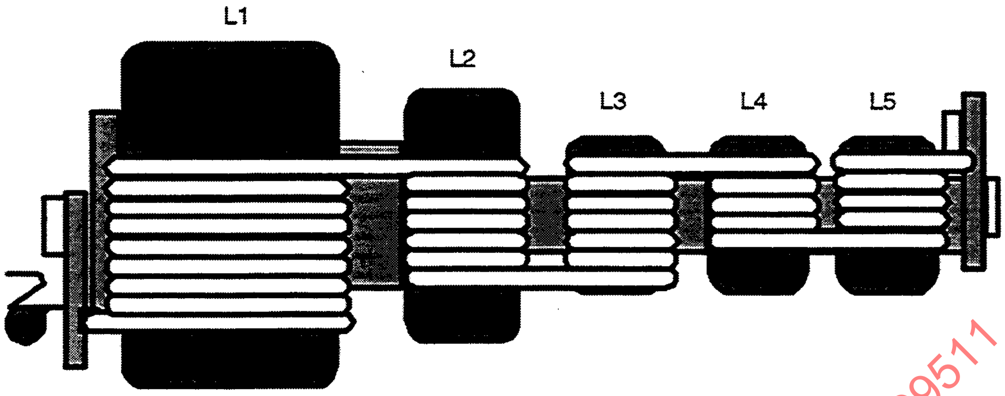


FIGURE A2—TYPICAL WINDING ARRANGEMENT