



# SURFACE VEHICLE STANDARD

J1113-3

REV.  
SEP2006

Issued 1995-11  
Revised 2006-09

Superseding J1113-3 NOV1995

Conducted Immunity, 250 kHz to 400 MHz, Direct Injection of  
Radio Frequency (RF) Power

## RATIONALE

This document has been revised to incorporate the latest BAN developments that facilitate usage of this test method on data and bus lines.

## 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 400 MHz range. It also brings the test method into closer harmony with ISO 11452-7.

## TABLE OF CONTENTS

1.	Scope .....	2
2.	References .....	2
2.1	Applicable Documents .....	2
3.	Definitions .....	2
4.	Test Conditions .....	2
4.1	Frequency Range .....	2
4.2	Test Severity Limits .....	3
5.	Test Facility Description and Specifications .....	3
5.1	Power Injection System .....	3
5.2	Instrumentation .....	3
5.3	Test Set-Up .....	3
6.	Test Procedure .....	5
6.1	Test Plan .....	5
6.2	Test Method .....	5
6.3	Test Report .....	5
7.	Notes .....	5
7.1	Marginal Indicia .....	5
Appendix A	Broadband Artificial Network (BAN) Design Requirements .....	6
Appendix B	Function Performance Status Classification (FPSC) .....	9
Appendix C	Test Set-up Calibration Procedure .....	10

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2006 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

**TO PLACE A DOCUMENT ORDER:** Tel: 877-606-7323 (inside USA and Canada)  
Tel: 724-776-4970 (outside USA)  
Fax: 724-776-0790  
Email: [CustomerService@sae.org](mailto:CustomerService@sae.org)

SAE WEB ADDRESS:

<http://www.sae.org>

## 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 the RF reference 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 400 MHz.

This direct RF power injection test is particularly effective when used as part of the engineering development of the electronic component (at the prototype PCB level) where the line by line diagnostic capabilities of this test facilitate cost-effective circuit board level improvements in the RF immunity performance of the module or component.

## 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, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE J1113-1 Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (50 Hz to 18 GHz)

#### 2.1.2 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, [www.ansi.org](http://www.ansi.org).

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

ISO 11452-7 Road vehicles—Electrical disturbances by narrowband radiated electromagnetic energy—Component test methods Part 7—Direct RF Power Injection

## 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 400 MHz can 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  $\Omega$  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  $\Omega$  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, line by line.

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. If the series inductance of the BAN inhibits data transfer on signal or bus lines, a reduced inductance (increased bandwidth) BAN is available for testing these lines with corresponding modifications to required test frequency ranges. For controller area network (CAN) lines, a common mode BAN with single point injection is used, refer to Appendix A. This BAN allows the test to be performed from 1 MHz to 250 MHz. A 470 pF DC blocking capacitor is used.

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  $\pm 1.5$  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.

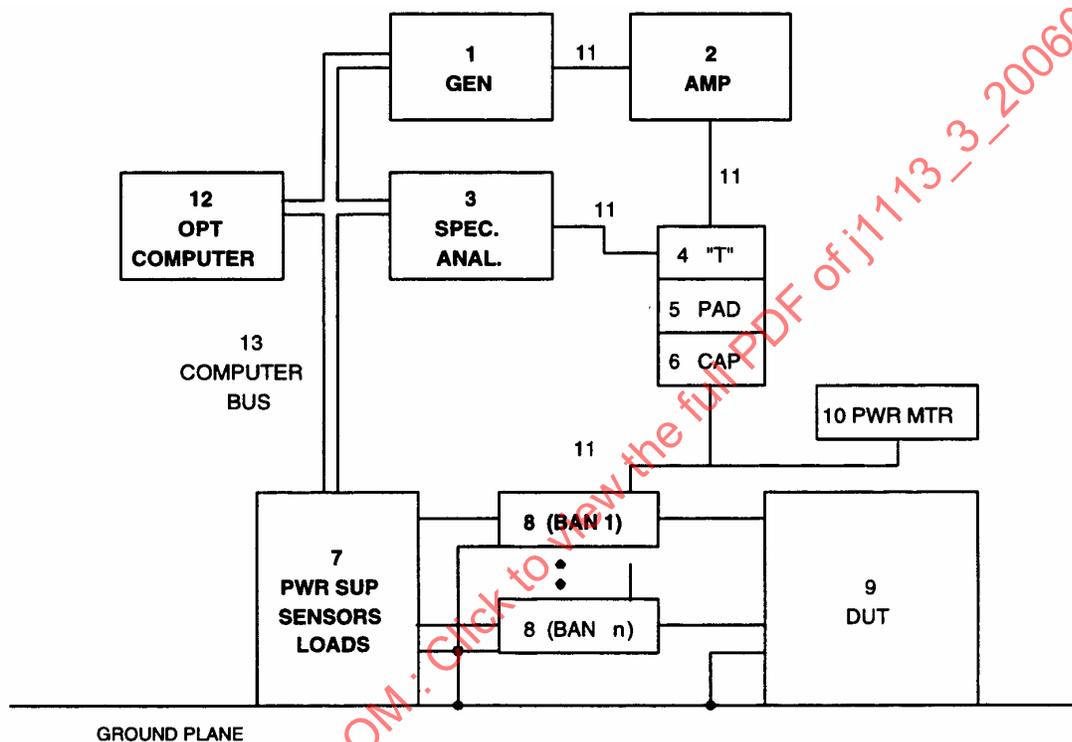
### 5.3 Test Set-Up

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  $\Omega$ , 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  $\Omega$ , typical)
- 3 Spectrum analyzer or RF power meter
- 4 RF sampling device ("T"), 50  $\Omega$ , 25 W power rating, 30 dB isolation
- 5 Attenuator (Pad)—50  $\Omega$ , 10 dB
- 6 DC blocking capacitor (impedance less than 5  $\Omega$  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  $\Omega$  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 blocking capacitor) 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  $\pm 3$  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.

## 7. NOTES

### 7.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

APPENDIX A - BROADBAND ARTIFICIAL NETWORK (BAN) DESIGN REQUIREMENTS<sup>1</sup>**Preface**

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

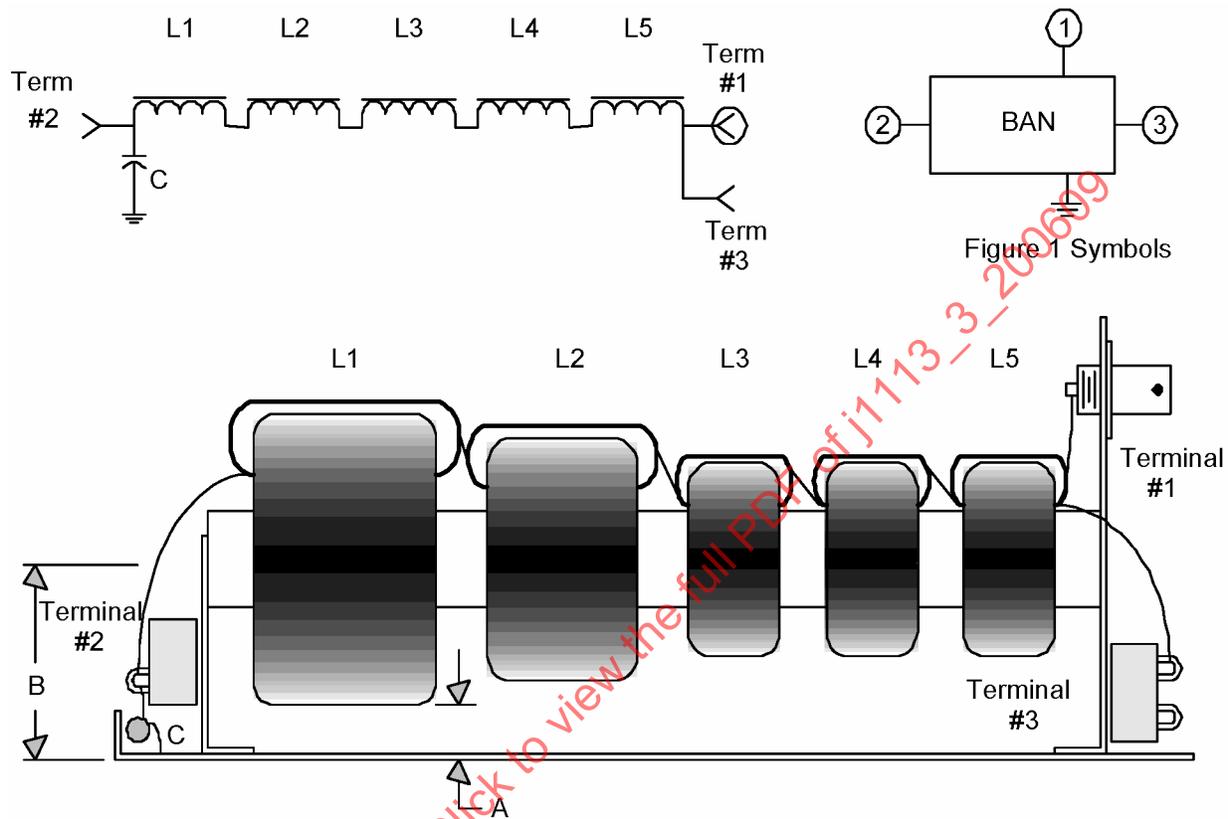


FIGURE A1 - EXAMPLE SCHEMATIC AND ASSEMBLY DRAWING OF THE BAN

NOTE: The location of the BNC connector is incorrectly shown on the 1 side of the BAN, it should be on the 3 side of the BAN with minimum lead length.

BAN Series Impedance Requirements (up to 8 A current rating)

- 0.25 MHz to 0.50 MHz      200  $\Omega$  min.
- 0.50 MHz to 300 MHz      500  $\Omega$  min.
- 300 MHz to 400 MHz      200  $\Omega$  min.

#### A.1 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. Suggested optimum bypass capacitor C is a 0.047  $\mu$ F ceramic monolithic capacitor for normal BANs, 0.01  $\mu$ F for high speed BANs and 470 pF for CAN BANs.

<sup>1</sup> DaimlerChrysler NA holds patent (#4,763,062) and patent (#5,541,521) on BAN designs which are available commercially.

## A.2 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.3 Suggested design for a 0.5 A BAN is given in Table A1, a 0.5 A CAN BAN in Table A2, a 2 A BAN in Table A3, and a 30 A BAN in Table A4.

TABLE A1 - COIL WINDING INFORMATION—0.5 A BAN

Coil	Core Type	Number of turns	L ( $\mu$ H)	$f_c$ (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).

High Data Rate BAN: A high data rate BAN for testing high-speed, single line signal or bus lines is obtained by modifying the 0.5 A BAN above. To fabricate a high data rate BAN, remove L1 (the 12-turn toroid) from the 0.5 A isolator described in Table A1, and replace the 0.047  $\mu$ F bypass capacitor with 0.01  $\mu$ F. This lowers the inductance of the isolator to approximately 2 microhenries and raises the resonant frequency allowing 125 k baud data transmission bandwidth. When this isolator is required, the frequency range for direct RF injection is modified to 20 MHz to 400 MHz.

CAN BAN: This BAN has been developed for testing of CAN bus lines. It is constructed with two lines bifilar wound (4 turns per cm or 10 per inch) on six cores with two bypass caps on each line (terminal #2) and two capacitor feeds from the two lines to a common BNC connector (terminal #1) for common mode testing. The bypass capacitor is 470 pF and the split feed capacitors are 470 pF each. This configuration of BAN with the split feed capacitors implements common mode single point RF injection. To preserve balance on the CAN bus, the tolerance on the capacitors is  $\pm 2\%$ .

TABLE A2 - COIL WINDING INFORMATION—0.5 A CAN BAN

Coil	Core Type	Number of turns
L1	FT82-77	12
L2	FT50-61	4
L3	FT50-67	4
L4	FT50-68	7
L5	FT50-68	5
L6	FT50-68	5

BNC connector is Amphenol 31-10 or equivalent, minimum 30 mm above the ground plane.

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

Core material - Ferrite (Amidon part numbers shown, equivalent parts are acceptable).

TABLE A3 - COIL WINDING INFORMATION—2 A BAN

Coil	Core Type	Number of turns	L ( $\mu$ H)	$f_c$ (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 A4 - COIL WINDING INFORMATION—30 A BAN

Coil	Core	Turns	L( $\mu$ H)
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.

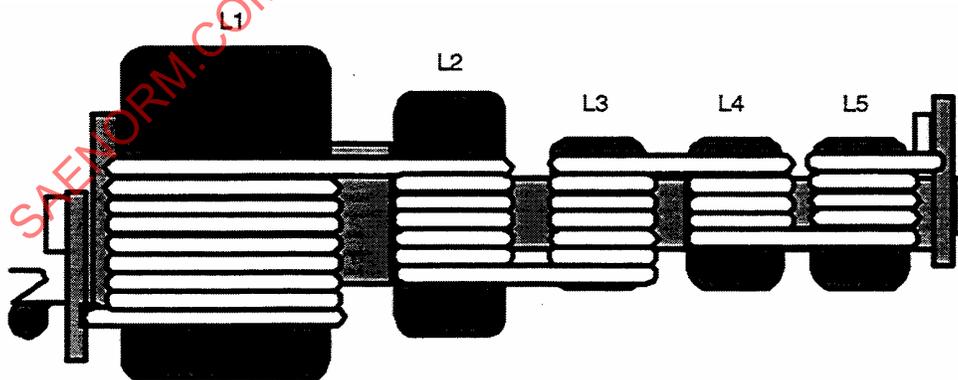


FIGURE A2 - TYPICAL WINDING ARRANGEMENT