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Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 7: **Direct radio frequency (RF) power injection**

Véhicules routiers — Méthodes d'essai d'un équipement soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite —

Partie 7: Injection directe de puissance aux fréquences radioélectriques (RF)

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11452-7 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 11452-7:1995), which has been technically revised.

ISO 11452 consists of the following parts, under the general title *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy*:

— *Part 1: General principles and terminology*

— *Part 2: Absorber-lined chamber*

— *Part 3: Transverse electromagnetic mode (TEM) cell*

— *Part 4: Bulk current injection (BCI)*

— *Part 5: Stripline*

— *Part 7: Direct radio frequency (RF) power injection*

Introduction

Immunity measurements of complete road vehicles are generally able to be carried out only by the vehicle manufacturer, owing to, for example, high costs of absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes or a large number of different vehicle models.

For research, development and quality control, a laboratory measuring method can be used by both vehicle manufacturers and equipment suppliers to test electronic components.

Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 7:
Direct radio frequency (RF) power injection

1 Scope

This part of ISO 11452 specifies a direct RF power injection test for determining the immunity of electronic components of passenger cars and commercial vehicles to electrical disturbances from narrowband electromagnetic energy, regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor). The test method, which involves providing differential mode excitation to the DUT (device under test), is applicable to all DUT leads except RF Ground. Applicable over the frequency range 0,25 MHz to 500 MHz, the method can be used to predict the compatibility in the vehicle environment with respect to radiated and conducted RF energy, including conducted transient RF energy, and is especially useful as a means of isolating the susceptible circuits within a DUT and evaluating potential solutions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11452-1, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11452-1 apply.

4 Test conditions

4.1 Standard test conditions

Standard test temperature, supply voltage, modulation, dwell time and frequency step size information shall be in accordance with ISO 11452-1.

4.2 Frequency range

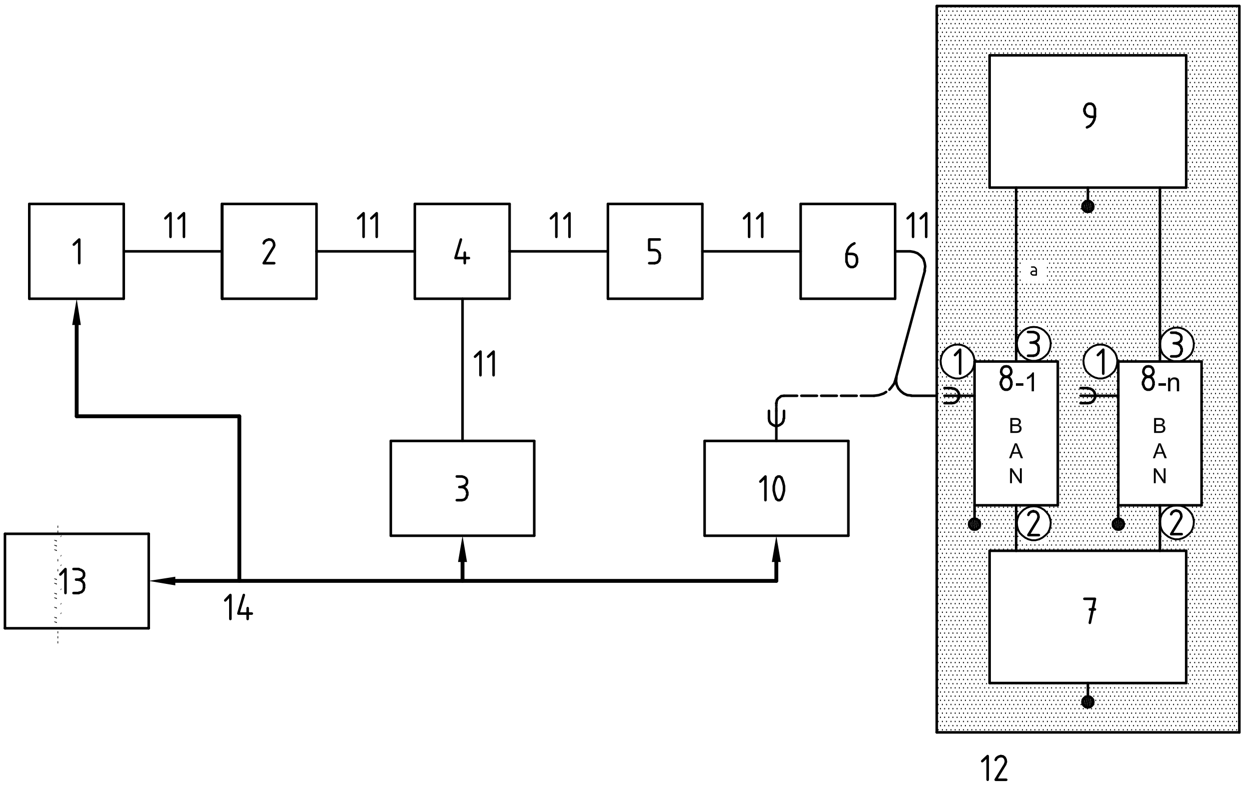
The upper limit of the test is limited by resonances and parasitic capacitances to Ground in the broadband artificial network (BAN) and leads from the BAN to the device under test (DUT). By using an appropriate BAN, a useful frequency range of 0,25 MHz to 500 MHz can be readily achieved.

See Annex A for information on BAN construction.

4.3 Test severity levels

The user should specify the test severity levels over the frequency range (see Annex B for suggested severity levels). These levels are expressed in terms of the equivalent root-mean-square value of the unmodulated wave.

The test severity level is measured at the output of the blocking capacitor (Item 6 in 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.



Key

1 RF signal generator
2 RF amplifier(s) (10 W to 25 W, typical)
3 spectrum analyzer or RF power meter
4 RF sampling device (sampling “T” or directional coupler), 50 Ω, 25 W, rating, 30 dB isolation
5 attenuator (pad) 50 Ω, 10 dB, 10 W
6 d.c. blocking capacitor (impedance less than 5 Ω across entire frequency range)
7 peripherals
8 BAN, one in series with each lead except RF reference ground (see Figure A.1 for connector numbering 1 to 3)
9 DUT
10 RF power meter (for calibration)
11 coaxial transmission line (double shielded or equivalent)
12 ground plane
13 programmable controller and data acquisition equipment (optional)
14 instrumentation data bus

[a] Lead length from BAN to DUT shall be ⩽ 150 mm.

Figure 1 — Example of RF power injection test configuration

5 Test facility description and specification

5.1 Power injection system

Direct RF power injection is a technique whereby RF power is injected into the operating DUT, while eliminating variables related to wiring harness length and routing. The RF power is injected directly into the DUT at its connector pins.

This is a substitution test method. In preparation for performing a test, the power delivered through the d.c. blocking capacitor is measured on a calibrated power meter while the reference level at the RF sampling device ("sampling tee" or directional coupler) is recorded so that it can be used to establish the DUT exposure.

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 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.

In cases where the characteristics of the BAN significantly affects an input signal waveform (e.g. data bus signals), a special BAN with lower series impedance may be used. In such cases, document the characteristics of the distortion or characteristics of the special BAN, or both, in the test report.

5.2 Instrumentation

Figure 1 shows an example of a set-up of a direct RF power injection measurement system. The spectrum analyzer or power meter shall be capable of measuring levels provided by the sampling device with an uncertainty of $\pm$ 1 dB.

If necessary to meet national regulations or to preclude interference with other test activities, this test shall be performed in a shielded room.

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 shortened mode. Any protective device shall be in place when the test reference level, specified in 6.2.1, is determined.

5.3 Test set-up

At the high frequencies within the range of this test, it is necessary to keep the leads between the DUT and the BANs as short as possible; they shall be spread out to minimize capacitive coupling between leads. The maximum length of the lead from the DUT to the BAN shall be 150 mm. Lengths of over 120 mm can begin to affect the test results at higher frequencies (i.e. $>$ 200 MHz) and therefore shall be avoided. When lengths of over 120 mm are used, these lengths and their positioning shall be documented in the test report. Care shall be taken to separate the DUT leads from the load and measuring instrument leads.

The RF power is delivered to the DUT through a 50 Ω, 10 dB attenuator, in order to minimize the effect of reflections at the injection point. A d.c. blocking capacitor is inserted at the injection point to prevent damage to the test equipment by the d.c. voltage on the device 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 centre conductor. An alternate method of connection is the use of test clips and individual wires that may not exceed 50 mm length. The lengths of coaxial transmission line between the blocking capacitor and the BAN shall be a maximum of 250 mm.

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

5.4 Ground plane

A ground plane that meets the material and size requirements of ISO 11452-1 shall be used. All BANs and loads used in the test shall be bonded to the ground plane. Copper inductive tape may be used to bond parts of the set-up to the ground plane, provided that a resistance of less than 0,1 Ω is achieved between the part and the ground plane.

6 Test method

6.1 Test plan

Prior to performing the tests, a test plan shall be prepared, specifying the frequencies, power levels, modulation, dwell time and the DUT leads to be tested. Each DUT shall be verified under the most significant situations, i.e. at least in stand-by mode and in a mode where all the actuators can be excited.

The DUT shall be configured to perform its required functions with as few leads connected as possible. Sensor or load leads that form a closed loop, are dedicated to the DUT without other interconnections and have the potential to support RF circulating currents shall be injected at the DUT without using an isolator. All other leads shall be connected through a BAN.

6.2 Test procedure

CAUTION — Hazardous voltages and fields may exist within the test area. Take care to ensure that the requirements for limiting the exposure of humans to RF energy are met.

NOTE Because power measurements are made only on lines which have matched termination loads, only forward power need be measured.

6.2.1 At least once daily, determine or verify the test reference level for the test stand. The test reference level is the sampling "T" output for a specified test level and is a function of frequency. Disconnect the blocking capacitor (Item 6 in Figure 1) and its coaxial cable from the BAN (Item 8) injection port and connect it to a 50 Ω power meter. (Item 10) for this task. The difference between the sampling "T" output and the power meter level is the power transfer function. The sampling "T" is susceptible to overload, which may affect the stability of the test stand power transfer function. If the power transfer function deviates from the previous readings by more than $\pm$ 3 dB, the test stand requires maintenance.

After determining or verifying the test reference level, disconnect the blocking capacitor and its coaxial cable from the power meter and connect it to the BAN for the first DUT line to be tested.

6.2.2 All DUT terminals except the RF reference ground are injected with RF power individually. When RF power is not being injected into a lead, the BAN RF connector shall be 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 0,2 dB, or as defined in the test plan, from a level of $\leqslant$ 10 mW.

6.2.3 While the injected RF power is being incremented to the level specified in the test plan, operate the DUT in all modes specified in the test plan.

6.2.4 Record the terminal identification, frequency, RF power and any interactions that occur during the test.

6.2.5 Increase incrementally the frequency and repeat until the entire frequency range has been tested (see 4.2).

6.3 Test report

When required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test site, systems tested, frequencies, power levels, system interactions and any other information relevant to the test.

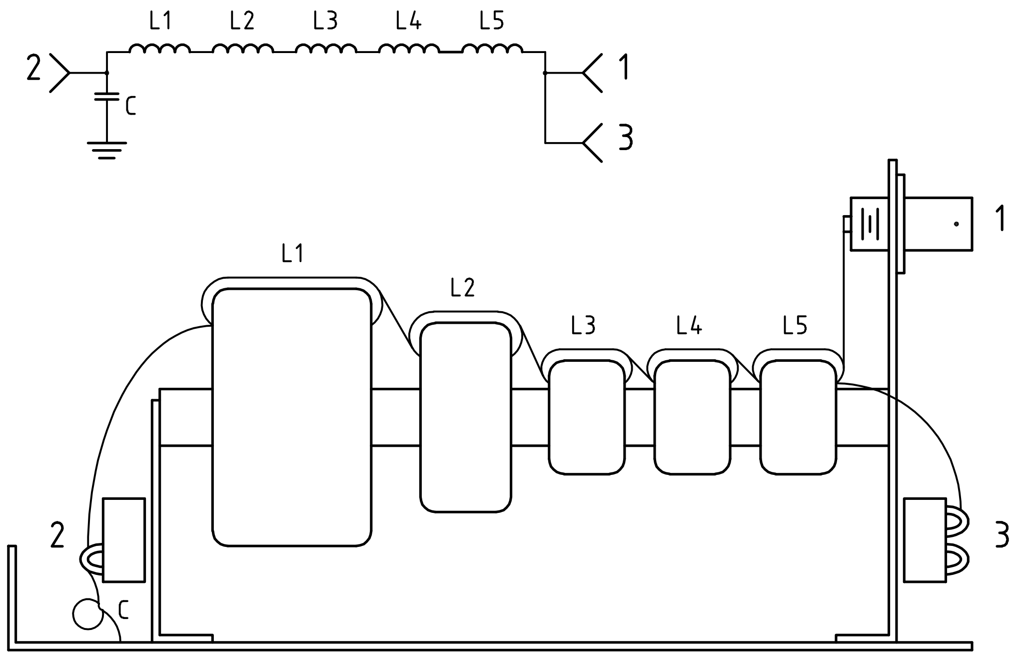
Annex A
(informative)

Broadband artificial network (BAN) design

NOTE DaimlerChrysler Corporation holds patents (Nos. 4 763 062 and 5 541 521) on a BAN which is commercially available. (This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this products. Equivalent products may be used if they can be shown to lead to the same results.)

A.1 Example

An example schematic and assembly drawing is shown in Figure A.1.



Key

C bypass capacitor[a]

L1 to L5 coils

1 Connector 1 — BNC or similar RF connector

2 Connector 2 — connection to the DUT supply/load support circuitry

3 Connector 3 — connection to the DUT

[a] The recommended optimum bypass capacitor is a 0,047 μF ceramic monolithic capacitor.

Figure A.1 — Example schematic and assembly drawing of BAN — Side view

A.2 BAN series impedance requirements

A.2.1 For BANs with current-carrying capacity up to 8 A

See Table A.1.

Table A.1 — BANs with current-carrying capacity up to 8 A

Frequency range MHz	Minimum impedance Ω
0,25 to 0,50	200
> 0,50 to 250	500
> 250 to 500	200

A.2.2 For BANs with current-carrying capacity of greater than 8 A, up to 30 A

See Table A.2.

Table A.2 — BANs with current-carrying capacity greater than 8 A up to 30 A

Frequency range MHz	Minimum impedance Ω
0,25 to 1,0	200
> 1,0 to 150	400
> 150 to 250	200
> 250 to 500	100

A.3 BAN through loss requirements (Port 1,3 to Port 2)

A.3.1 For BANs with current carrying capacity up to 8 A

See Table A.3.

Table A.3 — BANs with current carrying capacity up to 8 A

Frequency range MHz	Minimum through loss dB
0,25 to 1,0	20
> 1,0 to 500	35

A.3.2 For BANs with current carrying capacity greater than 8 A up to 30 A

See Table A.4.

Table A.4 — BANs with current carrying capacity greater than 8 A up to 30 A

Frequency range MHz	Minimum through loss dB
0,25 to 500	20

A.4 BAN bypassing

The supply/load/support circuitry end of the BAN shall be bypassed to Ground. This requires the optimum value of the capacitor or multiple capacitors, in order to provide a sufficiently low impedance across the frequency range utilized for the test. The minimum lead length shall be used.

A.5 Current handling capacity

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

A.6 Suggested designs

Suggested designs are given in Table A.5 for a 0,5 A BAN, Table A.6 for a 2 A BAN, and Table A.7 for a 30 A BAN.

Table A.5 — Coil winding information — 0,5 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 (No. 26 AWG or No. 26 B&S) and approx. 1 m long. Core material: Ferrite (amidon part numbers shown, equivalent parts are acceptable).					

Table A.6 — Coil winding information — 2 A BAN

Coil	Core type	Number of turns	L µH	f_c MHz	H Oe
L1	FT114AA-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 (No. 22 AWG or No. 22 B&S) approximately 1,3 m long. Core material: Ferrite (amidon part numbers shown, equivalent parts are acceptable). L is measured at 10 kHz for L1, calculated for L2 to L5.					

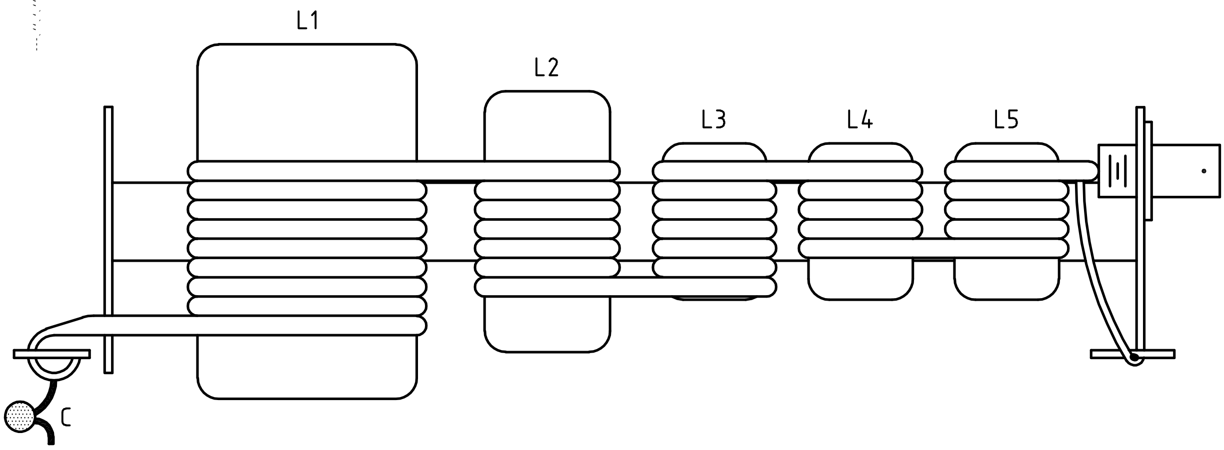
Table A.7 — Coil winding information — 30 A BAN

Coil	Core type	Number of 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 (No. 14 AWG or No. 14 B&S) approximately 1,5 m long. Core material: Powdered iron (amidon part numbers shown, equivalent parts are acceptable).			

A.7 Winding and installing the assembly

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 and 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 to L5 with the windings zig-zagging from L1 to L5. Figure A.2 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 non-metallic screws. Use minimum lead length for all connections.



Key

C bypass capacitor[a]

L1 to L5 coils

[a] The recommended optimum bypass capacitor is a 0,047 µF ceramic monolithic capacitor.

Figure A.2 — Typical winding arrangement — Top view

Annex B
(informative)

Function performance status classification (FPSC)

Suggested test severity levels and the frequency bands are given in Table B.1 and Table B.2, respectively.

NOTE See ISO 11452-1 for a detailed explanation of FPSC.

Table B.1 — Suggested test severity levels — 50 Ω system

Test severity level	Power W
I	0,1
II	0,2
III	0,3
IV	0,4
V	0,5
VI	Specific value agreed between the users of this part of ISO 11452, if necessary

Table B.2 — Frequency bands

Frequency band	Frequency range MHz
F1	0,25 to 10
F2	> 10 to 30
F3	> 30 to 80
F4	> 80 to 200
F5	> 200 to 500

Bibliography

[1] ISO 7637-1, *Road vehicles -— Electrical disturbances from conduction and coupling -— Part 1: Definitions and general considerations*

[2] ISO 7637-2, *Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only*

ICS 33.100.20; 43.040.10

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