

---

---

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

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

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

*Partie 4: Méthode d'injection de courant (BCI)*





**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2013

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

	Page
<b>Foreword</b> .....	<b>iv</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Test conditions</b> .....	<b>1</b>
<b>5 Test instrument description and specification</b> .....	<b>2</b>
5.1 BCI system .....	2
5.2 Instrumentation .....	2
5.3 Test set-up .....	2
<b>6 Test procedure</b> .....	<b>2</b>
6.1 Test plan .....	2
6.2 Test methods .....	2
6.3 Test report .....	4
<b>Annex A (normative) Current injection probe calibration method</b> .....	<b>5</b>
<b>Annex B (normative) Current measurement probe calibration method</b> .....	<b>7</b>
<b>Annex C (informative) Function performance status classification (FPSC)</b> .....	<b>8</b>

## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. [www.iso.org/patents](http://www.iso.org/patents)

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This third edition cancels and replaces the second edition (ISO 11451-4:2006), which has been technically revised.

ISO 11451 consists of the following parts, under the general title *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy*:

- *Part 1: General principles and terminology*
- *Part 2: Off-vehicle radiation sources*
- *Part 3: On-board transmitter simulation*
- *Part 4: Bulk current injection (BCI).*

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

## Part 4: Bulk current injection (BCI)

### 1 Scope

This part of ISO 11451 specifies bulk current injection (BCI) test methods for testing the electromagnetic immunity of electronic components for passenger cars and commercial vehicles regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor). The electromagnetic disturbance considered in this part of ISO 11451 is limited to continuous narrowband electromagnetic fields.

ISO 11451-1 gives definitions, practical use and basic principles of the test methods.

### 2 Normative references

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

ISO 11451-1:2005, *Road vehicles — Vehicle 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 11451-1 apply.

### 4 Test conditions

The applicable frequency range for this test method is 1 MHz to 400 MHz. The frequency range of the BCI test method is a direct function of the current probe characteristics. More than one type of current probe may be required to cover the applicable frequency range.

The users shall specify the test severity level(s) over the frequency range. Suggested test severity levels are given in [Annex C](#). These test severity levels are expressed in terms of the equivalent root-mean-square value of the unmodulated wave.

Standard test conditions are given in ISO 11451-1 for the following:

- test temperature,
- supply voltage,
- modulation,
- dwell time,
- frequency step sizes,
- definition of test severity levels, and

— test signal quality.

## 5 Test instrument description and specification

### 5.1 BCI system

BCI is a method of carrying out immunity tests by inducing disturbance signals directly into the wiring harness by means of a current injection probe. The injection probe is a current transformer through which the wires of the device under test (DUT) are passed. Immunity tests are then carried out by varying the test severity level and frequency of the induced disturbance.

**BCI shall be conducted on each individual system fitted to the vehicle.**

### 5.2 Instrumentation

[Figure 1](#) shows an example of a BCI test configuration.

An injection probe or set of probes capable of operating over the test frequency range is required to interface the test equipment of the DUT. The probe shall be capable of withstanding a continuous input power over the test frequency range regardless of the system loading.

The current measurement probe or set of probes shall be capable of operating over the test frequency range. The current measurement probe(s) shall be terminated in the load impedance at which they are calibrated.

### 5.3 Test set-up

**The vehicle should be tested as built; no additional grounding connections are allowed. Tests should be performed inside a shielded room.**

The distance between the vehicle and all other conductive structures, such as the walls of a shielded room (with the exception of the ground plane underneath the vehicle) shall be a minimum of 0,5 m.

## 6 Test procedure

### 6.1 Test plan

Prior to performing the tests, a test plan shall be prepared; it shall include interface test points, mode of operation for the DUT, acceptance criteria for the DUT, and any special instructions and changes from the standard test. Each DUT shall be verified under the most significant conditions, i.e. at least in stand-by mode and in a mode where all the actuators can be excited.

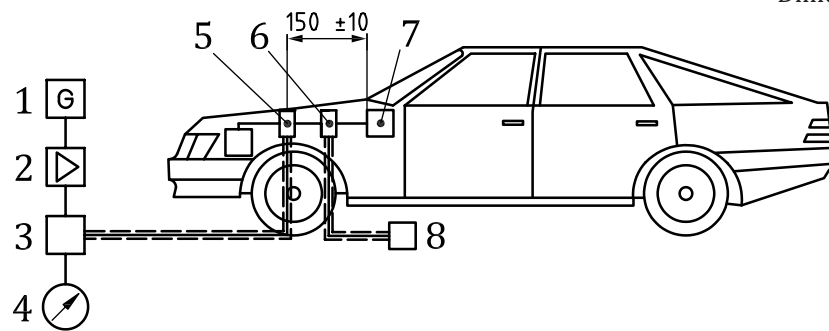
### 6.2 Test methods

**CAUTION — Hazardous voltages and fields may exist within the test area. Care shall be taken to ensure that the requirements for limiting the exposure of humans to radio frequency (RF) energy are met.**

There are two test methods for the BCI test: the Substitution method and the Closed-loop method (see [5.2.1](#) and [5.2.2](#), respectively).

**For both tests, the test equipment shall be connected in a manner similar to that shown in [Figure 1](#).**

Dimensions in millimetres

**Key**

- 1 signal generators
- 2 broadband amplifier
- 3 RF 50  $\Omega$  directional coupler
- 4 RF power level measuring device or equivalent
- 5 RF injection probe
- 6 RF current measurement probe (required for Closed-loop method, optional for Substitution method)
- 7 DUT
- 8 spectrum analyser or equivalent (required for Closed-loop method, optional for Substitution method)

**NOTE** It is recommended that appropriate ferrite chokes be placed on the coaxial cables to the injection and current measurement probes.

**Figure 1 — Example of BCI test configuration**

### 6.2.1 Substitution method

This method is based upon the use of forward power as the reference parameter for calibration and test.

In this method, the specific test level (current, voltage or power) shall be calibrated prior to the actual testing.

The test with the DUT is then conducted by subjecting it to the test signals based on the calibrated values as predetermined in the test plan.

Measurements using this method can be affected by coupling between the injection probe and the wiring harness as well as by reflected energy.

Mount the current injection probe around the harness ( $150 \pm 10$ ) mm from the connector or the outlet aperture of the DUT being tested on the vehicle.

Where the harness contains a number of branches to a DUT, the test should be repeated with the current probe(s) clamped around each of the branches ( $150 \pm 10$ ) mm from the branch termination. Under these test conditions, the measuring probe, if used, shall be left at its previous distance from the DUT.

Using the pre-calibrated level of forward power (see [Annex A](#)), conduct a search for events over the frequency range of the injection probe.

For each event, record the lowest forward power to the probe as the threshold of immunity even if this is found with the injection probe in different positions at different frequencies.

A current measurement probe may optionally be mounted between the current injection probe and the DUT. It may provide extra useful information but it may also modify the test conditions. Where this probe is used, the measured current cannot be used to determine the performance of the DUT, but should be retained and used during investigative work for the causes of events and the variances in test conditions after system modifications.

### 6.2.2 Closed-loop method

The RF to the current injection probe shall be increased until

- the predetermined maximum test current level, measured using the current measurement probe, is reached, or
- the maximum forward power (defined in the test plan) to the injection probe is achieved.

The current measurement probe shall be calibrated using the method in [Annex B](#).

Record the threshold of susceptibility as a function of frequency.

### 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 relevant information regarding the test.



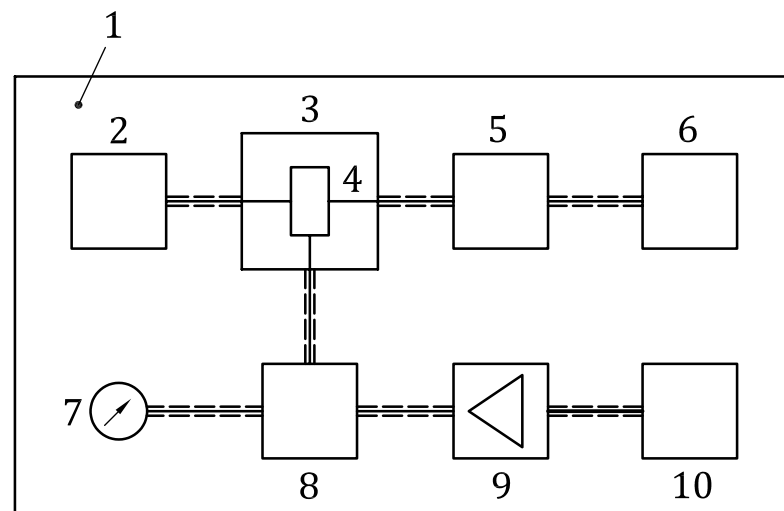
## Annex A (normative)

### Current injection probe calibration method

To determine the injected current flowing, the forward power measurement across a calibration fixture is used. [Figure A.1](#) shows an example of a test equipment configuration for the current injection probe calibration.

Mount the current injection probe centred in the calibration fixture (see [Figure A.2](#)), and while sweeping the test frequency range, monitor the forward power required to achieve the current at which testing is to be conducted.

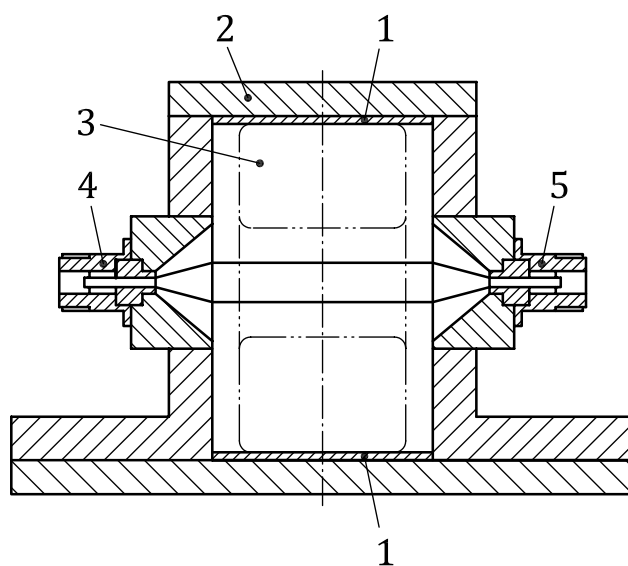
As an alternative method, once testing of the system is complete and all data has been recorded, mount the current injection probe in the calibration fixture. At each frequency showing an event, the recorded forward power levels are applied to the probe. The currents then observed in the calibration fixture are those at which events within the system occurred.



#### Key

- 1 shielded enclosure
- 2 50 Ω coaxial load, VSWR 1,2: 1 max
- 3 calibration fixture
- 4 injection probe
- 5 50 Ω attenuator
- 6 spectrum analyser or equivalent
- 7 RF power level measuring device (two are required)
- 8 RF 50 Ω dual directional coupler (with 30 dB minimum decoupling coefficient)
- 9 broadband amplifier with 50 Ω output impedance
- 10 RF signal generator

**Figure A.1 — Example of current injection probe calibration configuration**



**Key**

- 1 insulation
- 2 removable metal cover
- 3 current injection probe
- 4 direct connection to 50  $\Omega$  measurement equipment
- 5 direct connection to 50  $\Omega$  load

**Figure A.2 — Example of calibration fixture (jig)**

The physical size of the calibration fixture shall be in accordance with the probe manufacturer's requirements.

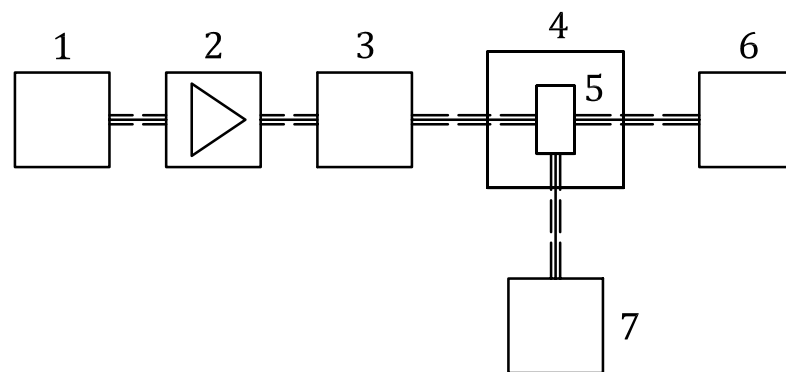
## Annex B (normative)

### Current measurement probe calibration method

Mount the current measurement probe in the proper size calibration fixture with the probe concentric about the centre conductor of the fixture (see [Figure B.1](#)).

Record the output of the current measurement probe as a function of frequency while maintaining a constant RF calibration signal power.

Based on a known termination impedance, the output voltage versus input current can be determined.



#### Key

- 1 RF signal generator
- 2 broadband amplifier with 50  $\Omega$  output impedance
- 3 directional coupler with power meters
- 4 calibration fixture
- 5 current measurement probe being calibrated
- 6 RF termination 50  $\Omega$
- 7 spectrum analyser or equivalent

**Figure B.1 — Example of current measurement probe calibration configuration**

## Annex C (informative)

### Function performance status classification (FPSC)

#### C.1 General

This annex gives examples of test severity levels which should be used in line with the principle of functional status classification (FPSC) described in ISO 11451-1.

#### C.2 Classification of test severity level

Examples of test severity levels for BCI are given in [Table C.1](#).

**Table C.1 — Example of test severity levels (BCI)**

Frequency band MHz	Test Level I mA	Test Level II mA	Test Level III mA	Test Level IV mA	Test Level V mA
1 to 3	$60 \times F_{(\text{MHz})} / 3$	$100 \times F_{(\text{MHz})} / 3$	$150 \times F_{(\text{MHz})} / 3$	$200 \times F_{(\text{MHz})} / 3$	Specific values agreed between the users of this part of ISO 11451
3 to 200	60	100	150	200	
200 to 400	$60 \times 200 / F_{(\text{MHz})}$	$100 \times 200 / F_{(\text{MHz})}$	$150 \times 200 / F_{(\text{MHz})}$	$200 \times 200 / F_{(\text{MHz})}$	

#### C.3 Example of FPSC application using test severity levels

Each DUT and its function(s) need to be evaluated prior to test. The category of the DUT function(s), test severity level(s), and response criteria should then be agreed upon between the supplier and vehicle manufacturer. This information should be documented in the test plan and used for determination of DUT acceptance upon completion of the testing and evaluation of the test results.

An example of severity levels is given in [Table C.2](#).

**Table C.2 — Example of test severity levels (BCI)**

Test severity level	Function Cat- egory 1	Function Cat- egory 2	Function Cat- egory 3	Function Cat- egory 4
L <sub>4i</sub>	Level IV	—	—	—
L <sub>3i</sub>	Level III	Level IV	—	—
L <sub>2i</sub>	Level II	Level III	Level IV	—
L <sub>1i</sub>	Level I	Level II	Level III	Level IV



