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

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

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

Partie 4: Méthodes d'injection de courant (BCI)



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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 3.

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 part of ISO 11452 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11452-4 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 11452-4:1995), 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 and definitions*
- *Part 2: Absorber-lined shielded enclosure*
- *Part 3: Transverse electromagnetic (TEM) cell*
- *Part 4: Bulk current injection (BCI)*
- *Part 5: Stripline*
- *Part 6: Parallel plate antenna*
- *Part 7: Direct radio frequency (RF) power injection*

Annexes A to C form a normative part of this part of ISO 11452. Annexes D and E are for information only.

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.

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

Part 4: Bulk current injection (BCI)

1 Scope

This part of ISO 11452 specifies bulk current injection (BCI) tests for determining the immunity of electronic components of passenger cars and commercial vehicles to electrical disturbances from narrowband radiated electromagnetic energy, regardless of the vehicle propulsion system (e.g. spark-ignition engine, diesel engine, electric motor).

The electromagnetic disturbances considered are limited to continuous narrowband electromagnetic fields.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 11452. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 11452 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

3 Terms and definitions

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

4 Test conditions

The frequency range of the BCI test method is a direct function of the current probe characteristic. More than one type of current probe may be necessary.

For testing automotive electronic systems, the applicable frequency range of the BCI test method is 1 MHz to 400 MHz.

The user shall specify the test severity level or levels over the frequency range. See annex D for suggested test severity levels.

Standard test conditions shall be those given in ISO 11452-1 for the following:

- test temperature;
- supply voltage;
- modulation;
- dwell time;
- frequency step sizes;
- definition of test severity levels.

For the calibrated injection probe method (6.2.2), the test signal quality criteria from ISO 11452-1 shall apply.

For the current monitoring probe method (6.2.3), none of the first five harmonics (up to 400 MHz) shall exceed – 9 dB relative to the carrier wave when a deviation of the device under test is observed. If this limit is exceeded, it shall be noted in the test report.

5 Test apparatus

5.1 BCI system

Bulk current injection 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 wiring harnesses of the device under test are passed. Immunity tests are carried out by varying the test severity level and the frequency of the induced disturbance.

5.2 Instrumentation

Figure 1 shows an example of a BCI measurement system set-up. When a battery is used, a charging source may be needed to achieve the specified test voltage.

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

The monitoring probe, or set of probes, shall be capable of operating over the test frequency range and shall be terminated in the load impedance at which it was calibrated.

Dimensions in millimetres

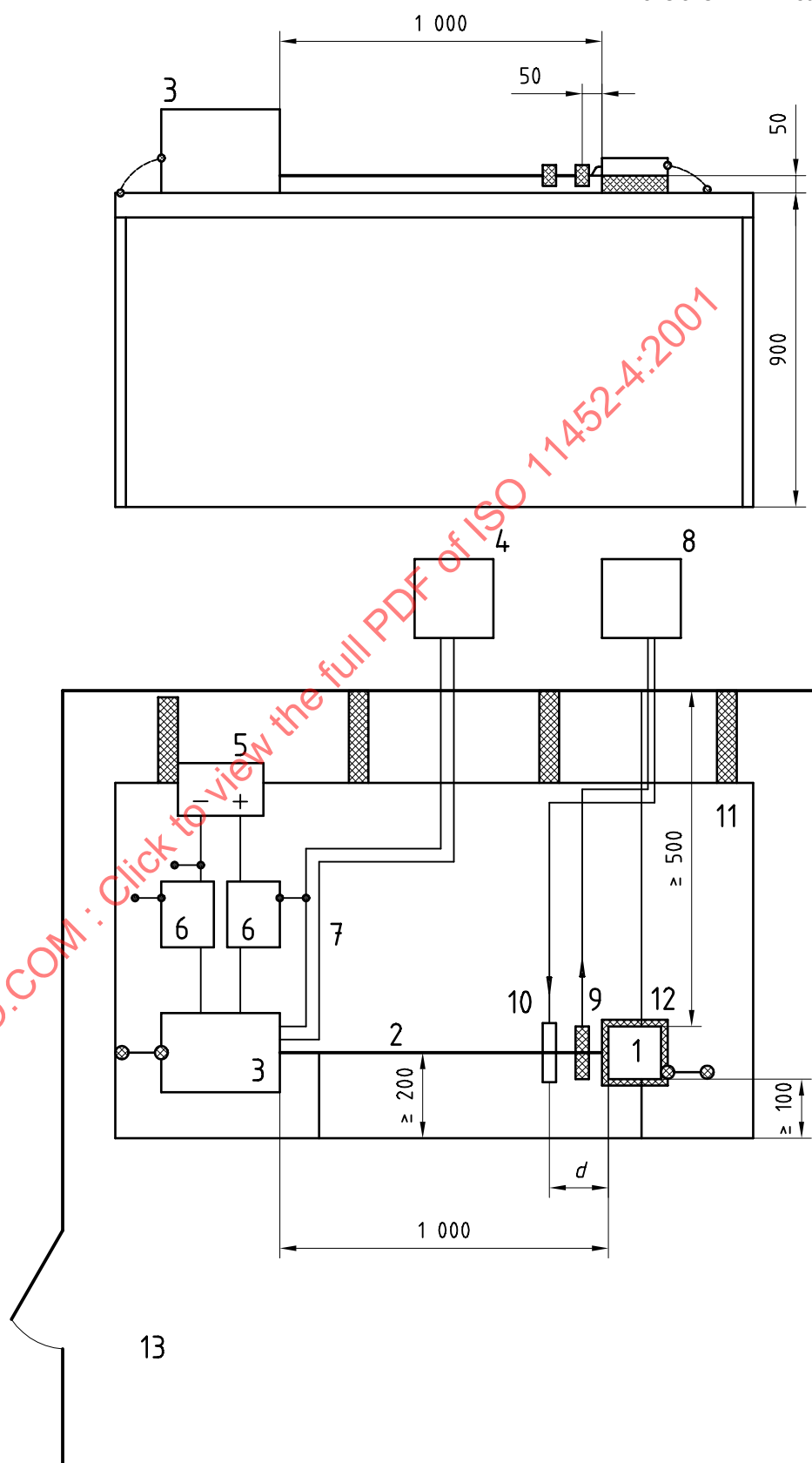


Figure 1 — Example BCI test configuration

5.3 Test set-up

5.3.1 General

The test shall be performed inside a shielded enclosure.

5.3.2 Test bench

The test bench shall have a ground plane made of copper, brass or galvanized steel, and have the following dimensions:

- thickness: 0,5 mm min.;
- length: 2 000 mm min. or that of the entire equipment plus 500 mm, whichever is larger;
- width: that of the equipment plus 200 mm on each side.

The ground plane shall be bonded to the wall of the shielded room at not more than 300 mm intervals to achieve a bonding resistance of less than 2,5 mΩ.

5.3.3 Installation of the device under test

See Figure 1 for example.

The device under test with associated test wiring harness and actual or simulated loads shall be tested. The length of the harness (between the device under test and load simulator) shall be $(1 \pm 0,1)$ m. The device under test, test harness and other peripherals which are part of the test shall be placed and arranged on the grounded test bench and connected to it according to its intended use in the vehicle. If no requirements are specified in the test plan, then the device under test shall be placed on a non-conductive material (50^{+10}_0) mm above the metallic surface of the table.

The front of the device under test shall be located at a minimum of 100 mm from the edge of the ground plane. The test harness shall be located at a minimum of 200 mm from the edge of the ground plane and placed on non-conductive supports (50^{+10}_0) mm above the ground plane. The harness shall pass concentrically through the centre of the current injection probe and all wires in the harness shall be terminated. When possible, the actual loads and actuators shall be used. If the return lead is remotely grounded, it shall be included in the coupling harness.

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

The artificial network (AN) or networks (see annex E for schematic) and the load simulator shall be placed directly on the ground plane. The AN case or cases shall be bonded to the ground plane. The load simulator case may be connected to the ground plane if called for in the test plan.

Power shall be applied to the device under test using a 5 μH/50 Ω AN. The grounding of the device under test will depend on its intended installation in the vehicle.

- If the device under test is remotely grounded (power return line longer than 200 mm), two artificial networks are required, one for the positive supply line and the other for the power return line.
- If the device under test is locally grounded (power return line 200 mm or shorter), only one AN is required for the positive supply line.

The artificial-network measuring port or ports shall be terminated with a 50 Ω load. The power supply return shall be connected to the test bench ground plane (between power supply and AN or ANs).

5.3.4 Device under test control actuation

The device under test shall be operated according to the test plan by actuators having a minimum effect on the electromagnetic characteristics (e.g. plastics blocks on the push-buttons, pneumatic actuators with plastic tubes). Connections to equipment monitoring electromagnetic interference reactions of the device under test may be accomplished by using fibre-optics or high-resistance leads. Other types of leads may be used but require extreme care to minimize interactions. The orientation, length and location of such leads shall be carefully documented to ensure repeatability of test results.

6 Test procedure

6.1 Test plan

Prior to performing the tests, a test plan shall be generated which shall cover the following:

- test set-up;
- frequency range;
- modulation;
- test method [calibrated injection (6.2.2) or current monitoring (6.2.3) probe];
- fixed or optimized position for current monitoring probe;
- device under test mode of operation;
- device under test acceptance criteria;
- definition of test severity levels;
- device under test monitoring conditions;
- device under test orientation;
- test report content (see 6.3);
- maximum forward power (for closed loop method only);
- any special instructions and changes from the standard test.

Each device under test shall be tested under the most significant situations: i.e. at least in stand-by mode and in a mode where all the actuators can be excited.

6.2 Test methods

6.2.1 General

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.

Two BCI test methods are specified: the calibrated injection (substitution) and current monitoring (closed-loop) probe methods. For both, the test equipment shall be connected in a manner similar to that shown in Figure 1.

6.2.2 Calibrated injection probe method

6.2.2.1 General

The calibrated injection probe method is based upon the use of net power as the reference parameter for calibration and test.

6.2.2.2 Calibration

The specific test level (current) shall be calibrated prior to the actual testing (see annex A).

6.2.2.3 Test of the device under test

The device under test is evaluated by subjecting it to the test signals based on the calibrated values 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. During the test, the net power shall be maintained relative to the calibration point up to a limit of a 2 dB increase in forward power. If the forward power has to be increased by 2 dB, this shall be indicated in the test report.

If the standing-wave ratio (SWR) in the test system can be demonstrated to be less than 1,2:1, then forward power may be used as the reference parameter to establish the test level.

To perform the test, mount the current injection probe around the harness (150 ± 10) mm from the connector or the outlet aperture of the device under test, or at an optimized position determined according to annex C.

When a harness containing a number of branches is used, the test should be repeated with the current probe or probes clamped around each of the branches, (150 ± 10) mm from the branch termination. Under these test conditions, the measuring probe, if used, shall be left at its previous distance from the device under test.

Using either the pre-calibrated level of net power (see annex A) or a relatively high level of fixed net power, search for the device under test immunity level using the following procedure.

- a) At each frequency, increase the level, linearly or logarithmically, up to the chosen test level. The rate of increase of the test level shall be controlled so that excessive overshoot does not occur. The test level parameter is field strength, voltage, current or power, as applicable to the particular test.
- b) Maintain the test level for the minimum response time needed to exercise the device under test (exposure time shall be 1 s minimum).
- c) Decrease the test level by at least 20 dB before moving to the next frequency. The rate of decrease of the level shall be controlled to avoid unreproducible susceptibilities.

NOTE Turning off the signal generator can cause unreproducible susceptibilities of the device under test.

- d) Move to the next frequency.

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

A current monitoring probe may be mounted between the current injection probe and the device under test.

The use of a current monitoring probe is optional; it can provide extra, useful information during investigative work on the causes of events and the variances in test conditions after system modifications.

6.2.3 Current monitoring probe method

This method uses an induced current value as the reference parameter, measured (50 ± 5) mm from the device under test with a current monitoring probe. Prior to the test, ensure that none of the first five harmonics (up to 400 MHz) exceeds – 9 dB relative to the carrier wave.

Use annex B to establish the relation between the current monitoring probe output voltage and its input current (the transfer impedance).

Perform the test as follows.

- a) Mount the current monitoring probe around the harness (50 ± 5) mm from the device under test.
- b) Mount the injection probe around the harness in positions at each of the following distances from the device under test:
 - 1) 120 mm,
 - 2) 450 mm, and
 - 3) 750 mm,or at an optimized position according to annex C and the test plan.
- c) At each injection probe position, conduct a search for events over the frequency range of the injection probe. Record all events found. For each event, record as the threshold of immunity the lowest induced current measured by the current monitoring probe.
- d) Continue the search for events by incrementing the power level until the specified maximum induced current level, or the maximum forward power to the injection probe specified in the test plan, is reached.

Record the stop criterion in the test report.

6.3 Test report

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

If the optimized injection probe position method is used, the test report shall include the distance between the injection probe and the connector of the device under test and the curve or curves representing the optimized transfer impedance.

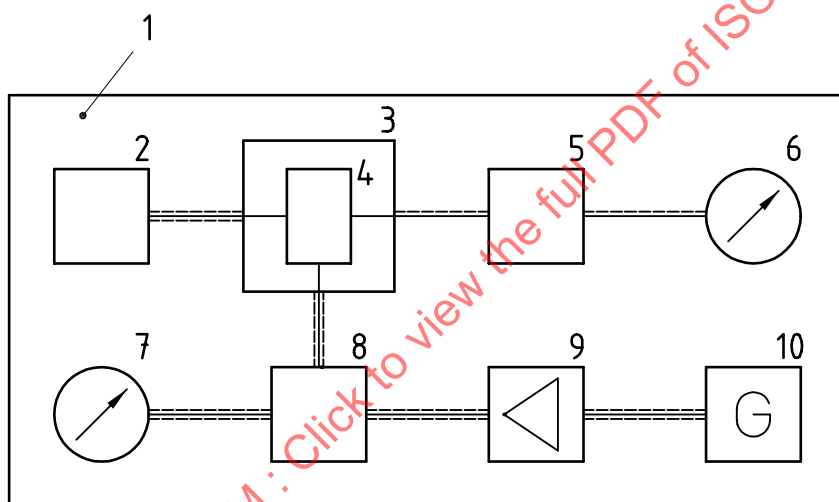
Annex A (normative)

Current injection probe calibration

A calibration fixture is used to determine the injected current. Figure A.1 shows an example of a test equipment configuration for the current-injection probe calibration.

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

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

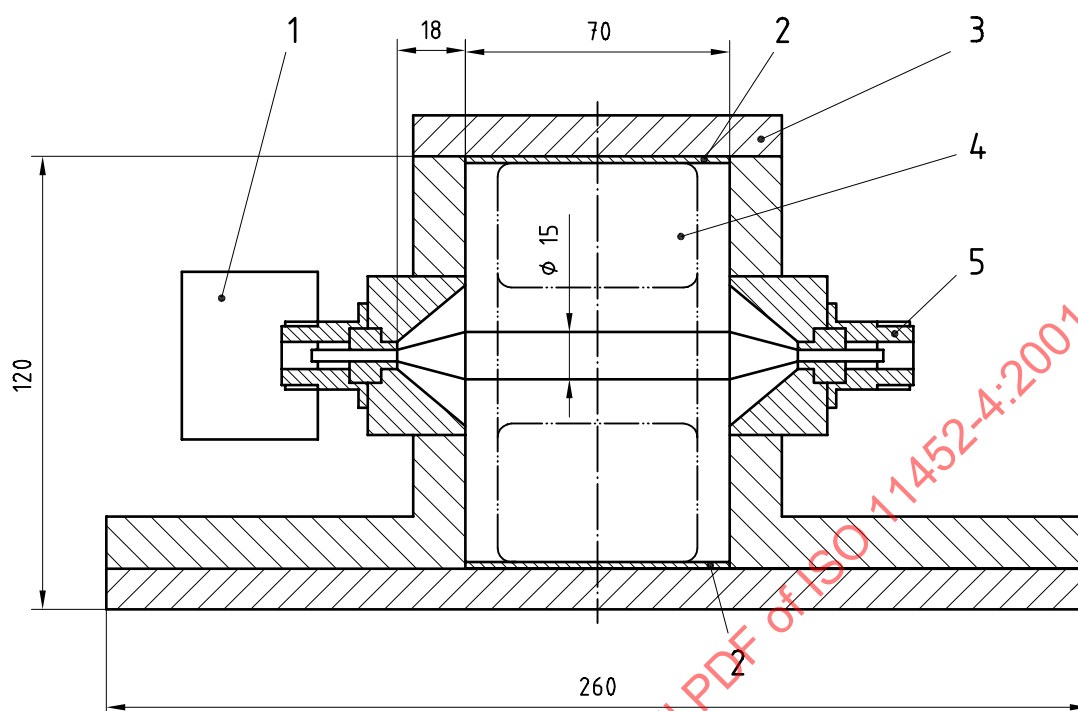


Key

- 1 Shielded enclosure
- 2 50 Ω coaxial load, VSWR 1,2:1 max.
- 3 Calibration fixture
- 4 Current injection probe 50 Ω
- 5 50 Ω attenuator
- 6 Spectrum analyser or equivalent
- 7 RF power level measuring device or equivalent (two are needed)
- 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 — Block diagram of current injection probe calibration configuration

Dimensions in millimetres

**Key**

- 1 50 Ω load
- 2 Insulation
- 3 Detachable metallic cover plate
- 4 Current injection probe
- 5 Connected directly to 50 Ω measuring instrument

Figure A.2 — Example of current injection probe calibration fixture

Annex B (normative)

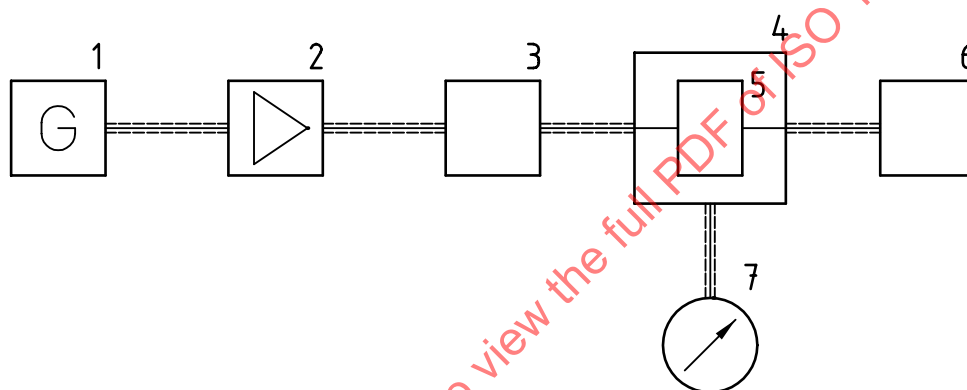
Current monitoring probe calibration

Use this calibration procedure to quantify the transfer impedance of the current monitoring probe.

Mount the monitoring probe in the appropriate size calibration fixture with the probe concentric about the centre conductor of the fixture (see Figure B.1).

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

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



Key

- 1 RF signal generator
- 2 Broadband amplifier with 50 Ω output impedance
- 3 Dual directional coupler with power meters
- 4 Calibration fixture
- 5 Monitoring probe being calibrated
- 6 RF termination 50 Ω (VSWR 1.2:1 max.)
- 7 Measuring instrument

Figure B.1 — Block diagram of current monitoring probe calibration configuration

Annex C (normative)

Optimization of the injection probe position

This optimization relates to the transfer impedance, Z_t . The transfer impedance of the injection probe is, in ohms, the ratio between the voltage applied to the probe and the current injected into the harness (measured according to the prescribed standard).

The measurement of Z_t may be made using a network analyser or spectrum analyser fitted with a tracking generator. The transfer impedance of each probe shall be taken into account to determine Z_t .

The position of the injection probe is optimized once the variation of the Z_t function of the frequency (throughout the whole frequency range) is as maximally flat as possible. In this case, Z_t can be found between $50 \Omega < Z_t < 300 \Omega$. The Z_t curve obtained in this way over the frequency band shall be given in the test report. In order to respond to the optimization criterion, the injection probe may be placed in different places over the harness in accordance with the different frequency bands. Corresponding positions shall also be indicated in the test report. For the high impedance components, the value of Z_t may be greater than 300Ω , whatever the injection probe position, in which case the maximum flatness of the Z_t curve shall be researched.