IVECO Standard

TESTING STANDARD

RESISTANCE OF ELECTRONIC DEVICES TO THE DISTURBANCES OF IRRADIATED TYPE "RADIATED SUSCEPTIBILITY THROUGH ANTENNAS" METHOD

16–2098

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Origin:
ISO WD 11451 PART 2

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1 PURPOSE

Defining test equipment and methods to verify at test bench the resistances of electronic devices to irradiated electromagnetic disturbances.
Purpose of the test is the preliminary setup of electronic devices from the point of view of immunity to electromagnetic fields irradiated from the outside.

2 SUBJECT

This standard is valid for equipment installed on vehicles with a 12–V and 24–V electric system, fitted with "OTTO" or "DIESEL" cycles internal combustion engines.

3 GENERAL TEST CONDITIONS

3.1 The tests must be carried out on electronic devices that have already passed the functional checks mentioned in IVECO STD. 18–2252 and in the special specifications.

3.2 Test environment

Measurement is carried out in a semianechoic chamber (for simulating free space) on systems installed on bench with a preset layout, in the most precise way in order to guarantee repeatability of results.

Edition	Date	Description of modifications	Group
1	13.09.1993	New.	PEL
2	01.12.1993	Point 4.2.2 modified	
3	25.10.1999	Point 3.6, 4.2.1, 4.2.2, 6.8.3, 6.8.4, 8.2 and Figure 3 modified.	
4	10.08.2001	Completely revised.	
5	03.03.2006	Added: Supervisor and Manager. Modified frequencies at points: 3.5, 3.6. Modified points: 4.2.2, 6.8.1, 6.8.2, 6.8.3, 8.2, 9 and 10. Editing modifications.	

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3.3 **Test environment type**

a) Chamber whose dimensions are such as to contain the structures (antennas and related accessories) and bench that has a minimum size of 2 x 1 m.
Indicative dimensions for the internal volume which can be used are:

- Length: 6 m;
- Width: 4 m;
- Height: 3 m.

b) Test environment must be free from noises that can affect test results.

c) The test chamber must be of the anechoic or semianechoic screened type in order to protect operators against electromagnetic fields generated during radiated susceptibility checks.

d) Minimum screening attenuations of the chamber, required against electromagnetic field are as follows:

- Electric fields: 10 KHz – 10 GHz: 100 dB
  10 GHz – 18 GHz: 90 dB
- Magnetic fields: at 10 KHz 60 dB
  at 200 KHz 80 dB

e) Minimum reflection attenuation required for anechoic material is as follows:

- 30 dB at 200 MHz;
- 50 dB at 1 GHz;
- 40 dB at 18 GHz.

f) Environmental climatic requirements:

- Temperature: 23 ± 5 °C.
- Relative humidity: 45 – 70 %.
- Atmospheric pressure: 860 – 1060 mbar.

3.4 **Test voltage**

Refer to the values given in **Table I**.

TABLE I

VOLTAGE	FOR 12 V SYSTEMS (V)	FOR 24 V SYSTEMS (V)
UA	13.5 ± 0.5 V	27 ± 1 V
UB	12 ± 0.2 V	24 ± 0.4 V

Where:

UA = System voltage (engine ON)

UB = Battery voltage (engine OFF)

3.5 **Test frequency range**

est range from 80 MHz to 2 GHz.

3.6 **Test levels**

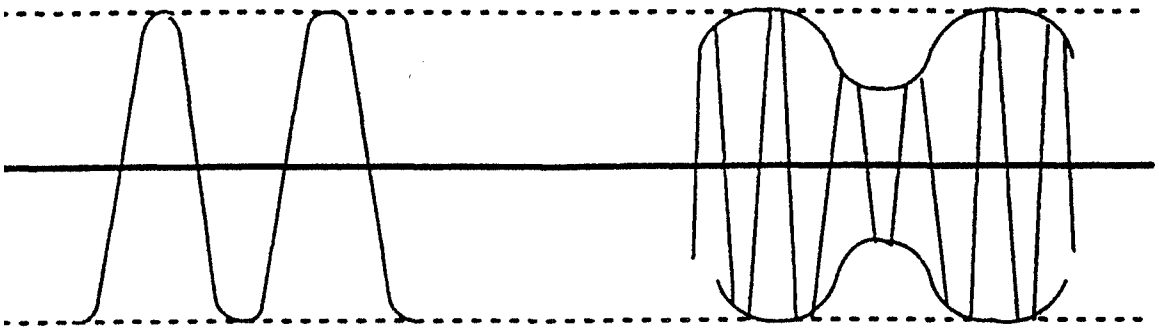
The test must be carried out within the frequency range and with the following limits:

– Frequency range:		80 MHz – 18 GHz (★)	
– Modulation type:	(★★)	Amplitude (A.M.)	80–800 MHz
	(★★★)	Pulse (rectangular)	800 MHz–18 GHz
– Modulation frequency:		400 Hz or 1000 Hz	(200 Hz for pulse one)
– Modulation index:		0 – 80 %	(100% for pulse one)
– Duty–cycle:		1/8 for pulse modulation	
– Field intensity:		200 V/m	
– Frequency change:		Logarithmic or linear	
– Points per decade:		100, or 1 MHz linear steps up to 200 MHz, 2.5 MHz up to 500 MHz, 5 MHz up to 1 GHz, 10 MHz up to 2 GHz, 50 MHz up to 5 GHz, 100 MHz up to 18GHz	
– Permanence time:		2 s at least for each frequency or the time necessary to check correct operation of device under test.	

(★) Only if 80 MHz–200 MHz and 2–18 GHz range is required.

(★★) If a test is required, use the module signal in amplitude instead of in CW conditions, peak to peak value of the electric field must however be:

E (CW peak) = E (AM peak)



CW AM

FIGURE 1

Relations between generated powers will be equal to:

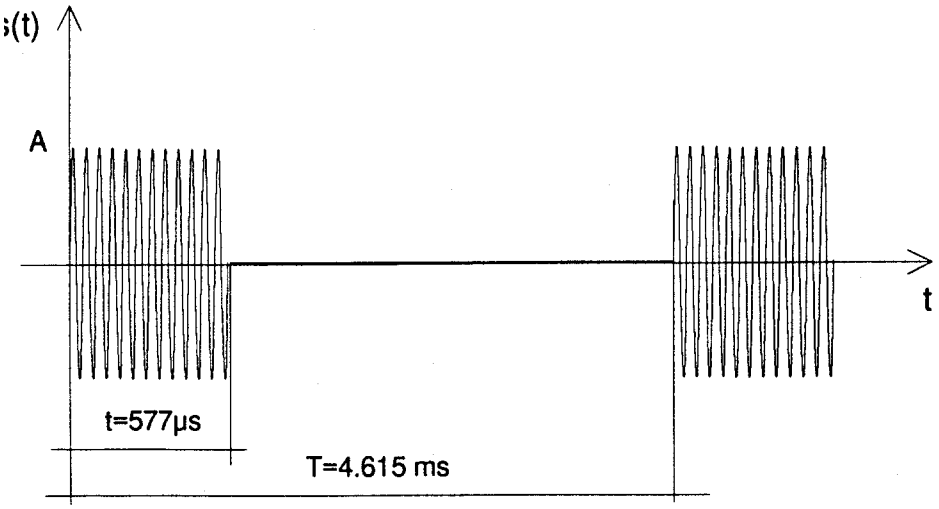
$$\frac{P\,(AM)}{P\,(CW)} = \frac{((1 + m^2)E^2)}{2} = \frac{E^2}{2} = \frac{(1 + m^2)}{2} \cdot \frac{E^2}{E^2} = \frac{(1 + m^2) : 2}{(1 + m)^2}$$

$$P\,(AM) = \frac{(2 + m^2)E^2)}{2(1 + m)^2}\,P\,(CW)$$

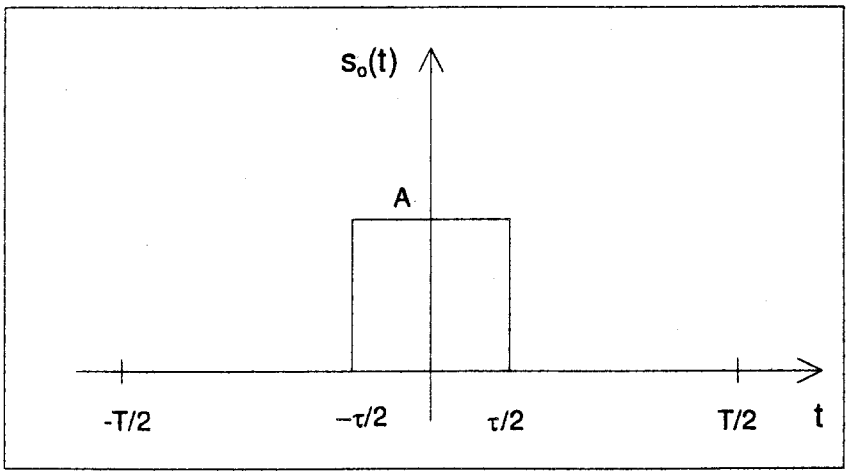
for m = 0.8 (AM 1 KHz 80 %) will result:

P (AM) = 0.407 P (CW).

(★★★) In the test range wherein the pulse modulation shall be used.
Irradiated RF signal, indicated with s(t), is of the CW packet type (carrier in the 890–915 MHz band) amplitude A, length τ = 577 μs and repetition frequency f_r =217 Hz as shown in the following diagram.



$s_o(t)$ envelope of s(t) is a rectangular wave with fundamental period T = 4.615 ms and duty cycle 1:8 as shown in the following diagram.



$$S(f) = A\frac{\tau}{T}\sum_{n=-\infty}^{+\infty}\frac{\sin(\pi\tau f)}{\pi\tau f}\delta(f - nf_r)$$

As shown in the equation, transmitted signal spectrum (in base band) consists of lines set at f_r multiple frequency values, having sin (x)/x type amplitudes.

3.7 Electric field uniformity

A ± 3 dB electric field uniformity with respect to central point (see **Figure 3**) must be guaranteed in the volume equal to a parallelepiped with dimensions 1000 x 200 x 200 and containing cable harness.

4 FUNCTIONAL CLASSES AND FAILURE CLASSIFICATIONS

4.1 Functional class classification

– *CLASS A:* All device functions comply with requirements both during and after the test.

– *CLASS B:* All device functions comply with requirements both during and after the test; however, one or more of them can be out of tolerance within the limits required by the special Specification or by the Product Specification.

– *CLASS C:* A function of the device can be in failure, but it automatically returns to its characteristic value at the end of the disturbance through an autoreset function that brings the device back to conditions that are complying with present parameters.

– *CLASS D:* A function of the device can be in failure and it does not return to its characteristic value at the end of the disturbance unless it is reset from the outside.

– *CLASE E:* One or more device functions can be in failure both during and after the test. These functions do not return to their characteristic value at the end of the disturbance, so that the device is not repaired or replaced.

NOTE **:** *Irreversible failures (FUNCTIONAL CLASS E) are not admissible on tested devices, subjected to the maximum test level.*

4.2 Failure classification and related test levels

4.2.1 *Failure classification*

With respect to the subfunctions carried out on the component/system, the following failure classification is provided:

– **P**: Priority failure that affects vehicle control, perceivable by the Driver or other road user, or that generates operation alterations which could cause confusion to other road users.

– **NP**: Non–priority failure that does not affect vehicle control or secondary functions for the examined system.

These classifications will be defined on the relevant product specifications.

4.2.2 *Test levels*

The test shall be carried out at 200 V/m, with 80 – 800 MHz amplitude odulation and 800 MHz – 2 GHz pulse modulation. Over 2 GHz tests are optional.

5 CHECK METHODS

5.1 Gauging of tested areas when system is absent

It consists in acquiring the power curve irradiated by the transmitting antenna necessary to generate, in the chosen measurement point, an electric field whose intensity is known and constant.
This reference curve allows, during checks on the component, and provided it is in the same radiation conditions, to return to the “loadless” value of the electric field through reading only the irradiated power, (net power) since the quadratic ratio linking the electric field with antenna power stands always valid.
By the term “power control” it is normally meant the feedback method applied on the gauging curve.
Gauging must be carried out in a really anechoic area of the screened test room.

5.2 Gauging procedure

Field meter must be placed at the same point where the wiring center point of the system under check after it is installed on the bench, gauging must be performed in free space.

The transmitting antenna must be set at a distance of 1 m from gauging point (where is situated electromagnetic field sensor).
Antenna maximum radiation direction must be: at right angles with tested system cable harness, parallel to ground plane and intersecting the field sensor center.
The place for horizontal and vertical polarizations must be gauged with a continuous signal (C.W.).
Calibration can be used for all the following checks provided of assuring always the same layout of the device being tested and of the transmitting antennas.

6 TESTING EQUIPMENT

6.1 Transmitting antennas

They must allow obtaining, in the test frequency band, the specific electromagnetic field intensity and uniformity in previous points 3.5, 3.6, and 3.7.
Typical antennas for these frequency bands are: Log–periodic, horn and logarithmic loop.
The distance between the radiant element and the anechoic material must never be less than 1 m and not less than 1.5 m from the chamber walls.

6.2 Isotropic electromagnetic field meters

They must carry out electromagnetic field surveys in the frequency range between 100 MHz – 18 GHz.
They must be fed by internal batteries and fitted with an optical fiber output for remote indication.

6.3 Ground plane

Sheet of material with a high electrical conductivity (copper, brass, aluminium), minimum thickness 1 mm, minimum dimensions 1 x 2 m.

6.4 Test bench

In insulating material (wood) with adequate dimensions for containing the ground plane.

6.5 Stimulating and monitoring system for the device being tested

a) It must allow the correct operation of the system being tested in normal conditions of use, as provided by the drawing or the related specification.

b) It must be capable of correctly interfacing with the system under test sensors and actuators, without altering their functional electric characteristics (impedances).

c) It must not be sensitive to electromagnetic fields generated inside the anechoic screened chamber.

To comply with the above mentioned requirements, the system must be made up as follows:

6.5.1 *Stimulating system*

– Instrumentation for generating sensor stimulating signals.

– Stimulating signal transmitting unit with electro–optical conversion.

– Signal reception unit with opto–electrical conversion.

– Injection devices of stimulating signals to sensors.

– Optical fibers connecting transmission and reception units.

6.5.2 *Monitoring system*

– Signal transmitting unit for monitoring the operation condition of the system under test with electro–optical conversion.

– Reception unit with signal opto–electrical conversion for monitoring operation condition.

– Optical fibers connecting transmission and reception units.

– Monitoring instruments.

6.6 Power supply

Power supply with adjustable voltage between 40 V, 80 A, according to IVECO STD. 16–2108, with a 12 V, 70 Ah, 350 A battery as a backup (1 battery for 12 V tests, 2 batteries in series for 24 V tests).

6.7 Impedance stabilization network (L.I.S.N.)

It must be realized according to the wiring diagram in **Figure 2a** and have the impedance characteristics varying with frequency as indicated in **Figure 2b**.
It must also comply with the following requirements:

– The resistance between P and B terminals, when A and B terminals are short–circuited must not deviate by more than 10% from the theoretical curve shown in **Figure 2b** in the 100 KHz – 20 MHz frequency band.

– Capacity C must stand continuous voltages of at least 1500 V.

– Inductance L must stand test device feed current.

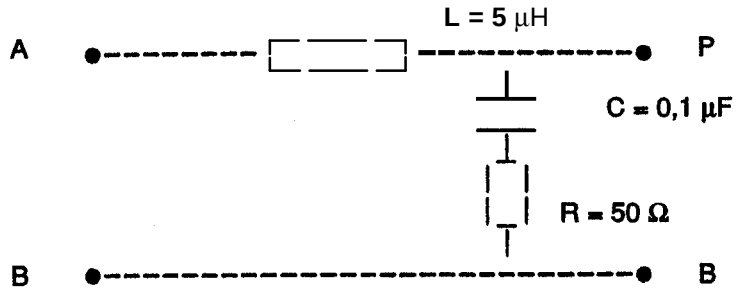


FIGURE 2a – IMPEDANCE STABILIZATION NETWORK (L.I.S.N.) – WIRING DIAGRAM

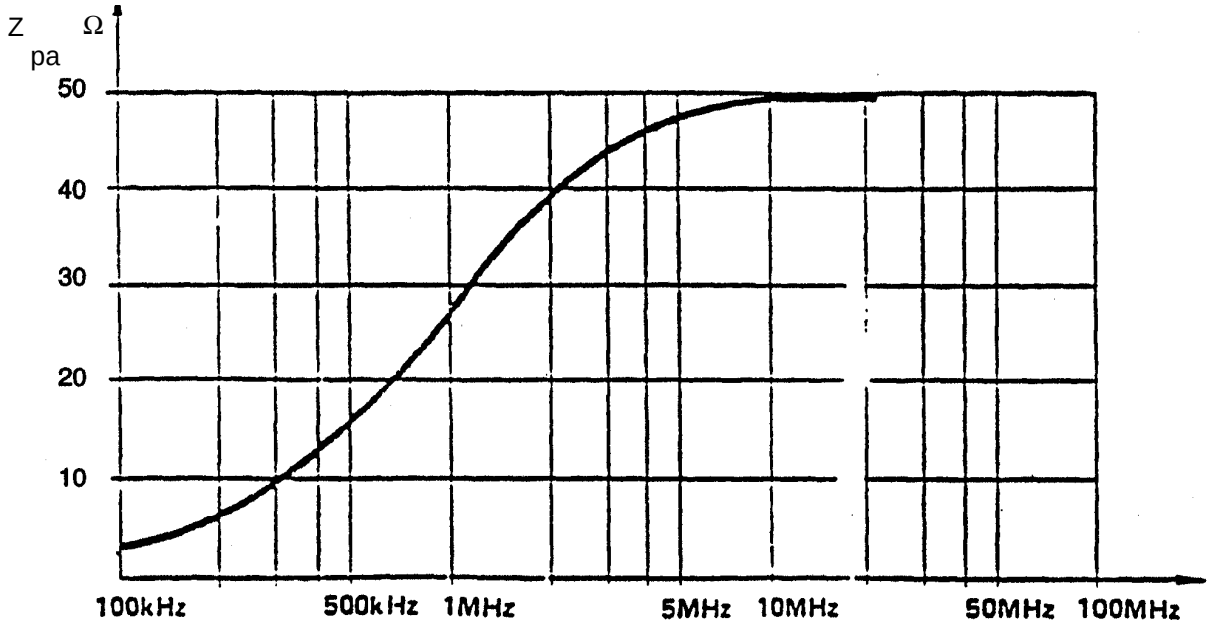


FIGURE 2b – IMPEDANCE MODULE BEHAVIOUR (A AND B TERMINALS ARE SHORT–CIRCUITED)

6.8 Radiofrequency generating/controlling system

Instrumentation must be situated outside the anechoic screened chamber and is composed as follows:

6.8.1 *Signal generator*

It must be able to generate sinusoidal signals in the frequency band from 80 MHz to 18 GHz, amplitude modulated with modulated index varying between 0 (absence of C.W. modulation) and 80%, with modulating frequencies (sinusoidal) of 400 – 1000 Hz and that can be modulated by pulses.

6.8.2 *Power amplifiers*

They must have the following technical characteristics:

- Minimum frequency band: 80 MHz – 18 GHz.
- Generated power adequate to obtain the electromagnetic field level (E.M.) required in point 3.6.
- Harmonics: at least 10 dB less than the fundamental frequency, for the whole operating band.
- Input power to obtain the maximum output power.
- Sensitivity: 1 mW (0 dBm) on a 50 Ω load.

6.8.3 ***Radiofrequency wattmeters***

They must have the following technical characteristics:

– Minimum frequency band: 80 MHz – 18 GHz.

– Measurement accuracy in the frequency band of at least ± 0.5 dB.

– Accepted input power: it must be compatible with the frequency coming out of the directional couplers.

6.8.4 ***Directional couplers***

They must have the following technical characteristics:

– Direct power measurement (with possibility of optionally measuring also the reflected power).

– Accepted input power: it must be compatible with the maximum power generated by radiofrequency power amplifiers.

– Measurement accuracy: ± 0.5 dB in the respective frequency bands.

6.8.5 ***Control and switching unit***

It must drive signal and power switches and radiofrequency amplifiers, coherently with the required test bands.

6.8.6 ***Electric field repeaters***

They must be with optical fiber input and indication, through digital or analogue display, of the measured quantity.

7 BENCH TEST CIRCUIT

Set tested circuit as shown in **Figure 3**, and lay on the bench with the ground plane the electronic system to be checked and the related wiring and provide connections as indicated in the specification or related drawing.
If standard production cable harness does not allow to perform the required layout, use a special cable harness.
The device under test must be positioned so as to make connector/s face the transmitting antenna.
If the device under test or any of the sensors or actuators is expressly designed to be directly connected to the frame, it must be connected to the ground plane in the shortest possible way.
Cable harness minimum length must be of 1 m except for connectors with a shorter length on the vehicle; in this particular case the length provided must be kept.
Each branch of main cable harness must be at a right angle (90° ± 15°) with respect to cable harness longitudinal axis.
Main cable harness height from ground plane must be 50 ± 10 mm, the distance of table edge facing the transmitting antenna must be 100 ± 10 mm.
Sensors must be stressed by means of the stimulating system described at point 6.5.
Signals considered as indicative of operating state of the checking device must be detected by means of the monitoring system described at point 6.5.2.
The transmitting antenna must be positioned as shown in the gauging procedure for tested place (see point 5). A net power proportional to the ratio square between the required EM field and that used as reference at gauging ($P = Pr \cdot (E/E_r)^2$) must be reinjected on the antenna, taking into account that during the test with amplitude modulation (AM), the injected power peak and not its effective value shall be considered.

BENCH TEST CIRCUIT IN ANECHOIC CHAMBER FOR CHECKING ELECTRONIC DEVICE IMMUNITY TO ELECTROMAGNETIC FIELDS

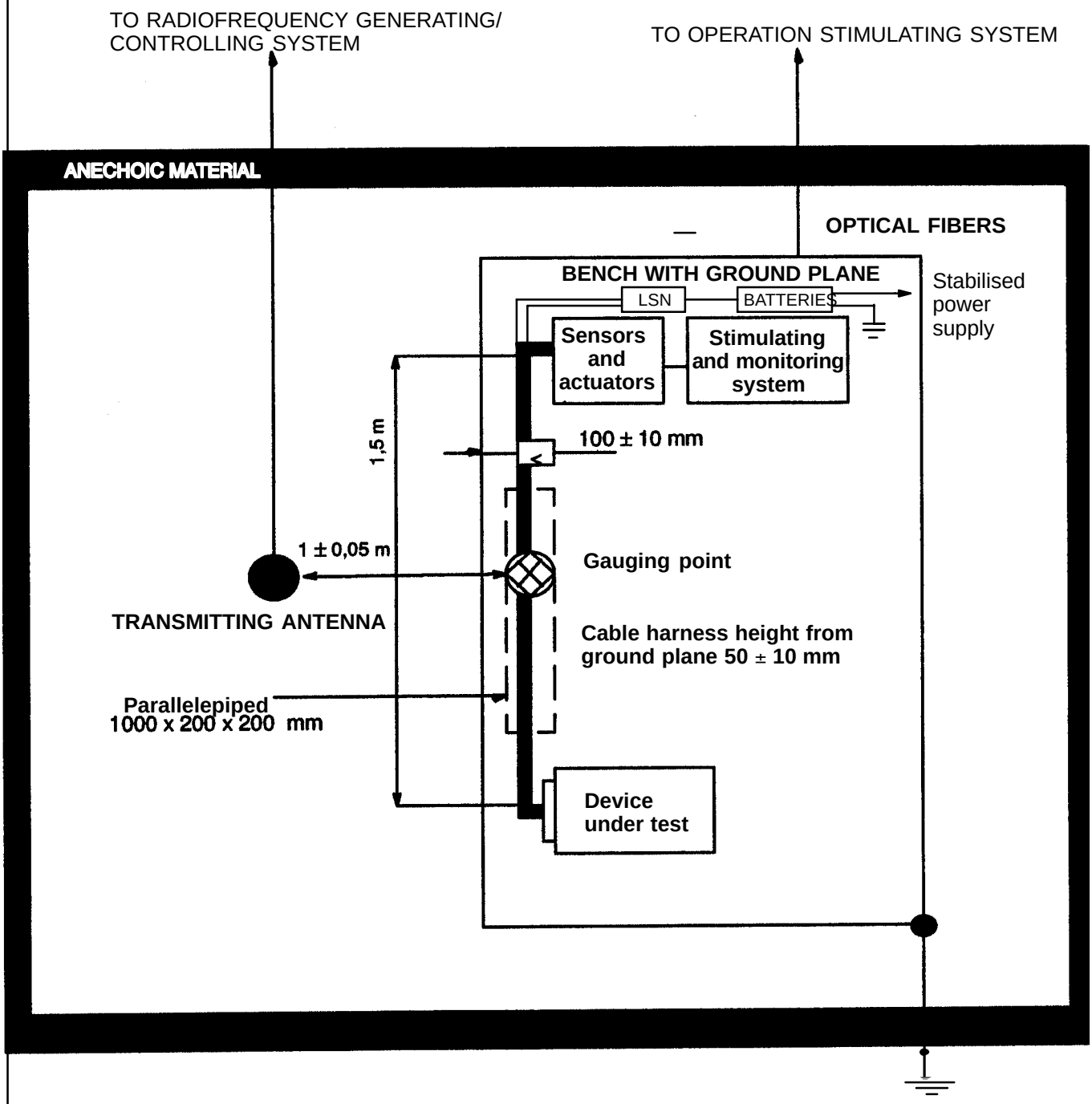


FIGURE 3 – ANECHOIC CHAMBER

8 TEST EXECUTION

8.1 Supply and activate the device under test as specified in drawing or in the related Specification

8.1.1 Adjust signal characteristics sent to transmitting antennas in order to obtain the electrical field intensity and test frequencies required in the Specification or in the related drawing.

8.1.2 Front radiation of the device under test and automatic frequency scanning at electric field levels, complying with frequency step and preset permanence times using different types of signal generators, power amplifier, and antennas coherently with the respective frequency bands.
For every generated frequency adjust amplitude of the signal produced by generator in order to obtain, at amplifier output, the necessary power (defined at gauging stage) for carrying out the required electromagnetic field.
If it is not possible to attain the required electromagnetic field intensity; maximum output power from amplifier must in any case be obtained.

8.2 Test summary table

SYSTEM POSITIONING	ON GROUND PLANE SUPPORTED BY THE WOOD BENCH
System operation conditions	Normal operation under the operating conditions imposed to vehicle.
Position of the antenna	Positioning towards bench axis of rotation with propagation direction according to chamber longitudinal axis. Distance from bench axis D : 1 m, for front radiation.
Test area gauging	In the absence of system, with the field sensor positiond on the bench positioned at a height of 1 m and at a distance of 1 m from antenna, along the chamber longitudinal axis, with front radiation.
Type of antenna used	Band 80–1000 MHz. Typically Log Periodic or Double Ridged. Band 1–18 GHz. Typically Horn.
Frequency bands	Band 1: 80–200 MHz (★) Band 2: 200–500 MHz Band 3: 500–1000 MHz Band 4: 1–2 GHz Band 5: 2–5 GHz (★) Band 6: 5–18 GHz (★)
Frequency step	Band 1: 80–200 MHz : 1 MHz Band 2: 200–500 MHz : 2,5 MHz Band 3: 500–1000 MHz: 5 MHz } or logarithmic with 100 points per decade Band 4: 1–2 GHz linear scanning with 10 MHz step Band 5: 2–5 GHz linear scanning with 50 MHz step Band 6: 5–18 GHz linear scanning with 100 MHz step
Frequency permanence	2 s or the time necessary to check correct operation of the device being tested.
Required qualification level	Band 80 MHz –18 GHz: see point 4.2.2.
Electric field polarization	Band 80 MHz –18 GHz: vertical (horizontal only if required by product specification)
Modulation type	Band 80 MHz – 800 MHz: AM modulation at 1 KHz, 80% depth Band 800 MHz – 18 GHz: pulse modulation Modulation frequency: 200 Hz Modulation index: 100 % Duty–cycle: 1/8
System radiation	Band 80 MHz –18 GHz: Front
Test methods	Automatic frequency scanning with closed ring check of radiated power on the basis of gauging curve. Manual search of susceptibility limits.

(★) Only if expressly required for functional purposes of the Product Specification.

9 ACCEPTABILITY LIMITS

The relevant functional class (A – B – C – D – E) achieved by the product being examined during **electric field radiation** shall be compliant with or higher than what specified for all the test levels or by the related product specification.
In case of device malfunctioning, carry out a manual detection of minimum levels **electric field** at which the device restarts regular operation (susceptibility limit detection).

– From 0 to 100 V/m no defect tolerated.

– From 101 to 150 V/m some non–priority functions can be out of tolerance but they shall return automatically to conformity levels as soon as disturbance disappears.

– From 151 to 200 V/m some priority functions can be out of tolerance but they shall return automatically to conformity levels as soon as disturbance disappears.

10 PRODUCTION OF RESULTS ACCORDING TO THE RELEVANT FUNCTIONAL CLASS ACHIEVED

Types of anomalies found must be shown for every system being verified, for every test condition and for every test level, the **electric field/frequency** diagrams representing the susceptibility curves and the achieved relevant functional class (A – B – C – D – E). Product functions being examined must comply with the tabulated prescriptions.

LEVEL	CLASS ACHIEVED	RESULTS/REMARKS
0 – 100 V/m	A	No defects, both during and after disturbance
101 – 150 V/m	B	Non–priority function defect that resets automatically as soon as disturbance disappears
151 – 200 V/m	B	Priority function defect that resets automatically as soon as disturbance disappears

STANDARDS QUOTED

IVECO STD.: 16–2108, 18–2252.