RESISTANCE OF ELECTRONIC DEVICES TO THE DISTURBANCES OF IRRADIATED TYPE "STRIP–LINE" METHOD

Origin:
ISO WD 11451 PART 5

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1 SUBJECT

The present 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.

2 PURPOSE

Defining test equipment and methods to verify at the bench the resistances of electronic devices to irradiated electromagnetic disturbances.

3 GENERAL TEST CONDITIONS

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

3.2 **Test environment** (unless otherwise required)

a) Premises the dimensions of which are such as to contain the structuring and test bench with the Strip–line structure which has a minimum size of 5 x 4 m.

b) Test environment must be free from noises that can affect the test results and the Strip–line structure must also be duly protected (shielding) in order to obtain an adequate protection towards the outside.

c) Environmental climatic requirements:

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

Edition	Date	Description of modifications	Group
1	13.09.1993		PEL
2	01.12.1993	Point 4.2 modified	
3	28.08.1999	Modified: points 3.4, 4.2.1, 4.2.2, 5.5, 5.6.	
4	12.09.2001	Point 8 "Presenting results" modified and point 7 "Acceptability limits" added.	
5	03.03.2006	Added: Supervisor and Manager. Modified frequencies at points: 3.4, 5.1, 5.2, 5.5, 5.6. Modified points: 4.2.2, 7, 8. Editing modifications.	

3.3 **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)

3.4 **Test levels**

The test must fall within the frequency range and the following limits:

– Frequency range: 10 KHz – 400 MHz

– (*) Modulation type: Amplitude (A.M.)

– (*) Modulation frequency: 400 Hz or 1000 Hz

– (*) Modulation index: 0 – 80 % (**)

– Field intensity: 200 V/m

– Frequency change: Logarithmic/Linear

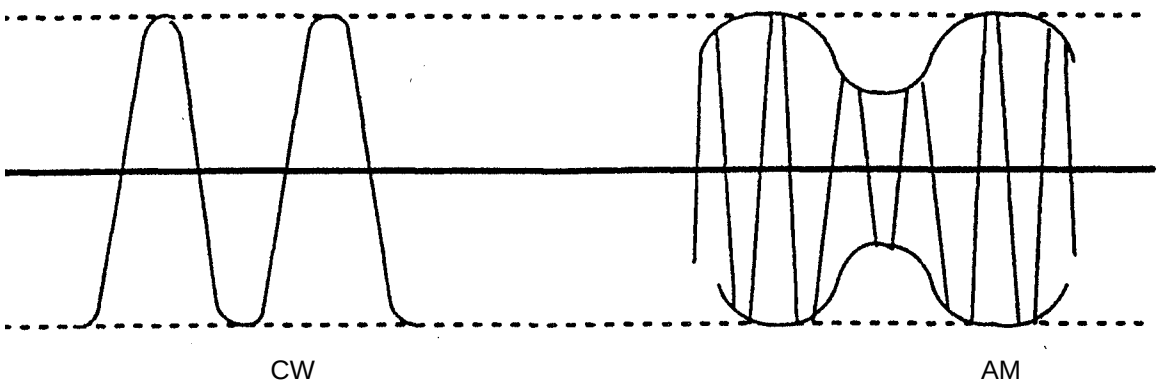
– Points for decade: 100, or 1MHz to 400 MHz with 1 MHz linear steps

– Permanence time: 3 s or the time necessary to check correct operation of tested device

(*) Only if required

(**) If a test is required, use the module signal in amplitude instead of that in CW conditions; peak to peak value of the electric field must in any case be:

E (CW peak) = E (AM peak)



CW AM

FIGURE 1

Relations between generated powers will be equal to:

$$\frac{P\,(AM)}{P\,(CW)} = \frac{((1 + m^2)E^2)}{2} = \frac{E^2}{2} = \frac{(1 + m^2)}{2} \cdot \frac{E^2}{E^2} = \frac{(1 + m2) : 2}{(1 + m)^2}$$

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

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

P (AM) = 0.407 P (CW).

4 FUNCTIONAL CLASSES AND FAILURE CLASSIFICATIONS

4.1 Functional classes classifications

– *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.
These functions however fall back into their characteristic value at the end of disturbance.

– *CLASS C:* A 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 into conditions complying with present parameters.

– *CLASS D:* One or more device functions can be in failure and do not return to their characteristics at the end of the disturbance, except with an external reset.

– *CLASS E:* One or more device functions can be in failure both during and after the test. These functions do not return to their characteristics when the disturbance ceases, 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 functions carried out by 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 defect.

These classifications will be defined on the relevant product specifications.

4.2.2 ***Test levels***

Carry out the test at 200 V/m from 10 KHz to 400 MHz with amplitude modulation with 1 KHz frequency modulation and 80% modulation index.

5 TEST EQUIPMENT

5.1 Test generator

It must be able to supply sinusoidal signals from 10 KHz to 400 MHz which can be amplitude modulated with a depth varying from 0 to 80% with sinusoidal frequencies from 400 to1000 Hz.
The accuracy of the generated frequency (carrier) must be ±1% and the harmonics or spurious signals must be at least 25 dB below the fundamental frequency.

5.2 Power amplifier

Frequency covering from 10 KHz to 400 MHz, generation of harmonics of at least 20 dB below the fundamental frequency.
Generated power of at least 150 W on 50 Ω resistive load on the whole frequency range.

5.3 Strip–line

Figure 2 gives the geometric dimensions and **Figure 3** shows an example of its termination.
Standing wave ratio (R.O.S.), measured at loadless Strip–line input, closed on a 50 Ω resistive load, must be less than 2:1.

5.4 Resistive load

50 Ω impedance, maximum dissipated power higher than power generated by R.F. amplifier.
Standing wave ratio (R.O.S.) less than 1.2:1.

5.5 Directional coupler

Measuring at the same time direct and reflected power: frequency band from 10 KHz to 400 MHz.
Input power compatible with maximum amplifier power.
Measurement accuracy ± 0.5 dB.

5.6 Radiofrequency wattmeter

Frequency band from 10 KHz to 400 MHz, input power compatible with maximum power generated by R.F. amplifier.
Measurement accuracy ± 0.5 dB.

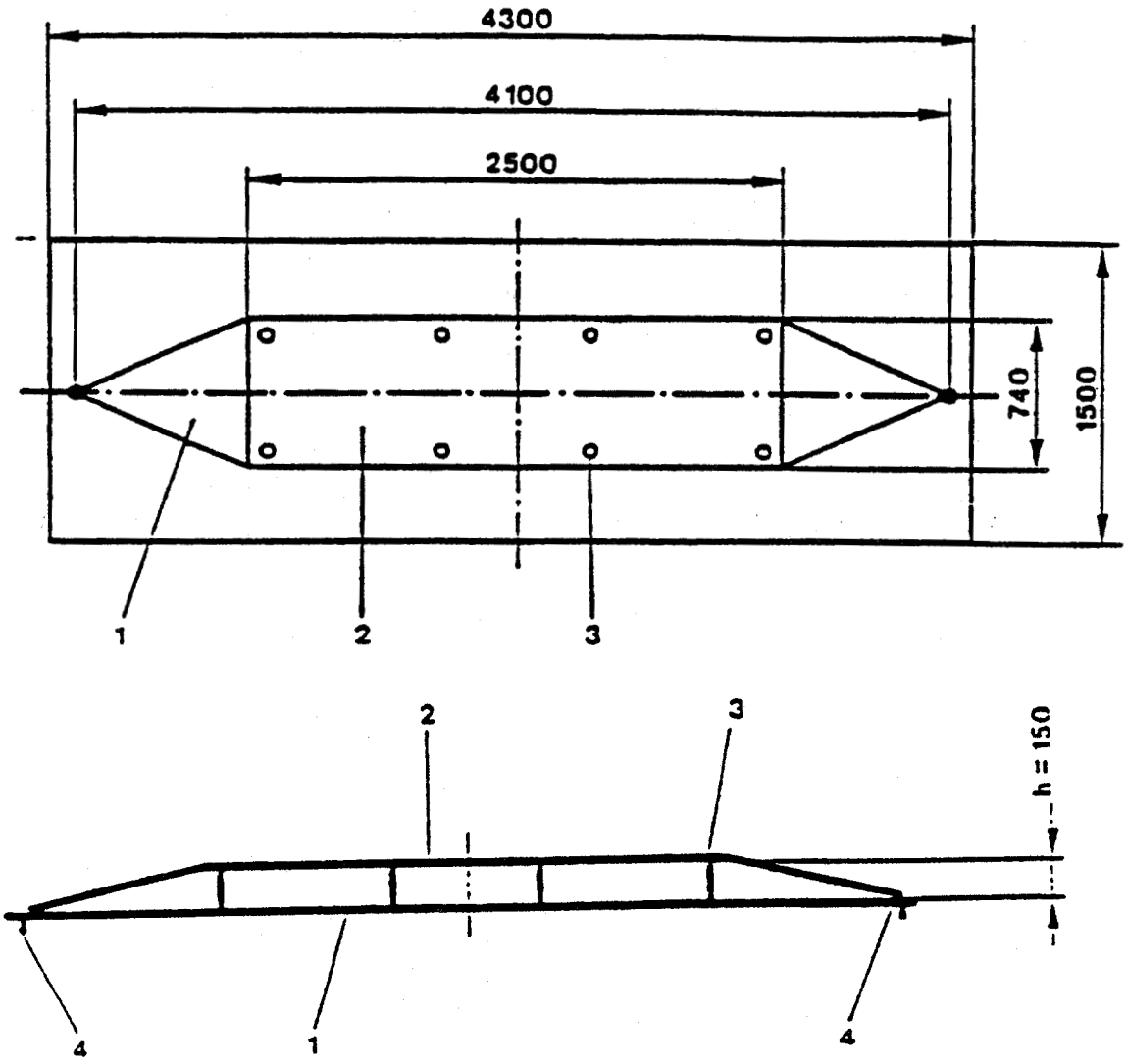


FIGURE 2 – STRIP LINE

Key:

1	Ground metal surface
2	Strip Line upper metal surface
3	Dielectric material support (e.g.: wood)
4	N type connector
h	Internal gap between ground metal surface and Strip Line upper metal surface

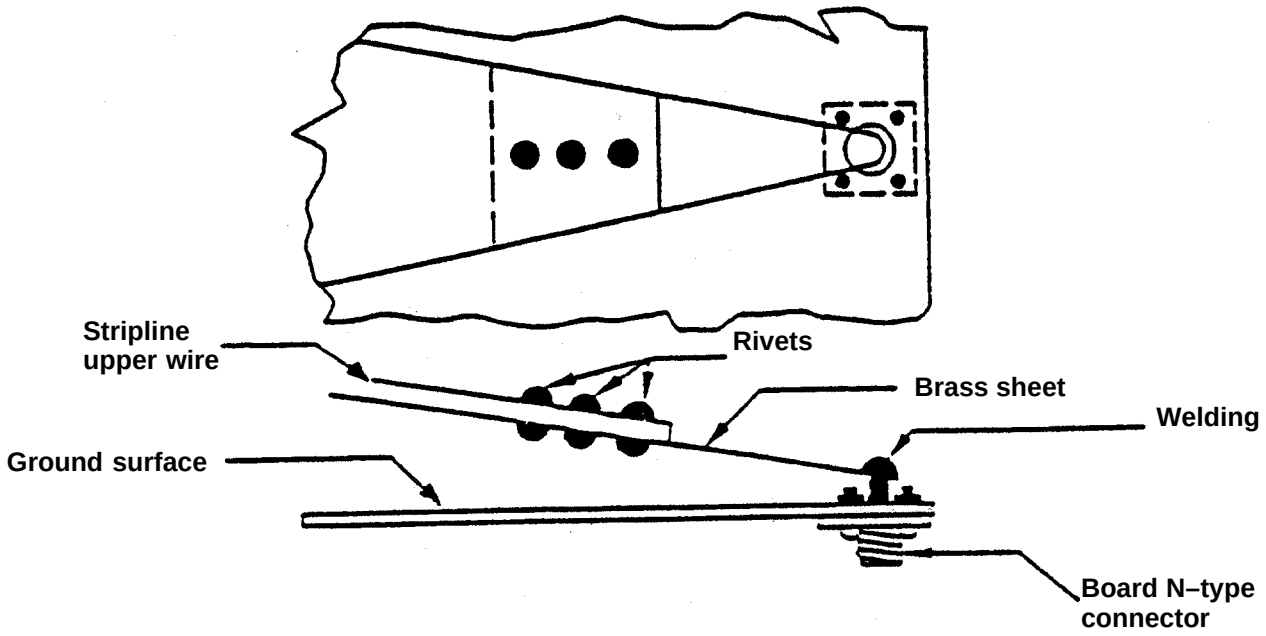


FIGURE 3 – EXAMPLE OF STRIP LINE TERMINATION

5.7 **Stimulating and monitoring system**

Simulator capable of reproducing the operation of the sensors and actuators making up the testing system.
This device must not alter its own set of signals even in the presence of disturbances circulating on cables connecting the system being tested.

5.8 **Test bench**

Test bench in insulating material (wood) of adequate dimensions for containing the Strip–line structure.

5.9 **Power supply**

Power supply with adjustable voltage between 0 V and 40 V, 80 A, according to IVECO STD. 16–2108 as a back–up to the 12 V, 70 Ah, 350 A battery (1 battery for 12 V tests, 2 batteries in series for 24 V tests).

5.10 **Artificial impedance network (L.I.S.N.)**

It must be realized according to the wiring diagram in **Figure 4a** and have the impedance characteristics varying as the frequency indicated in **Figure 4b** varies.
It must also comply with the following requirements:

– when A and B terminals are short–circuited the resistance between P and B terminals, must not deviate over 10% from the theoretical curve shown in **Figure 4b** in the 100 KHz – 20 MHz frequency band;

– capacity C must be able to stand a continuous voltage of at least 1500 V;

– inductance L must stand a 40 A maximum current.

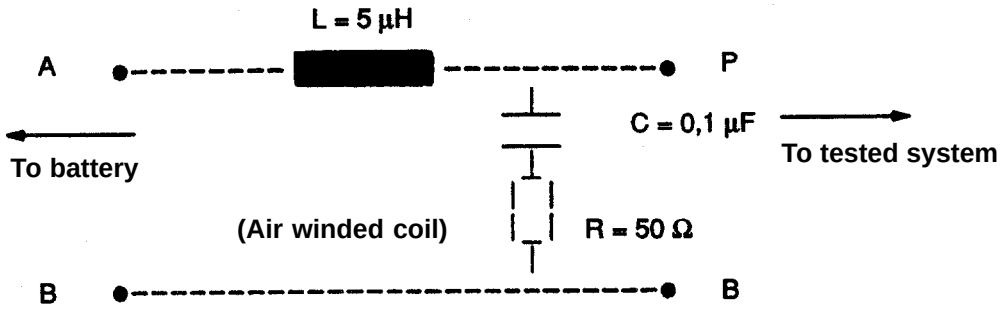


FIGURE 4a – IMPEDANCE STABILIZER LINE (L.I.S.N.) – WIRING DIAGRAM

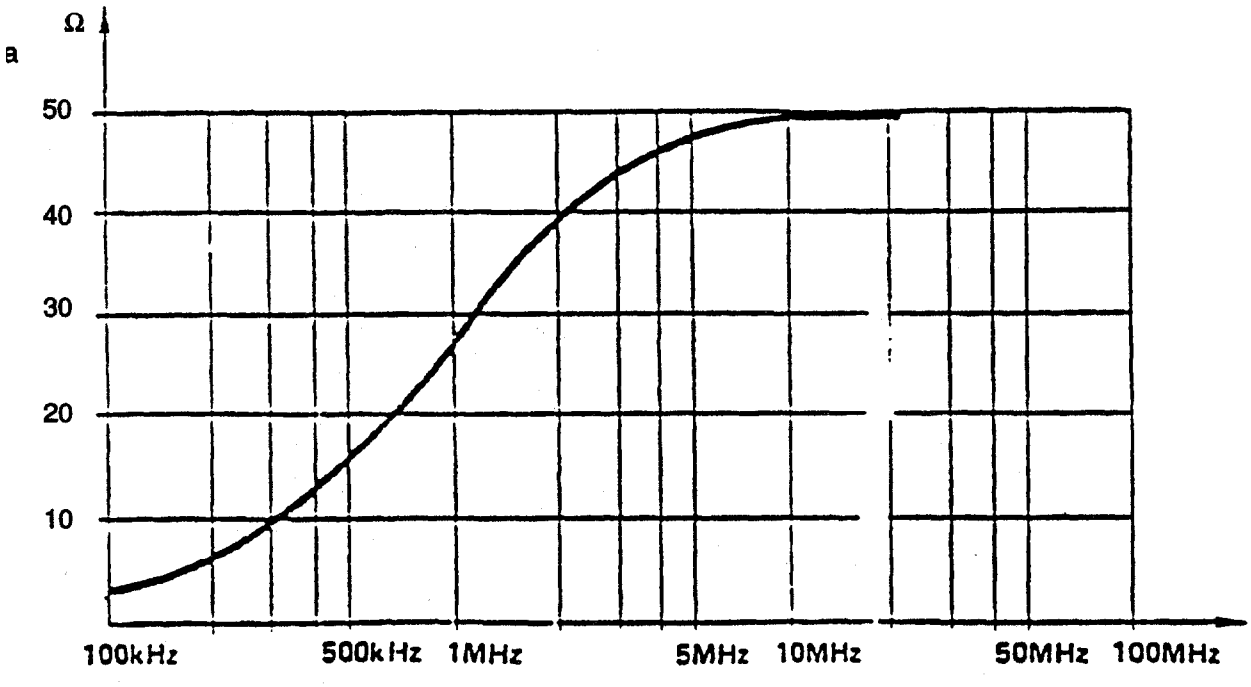


FIGURE 4b – IMPEDANCE MODULE BEHAVIOUR (A AND B TERMINALS ARE SHORT–CIRCUITED)

6 BENCH TEST CIRCUIT

6.1 Position: R.F. signal generator, power amplifier, Strip Line, 50 Ohm resistive load, directional coupler, wattmeter, L.I.S.N., power supply and stimulating and monitoring system as shown in **Figure 5**. Test instruments like: signal generator, amplifier, wattmeter, directional coupler, power supply and simulating and monitoring system must not be susceptible to the fields generated by the Strip Line structure. For this reason the Strip Line structure must be positioned inside suitable screening (Faraday cage).

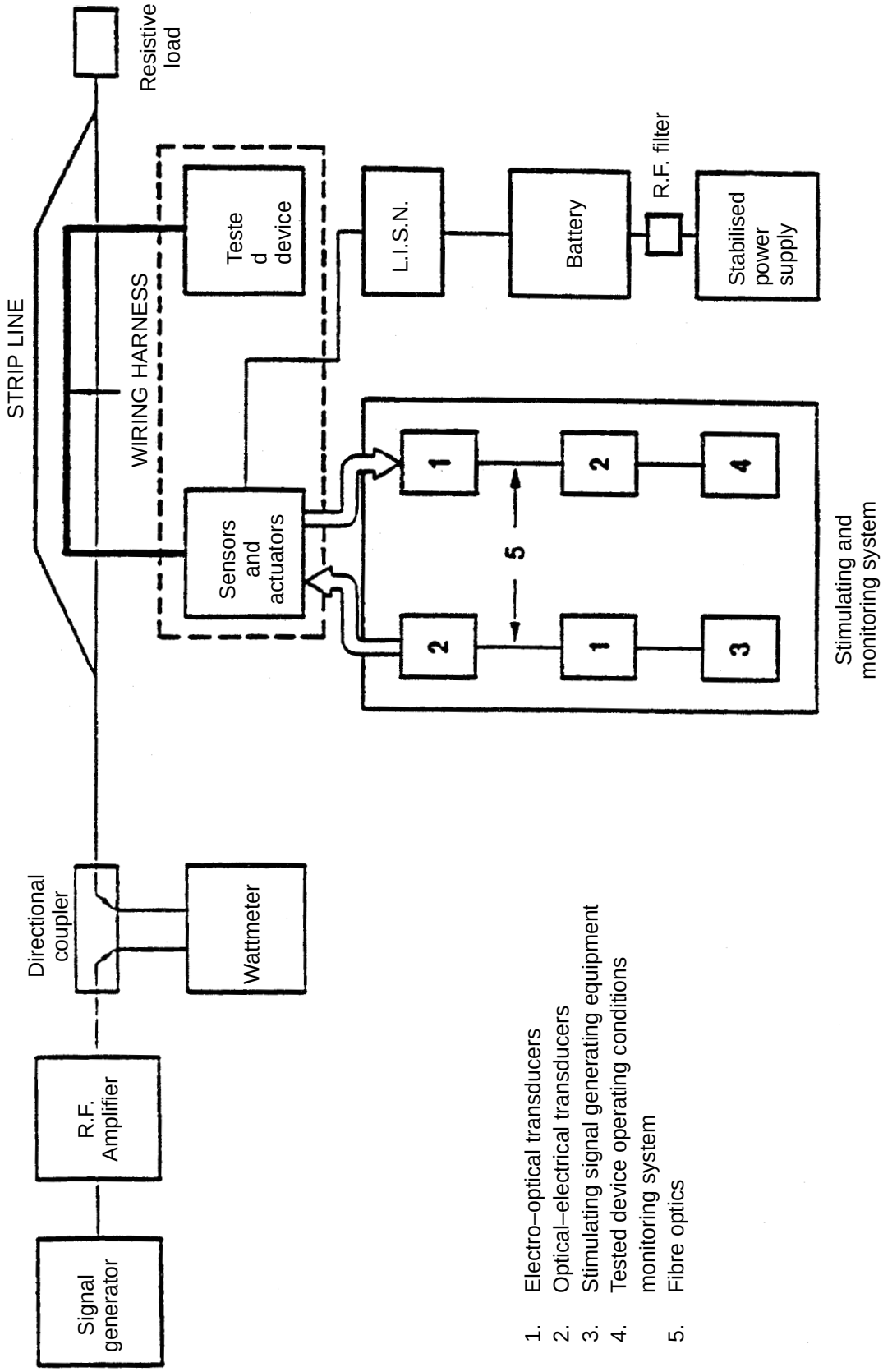


FIGURE 5 – TEST BENCH BLOCK DIAGRAM

6.2 Position the device being tested, the wiring, and the sensor and actuator set or the general–purpose simulator, as shown in **Figure 6**.

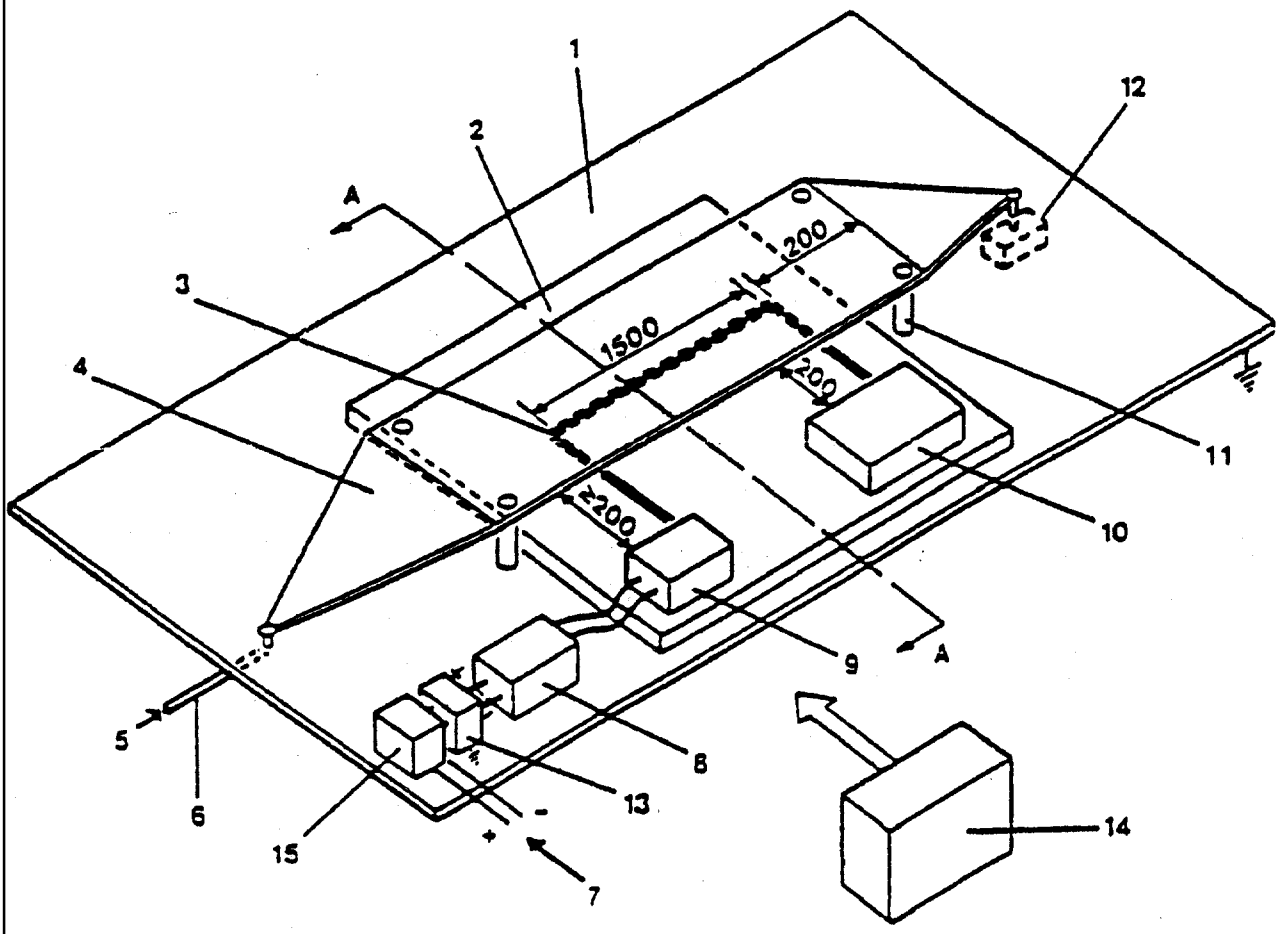
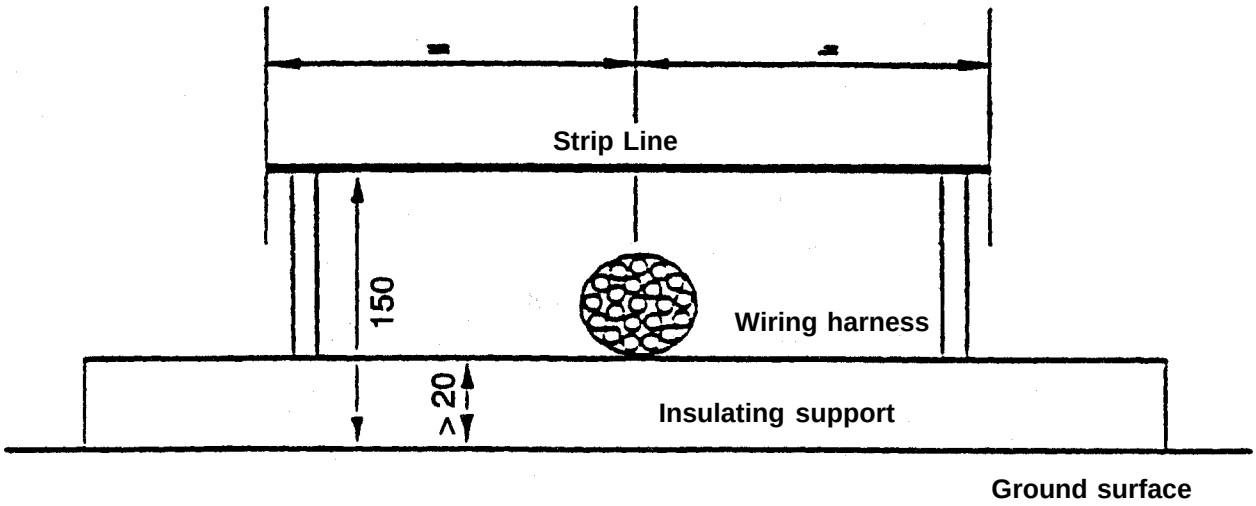


FIGURE 6 – EQUIPMENT LAYOUT

Key:

1	Ground metal surface
2	Insulating support
3	Tested device wiring harness
4	Strip Line
5	From medium frequency amplifier
6	Coaxial cable
7	From power supply
8	L.I.S.N.
9	Tested device sensors and actuators
10	Tested device
11	Insulating supports
12	50 Ohm resistive load
13	Battery
14	Stimulating and monitoring system
15	Radio frequency filter

6.3 Wiring harness shall be set straight inside the Strip Line for 1.5 m and it shall be resting on a dielectric material support of at least 2 cm (**Figures 6** and **7**). Wiring harness shall be positioned along the center line of the radiant structure.
The wiring harness section exceeding 1.5 m shall be positioned at 90 ± 15° with respect to the Strip Line and shall be resting on the same insulating support.
Should current production wiring harness be not suitable to comply with the specified position, use another wiring harness suitable to guarantee the required layout conditions.



NOTE: Dimensions are expressed in mm

FIGURE 7 – STRIP LINE CROSS SECTION

6.4 If the device being tested or any of the sensors/actuators is grounded in its normal installation on vehicle, this condition must be observed also in the bench test by realizing the shortest possible ground connection from the involved element to the ground plane.

6.5 Sensors must be stimulated through a suitable system or, if a general–purpose simulator is used, this must ensure actual sensors and actuators impedance characteristics.
During the test, fundamental signals for checking correct system operation must be monitored by means of optical links.

6.6 Supply and activate the device according to the test pattern indicated in the special Specification.

6.7 Adjust input signal characteristics of the radiant element in order to obtain the electrical field, test frequencies and modulation type required at point 3.4.
The electric field shall be calculated according to the following formula:

$$E = \frac{\sqrt{Pi - Pr\frac{R}{A}}}{h}$$

Where:

- E = Electric field strength in V/m
- Pi = Power measured by the wattmeter in W
- Pr = Reflected power measured by the wattmeter in W
- R = 50 Ohm load
- A = Power attenuation value (n < 1) provided by resistive attenuator (e.g.: 20 dB attenuator, A = 0,01)
- h = Gap between ground surface and Strip line upper wire in m (normal 0.15 m)

7 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 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.

8 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.