Council Directive 72/245/EEC of 20 June 1972 relating to the radio interference (electromagnetic compatibility) of vehicles (repealed)

[F1ANNEX IX

METHOD(S) OF TESTING FOR IMMUNITY OF ELECTRICAL/ ELECTRONIC SUB-ASSEMBLIES TO ELECTROMAGNETIC RADIATION

Textual Amendments

F1 Substituted by Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers.

1. General

1.1. The test method(s) described in this Annex may be applied to ESAs.

1.2. Test methods

1.2.1. ESAs may comply with the requirements of any combination of the following test methods at the manufacturer's discretion provided that this results in the full frequency range specified in paragraph 5.1 of this Annex being covered.

— Stripline testing: see Appendix 1 to this Annex
— Bulk current injection testing: see Appendix 2 to this Annex
— TEM cell testing: see Appendix 3 to this Annex
— Free field test: see Appendix 4 to this Annex

1.2.2. Due to radiation of electromagnetic fields during these tests, all testing shall be conducted in a shielded area (the TEM cell is a shielded area).

2. Expression of results

For the tests described in this Annex, field strengths shall be expressed in volts/m and injected current shall be expressed in milliamps.

3. Measuring location

3.1. The test facility shall be capable of generating the required test signal over the frequency ranges defined in this Annex. The test facility shall comply with (national) legal requirements regarding the emission of electromagnetic signals.

3.2. The measuring equipment shall be located outside the chamber.

4. State of ESA during tests

4.1. The ESA under test shall be in normal operation mode. It shall be arranged as defined in this Annex unless individual test methods dictate otherwise.

4.2. Power shall be applied to the ESA under test via an (5 μ H/50 Ω) artificial network (AN), which shall be electrically grounded. The electrical supply voltage shall be maintained to ± 10 % of its nominal system operating voltage. Any ripple voltage shall be less than 1,5 % of the nominal system operating voltage measured at the AN monitoring port.

4.3. Any extraneous equipment required to operate the ESA under test shall be in place during the calibration phase. No extraneous equipment shall be closer than 1 m from the reference point during calibration.

4.4. To ensure reproducible measurement results are obtained when tests and measurements are repeated, the test signal generating equipment and its layout shall be to the same specification as that used during each appropriate calibration phase (paragraphs 7.2, 7.3.2.3, 8.4, 9.2 and 10.2 of this Annex).

4.5. If the ESA under test consists of more than one unit, the interconnecting cables should ideally be the wiring harness as intended for use in the vehicle. If these are not available, the length between the electronic control unit and the AN shall be 1 500 ± 75 mm. All cables in the loom should be terminated as realistically as possible and preferably with real loads and actuators.

5. Frequency range, dwell times

5.1. Measurements shall be made in the 20 to 1 000 MHz frequency range.

5.2. To confirm that the ESA(s) meet(s) the requirements of this Annex, the tests shall be performed at up to 14 spot frequencies in the range, e.g.:

27, 45, 65, 90, 120, 150, 190, 230, 280, 380, 450, 600, 750 and 900 MHz

The response time of the equipment under test shall be considered and the dwell time shall be sufficient to allow the equipment under test to react under normal conditions. In any case, it shall not be less than two seconds.

6. Characteristics of test signal to be generated

6.1. Maximum envelope excursion

The maximuim envelope excursion of the test signal shall equal the maximum envelope excursion of an unmodulated sine wave whose rms value is defined in paragraph 6.4.2 of Annex I (see Appendix 4 of Annex VI).

6.2. Test signal wave form

The test signal shall be a radio frequency sine wave, amplitude modulated by a 1 kHz sine wave at a modulation depth m of 0,8 ± 0,04.

6.3. Modulation depth

The modulation depth m is defined as:

$$m = \frac{\text{maximum envelope excursion} - \text{minimum envelope excursion}}{\text{maximum envelope excursion} + \text{minimum envelope excursion}}$$

7. Stripline testing

7.1. Test method

This test method consists of subjecting the wiring harness connecting the components in an ESA to specified field strengths.

7.2. Field strength measurement in the stripline

At each desired test frequency a level of power shall be fed into the stripline to produce the required field strength in the test area with the ESA under test absent, this level of forward power, or another parameter directly related to the forward power required to define the field, shall be measured and the results recorded. These results shall be used for type approval tests unless changes occur in the facilities or equipment which necessitate this procedure being repeated. During this process, the position of the field probe head shall be under the active conductor, centred in longitudinal, vertical and transversal directions. The housing of the probe's electronics shall be as far away from the longitudinal stripline axis as possible.

7.3. Installation of the ESA under test

7.3.1. 150 mm stripline testing

The test method allows the generation of homogeneous fields between an active conductor (the stripline 50 Ω impedance), and a ground plane (the conducting surface of the mounting table), between which part of the wiring harness may be inserted. The electronic controller(s) of the ESA under test shall be installed on the ground plane but outside the stripline with one of its edges parallel to the active conductor of the stripline. It shall be 200 ± 10 mm from a line on the ground plane directly under the edge of the active conductor. The distance between any edge of the active conductor and any peripheral device used for measurement shall be at least 200 mm. The wiring harness section of the ESA under test shall be placed in a horizontal attitude between the active conductor and the ground plane (see Figures 1 and 2 of Appendix 1 to this Annex).

7.3.1.1. The minimum length of the wiring harness, which shall include the power harness to the electronic control unit and shall be placed under the stripline, shall be 1,5 m unless the wiring harness in the vehicle is less than 1,5 m. In this case, the length of the wiring harness shall be that of the longest length of harness used in the vehicle installation. Any line branches occurring in this length shall be routed perpendicularly to the longitudinal axis of the line.

7.3.1.2. Alternatively, the fully extended length of the wiring harness, including the length of the longest of any branches, shall be 1,5 m.

7.3.2. 800 mm stripline testing

7.3.2.1. Test method

The stripline consists of two parallel metallic plates separated by 800 mm. Equipment under test is positioned centrally between the plates and subjected to an electromagnetic field (see Figures 3 and 4 of Appendix 1 to this Annex).

This method can test complete electronic systems including sensors and actuators as well as the controller and wiring loom. It is suitable for apparatus whose largest dimension is less than one-third of the plate separation.

7.3.2.2. Positioning of stripline

The stripline shall be housed in a screened room (to prevent external emissions) and positioned 2 m away from walls and any metallic enclosure to prevent electromagnetic reflections. RF absorber material may be used to damp these reflections. The stripline shall be placed on non-conducting supports at least 0,4 m above the floor.

7.3.2.3. Calibration of the stripline

A field measuring probe shall be positioned within the central one-third of the longitudinal, vertical and transverse dimensions of the space between the parallel plates with the system under test absent. The associated measuring equipment shall be sited outside the screen room.

At each desired test frequency, a level of power shall be fed into the stripline to produce the required field strength at the antenna. This level of forward power, or another parameter directly related to the forward power required to define the field, shall be used for type approval tests unless changes occur in the facilities or equipment which necessitate this procedure being repeated.

7.3.2.4. Installation of the ESA under test

The main control unit shall be positioned within the central one-third of the longitudinal, vertical and transverse dimensions of the space between the parallel plates. It shall be supported on a stand made from non-conducting material.

7.3.2.5. Main wiring loom and sensor/actuator cables

The main wiring loom and any sensor/actuator cables shall rise vertically from the control unit to the top ground plate (this helps to maximise coupling with the electromagnetic field). Then they shall follow the underside of the plate to one of its free edges where they shall loop over and follow the top of the ground plate as far as the connections to the stripline feed. The cables shall then be routed to the associated equipment which shall be sited in an area outside the influence of the electromagnetic field, e.g.: on the floor of the screened room 1 m longitudinally away from the stripline.

8. Free field ESA immunity test

8.1. Test method

This test method allows the testing of vehicle electrical/electronic systems by exposing an ESA to electromagnetic radiation generated by an antenna.

8.2. Test bench description

The test shall be performed inside a semi-anechoic chamber on a bench top.

8.2.1. Ground plane

8.2.1.1. For free field immunity testing, the ESA under test and its wiring harnesses shall be supported 50 ± 5 mm above a wooden or equivalent non-conducting table. However, if any part of the ESA under test is intended to be electrically bonded to a vehicle's metal bodywork, that part shall be placed on a ground plane and shall be electrically bonded to the ground plane. The ground plane shall be a metallic sheet with a minimum thickness of 0,5 mm. The minimum size of the ground plane depends on the size of the ESA under test but shall allow for the distribution of the ESA's wiring harness and components. The ground plane shall be connected to the protective conductor of the earthing system. The ground plane shall be situated at a height of 1,0 ± 0,1 m above the test facility floor and shall be parallel to it.

8.2.1.2. The ESA under test shall be arranged and connected according to its requirements. The power supply harness shall be positioned along, and within 100 mm of, the edge of the ground plane/table closest to the antenna.

8.2.1.3. The ESA under test shall be connected to the grounding system according to the manufacturer's installation specification, no additional grounding connections shall be permitted.

8.2.1.4. The minimum distance between the ESA under test and all other conductive structures, such as walls of a shielded area (with the exception of the ground plane/table underneath the test object) must be 1,0 m.

8.2.1.5. The dimension of any ground plane shall be 2,25 square meter or larger in area with the smaller side no less than 750 mm. The ground plane shall be bonded to the chamber with bonding straps such that the DC bonding resistance shall not exceed 2,5 milliohms.

8.2.2. Installation of ESA under test

For large equipment mounted on a metal test stand, the test stand shall be considered a part of the ground plane for testing purposes and shall be bonded accordingly. The faces of the test sample shall be located at a minimum of 200 mm from the edge of the ground plane. All leads and cables shall be a minimum of 100 mm from the edge of the ground plane and the distance to the ground plane (from the lowest point of the harness) shall be 50 ± 5 mm above the ground plane. Power shall be applied to the ESA under test via an (5 μ H/50 Ω) artificial network (AN).

8.3. Field generating device type, position and orientation

8.3.1. Field generating device type

8.3.1.1. The field generating device type(s) shall be chosen such that the desired field strength is achieved at the reference point (see paragraph 8.3.4 of this Annex) at the appropriate frequencies.

8.3.1.2. The field generating device(s) may be (an) antenna(s) or a plate antenna.

8.3.1.3. The construction and orientation of any field generating device shall be such that the generated field is polarised:

from 20 to 1 000 MHz horizontally or vertically.

8.3.2. Height and distance of measurement

8.3.2.1. Height

The phase centre of any antenna shall be 150 ± 10 mm above the ground plane on which the ESA under test rests. No parts of any antenna's radiating elements shall be closer than 250 mm to the floor of the facility.

8.3.2.2. Distance of measurement

8.3.2.2.1. In-service conditions may best be approximated by placing the field generating device as far from the ESA as practical. This distance will typically lie within the range 1 to 5 m.

8.3.2.2.2. If the test is carried out in an enclosed facility, the field generating device's radiating elements shall be no closer than 0,5 m to any radio absorbent material and no closer than 1,5 m to the wall of the facility. There shall be no absorbent material interposed between the transmitting antenna and the ESA under test.

8.3.3. Antenna location relative to ESA under test

8.3.3.1. The field generating device's radiating elements shall not be closer than 0,5 m to the edge of the ground plane.

8.3.3.2. The phase centre of the field generating device shall be on a plane which:

(a) is perpendicular to the ground plane;

(b) bisects the edge of the ground plane and the midpoint of the principal portion of the wiring harness;

and

(c) is perpendicular to the edge of the ground plane and the principal portion of the wiring harness.

The field generating device shall be placed parallel to this plane (see Figures 1 and 2 of Appendix 4 to this Annex).

8.3.3.3. Any field generating device which is placed over the ground plane or ESA under test shall extend over the ESA under test.

8.3.4. Reference point

For the purpose of this Annex the reference point is the point at which the field strength shall be established and shall be defined as follows:

8.3.4.1. at least 1 m horizontally from the antenna phase centre or at least 1 m vertically from the radiating elements of a plate antenna;

8.3.4.2. on a plane which:

(a) is perpendicular to the ground plane;

(b) is perpendicular to the edge of the ground plane along which the principal portion of the wiring harness runs;

and

(c) bisects the edge of the ground plane and the midpoint of the principal portion of the wiring harness;

(d) coincident with the midpoint of the principal portion of the harness which runs along the edge of the ground plane closest to the antenna;

8.3.4.3. 150 ± 10 mm above the ground plane.

8.4. Generation of required field strength: test methodology

8.4.1. the ‘substitution method’ shall be used to establish the test field conditions.

8.4.2. Substitution method

At each desired test frequency, a level of power shall be fed into the field generating device to produce the required field strength at the reference point (as defined in paragraph 8.3.4 in the test area with the ESA under test absent), this level of forward power, or another parameter directly related to the forward power required to define the field, shall be measured and the results recorded. These results shall be used for type approval tests unless changes occur in the facilities or equipment which necessitates this procedure being repeated.

8.4.3. Extraneous equipment must be a minimum of 1 m from the reference point during calibration.

8.4.4. Field strength measuring device

A suitable compact field strength measuring device shall be used to determine the field strength during the calibration phase of the substitution method.

8.4.5. The phase centre of the field strength measuring device shall be positioned at the reference point.

8.4.6. The ESA under test which may include an additional ground plane shall then be introduced into the test facility and positioned in accordance with the requirements of paragraph 8.3. If a second ground plane is used, then it shall be within 5 mm of the bench ground plane and electrically bounded to it. The required forward power defined in paragraph 8.4.2 at each frequency as defined in paragraph 5 shall then be applied to the field generating device.

8.4.7. Whatever parameter was chosen in paragraph 8.4.2 to define the field, the same parameter shall be used to determine the field strength during the test.

8.5. Field strength contour

8.5.1. During the calibration phase of the substitution method (prior to an ESA under test being introduced into the test area), the field strength shall not be less than 50 % of the nominal field strength 0,5 ± 0,05 m either side of the reference point on a line parallel to the edge of the ground plane nearest to the antenna and passing through the reference point.

9. TEM cell testing

9.1. Test method

The TEM (transverse electromagnetic mode) cell generates homogeneous fields between the internal conductor (septum) and housing (ground plane). It is used for testing ESAs (see Figure 1 of Appendix 3 to this Annex)).

9.2. Field strength measurement in a TEM cell

9.2.1. The electric field in the TEM cell shall be determined by using the equation:

$$|E| = \frac{\sqrt{(P \times Z)}}{d}$$

E	=	Electric field (volts/metre)
P	=	Power flowing into cell (W)
Z	=	Impedance of cell (50 Ω)
d	=	Separation distance (metres) between the upper wall and the plate (septum).

9.2.2. Alternatively an appropriate field strength sensor shall be placed in the upper half of the TEM cell. In this part of the TEM cell the electronic control unit(s) has only a small influence on the test field. The output of this sensor shall determine the field strength.

9.3. Dimensions of TEM cell

In order to maintain a homogeneous field in the TEM cell and to obtain repeatable measurement results, the test object shall not be larger than one-third of the cell inside height. Recommended TEM cell dimensions are given in Appendix 3, Figures 2 and 3 to this Annex.

9.4. Power, signal and control wires

The TEM cell shall be attached to a co-axial socket panel and connected as closely as possible to a plug connector with an adequate number of pins. The supply and signal leads from the plug connector in the cell wall shall be directly connected to the test object.

The external components such as sensors, power supply and control elements can be connected:

(a) to a screened peripheral;

(b) to a vehicle next to the TEM cell;

or

(c) directly to the screened patchboard.

Screened cables must be used in connecting the TEM cell to the peripheral or the vehicle if the vehicle or peripheral is not in the same or adjacent screened room.

10. Bulk current injection testing

10.1. Test method

This is a method of carrying out immunity tests by inducing currents directly into a wiring harness using a current injection probe. The injection probe consists of a coupling clamp through which the cables of the ESA under test are passed. Immunity tests can then be carried out by varying the frequency of the induced signals.

The ESA under test may be installed on a ground plane as in paragraph 8.2.1 or in a vehicle in accordance with the vehicle design specification.

10.2. Calibration of bulk current injection probe prior to commencing tests

The injection probe shall be mounted in a calibration jig. Whilst sweeping the test frequency range, the power required to achieve the current specified in Annex I, paragraph 6.7.2.1 shall be monitored. This method calibrates the bulk current injection system forward power versus current prior to testing, and it is this forward power which shall be applied to the injection probe when connected to the ESA under test via the cables used during calibration. It should be noted that the monitored power applied to the injection probe is the forward power.

10.3. Installation of the ESA under test

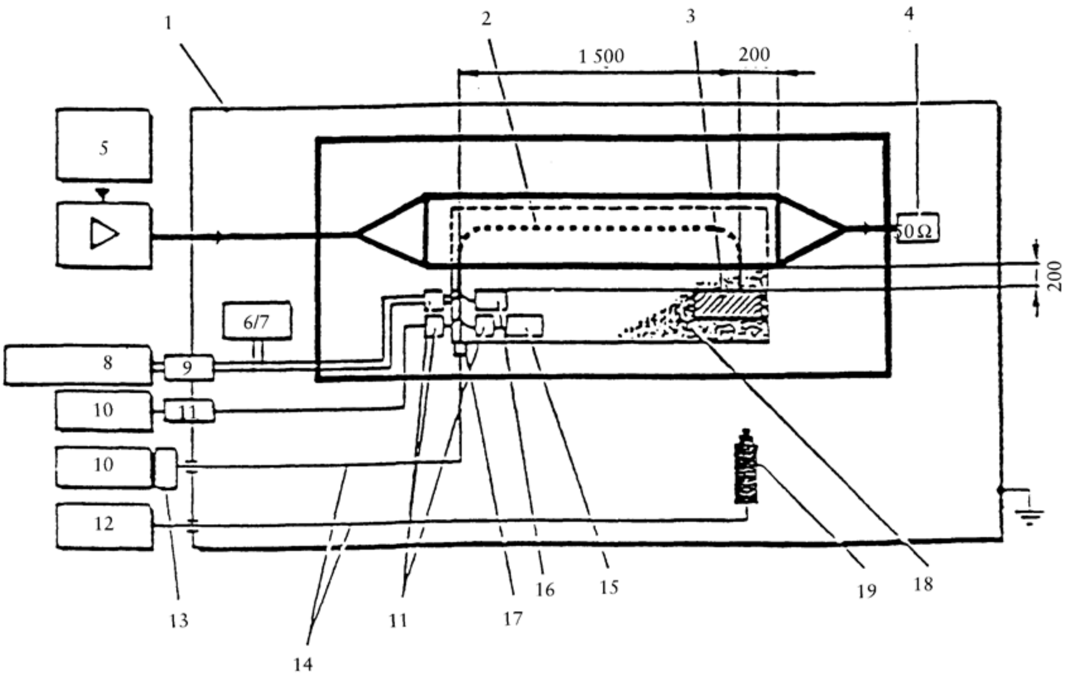
For an ESA mounted on a ground plane as in paragraph 8.2.1 all cables in the wiring harness should be terminated as realistically as possible and preferably with real loads and actuators. For both vehicle mounted and ground plane mounted ESAs the current injection probe shall be mounted in turn around all the wires in the wiring harness to each connector and 150 ± 10mm from each connector of the ESA under test electronic control units (ECU), instrument modules or active sensors as illustrated in Figure 1 of Appendix 2.

10.4. Power, signal and control wires

For an ESA under test mounted on a ground plane as in paragraph 8.2.1, a wiring harness shall be connected between an artificial network (AN) and the principal electronic control unit (ECU). This harness shall run parallel to the edge of the ground plane and 200 mm minimum from its edge. This harness shall contain the power feed wire which is used to connect the vehicle battery to this ECU and the power return wire if used on the vehicle.

The distance from the ECU to the AN shall be 1,0 ± 0,1 m or shall be the harness length between the ECU and the battery as used on the vehicle, if known, whichever is the shorter. If a vehicle harness is used then any line branches which occur in this length shall be routed along the ground plane but perpendicular away from the edge of the ground plane. Otherwise the ESA under test wires which are in this length shall break out at the AN.

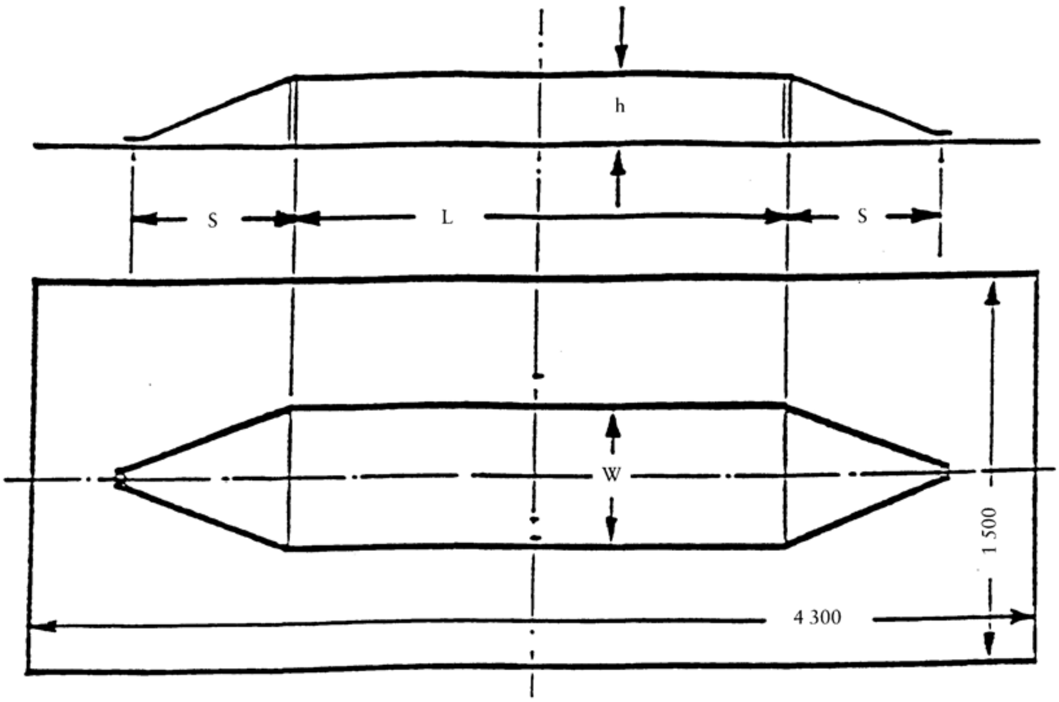
Appendix 1



1 = Shielded room
2 = Cable harness
3 = Test object
4 = Terminating resistance
5 = Frequency generator
6 /7 = Alternative battery
8 = Power supply
9 = Filter
10 = Peripheral
11 = Filter
12 = Video peripheral
13 = Opto-electrical converter
14 = Optical lines
15 = Non irradiation-proof peripheral
16 = Linear or radiation-proof peripheral
17 = Opto-electrical converter
18 = Insulating base
19 = Video camera

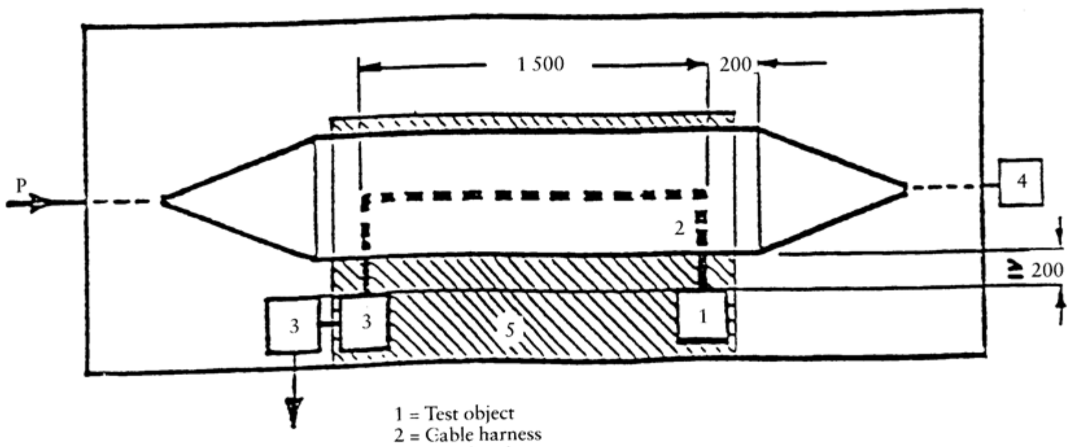
All dimensions in millimetres

Appendix 1



L = 2 500 mm
S = 800 mm
W = 740 mm
h = 150 mm

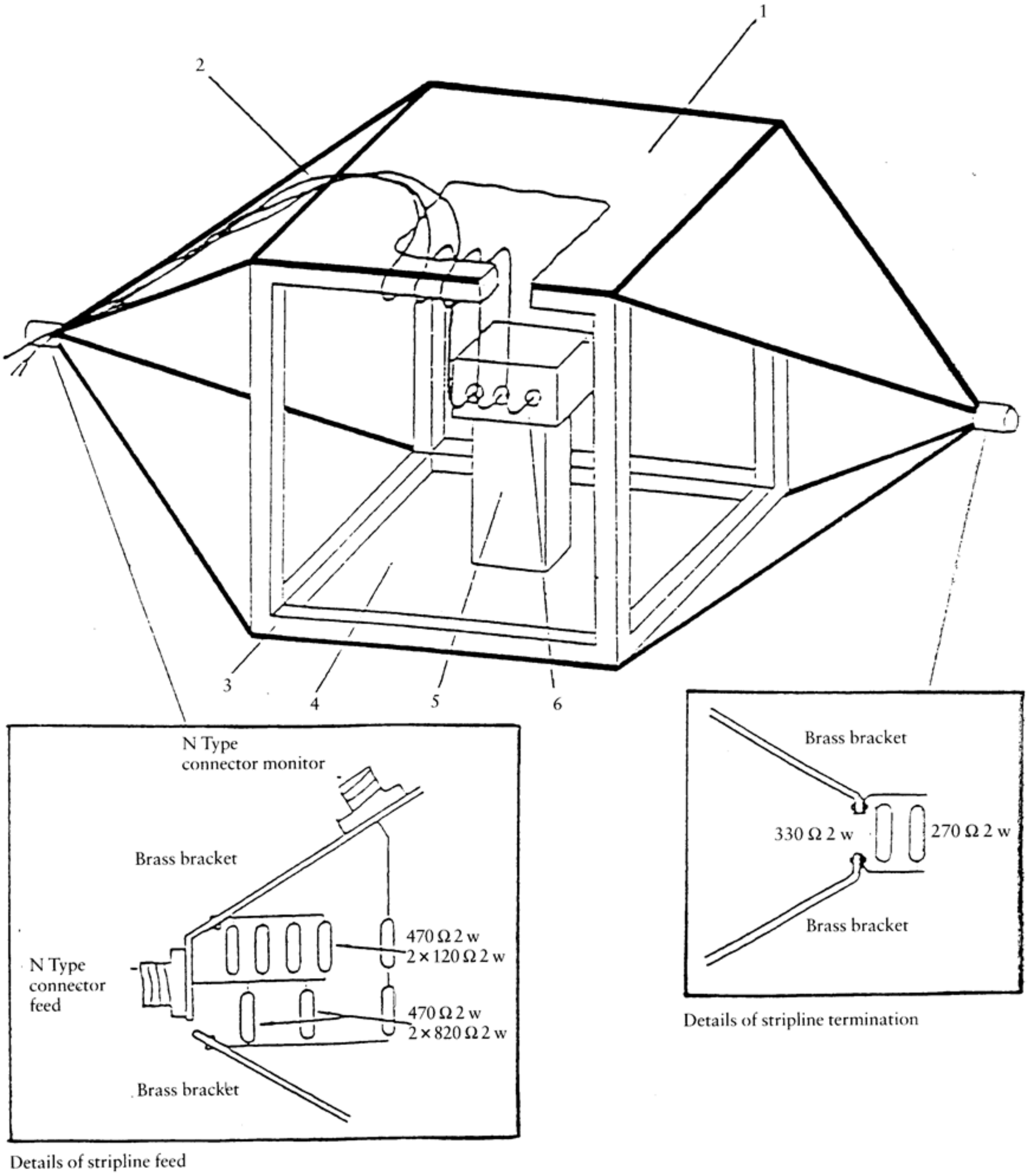
All dimensions in millimetres



1 = Test object
2 = Cable harness
3 = Peripheral
4 = Terminating resistance
5 = Insulting base

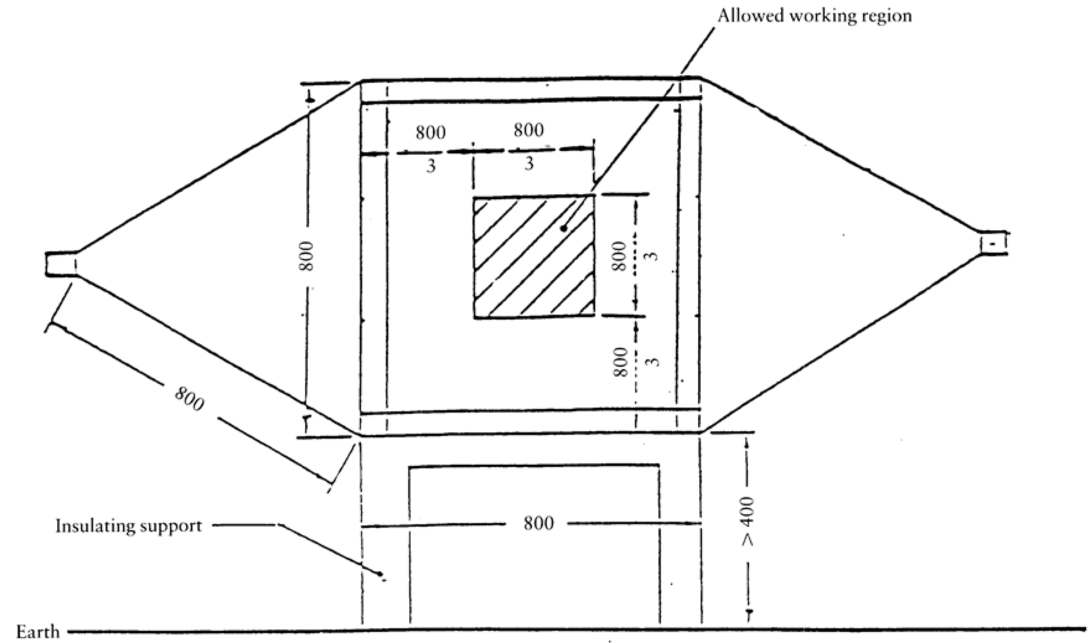
150 mm Stripline testing

Appendix 1

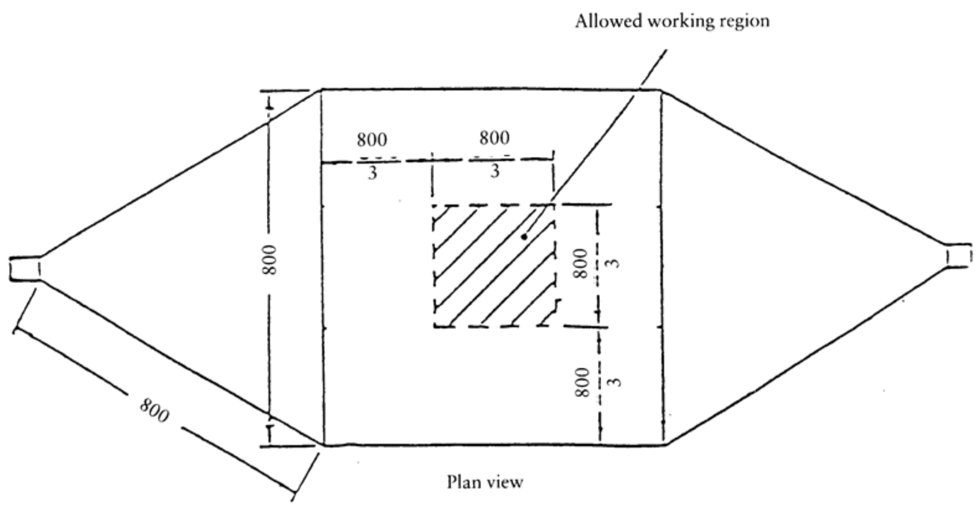


1 = Ground plate
2 = Main loom and sensor/actuator cables
3 = Wooden frame
4 = Driven plate
5 = Insulator
6 = Test object

Appendix 1



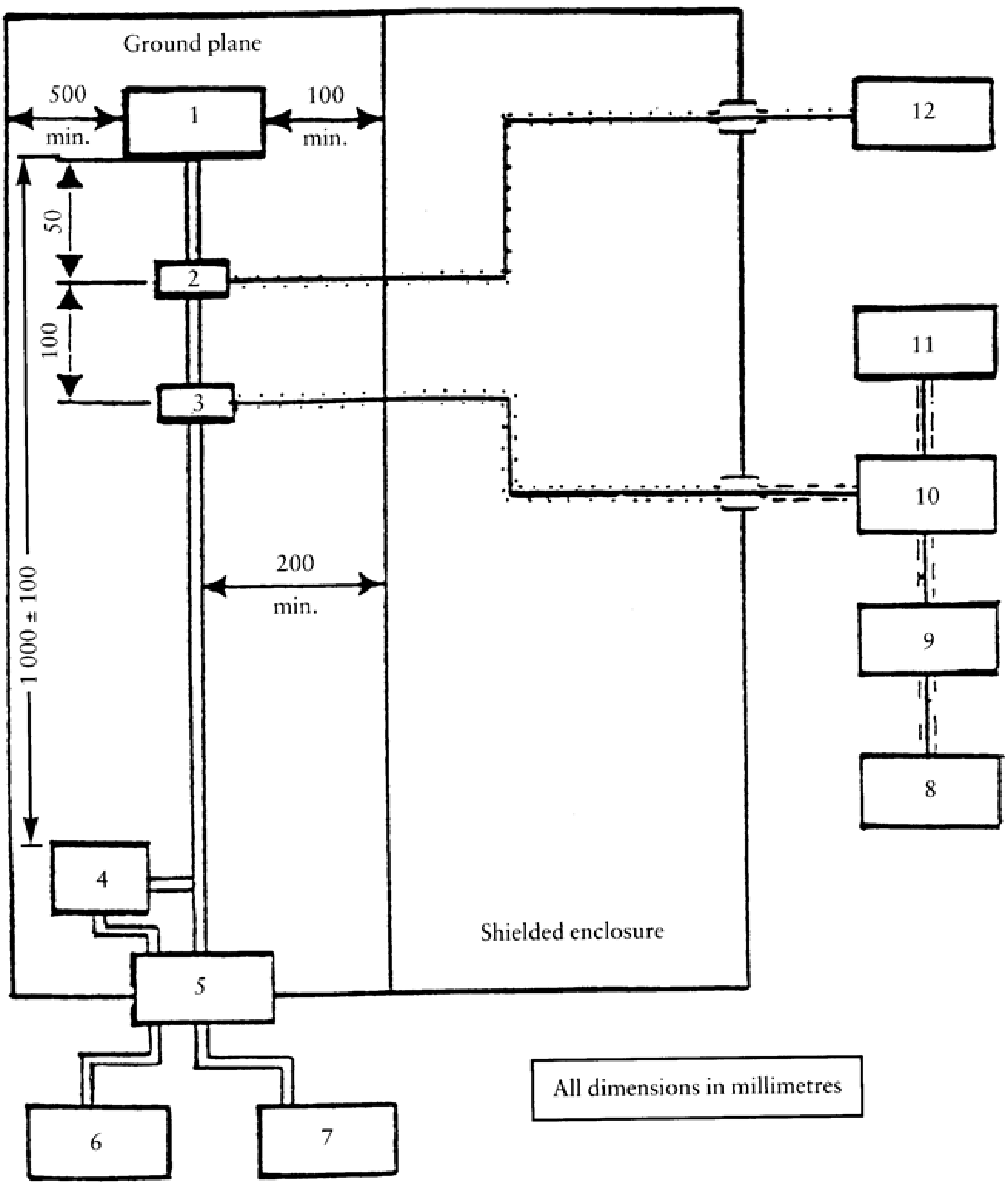
Side view



Plan view

All dimensions in millimetres

Appendix 2

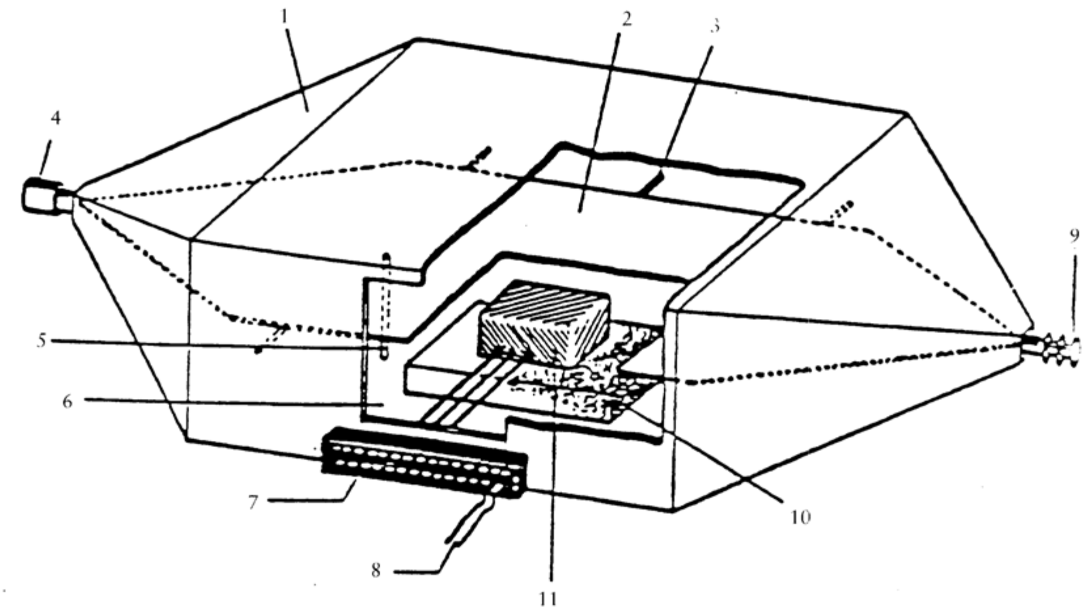


1	=	DUT
2	=	RF measuring probe (optional)
3	=	RF injection probe
4	=	Artifical network
5	=	Shielded room filter network
6	=	Power source
7	=	DUT interface: stimulation and monitoring equipment
8	=	Signal generator
9	=	Broadband amplifier
10	=	RF 50 Ω directional complex
11	=	RF power level measuring device or equivalent

12	=	Spectrum analyser or equivalent (optional)

Example of BCI test configuration

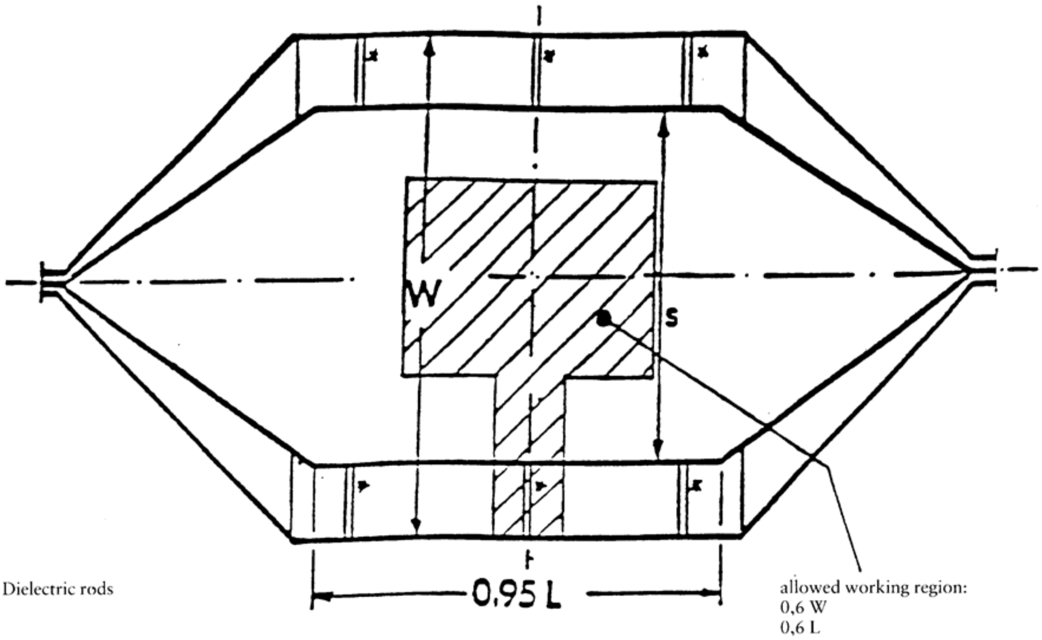
Appendix 3



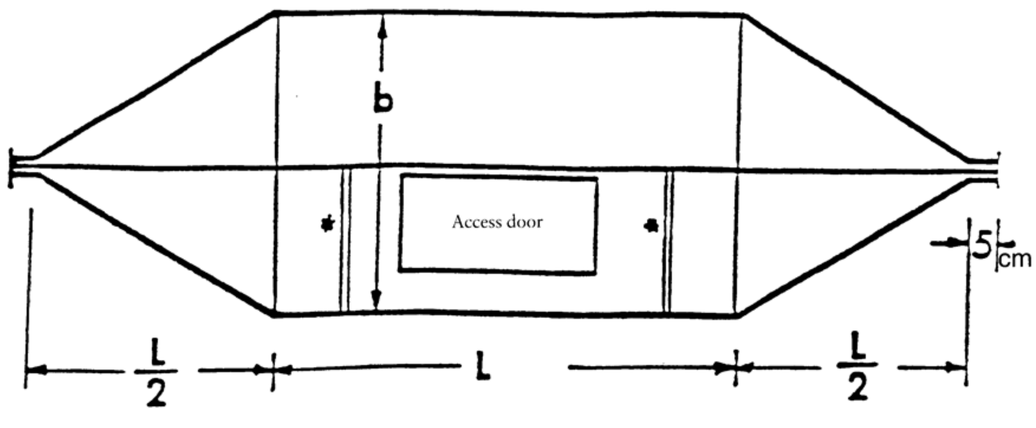
1	=	Outer conducter, shield
2	=	Inner conducter (septum)
3	=	Insulator
4	=	Input
5	=	Insulator
6	=	Door
7	=	Socket panel
8	=	Test object power supply
9	=	Terminating resistance 50 Ω
10	=	Insulation
11	=	Test object (maximum height one third of distance between cell floor and septum)

Appendix 3

TEM cell dimensions



Horizontal section view at septum



Vertical section view

Design of rectangular TEM cell

Appendix 3

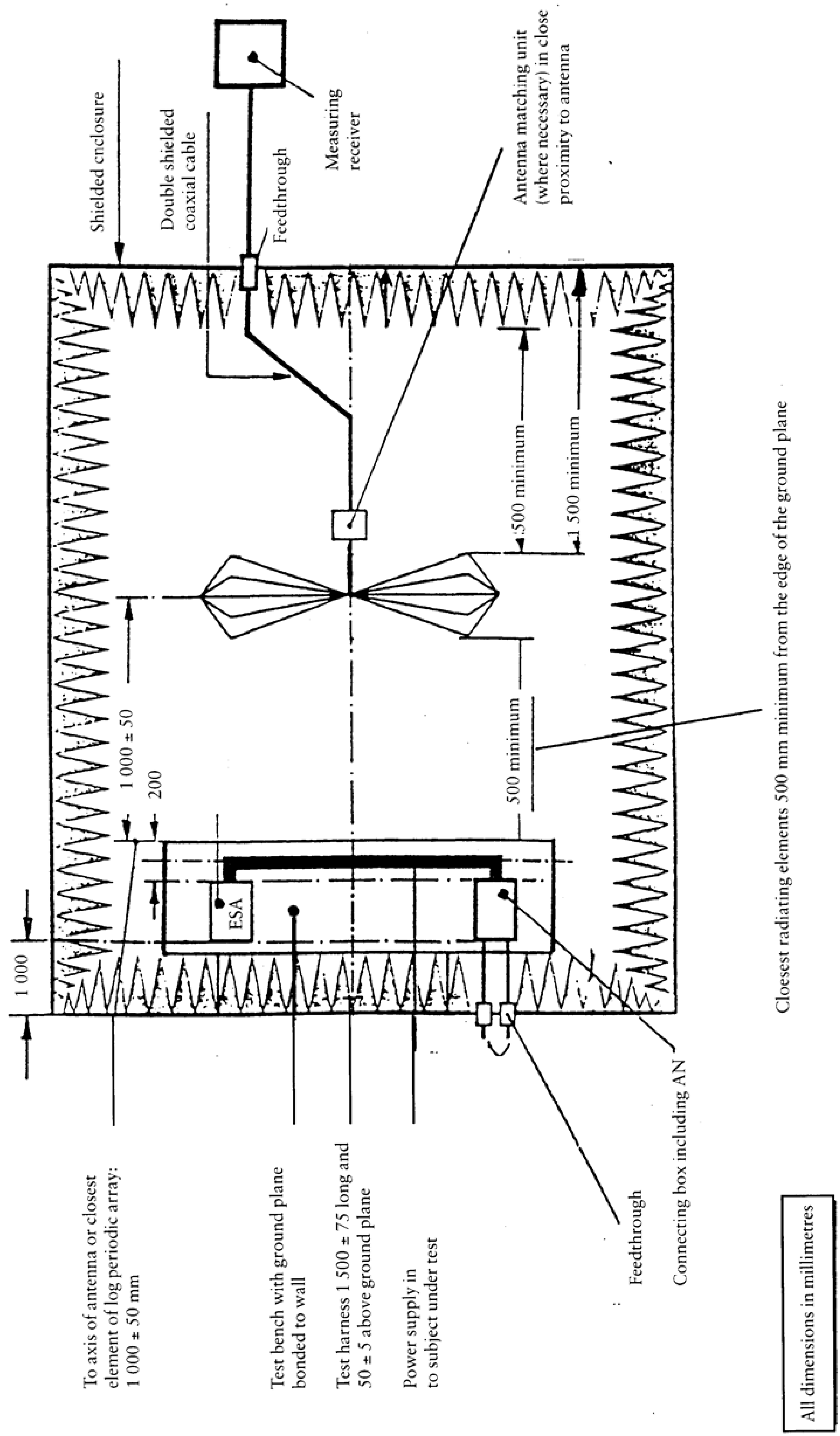
Figure 3

The following table shows the dimensions for constructing a cell with specified upper frequency limits:

Upper frequency(MHz)	**Cell form factorW: b**	**Cell form factorL/W**	**Plate separationb (cm)**	**SeptumS (cm)**
200	1,69	0,66	56	70
200	1,0	1	60	50

Typical TEM cell dimensions

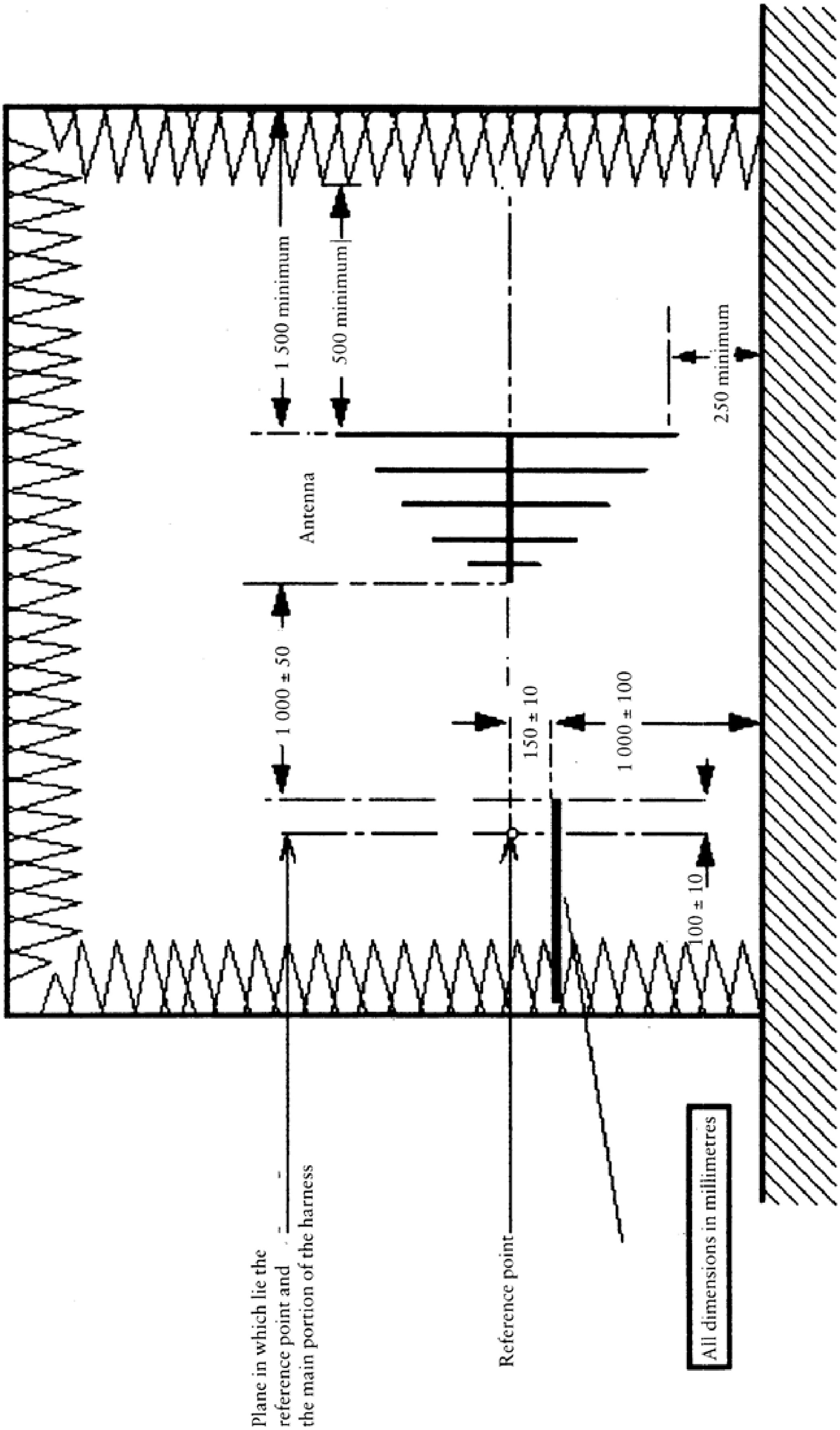
Appendix 4


Shielded enclosure
Double shielded coaxial cable
Feedthrough
Measuring receiver
Antenna matching unit (where necessary) in close proximity to antenna
500 minimum
1 500 minimum
500 minimum
Closest radiating elements 500 mm minimum from the edge of the ground plane
1 000 ± 50
200
1 000
ESA
To axis of antenna or closest element of log periodic array: 1 000 ± 50 mm
Test bench with ground plane bonded to wall
Test harness 1 500 ± 75 long and 50 ± 5 above ground plane
Power supply in to subject under test
Feedthrough
Connecting box including AN
All dimensions in millimetres

Free field ESA immunity test

Test layout (general plan view)

Appendix 4


1 500 minimum
500 minimum
250 minimum
Antenna
1 000 ± 50
150 ± 10
1 000 ± 100
100 ± 10
Plane in which lie the reference point and the main portion of the harness
Reference point
All dimensions in millimetres

Free field ESA immunity test

View of test bench plane of longitudinal symmetry]