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From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
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To:	Mr Uwe CORSEPIUS, Secretary-General of the Council of the European Union
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Subject:	ANNEXES to the Commission Delegated Regulation (EU) No .../... of XXX supplementing Regulation (EU) No 167/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of agricultural and forestry vehicles

Delegations will find attached document C(2014) 9198 final ANNEXES 15 to 16.

Encl.: C(2014) 9198 final ANNEXES 15 to 16

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ANNEXES 15 to 16

ANNEXES

to the

Commission Delegated Regulation (EU) No .../... of XXX

supplementing Regulation (EU) No 167/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of agricultural and forestry vehicles

ANNEX XV
Requirements on the electro-magnetic compatibility

PART 1

This Annex applies to the electromagnetic compatibility of vehicles covered by Article 2 of Regulation (EU) No 167/2013. It also applies to electrical or electronic separate technical units intended to be fitted to the vehicles.

Definitions

For the purposes of this Annex, the following definitions apply:

1. 'Electromagnetic compatibility' means the ability of a vehicle or component(s) or separate technical unit(s) to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment;

2. 'Electromagnetic disturbance' means any electromagnetic phenomenon which may degrade the performance of a vehicle or component(s) or separate technical unit(s). An electromagnetic disturbance may be electromagnetic noise, an unwanted signal or a change in the propagation medium itself;

3. 'Electromagnetic immunity' means the ability of a vehicle or component(s) or separate technical unit(s) to perform without degradation of performance in the presence of specified electromagnetic disturbances;

4. 'Electromagnetic environment' means the totality of electromagnetic phenomena existing at a given location;

5. 'Reference limit' means the nominal level to which type-approval and conformity of production limit values are referenced;

6. 'Reference antenna' for the frequency range 20 to 80 MHz: means a shortened balanced dipole being a half wave resonant dipole at 80 MHz, and for the frequency range above 80 MHz: means a balanced half wave resonant dipole tuned to the measurement frequency;

7. 'Broadband electromagnetic emission' means an emission which has a bandwidth greater than that of a particular measuring apparatus or receiver;

8. 'Narrowband electromagnetic emission' means an emission which has a bandwidth less than that of a particular measuring apparatus or receiver;

9. 'Electrical/electronic system' means (an) electrical and/or electronic device(s) or set(s) of devices together with any associated electrical connections which form part of a vehicle but which are not intended to be type approved separately from the vehicle;

10. 'Electrical/electronic sub-assembly' (ESA) means an electrical and/or electronic device or set(s) of devices intended to be part of a vehicle, together with any associated electrical connections and wiring, which performs one or more specialised functions;

11. 'Type of ESA' in relation to electromagnetic compatibility means ESAs which do not differ as to the function performed or the general arrangement of the electrical and/or electronic components, if applicable.

PART 2

Requirements to be met by vehicles and electrical / electronic sub-assemblies fitted to a vehicle

1. Application for EU type-approval

1.1 Approval of a vehicle type

1.1.1. The application for approval of a vehicle type, with regard to its electromagnetic compatibility pursuant to Articles 22, 24 and 26 of Regulation (EU) No 167/2013 shall be submitted by the vehicle manufacturer.

1.1.2. The vehicle manufacturer shall submit the information document, the model of which is set out in Article 68(a) of Regulation (EU) No 167/2013.

1.1.3. The vehicle manufacturer shall draw up a schedule describing all projected combinations of relevant vehicle electrical/electronic systems or ESAs, body styles[1], variations in body material[2], general wiring arrangements, engine variations, left-hand/right-hand drive versions and wheelbase versions. Relevant vehicle electrical/electronic systems or ESAs are those which may emit significant broadband or narrowband radiation and/or those which are involved in the driver's direct control (see point 3.4.2.3) of the vehicle.

1.1.4. A representative vehicle shall be selected from this schedule for the purpose of being tested, in mutual agreement between the manufacturer and the competent authority. This vehicle shall represent the vehicle type specified in the information document set out in Article 68(a) of Regulation (EU) No 167/2013. The choice of vehicle shall be based on the electrical/electronic systems offered by the manufacturer. One more vehicle may be selected from this schedule for the purpose of being tested if it is considered by mutual agreement between the manufacturer and the competent authority that different electrical/electronic systems are included which are likely to have a significant effect on the vehicle's electromagnetic compatibility compared with the first representative vehicle.

1.1.5. The choice of the vehicle(s) in conformity with point 1.1.4 is limited to vehicle/electrical/electronic system combinations intended for actual production.

1.1.6. The manufacturer may supplement the application with a report from tests which have been carried out. Any such data provided may be used by the approval authority for the purpose of drawing up the EU type-approval certificate.

1.1.7. A vehicle representative of the type to be approved, according to point 1.1.4 shall be provided to the technical service that carries out the test itself.

1.2. Approval of a type of ESA

1.2.1. The application for approval of a type of ESA with regard to its electromagnetic compatibility pursuant to Articles 22, 24 and 26 of Regulation (EU) No 167/2013 shall be submitted by the vehicle manufacturer or by the manufacturer of the ESA. An ESA may be approved at the request of a manufacturer as either a ‘component’ or a ‘separate technical unit (STU)’.

1.2.2. The vehicle manufacturer shall submit the information document, the model of which is set out in Article 68(a) of Regulation (EU) No 167/2013.

[1] If applicable.
[2] If applicable.

1.2.3. The manufacturer may supplement the application with a report from tests which have been carried out. Any such data provided may be used by the approval authority for the purpose of drawing up the EU type-approval certificate.

1.2.4. A sample of the ESA representative of the type to be approved shall be provided to the technical service that carries out the test itself, if necessary, after discussion with the manufacturer on, for example, possible variations in the layout, the number of components and the number of sensors. If the technical service deems it necessary, it may select a further sample.

1.2.5. The sample(s) shall be clearly and indelibly marked with the manufacturer's trade name or mark and the type designation.

1.2.6. Where applicable, any restrictions on use shall be identified. Any such restrictions shall be included in the information document set out in Article 68(a) of Regulation (EU) No 167/2013 and/or in the EU type-approval certificate set out in Article 68(c) of Regulation (EU) No 167/2013.

2. Marking

2.1. Every ESA conforming to a type approved pursuant to this Regulation shall bear an EU type-approval mark in accordance with Article 34 of Regulation (EU) No 167/2013 and Annex XX to this Regulation.

2.2. No marking is required for electrical/electronic systems included in vehicle types approved by this Regulation.

2.3. Markings on ESAs in compliance with points 2.1 and 2.2 need not be visible when the ESA is installed in a vehicle.

3. Specifications

3.1. General specification

3.1.1. A vehicle (and its electrical/electronic system(s) or ESAs) shall be so designed, constructed and fitted as to enable the vehicle, in normal conditions of use, to comply with this Regulation.

3.2. Specifications concerning broadband electromagnetic radiation from vehicles fitted with spark ignition.

3.2.1. Method of measurement

The electromagnetic radiation generated by the vehicle representative of its type shall be measured using the method described in Part 3 at either of the defined antenna distances. The choice shall be made by the vehicle manufacturer.

3.2.2. Vehicle broadband reference limits

3.2.2.1. If measurements are made using the method described in Part 3 using a vehicle-to-antenna spacing of 10,0 ± 0,2 m, the radiation reference limits shall be 34 dB microvolts/m (50 microvolts/m) in the 30 to 75 MHz frequency band and 34 to 45 dB microvolts/m (50 to 180 microvolts/m) in the 75 to 400 MHz frequency band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 5. In the 400 to 1,000 MHz frequency band the limit remains constant at 45 dB microvolts/m

(180 microvolts/m).

3.2.2.2. If measurements are made using the method described in Part 3 using a vehicle-to-antenna spacing of 3.0 ± 0.05 m, the radiation reference limits shall be 44 dB microvolts/m (160 microvolts/m) in the 30 to 75 MHz frequency band and 44 to 55 dB microvolts/m (160 to 562 microvolts/m) in the 75 to 400 MHz frequency band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 6. In the 400 to 1,000 MHz frequency band the limit remains constant at 55 dB microvolts/m (562 microvolts/m).

3.2.2.3. On the vehicle representative of its type, the measured values, expressed in dB microvolts/m (microvolts/m), shall be at least 2.0 dB (20 %) below the reference limits.

3.3. Specifications concerning narrowband electromagnetic radiation from vehicles

3.3.1. Method of measurement

The electromagnetic radiation generated by the vehicle representative of its type shall be measured using the method described in Part 4 at either of the defined antenna distances. The choice shall be made by the vehicle manufacturer.

3.3.2. Vehicle narrowband reference limits

3.3.2.1. If measurements are made using the method described in Part 4 using a vehicle-to-antenna spacing of 10.0 ± 0.2 m, the radiation-reference limits shall be 24 dB microvolts/m (16 microvolts/m) in the 30 to 75 MHz frequency band and 24 to 35 dB microvolts/m (16 to 56 microvolts/m) in the 75 to 400 MHz frequency band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 7. In the 400 to 1000 MHz frequency band the limit remains constant at 35 dB microvolts/m (56 microvolts/m).

3.3.2.2. If measurements are made using the method described in Part 4 using a vehicle-to-antenna spacing of 3.0 ± 0.05 m, the radiation reference limit shall be 34 dB microvolts/m (50 microvolts/m) in the 30 to 75 MHz frequency band and 34 to 45 dB microvolts/m (50 to 180 microvolts/m) in the 75 to 400 MHz frequency band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 8. In the 400 to 1000 MHz frequency band the limit remains constant at 45 dB microvolts/m (180 microvolts/m).

3.3.2.3. On the vehicle representative of its type, the measured values, expressed in dB microvolts/m (microvolts/m), shall be at least 2.0 dB (20 %) below the reference limit.

3.3.2.4. Notwithstanding the limits defined in points 5.3.2.1, 5.3.2.2 and 5.3.2.3, if, during the initial step described in point 1.3 of Part 4, the signal strength measured at the vehicle broadcast radio antenna is less than 20 dB microvolts/m (10 microvolts/m) over the frequency range 88 to 108 MHz, then the vehicle shall be deemed to comply with the limits for narrowband emissions and no further testing shall be required.

3.4. Specifications concerning immunity of vehicles to electromagnetic radiation

3.4.1. Method of testing

The immunity to electromagnetic radiation of the vehicle representative of its type shall be tested by the method described in Part 5.

3.4.2. Vehicle immunity reference limits

3.4.2.1. If tests are made using the method described in Part 5, the field strength reference level shall be 24 volts/m rms in over 90 % of the 20 to 1,000 MHz frequency band and 20 volts/m rms over the whole 20 to 1,000 MHz frequency band.

3.4.2.2. The vehicle representative of its type shall be considered as complying with immunity requirements if, during the tests performed in accordance with Part 5, and subjected to a field strength, expressed in volts/m, of 25 % above the reference level, there shall be no abnormal change in the speed of the driven wheels of the vehicle, no degradation of performance which would cause confusion to other road users, and no degradation in the driver's direct control of the vehicle which could be observed by the driver or other road user.

3.4.2.3. The driver's direct control of the vehicle is exercised by means of steering, braking, or engine speed control.

3.5. Specification concerning broadband electromagnetic interference generated by ESAs

3.5.1. Method of measurement

The electromagnetic radiation generated by the ESA representative of its type shall be measured by the method described in Part 6.

3.5.2. ESA broadband reference limits

3.5.2.1. If measurements are made using the method described in Part 6, the radiation reference limits shall be 64 to 54 dB microvolts/m (1,600 to 500 microvolts/m) in the 30 to 75 MHz frequency band, this limit decreasing logarithmically (linearly) with frequencies above 30 MHz, and 54 to 65 dB microvolts/m (500 to 1,800 microvolts/m) in the 75 to 400 MHz band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 9 of this Part. In the 400 to 1,000 MHz frequency band the limit remains constant at 65 dB microvolts/m (1,800 microvolts/m).

3.5.2.2. On the ESA representative of its type, the measured values, expressed in dB microvolts/m, (microvolts/m) shall be at least 2.0 dB (20 %) below the reference limits.

3.6. Specifications concerning narrowband electromagnetic interference generated by ESAs

3.6.1. Method of measurement

The electromagnetic radiation generated by the ESA representative of its type shall be measured by the method described in Part 7.

3.6.2. ESA narrowband reference limits

3.6.2.1. If measures are made using the method described in Part 7, the radiation reference limits shall be 54 to 44 dB microvolts/m (500 to 160 microvolts/m) in the 30 to 75 MHz frequency band, this limit decreasing logarithmically (linearly) with frequencies above 30 MHz, and 44 to 55 dB microvolts/m (160 to 560 microvolts/m) in the 75 to 400 MHz band, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in point 10 of this Part. In the 400 to 1,000 MHz frequency band the limit remains constant at 55 dB microvolts/m (560 microvolts/m).

3.6.2.2. On the ESA representative of its type, the measured value, expressed in dB microvolts/m

(microvolts/m) shall be at least 2.0 dB (20 %) below the reference limits.

3.7. Specifications concerning immunity of ESAs to electromagnetic radiation

3.7.1. Method(s) of testing

The immunity to electromagnetic radiation of the ESA representative of its type shall be tested by the method(s) chosen from those described in Part 8.

3.7.2. ESA immunity reference limits

3.7.2.1. If tests are made using the methods described in Part 8, the immunity test reference levels shall be 48 volts/m for the 150 mm stripline testing method, 12 volts/m for the 800 mm stripline testing method, 60 volts/m for the transverse electromagnetic mode (TEM) cell testing method, 48 mA for the bulk current injection (BCI) testing method and 24 volts/m for the free field testing method.

3.7.2.2. On the ESA representative of its type at a field strength or current expressed in appropriate linear units 25 % above the reference limit, the ESA shall not exhibit any malfunction which would cause any degradation of performance which could cause confusion to other road users or any degradation in the driver's direct control of a vehicle fitted with the system which could be observed by the driver or other road user.

4. Exceptions

4.1. Where a vehicle or electrical/electronic system or ESA does not include an electronic oscillator with an operating frequency greater than 9 kHz, it shall be deemed to comply with point 3.3.2 or 3.6.2 and with Parts 4 and 7.

4.2. Vehicles which do not have electrical/electronic systems or ESAs involved in the direct control of the vehicle need not be tested for immunity and shall be deemed to comply with point 3.4 and with Part 5.

4.3. ESAs whose functions are not involved in the direct control of the vehicle need not be tested for immunity and shall be deemed to comply with point 3.7 and with Part 8.

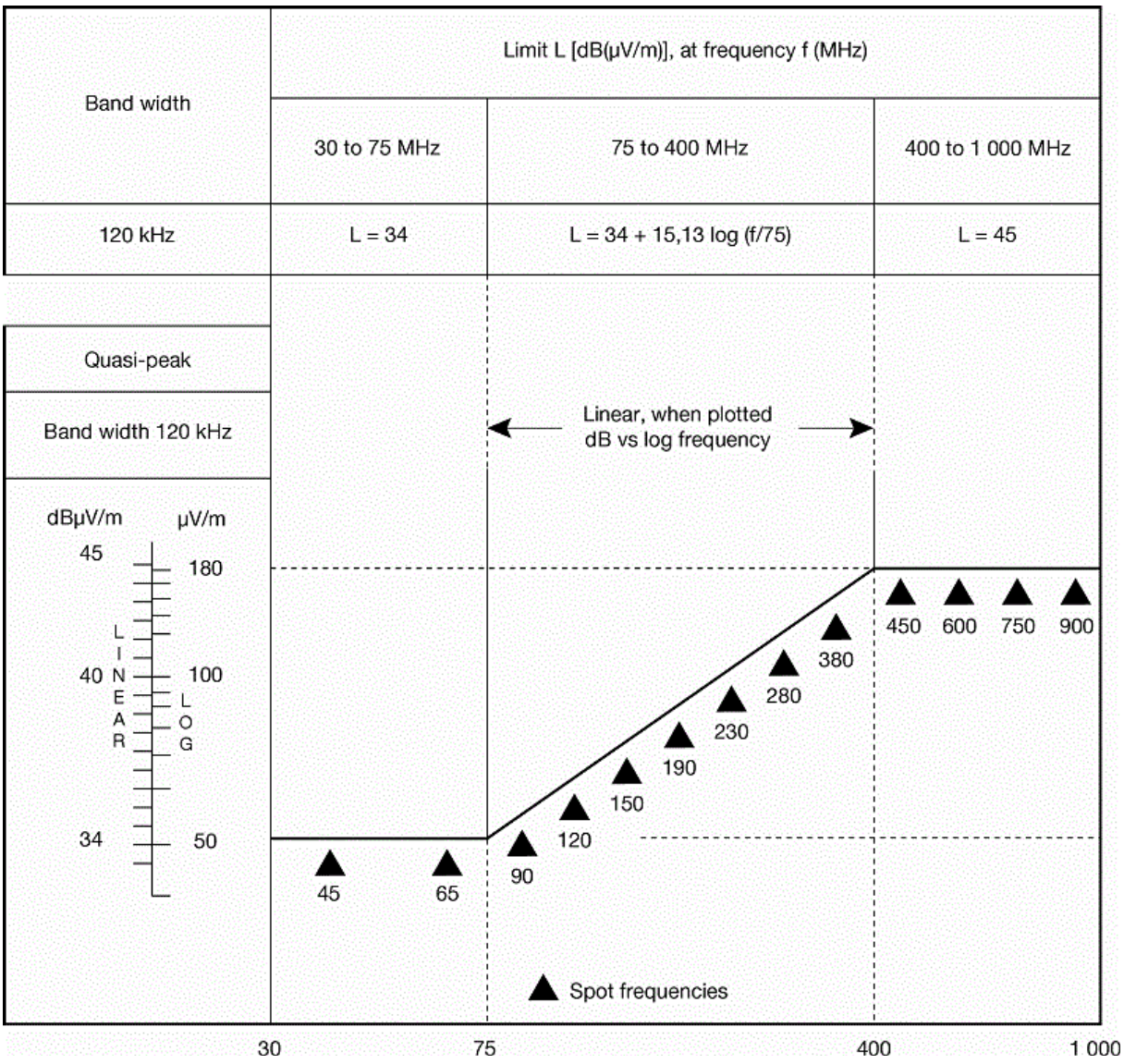
4.4. Electrostatic discharge

For vehicles fitted with tyres, the vehicle body/chassis can be considered to be an electrically isolated structure. Significant electrostatic forces in relation to the vehicle's external environment only occur at the moment of occupant entry into or exit from the vehicle. As the vehicle is stationary at these moments, no type-approval test for electrostatic discharge is deemed necessary.

4.5. Conducted transients

Since during normal driving no external electrical connections are made to vehicles, no conducted transients are generated in relation to the external environment. The responsibility of ensuring that equipment can tolerate the conducted transients within a vehicle, for example due to load switching and interaction between systems, shall lie with the manufacturer. No type-approval test for conducted transients shall be deemed necessary.

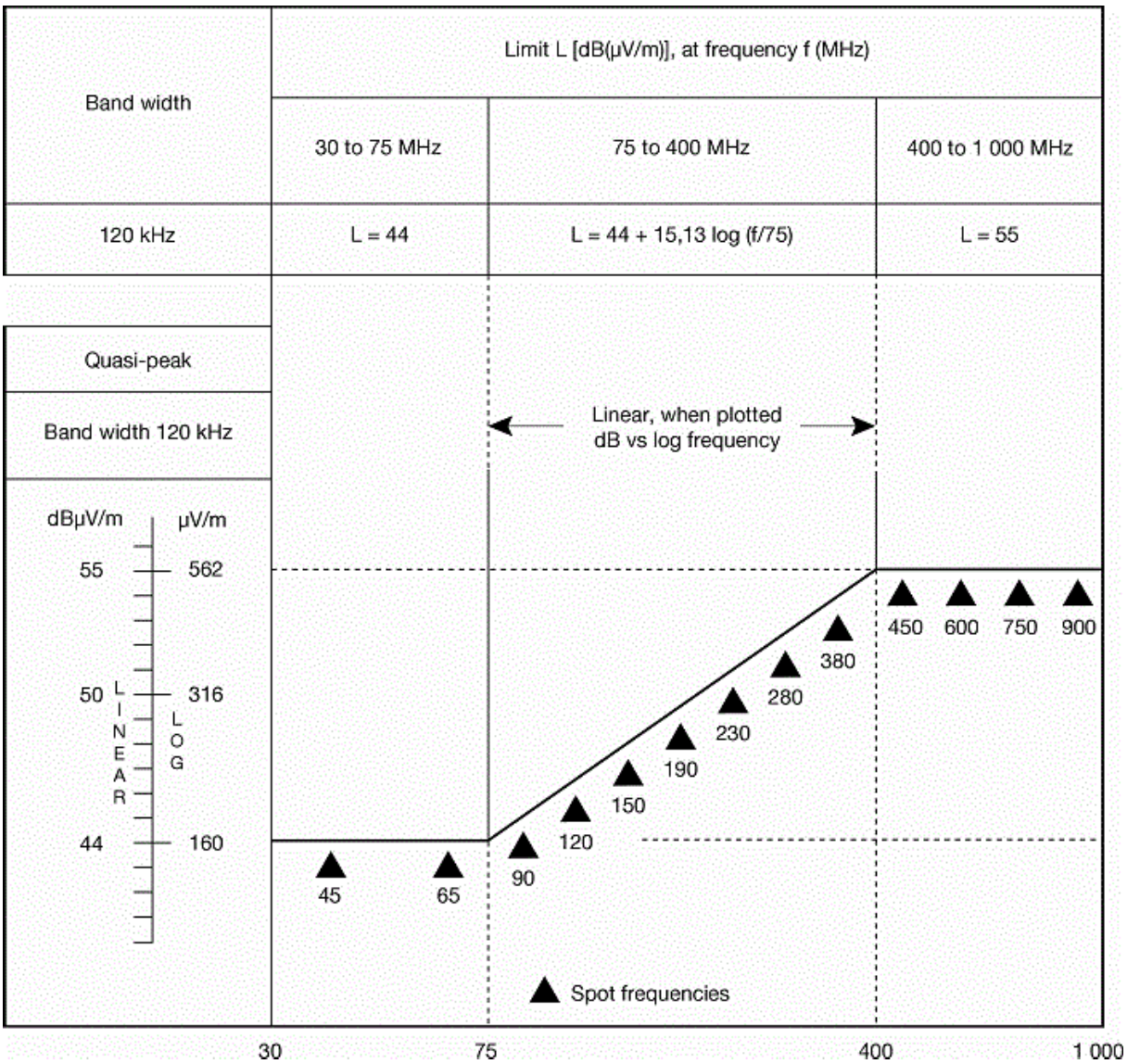
5. Vehicle broadband reference limits with antenna-vehicle separation of 10 m



Frequency — megahertz — logarithmic

See point 3.2.2.1 of Part 2

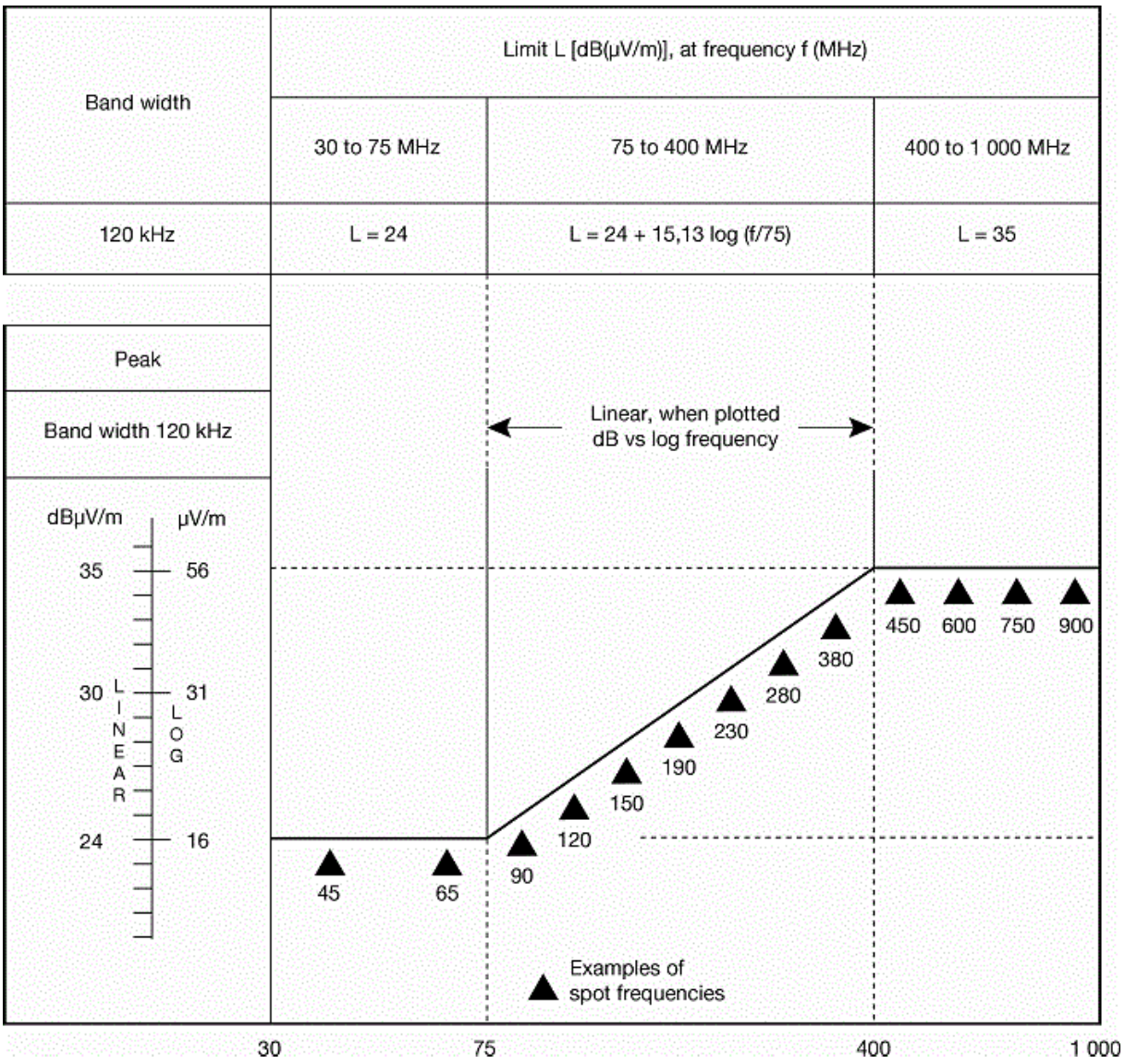
6. Vehicle broadband reference limits with antenna-vehicle separation of 3m



Frequency — megahertz — logarithmic

See point 3.2.2.2 of Part 2

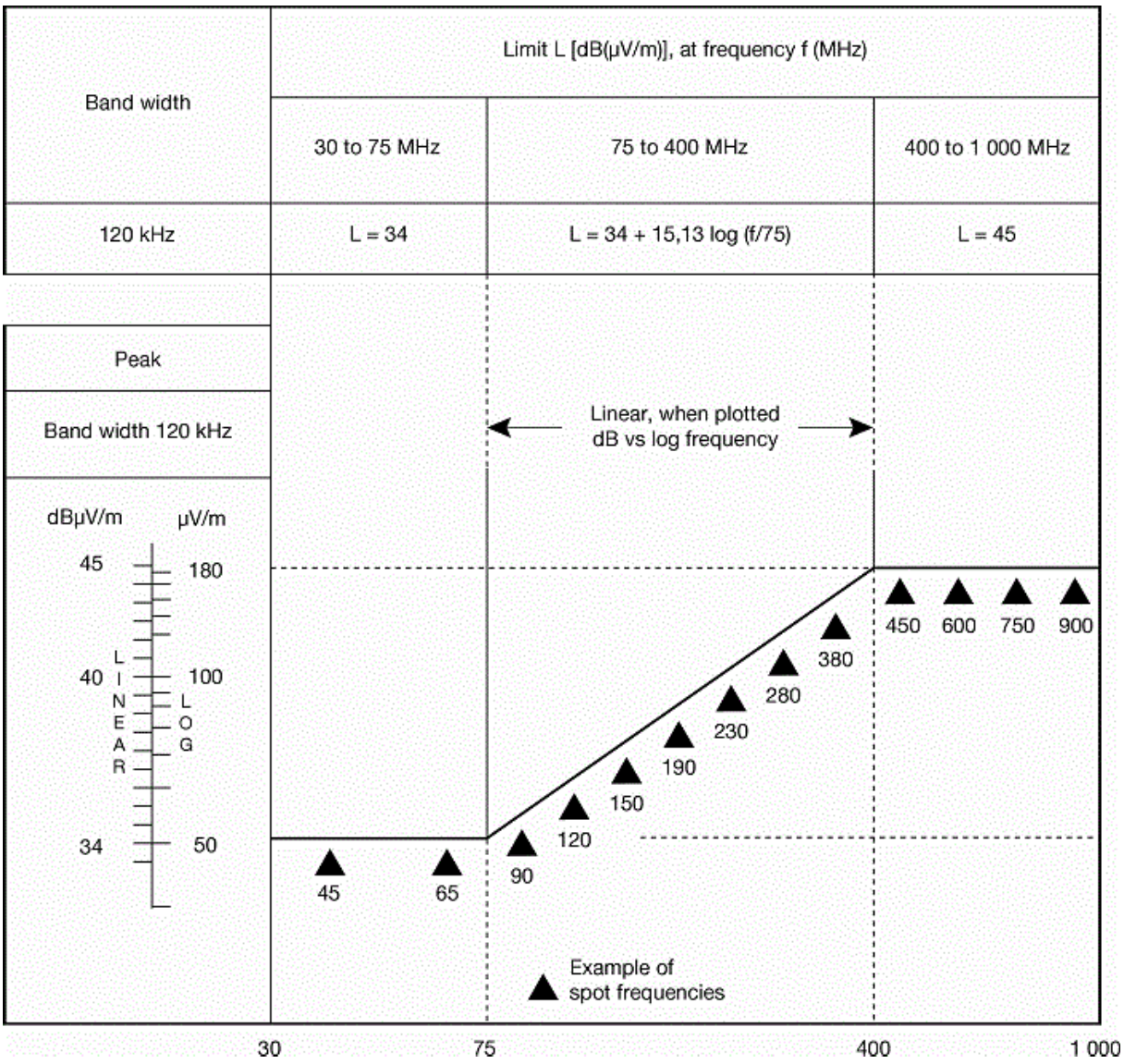
7. Vehicle narrowband reference limits with antenna-vehicle separation of 10 m



Frequency — megahertz — logarithmic

See point 3.3.2.1 of Part 2

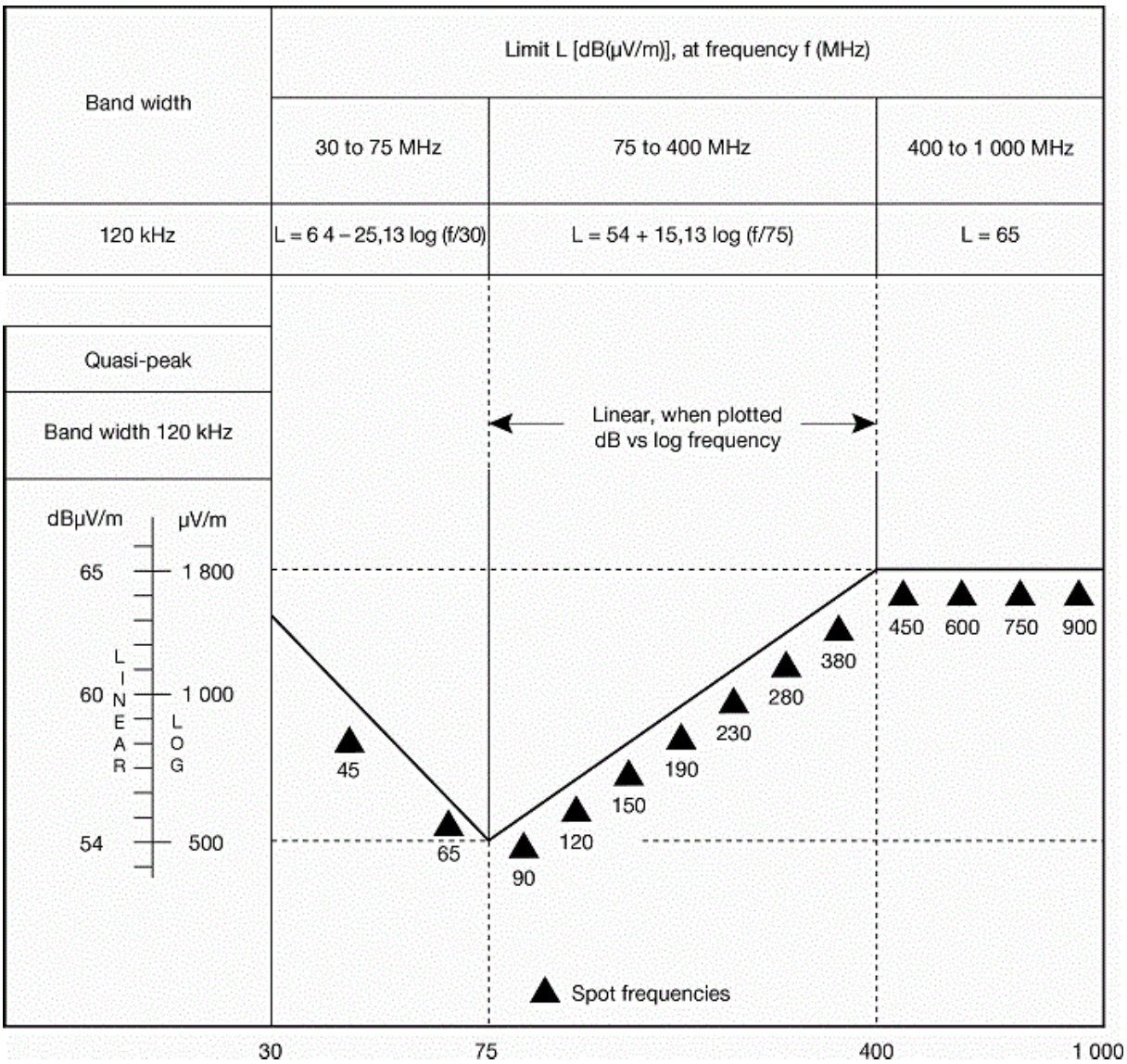
8. Vehicle narrowband reference limits with antenna-vehicle separation of 3 m



Frequency — megahertz — logarithmic

See point 3.3.2.2 of Part 2

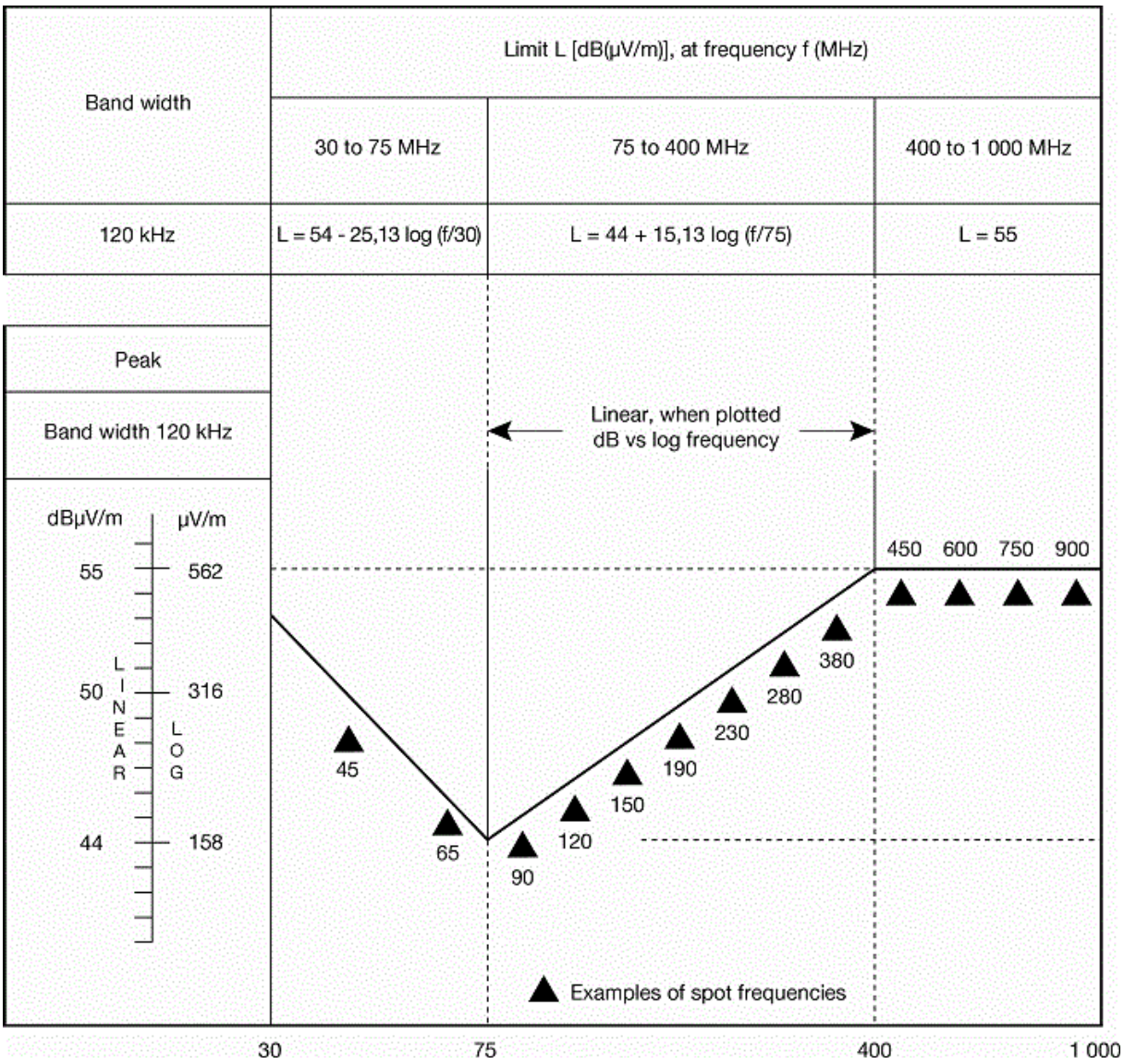
9. Broadband reference limits of electrical / electronic sub-assembly



Frequency — megahertz — logarithmic

See point 3.5.2.1 of Part 2

10. Narrowband reference limits of electrical / electronic sub-assembly



Frequency — megahertz — logarithmic

See point 3.6.2.1 of Part 2

PART 3

Requirements to be met by vehicles: method of measurement of radiated broadband electromagnetic emissions from vehicles

1. General

1.1. The test method described in this Part shall only be applied to vehicles.

1.2. Measuring apparatus

The measuring equipment shall comply with the requirements of publication No 16-1 series of the International Special Committee on Radio Interference (CISPR).

A quasi-peak detector shall be used for the measurement of broadband electromagnetic emissions in this Part, or if a peak detector is used an appropriate correction factor shall be used depending on the spark pulse rate.

1.3. Test method

This test is intended to measure the broadband electromagnetic emissions generated by spark-ignition systems and by electric motors (electric traction motors, engines for heating or de-icing systems, fuel pumps, water pumps, etc.) permanently fitted to the vehicle.

Two alternative reference antenna distances are permissible: 10 or 3 m from the vehicle. In either case point 3 shall apply.

2. Expression of results

The results of measurements shall be expressed in dB microvolts/m (microvolt/m) for 120 kHz band width. If the actual band width B (expressed in kHz) of the measuring apparatus differs from 120 kHz, the readings taken in microvolts/m shall be converted to 120 kHz band width through multiplication by a factor 120/B.

3. Measuring location

3.1. The test site shall be a level, clear area free from electromagnetic reflecting surfaces within a circle of minimum radius 30 m measured from a point midway between the vehicle and the antenna (see Figure 1 in point 7).

3.2. The measuring set, test hut, or vehicle in which the measurement set is located may be within the test site, but only in the permitted region shown in Figure 1 in point 7.

Other measuring antennae are allowed within the test area, at a minimum distance of 10 m both from receiving antenna and the vehicle under test, provided that it can be shown that the test results will not be affected.

3.3. Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of Figure 1 in point 7 other than the distance from the antenna to the vehicle and the height of the antenna. Neither do they need to have ambient emissions checked before or after the test as indicated in point 3.4.

3.4. Ambient

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, measurements shall be taken before and after the main test. If the vehicle is present when ambient measurements are taken, the technical service shall ensure that any emissions from the vehicle do not affect significantly the ambient measurements, for example by removing the vehicle from the test area, removing the ignition key, or disconnecting the battery. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in point 3.2.2.1 or 3.2.2.2 (as appropriate) of Part 2, except for intentional narrowband ambient transmissions.

4. Vehicle state during tests

4.1. Engine

The engine shall be running at its normal operating temperature and the transmission shall be in neutral. If for practical reasons this cannot be achieved, alternative arrangements mutually agreed between the manufacturer and the test authorities may be made.

Care shall be taken to ensure that the speed setting mechanism does not influence electromagnetic radiations. During each measurement, the engine shall be operated as follows:

Engine type	Method of measurements	
	Quasi peak	Peak
Spark ignition	Engine speed	Engine speed
One cylinder	2,500 rpm ± 10 %	2,500 rpm ± 10 %
More than one cylinder	1,500 rpm ± 10 %	1,500 rpm ± 10 %

4.2. Testing shall not be conducted while rain or other precipitation is falling on the vehicle or within 10 minutes after such precipitation has stopped.

5. Antenna type, position and orientation

5.1. Antenna type

Any antenna may be used provided it can be normalised to the reference antenna. The method described in CISPR publication No 12, Edition 6, Annex C may be used to calibrate the antenna.

5.2. Height and distance of measurement

5.2.1. Height

5.2.1.1. 10 m test

The phase centre of the antenna shall be 3.00 ± 0.05 m above the plane on which the vehicle rests.

5.2.1.2. 3 m test

The phase centre of the antenna shall be 1.80 ± 0.05 m above the plane on which the vehicle rests.

5.2.1.3. No part of any antenna's receiving elements shall be closer than 0.25 m to the plane on which the vehicle rests.

5.2.2. Distance of measurement

5.2.2.1. 10 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in point 5.1 to the outer body surface of the vehicle shall be 10.0 ± 0.2 m.

5.2.2.2. 3 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in point 5.1 to the outer body surface of the vehicle shall be 3.00 ± 0.05 m.

5.2.2.3. If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 1.0 m to any radio absorbent material and no closer than 1.5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and vehicle under test.

5.3. Antenna location relative to vehicle

The antenna shall be located successively on the left and right-hand sides of the vehicle, with the antenna parallel to the plane of longitudinal symmetry of the vehicle, in line with the engine mid-point (see Figure 1 in point 7) and in line with the vehicle mid-point defined as the point on the principal axis of the vehicle midway between the centres of the front and rear axles of the vehicle.

5.4. Antenna position

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation (see Figure 2 in point 7).

5.5. Readings

The maximum of the four readings taken in accordance with points 5.3 and 5.4 at each spot frequency shall be taken as the characteristic reading at the frequency at which the measurements were made.

6. Frequencies

6.1. Measurements

Measurements shall be made throughout the 30 to 1,000 MHz frequency range. To confirm that the vehicle meets the requirements of this Part, the Testing Authority shall test at up to 13 frequencies in the range, for example 45, 65, 90, 120, 150, 190, 230, 280, 380, 450, 600, 750, 900 MHz. In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the vehicle and not to background radiation.

6.1.1. The limits apply throughout the frequency range 30 to 1,000 MHz.

6.1.2. Measurements can be performed with either quasi-peak or peak detectors. The limits given in points 3.2 and 3.5 of Part 2 are for quasi-peak. If peak is used, add 38 dB for 1 MHz band width or subtract 22 dB for 1 kHz band width.

6.2. Tolerances

Spot frequency (MHz)	Tolerance (MHz)
45, 65, 90, 120, 150, 190 and 230	±5
280, 380, 450, 600, 750 and 900	±20

The tolerances apply to frequencies quoted and are intended to avoid interference from transmissions operating on or near the nominal spot frequencies during the time of measurement.

7. Figures

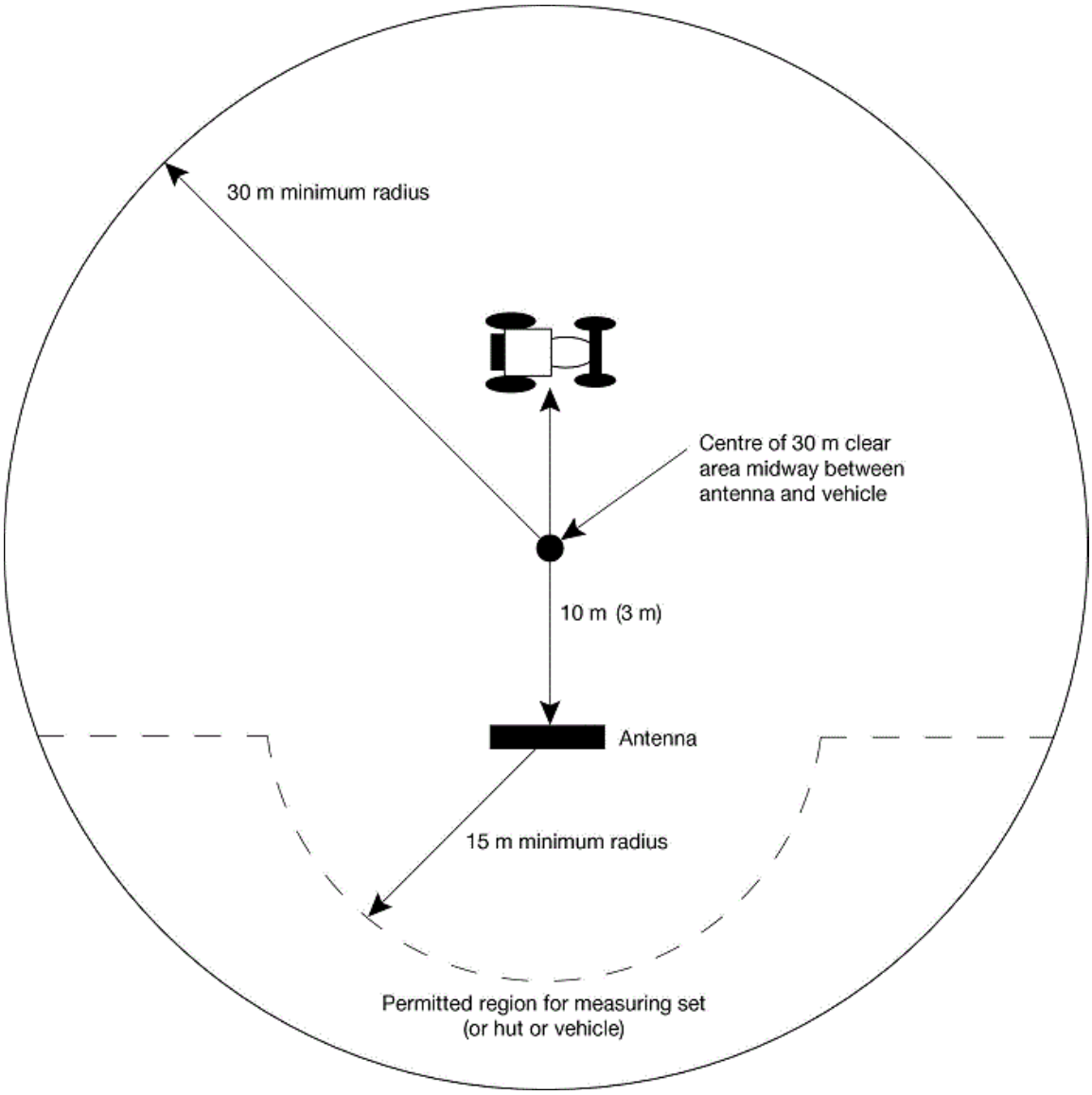
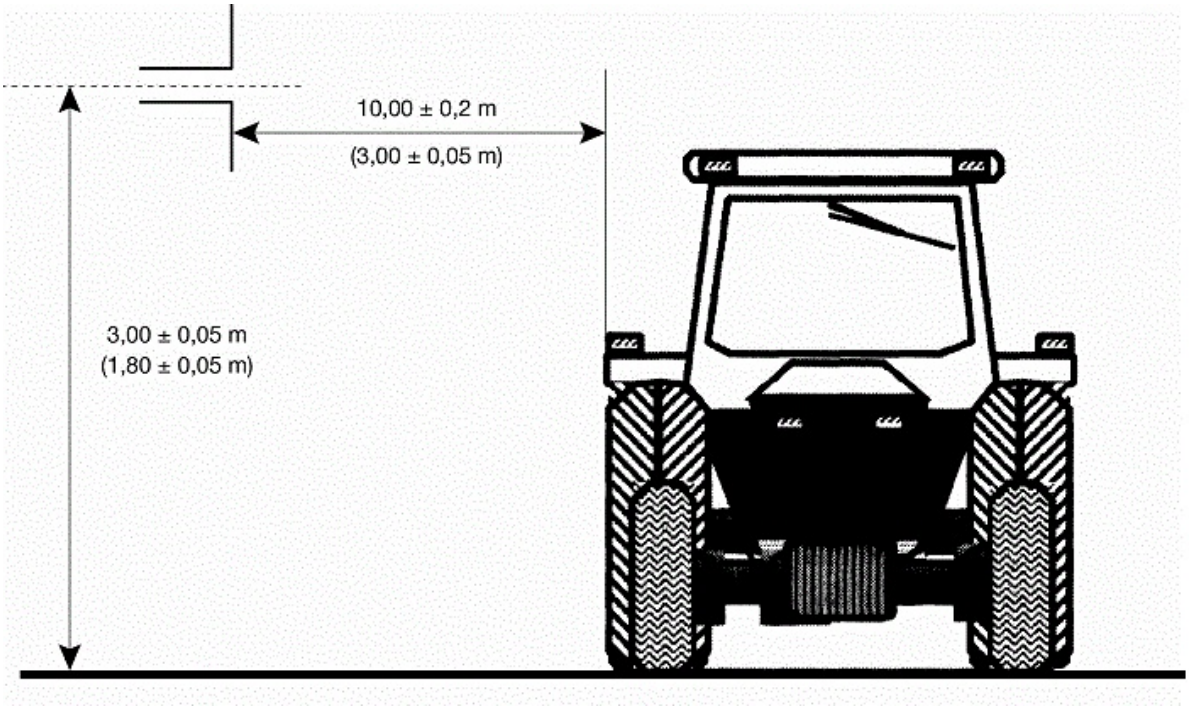


Figure 1

Tractor test area

(Level area free from reflecting electromagnetic surfaces)



Position of antenna relative to tractor

Elevation

Dipole antenna in position to measure vertical component of radiation

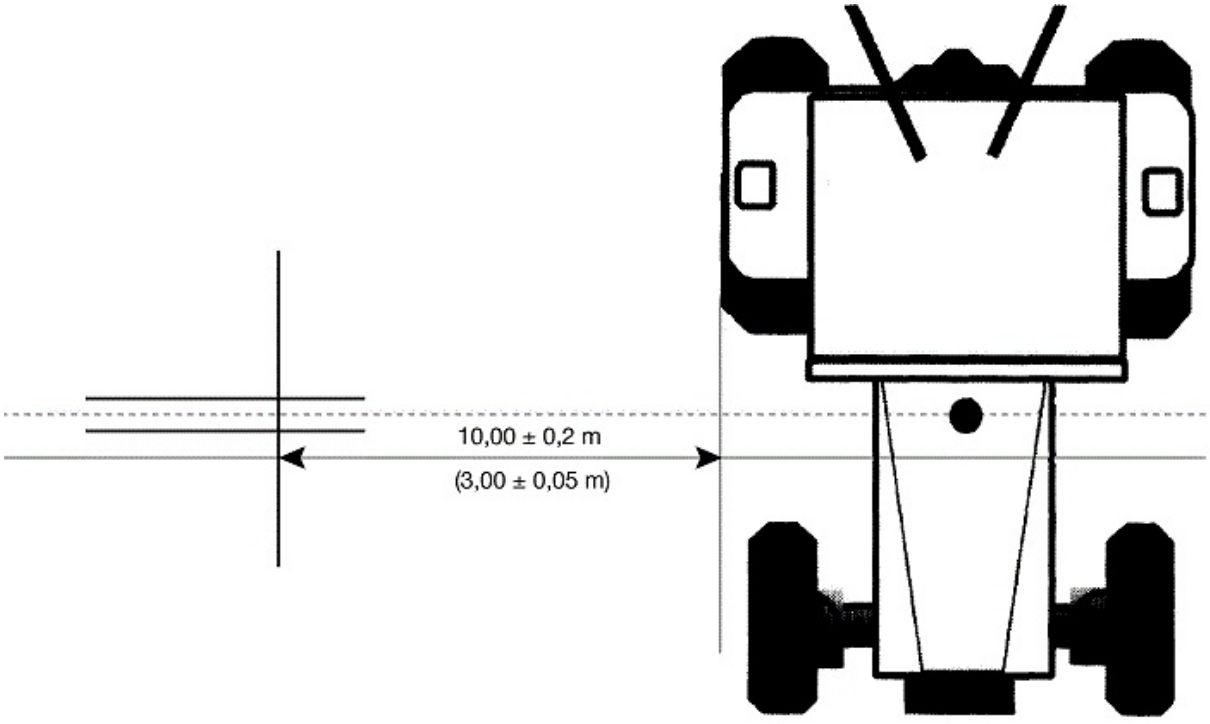


Figure 2

Plan

Dipole antenna in position to measure horizontal component of radiation

PART 4

Method of measurement of radiated narrowband electromagnetic emissions from vehicles

1. General

1.1. The test method described in this Part shall only be applied to vehicles.

1.2. Measuring apparatus

The measuring equipment shall comply with the requirements of publication No 16-1 series of the International Special Committee on Radio Interference (CISPR).

An average detector or a peak detector shall be used for the measurement of radiated narrowband electromagnetic emissions in this Annex.

1.3. Test method

1.3.1. This test is intended to measure narrowband electromagnetic emissions such as might emanate from a microprocessor-based system or other narrowband source.

1.3.2. As an initial step the levels of emissions in the FM frequency band (88 to 108 MHz) shall be measured at the vehicle broadcast radio antenna with equipment as specified in point 1.2. If the level specified in point 3.3.2.4 of Part 2 is not exceeded, the vehicle shall be deemed to comply with the requirements set out in this Part in respect of that frequency band and the full test shall not be carried out.

1.3.3. In the full test procedure two alternative antenna distances are permissible: 10 or 3 m from the vehicle. In either case, the requirements set out in point 3 shall be complied with.

2. Expression of results

The results of measurements shall be expressed in dB microvolts/m (microvolts/m).

3. Measuring location

3.1. The test site shall be a level, clear area free from electromagnetic reflecting surfaces within a circle of minimum radius 30 m measured from a point midway between the vehicle and the antenna (see Figure 1 in Part 3).

3.2. The measuring set, test hut, or vehicle in which the measurement set is located may be within the test site, but only in the permitted region shown in Figure 1 in Part 3.

Other measuring antennae are allowed within the test area, at a minimum distance of 10 m both from receiving antenna and the vehicle under test, provided that it can be shown that the test results will not be affected.

3.3. Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of Figure 1 in point 7 of Part 3 other than the distance from the antenna to the vehicle and the height of the antenna. Neither do they need to have ambient emissions checked before or after the test as indicated in point 3.4 of this Part.

3.4. Ambient

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, ambient measurements shall be taken before and after the main test. The technical service shall ensure that any emissions from the vehicle do not affect significantly the ambient measurements, for example by removing the vehicle from the test area, removing the ignition key, or disconnecting the battery(ies). In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in point 3.3.2.1 or 3.3.2.2 (as appropriate) of Part 2, except for intentional narrowband ambient transmissions.

4. Vehicle state during tests

4.1. The vehicle's electronic systems shall all be in normal operating mode with the vehicle stationary.

4.2. The ignition shall be switched on. The engine shall not be operating.

4.3. Measurements shall not be made while rain or other precipitation is falling on the vehicle or within 10 minutes after such precipitation has stopped.

5. Antenna type, position and orientation

5.1. Antenna type

Any antenna may be used provided that it can be normalised to the reference antenna. The method described in the CISPR publication No 12, Edition 6, Annex C, may be used to calibrate the antenna.

5.2. Height and distance of measurement

5.2.1. Height

5.2.1.1. 10 m test

The phase centre of the antenna shall be 3.00 ± 0.05 m above the plane on which the vehicle rests.

5.2.1.2. 3 m test

The phase centre of the antenna shall be 1.80 ± 0.05 m above the plane on which the vehicle rests.

5.2.1.3. No part of any antenna's receiving elements shall be closer than 0.25 m to the plane on which the vehicle rests.

5.2.2. Distance of measurement

5.2.2.1. 10 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in point 5.1 to the outer body surface of the vehicle shall be 10.0 ± 0.2 m.

5.2.2.2. 3 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in point 5.1 to the outer body surface of the vehicle shall be 3.00 ± 0.05 m.

5.2.2.3. If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 1.0 m to any radio absorbent material and no closer than 1.5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and vehicle under test.

5.3. Antenna location relative to vehicle

The antenna shall be located successively on the left and right-hand sides of the vehicle with the antenna parallel to the plane of longitudinal symmetry of the vehicle and in line with the engine mid-point (see Figure 2 in point 7 of Part 3).

5.4. Antenna position

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation (see Figure 2 in point 7 of Part 3).

5.5. Readings

The maximum of the four readings taken in accordance with points 5.3 and 5.4 at each spot frequency shall be taken as the characteristic reading at the frequency at which the measurements are made.

6. Frequencies

6.1. Measurements

Measurements shall be made throughout the 30 to 1,000 MHz frequency range. This range shall be divided into 13 bands. In each band one spot frequency may be tested to demonstrate that the required limits are satisfied. To confirm that the vehicle meets the requirements of this Part, the testing authority shall test at one such point in each of the following 13 frequency bands:

30 to 50, 50 to 75, 75 to 100, 100 to 130, 130 to 165, 165 to 200, 200 to 250, 250 to 320, 320 to 400, 400 to 520, 520 to 660, 660 to 820, 820 to 1,000 MHz.

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the vehicle and not to background radiation.

PART 5

Method of testing for immunity of vehicles to electromagnetic radiation

1. General

1.1. The test method described in this Part shall only be applied to vehicles.

1.2. Test method

This test is intended to demonstrate the immunity to degradation in the direct control of the vehicle. The vehicle shall be subject to electromagnetic fields as described in this Part. For tests with the vehicle exposed to electromagnetic radiation of frequency not exceeding 1,000 MHz, manufacturers may choose whether to apply either this Part or Annex 6 to UNECE Regulation No 10 as referenced in Annex I. For tests with the vehicle exposed to electromagnetic radiation of frequency exceeding 1,000 MHz and not exceeding 2,000 MHz, manufacturers shall apply Annex 6 to UNECE Regulation No 10 as referenced in Annex I. The vehicle shall be monitored during the tests.

2. Expression of results

For the test described in this Part, field strengths shall be expressed in volts/m.

3. Measuring location

The test facility shall be capable of generating the field strengths over the frequency ranges defined in this Part. The test facility shall comply with legal requirements regarding the emission of electromagnetic signals.

Care shall be taken so that the control and monitoring equipment shall not be affected by radiated fields in such a way as to invalidate the tests.

4. Vehicle state during tests

4.1. The vehicle shall be in an unladen condition except for necessary test equipment.

4.1.1. The engine shall turn the driving wheels normally at a constant speed corresponding to three quarters of the maximum speed of the vehicle if there is no technical reason for the manufacturer to prefer another speed. The vehicle's engine shall be loaded with an appropriate torque. If need be, the transmission shafts may be disengaged (for example, in the case of vehicles with more than two axles), provided they do not drive a component-emitting interference.

4.1.2. Headlamps shall be on dipped beam.

4.1.3. Left or right-direction indicator shall be operating.

4.1.4. All other systems which affect the driver's control of the vehicle shall be (on) as in normal operation of the vehicle.

4.1.5. The vehicle shall not be electrically connected to the test area and no connections shall be made to the vehicle from any equipment, except as required by point 4.1.1 or 4.2. Tyre contact with the test area floor shall not be considered to be an electrical connection.

4.2. If there are vehicle electrical/electronic systems which form an integral part of the direct control of the vehicle, which will not operate under the conditions described in point 4.1, the manufacturer may provide a report or additional evidence to the testing authority that the vehicle electrical/electronic system meets the requirements of this Regulation. Such evidence shall be retained in the type-approval documentation.

4.3. Only non-perturbing equipment shall be used while monitoring the vehicle. The vehicle exterior and the passenger compartment shall be monitored to determine whether the

requirements of this Part are met (for example by using (a) video camera(s)).

4.4. The vehicle shall normally face a fixed antenna. However, where the electronic control units and the associated wiring harness are predominantly in the rear of the vehicle, the test shall normally be carried out with the vehicle facing away from the antenna. In the case of long vehicles (namely excluding cars and light vans), which have electronic control units and associated wiring harness predominantly towards the middle of the vehicle, a reference point (see point 5.4) may be established based on either the right-side surface or the left-side surface of the vehicle. This reference point shall be at the midpoint of the vehicle's length or at one point along the side of the vehicle chosen by the manufacturer in conjunction with the competent authority after considering the distribution of electronic systems and the layout of any wiring harness.

Such testing may only take place if the physical construction of the chamber permits. The antenna location shall be noted in the test report.

5. Field generating device type, position and orientation

5.1. Field generating device type

5.1.1. The field generating device type(s) shall be chosen such that the desired field strength is achieved at the reference point (see point 5.4) at the appropriate frequencies.

5.1.2. The field generating device(s) may be an antenna or antennas or a transmission line system (TLS).

5.1.3. 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.

5.2. Height and distance of measurement

5.2.1. Height

5.2.1.1. The phase centre of any antenna shall not be less than 1.5 m above the plane on which the vehicle rests or not less than 2.0 m above the plane on which the vehicle rests if the vehicle roof exceeds 3 m in height.

5.2.1.2. No part of any antenna's radiating elements shall be closer than 0.25 m to the plane on which the vehicle rests.

5.2.2. Distance of measurement

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

5.2.2.2. If the test is carried out in an enclosed facility, the field generating device's radiating elements shall be no closer than 1.0 m to any radio absorbent material and no closer than 1.5 m to the wall of the enclosed facility. There shall be no absorbent material between the transmitting antenna and the vehicle under test.

5.3. Antenna location relative to vehicle

5.3.1. The field generating device's radiating elements shall not be closer than 0.5 m to the outer body surface of the vehicle.

5.3.2. The field generating device shall be positioned on the vehicle's centre line (plane of

longitudinal symmetry).

5.3.3. No part of a TLS, with the exception of the plane on which the vehicle rests, shall be closer than 0.5 m to any part of the vehicle.

5.3.4. Any field generating device which is placed over the vehicle shall extend centrally over at least 75 % of the length of the vehicle.

5.4. Reference point

5.4.1. For the purposes of this Part the reference point is the point at which the field strength shall be established and shall be defined as follows:

5.4.1.1. at least 2 m horizontally from the antenna phase centre or at least 1 m vertically from the radiating elements of a TLS,

5.4.1.2. on the vehicle's centre line (plane of longitudinal symmetry),

5.4.1.3. at a height of 1.0 ± 0.05 m above the plane on which the vehicle rests or 2.0 ± 0.05 m if the minimum height of the roof of any vehicle in the model range exceeds 3.0 m,

5.4.1.4. for front illumination, either:

– 1.0 ± 0.2 m inside the vehicle, measured from the point of intersection of the windscreen and bonnet (see point C in Figure 1 of point 8), or

– 0.2 ± 0.2 m from the centre line of the front axle of the tractor, measured towards the centre of the tractor (see point D in Figure 2 of point 8),

whichever results in a reference point closer to the antenna,

5.4.1.5. for rear illumination, either:

– 1.0 ± 0.2 m inside the vehicle, measured from the point of intersection of the windscreen and bonnet (see point C in Figure 1 of point 8), or

– 0.2 ± 0.2 m from the centre line of the rear axle of the tractor, measured towards the centre of the tractor (see point D in Figure 2 of point 8),

whichever results in a reference point closer to the antenna.

5.5. If it is decided to radiate the rear of the vehicle, the reference point shall be established as in point 5.4. The vehicle shall then be installed facing away from the antenna and positioned as if it had been horizontally rotated 180° around its centre point, namely in such a way that the distance from the antenna to the nearest part of the outer body of the vehicle remains the same, as illustrated in Figure 3 of point 8.

6. Test requirements

6.1. Frequency range, dwell times, polarisation

The vehicle shall be exposed to electromagnetic radiation in the 20 to 1,000 MHz frequency range.

6.1.1. To confirm that the vehicle meets the requirements of this Part, the vehicle shall be tested at up to 14 spot frequencies in the range, for example:

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.

6.1.2. One mode of polarisation shall be used at each frequency — see point 5.1.3.

6.1.3. All other test parameters shall be as defined in this Part.

6.1.4. If a vehicle fails the test defined in point 6.1.1, the technical service shall verify as having failed under the relevant test conditions and not as a result of the generation of uncontrolled fields.

7. Generation of required field strength

7.1. Test methodology

7.1.1. The 'substitution method' shall be used to establish the test field conditions.

7.1.2. Calibration phase

At each 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 point 5) in the test area with the vehicle absent, the 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. Test frequencies shall lie in the range 20 to 1,000 MHz. Calibration shall be made, starting at 20, in steps not greater than two per cent of the previous frequency finishing at 1,000 MHz. These results shall be used for type-approval tests unless changes occur in the facilities or equipment which necessitate this procedure being repeated.

7.1.3. Test phase

The vehicle shall then be introduced into the test facility and positioned in accordance with the requirements of point 5. The required forward power defined in point 7.1.2 at each frequency as defined in point 6.1.1 shall then be applied to the field generating device.

7.1.4. Whatever parameter was chosen in point 7.1.2 to define the field, the same parameter shall be used to establish the field strength during the test.

7.1.5. The field generating equipment and its layout employed during the test shall be to the same specification as that used during the operations performed in point 7.1.2.

7.1.6. 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.

7.1.7. During the calibration phase of the substitution method, the phase centre of the field strength measuring device shall be positioned at the reference point.

7.1.8. If a calibrated receiving antenna is used as the field strength measuring device, readings shall be obtained in three mutually orthogonal directions and the isotropic equivalent value of the readings shall be taken as the field strength

7.1.9. To take account of different vehicle geometries, a number of antennae positions or reference points may need to be established for a given test facility.

7.2. Field strength contour

7.2.1. During the calibration phase of the substitution method (prior to a vehicle being introduced into the test area), the field strength in at least 80 % of the calibration steps shall not be less than 50 % of the nominal field strength, at the following locations:

(a) for all field generating devices, 0.5 ± 0.05 m either side of the reference point on a line passing through the reference point and at the same height as the reference point, and perpendicular to the vehicle plane of longitudinal symmetry;

(b) in the case of a TLS, 1.50 ± 0.05 m on a line passing through the reference point at the same height as the reference point and along the line of longitudinal symmetry.

7.3. Chamber resonance

Notwithstanding the condition set out in point 7.2.1, tests shall not be performed at chamber resonant frequencies.

7.4. Characteristics of the test signal to be generated

7.4.1. Maximum envelope excursion

The maximum envelope excursion of the test signal shall equal the maximum envelope excursion of an unmodulated sine wave whose rms value in volts/m is defined in point 3.4.2 of Part 2 (see Figure 3 of this Part).

7.4.2. 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.

7.4.3. Modulation depth

The modulation depth m is defined as:

m	=	(maximum envelop excursion – minimum envelope excursion)/(maximum envelope excursion + minimum envelope excursion).

8. Figures

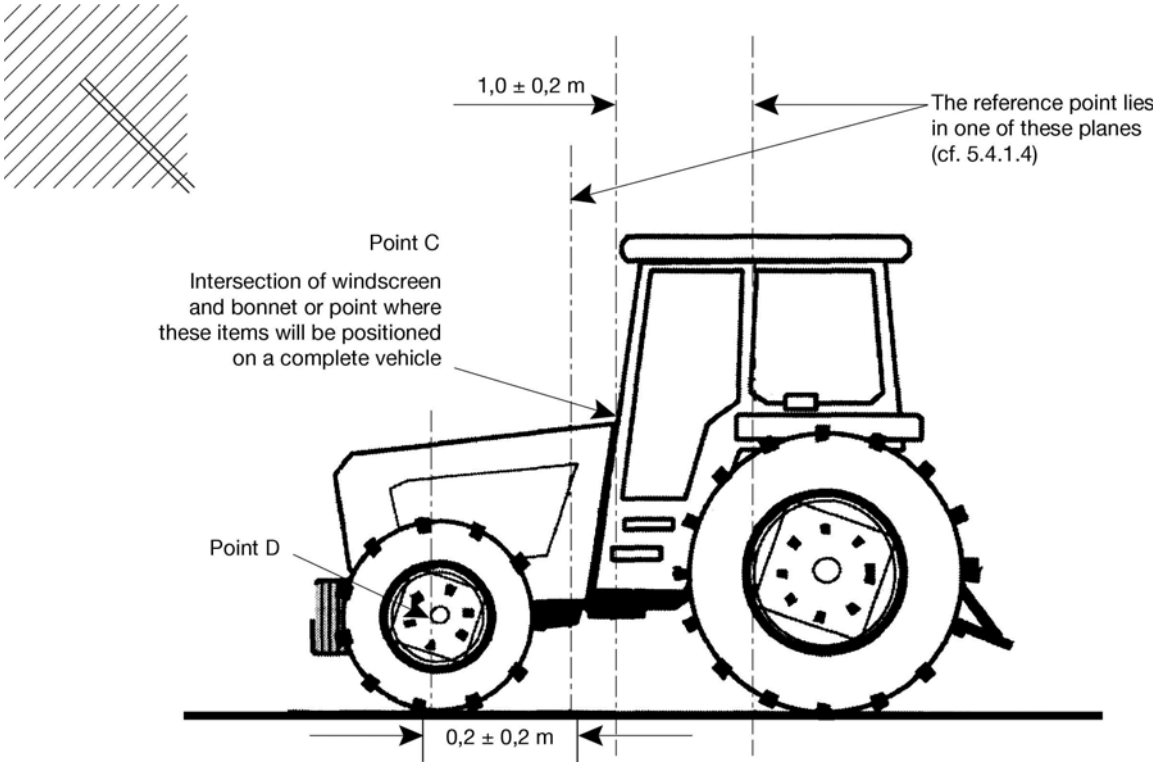


Figure 1

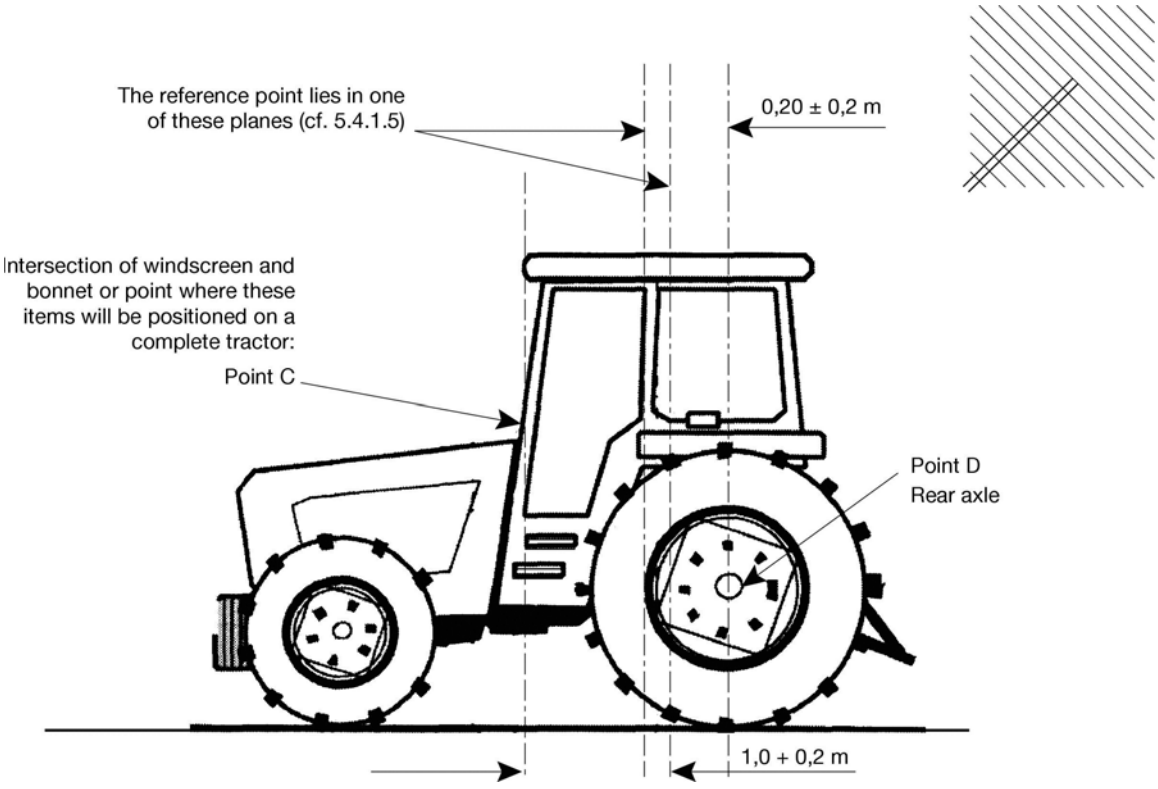


Figure 2

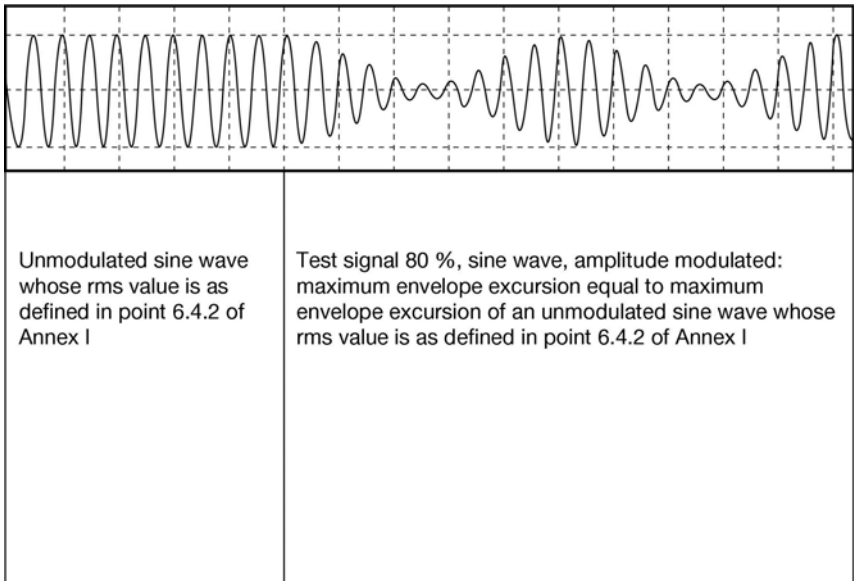


Figure 3

Characteristics of test signal to be generated

PART 6

Method of measurement of radiated broadband electromagnetic emissions from electrical / electronic sub-assemblies

1. General

1.1. The test method described in this Part may be applied to ESAs which may be subsequently fitted to vehicles which comply with Part 3.

1.2. Measuring apparatus

The measuring equipment shall comply with the requirements of publication No 16-1 series of the International Special Committee on Radio Interference (CISPR).

A quasi-peak detector shall be used for the measurement of broadband electromagnetic emissions in this Part, or if a peak detector is used an appropriate correction factor shall be used depending on the interference pulse rate.

1.3. Test method

This test is intended to measure broadband electromagnetic emissions from ESAs.

2. Expression of results

The results of measurements shall be expressed in dB microvolts/m (microvolts/m), for 120 kHz band width. If the actual band width B (expressed in kHz) of the measuring apparatus differs from 120 kHz, the readings taken in microvolts/m shall be converted to 120 kHz band width through multiplication by a factor 120/B.

3. Measuring location

3.1. The test site shall comply with the requirements of CISPR publication No 16-1 series (see point 7).

3.2. The measuring set, test hut or vehicle in which the measurement set is located shall be outside the boundary shown in point 7.

3.3. Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an approved outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of point 7 other than the distance from the antenna to the ESA under test and the height of the antenna (see Figures 1 and 2 in point 8).

3.4. Ambient

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, measurements shall be taken before and after the main test. In both of these measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in point 3.5.2.1 of Part 2, except for intentional narrowband ambient transmissions.

4. ESA state during tests

4.1. The ESA under test shall be in normal operation mode.

4.2. Measurements shall not be made while rain or other precipitation is falling on the ESA under test or within 10 minutes after such rain or other precipitation has stopped.

4.3. Test arrangements

4.3.1. 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.

4.3.2. 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.

4.3.3. 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.

4.3.4. 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) shall be 1.0 m.

4.4. Power shall be applied to the ESA under test via a 5 µH/50 Ω artificial network (AN) which shall be electrically bonded to the ground plane. 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.

4.5. If the ESA under test consists of more than one unit, the interconnecting cables shall 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 shall be terminated as realistically as possible and preferably with real loads and actuators.

If extraneous equipment is required for the correct operation of the ESA under test, compensation shall be made for the contribution it makes to the emissions measured.

5. Antenna type, position and orientation

5.1. Antenna type

Any linearly polarised antenna may be used provided it can be normalised to the reference antenna.

5.2. Height and distance of measurement

5.2.1. Height

The phase centre of the antenna shall be 150 ± 10 mm above ground plane.

5.2.2. Distance of measurement

The horizontal distance from the phase centre, or tip of the antenna as appropriate, to the edge of the ground plane shall be 1.00 ± 0.05 m. No part of the antenna shall be closer than 0.5 m to the ground plane.

The antenna shall be placed parallel to a plane which is perpendicular to the ground plane and coincident with the edge of the ground plane along which the principal portion of the harness runs.

5.2.3. If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving 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 enclosed facility. There shall be no absorbent material between the receiving antenna and the ESA under test.

5.3. Antenna orientation and polarisation

At the measuring point, readings shall be taken both with the antenna in a vertical and in a horizontal polarisation.

5.4. Readings

The maximum of the two readings taken (in accordance with point 5.3) at each spot frequency shall be taken as the characteristic reading at the frequency at which the measurements were made.

6. Frequencies

6.1. Measurements

Measurements shall be made throughout the 30 to 1,000 MHz frequency range. An ESA is considered as very likely to satisfy the required limits over the whole frequency range if it satisfies them at the following 13 frequencies in the range: 45, 65, 90, 120, 150, 190, 230,

280, 380, 450, 600, 750 and 900 MHz

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the ESA and not to background radiation.

6.1.1. The limits apply throughout the frequency range 30 to 1,000 MHz.

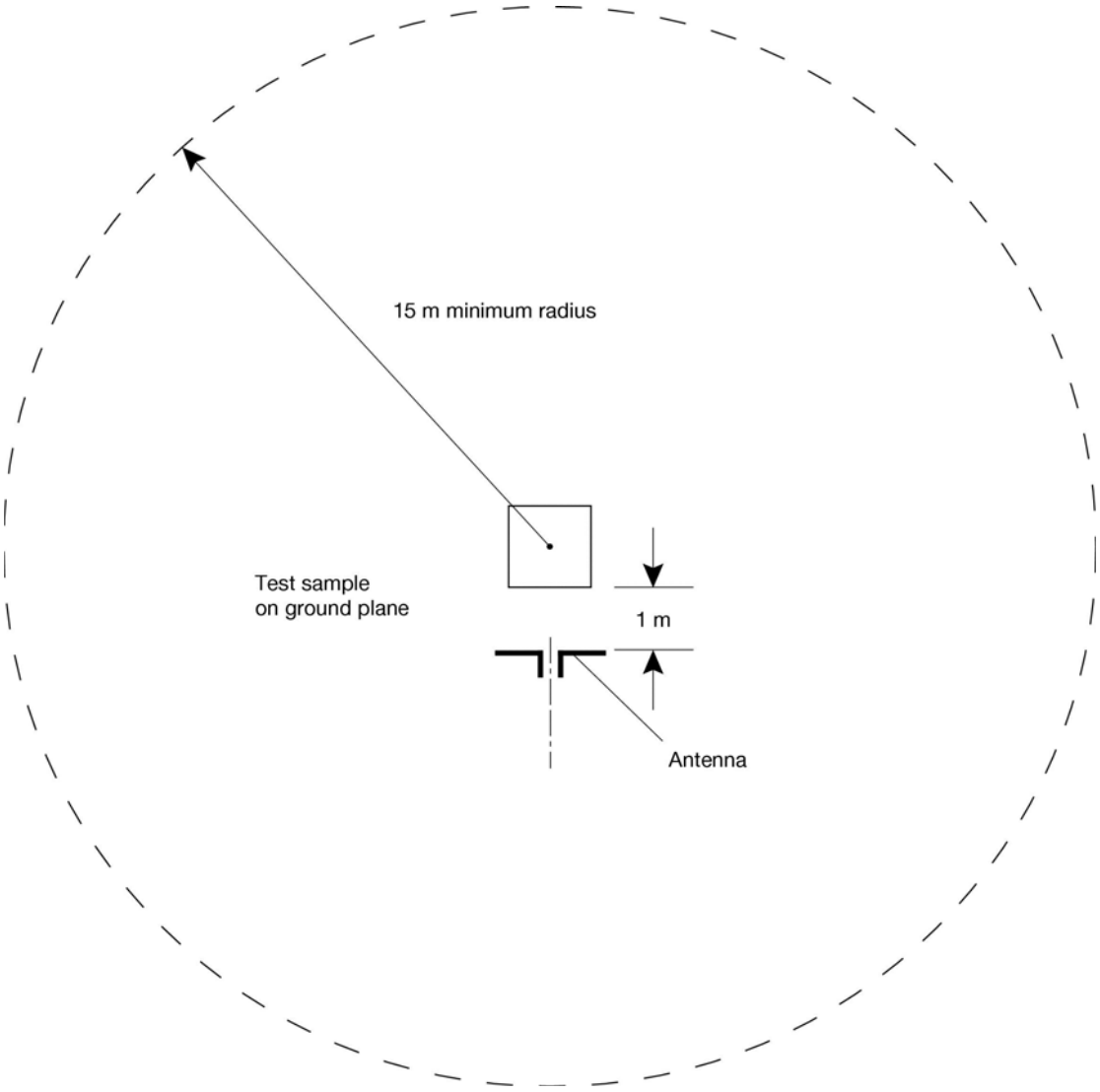
6.1.2. Measurements can be performed with either quasi-peak or peak detectors. The limits given in points 3.2 and 3.5 of Part 2 are for quasi-peak. If peak is used, add 38 dB for 1 MHz band width or subtract 22 dB for 1 kHz band width.

6.2. Tolerances

Spot frequency (MHz)	Tolerance (MHz)
45, 65, 90, 120, 150, 190 and 230	±5
280, 380, 450, 600, 750 and 900	±20

The tolerances apply to frequencies quoted and are intended to avoid interference from transmissions operating on or near the nominal spot frequencies during the time of measurement.

7. Electrical / electronic sub-assembly test area boundary



Level clear area free from electromagnetic reflecting surfaces

8. Radiated electromagnetic emissions at tests

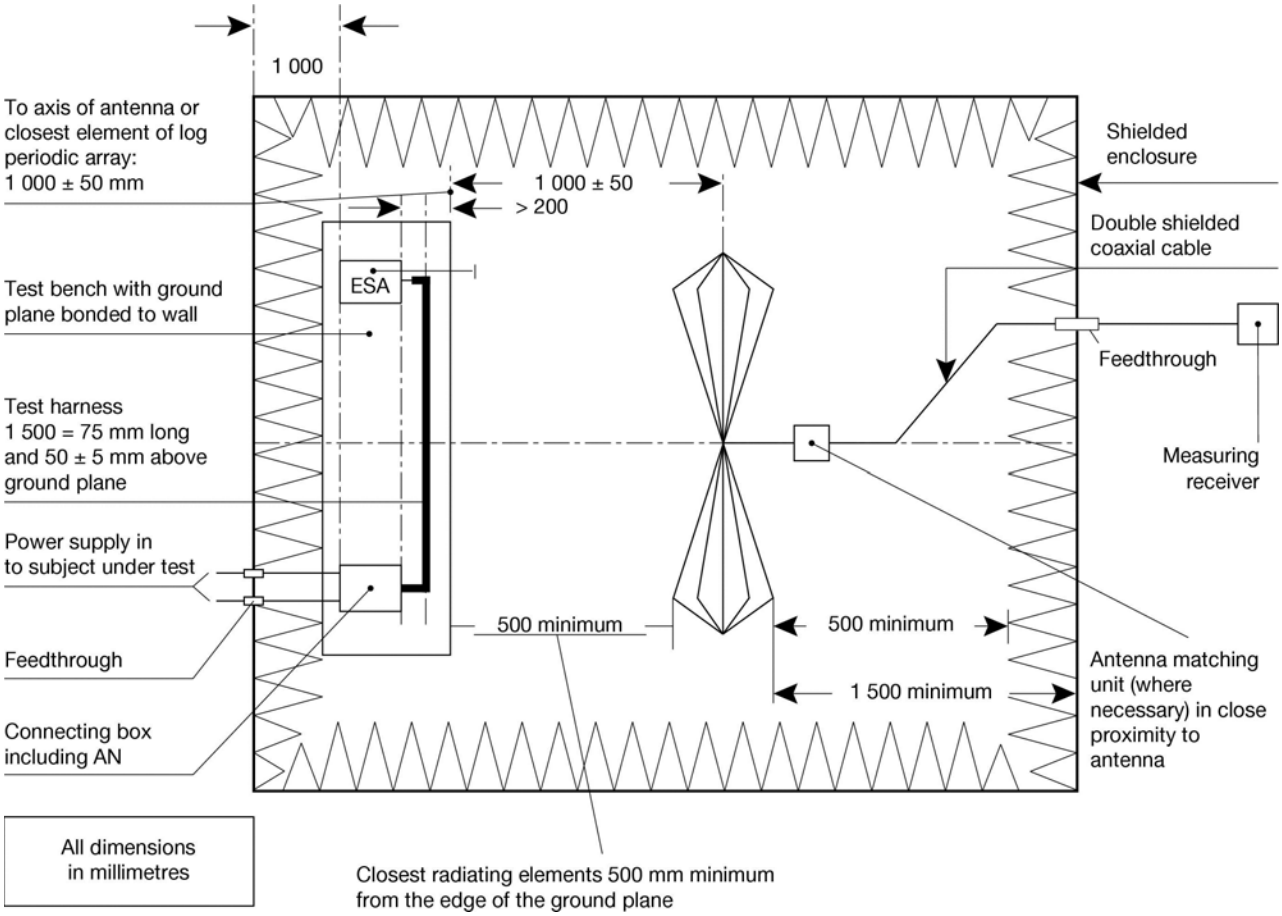


Figure 1

Radiated electromagnetic emissions from an ESA test layout (general plan view)

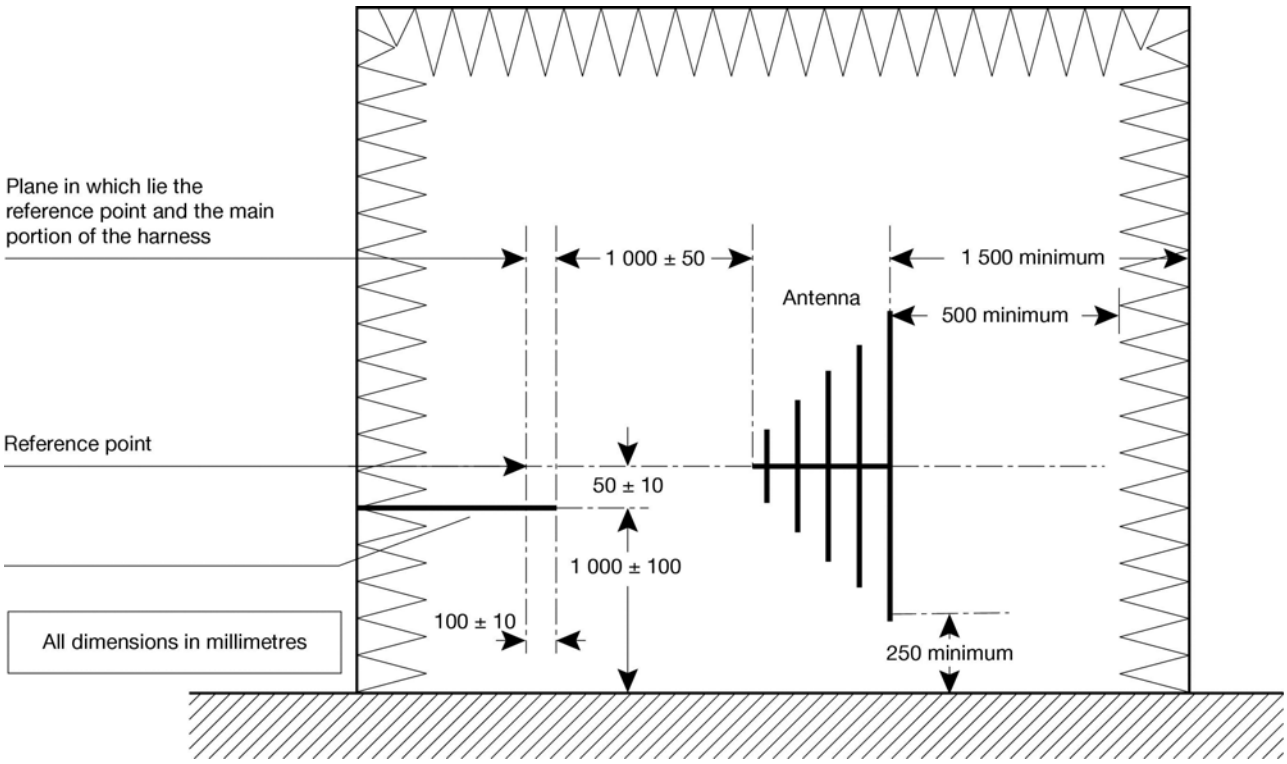


Figure 2

Radiated electromagnetic emissions from an ESA view of test bench plane of longitudinal symmetry

PART 7

Method of measurement of radiated narrowband electromagnetic emissions from electrical / electronic sub-assemblies

1. General

1.1. The test method described in this Part may be applied to ESAs.

1.2. Measuring apparatus

The measuring equipment shall comply with the requirements of publication No 16-1series of the International Special Committee on Radio Interference (CISPR).

An average detector or a peak detector shall be used for the measurement of radiated narrowband electromagnetic emissions in this Part.

1.3. Test method

1.3.1. This test is intended to measure the narrowband electromagnetic radiation such as might emanate from a microprocessor-based system.

1.3.2. As a short (2 to 3 minutes) initial step, choosing one antenna polarisation, it is permitted to make sweeps of the frequency range identified in point 6.1 using a spectrum analyser to indicate the existence and/or whereabouts of peak emissions. This may assist in the choice of frequencies to be tested (see point 6).

2. Expression of results

The results of measurements shall be expressed in dB microvolts/m (microvolts/m).

3. Measuring location

3.1. The test site shall comply with the requirements of CISPR publication No 16-1 series (see point 7 of Part 6).

3.2. The measuring set, test hut or vehicle in which the measurement set is located shall be outside the boundary shown in point 7 of Part 6.

3.3. Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of point 7 of Part 6 other than the distance from the antenna to the ESA under test and the height of the antenna (see Figures 1 and 2 in point 8 of Part 6).

3.4. Ambient

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, measurements shall be taken before and after the main test. In both of these measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in point 3.6.2.1 of Part 2, except for intentional narrowband ambient transmissions.

4. ESA state during tests

4.1. The ESA under test shall be in normal operation mode.

4.2. Measurements shall not be made while rain or other precipitation is falling on the ESA under test or within 10 minutes after rain or other precipitation has stopped.

4.3. Test arrangements

4.3.1. 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.

4.3.2. 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.

4.3.3. 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.

4.3.4. 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) shall be 1.0 m.

4.4. Power shall be applied to the ESA under test via a 5 μH/50 Ω resistance artificial network (AN) which shall be electrically bonded to the ground plane. 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.

4.5. If the ESA under test consists of more than one unit, the interconnecting cables shall 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 shall be terminated as realistically as possible and preferably with real loads and actuators. If extraneous equipment is required for the correct operation of the ESA under test, compensation shall be made for the contribution it makes to the emissions measured.

5. Antenna type, position and orientation

5.1. Antenna type

Any linearly polarised antenna may be used provided it can be normalised to the reference antenna.

5.2. Height and distance of measurement

5.2.1. Height

The phase centre of the antenna shall be 150 ± 10 mm above ground plane.

5.2.2. Distance of measurement

The horizontal distance from the phase centre, or tip of the antenna as appropriate, to the edge of the ground plane shall be 1.00 ± 0.05 m. No part of the antenna shall be closer than 0.5 m to the ground plane.

The antenna shall be placed parallel to a plane which is perpendicular to the ground plane and coincident with the edge of the ground plane along which the principal portion of the harness runs.

5.2.3. If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving 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 enclosed facility. There shall be no absorbent material between the receiving antenna and the ESA under test.

5.3. Antenna orientation and polarisation

At the measuring point, readings shall be taken both with the antenna in a vertical and in a horizontal polarisation.

5.4. Readings

The maximum of the two readings taken (in accordance with point 5.3) at each spot frequency shall be taken as the characteristic reading at the frequency at which the

measurements were made.

6. Frequencies

6.1. Measurements

Measurements shall be made throughout the 30 to 1,000 MHz frequency range. This range shall be divided into 13 bands. In each band one spot frequency may be tested to demonstrate that the required limits are satisfied. To confirm that the ESA under test meets the requirements of this Part, the testing authority shall test one such point in each of the following 13 frequency bands:

30 to 50, 50 to 75, 75 to 100, 100 to 130, 130 to 165, 165 to 200, 200 to 250, 250 to 320, 320 to 400, 400 to 520, 520 to 660, 660 to 820, 820 to 1,000 MHz.

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the ESA under test and not to background radiation.

6.2. If during the initial step which may have been carried out as described in point 1.3, the radiated narrowband emissions for any of the bands identified in point 6.1 are at least 10 dB below the reference limit, then the ESA shall be deemed to comply with the requirements set out in this Part in respect of that frequency band.

PART 8

Method(s) of testing for immunity of electrical / electronic sub-assemblies to electromagnetic radiation

1. General

1.1. The test method(s) described in this Part 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 point 5.1 being covered.

– Stripline testing: see point 11

– Bulk current injection testing: see point 12

– TEM cell testing: see point 13

– Free field test: see point 14

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

2. Expression of results

For the tests described in this Part, 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 Part. The test facility shall comply with 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 Part 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 (points 7.2, 7.3.2.3, 8.4, 9.2 and 10.2).

4.5. If the ESA under test consists of more than one unit, the interconnecting cables shall 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 shall 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 Part, the tests shall be performed at up to 14 spot frequencies in the range, for example:

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 maximum envelope excursion of the test signal shall equal the maximum envelope excursion of an unmodulated sine wave whose rms value is defined in point 3.4.2 of Part 2

(see Figure 3 in point 8 of Part 5).

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	=	(maximum envelop excursion — minimum envelop excursion)/(maximum envelop excursion + minimum envelop 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 in point 11).

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 in point 11).

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, for example: 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 metres 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 point 8.3.4) 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 shall 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 8 and 9 in point 14).

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 Part 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;

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

(d) is 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 point 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 shall 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 point 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 point 8.4.2 at each frequency as defined in point 5 shall then be applied to the field generating device.

8.4.7. Whatever parameter was chosen in point 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 transverse electromagnetic mode (TEM) cell generates homogeneous fields between the internal conductor (septum) and housing (ground plane). It is used for testing ESAs (see

Figure 6 in point 13).

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:

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

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 that 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 point 13, Figure 7.

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 point 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 point 3.7.2.1 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

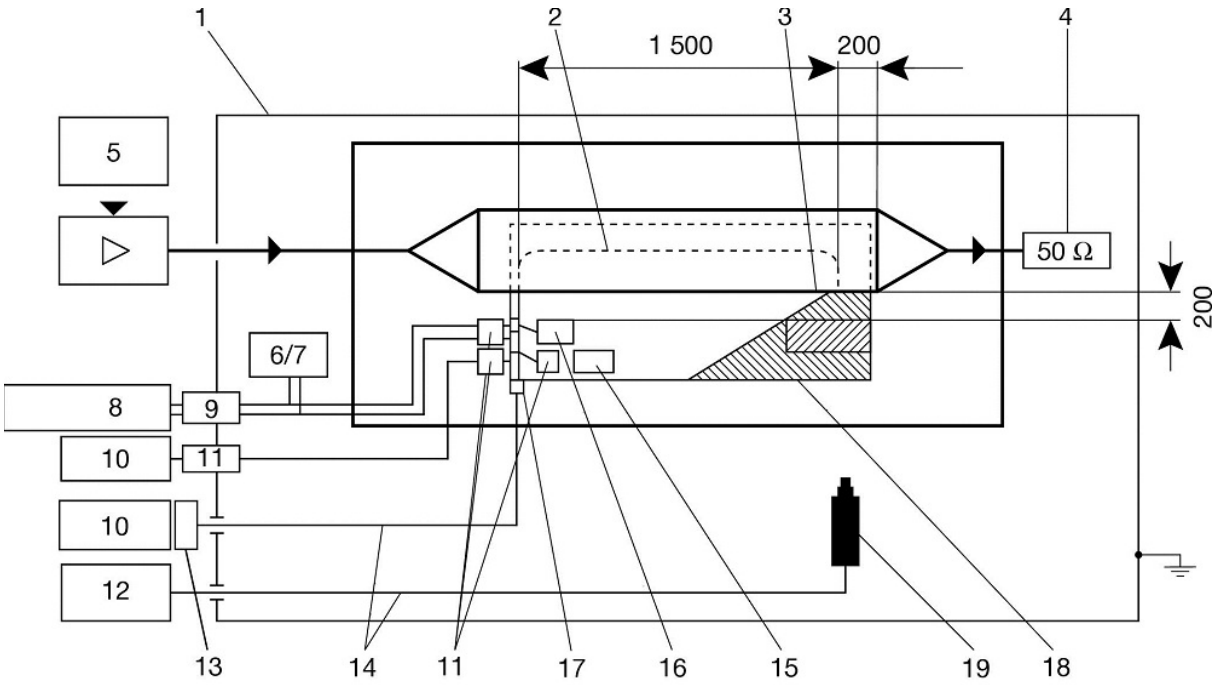
For an ESA mounted on a ground plane as in point 8.2.1 all cables in the wiring harness shall be terminated with realistic loads and actuators. For both vehicle mounted and ground plane mounted ESAs the current injection probe shall be mounted in turn around all the wires in the wiring harness to each connector and 150 ± 10mm from each connector of the ESA under test electronic control units (ECU), instrument modules or active sensors as illustrated in point 12.

10.4. Power, signal and control wires

For an ESA under test mounted on a ground plane as in point 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.

11. Stripline testing and dimensions

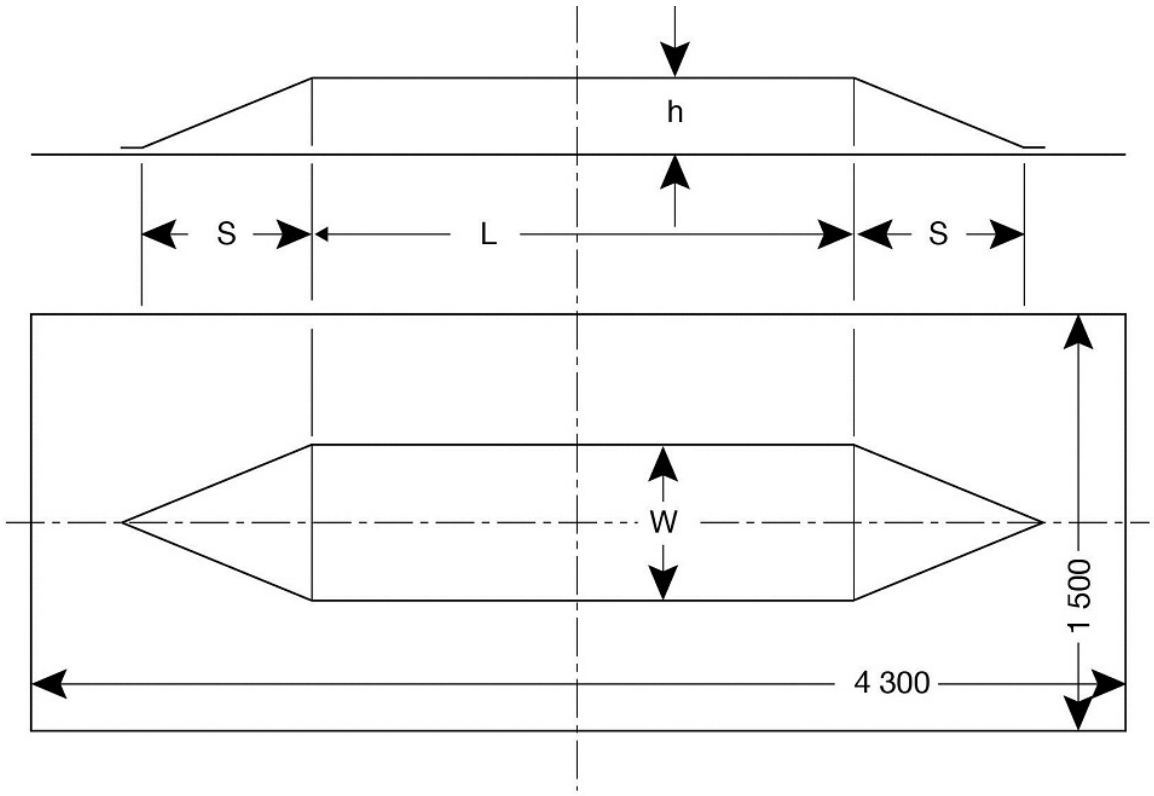


All dimensions in millimetres

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

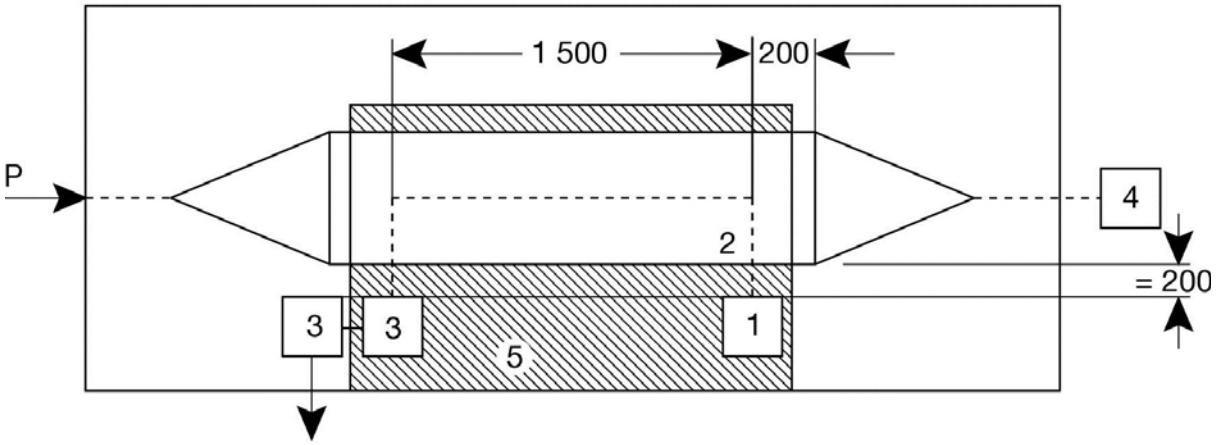
Figure 1

150 mm stripline testing



All dimensions in millimetres

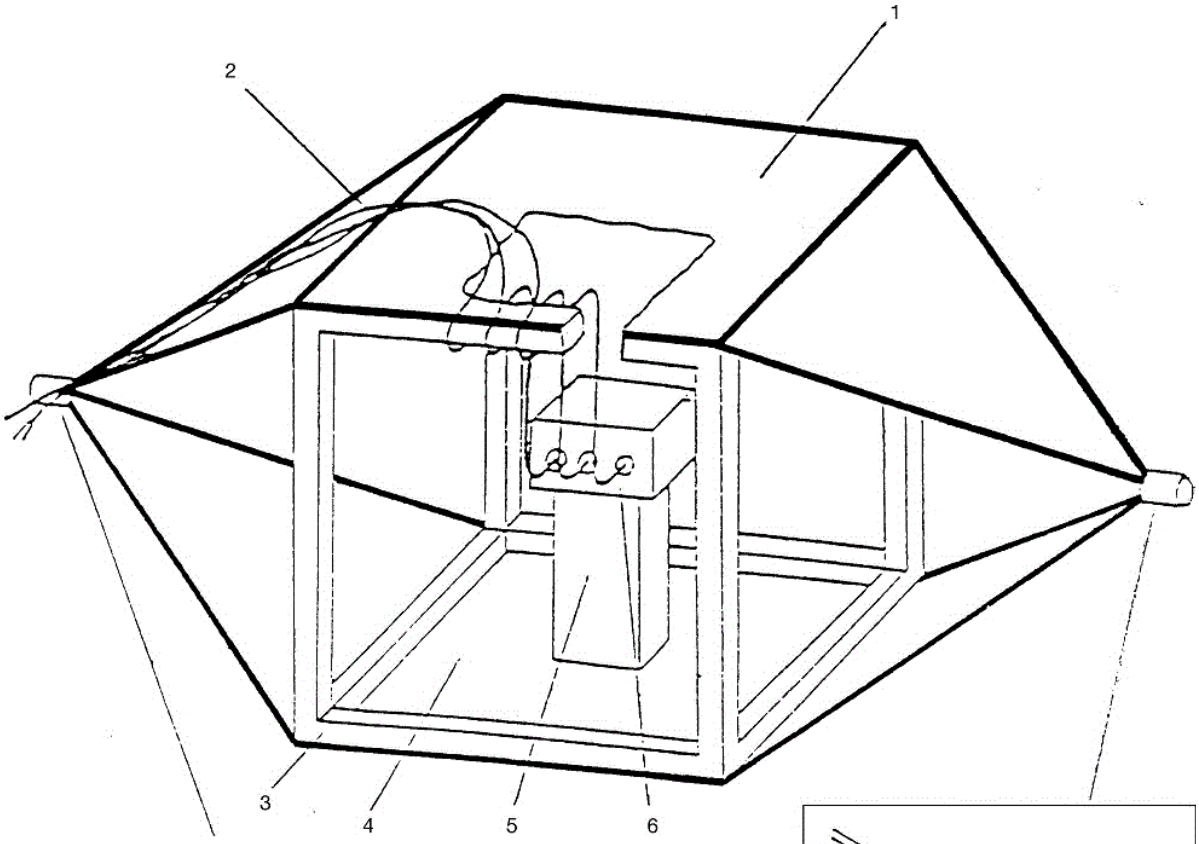
L = 2,500 mm
S = 800 mm
W = 740 mm
h = 150 mm

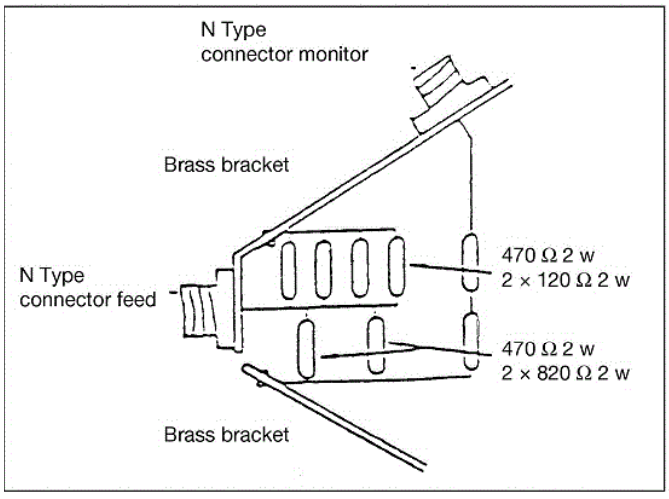


1 = Test object
2 = Cable harness
3 = Peripheral
4 = Terminating resistance
5 = Insulating base

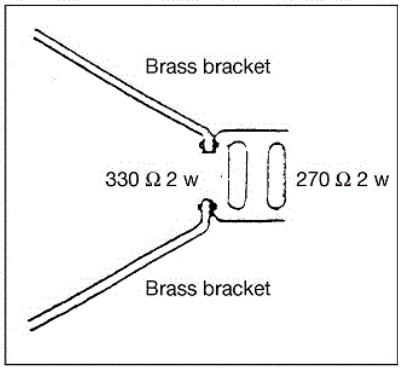
Figure 2

150 mm stripline testing





Details of stripline feed



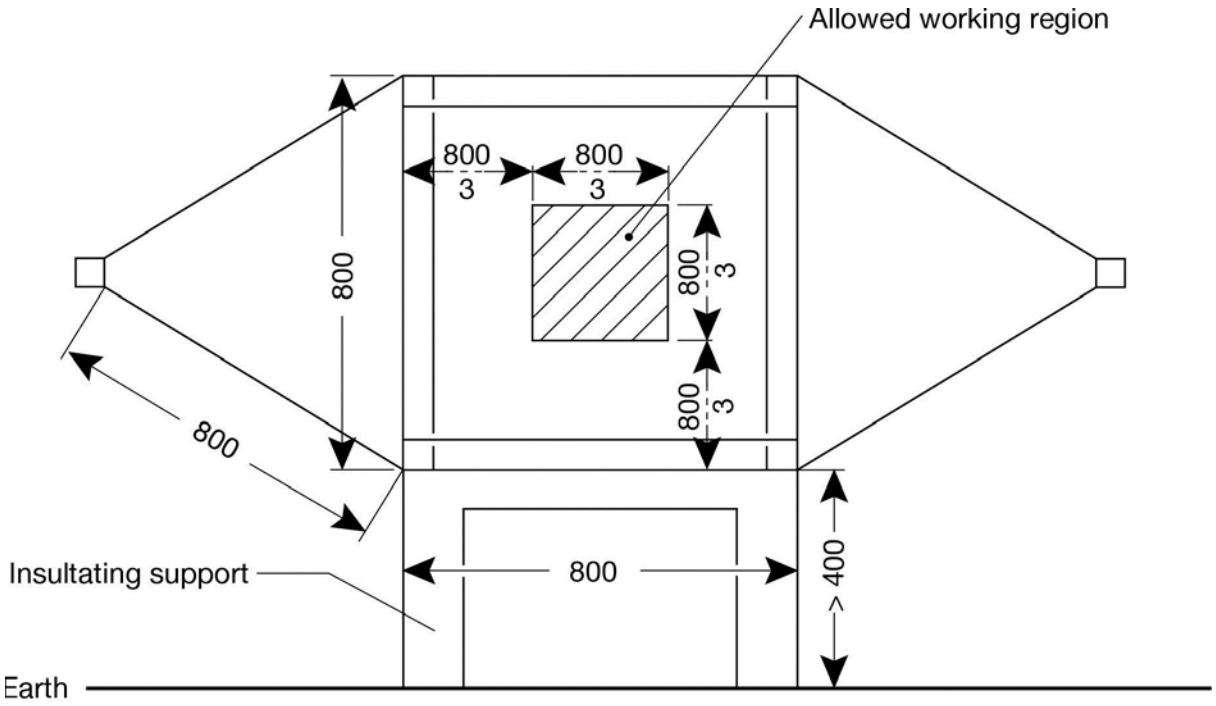
Details of stripline termination

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

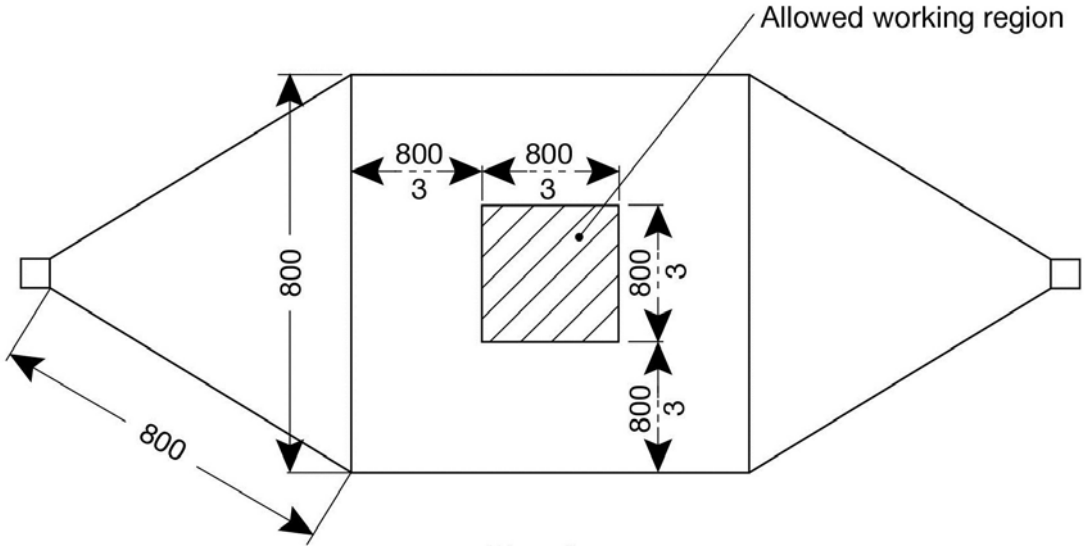
6	=	Test object

Figure 3

800 mm stripline testing



Side view



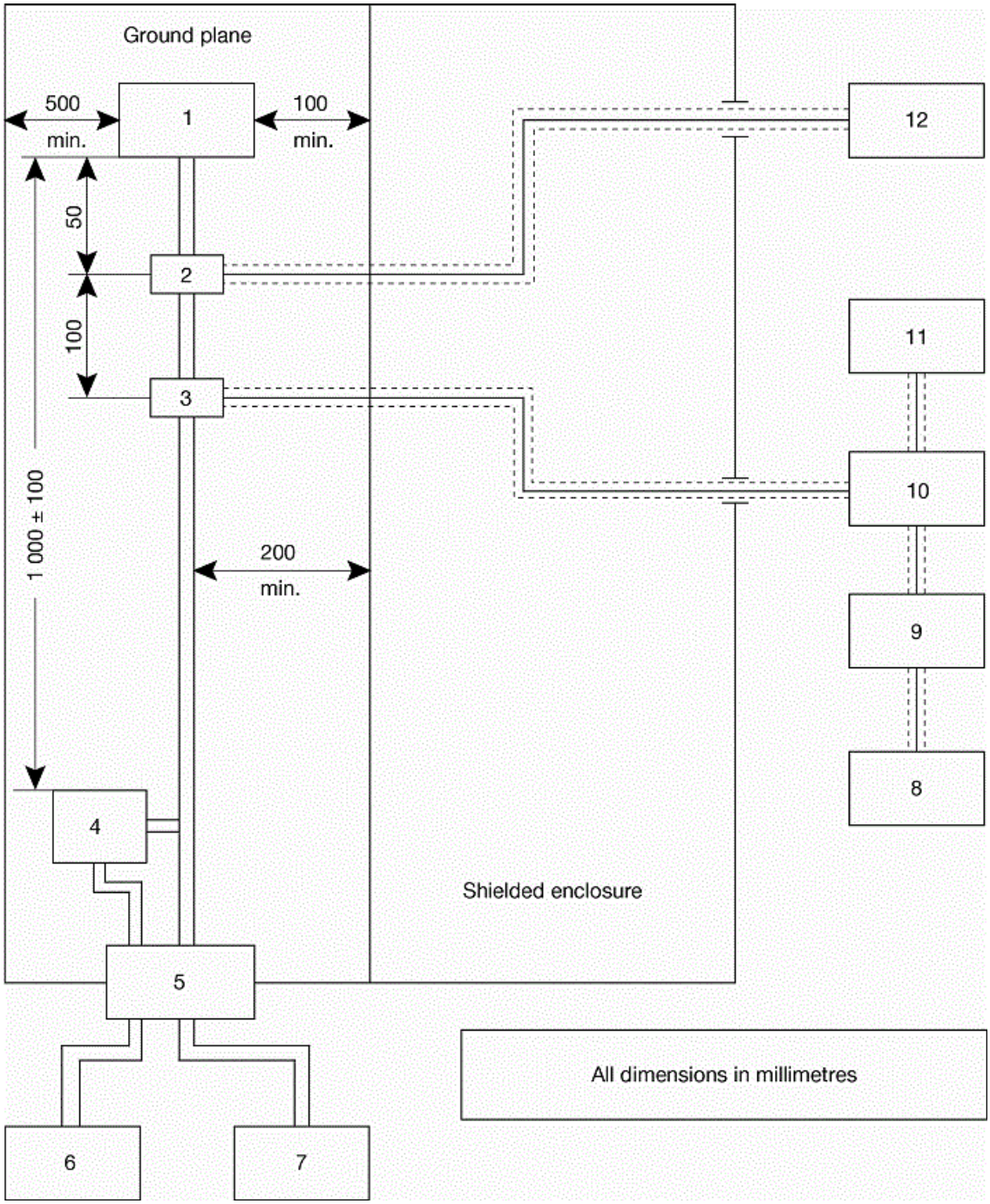
Plan view

All dimensions in millimetres

Figure 4

800 mm stripline dimensions

12. Example of BCI test configuration

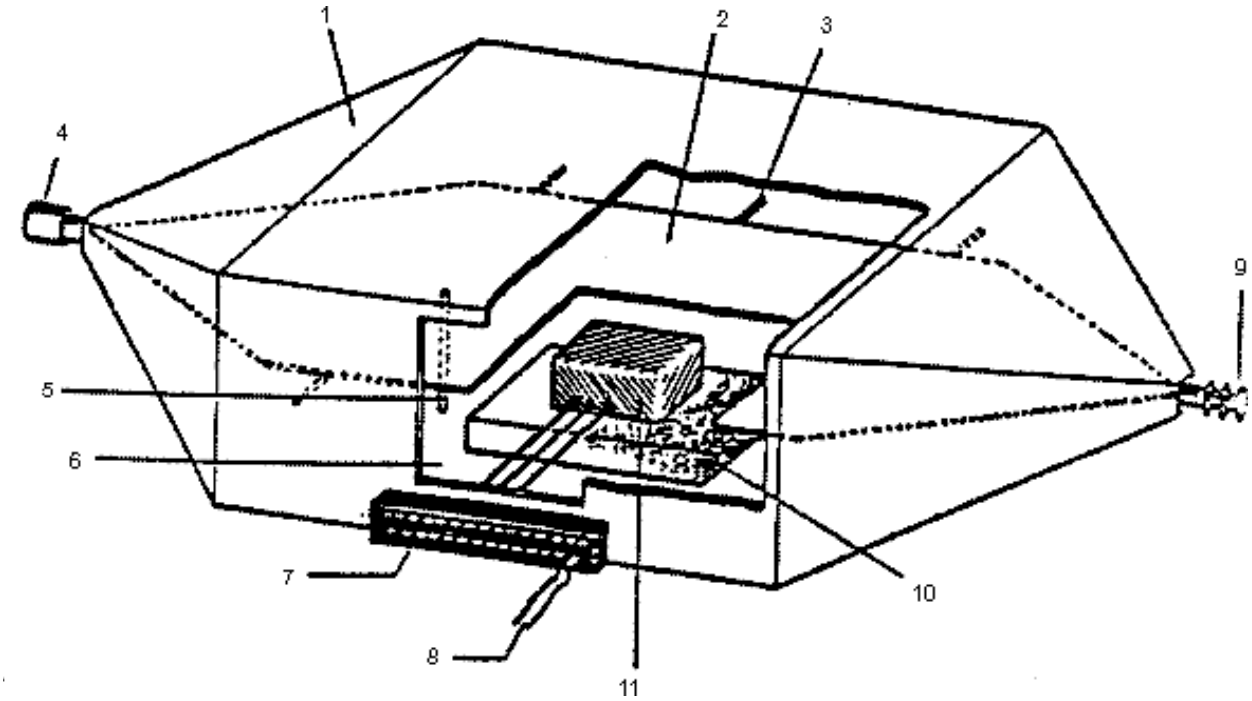


1	=	DUT

2	=	RF measuring probe (optional)
3	=	RF injection probe
4	=	Artificial 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)

Figure 5

13. TEM cell testing



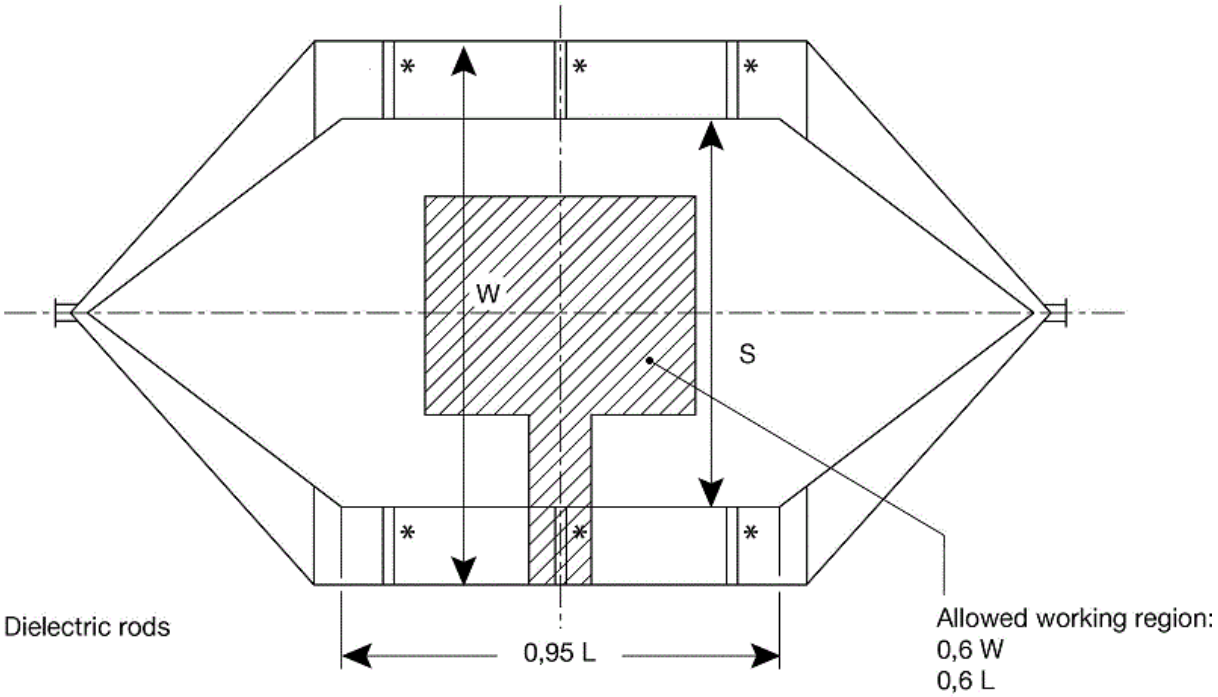
1	=	Outer conductor, shield
2	=	Inner conductor (septum)
3	=	Insulator

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)

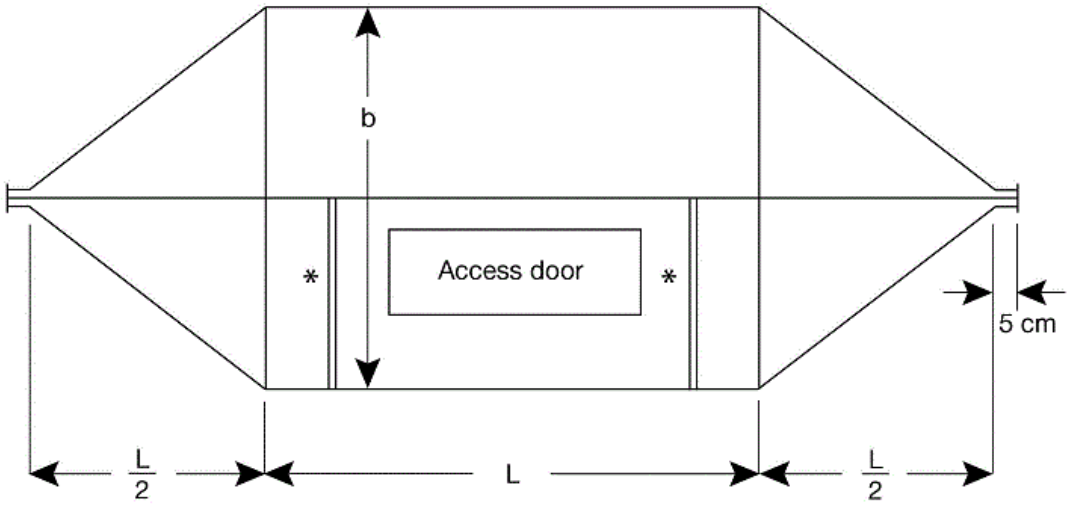
Figure 6

TEM cell testing

TEM cell dimensions



Horizontal section view at septum



Vertical section view

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

Upper frequency (MHz)	Cell form factor W: b	Cell form factor L/W	Plate separation b (cm)	Septum S (cm)

200	1.69	0.66	56	70
200	1.00	1.00	60	50

Figure 7

Design of rectangular TEM cell - typical TEM cell dimensions

14. Free field ESA immunity test

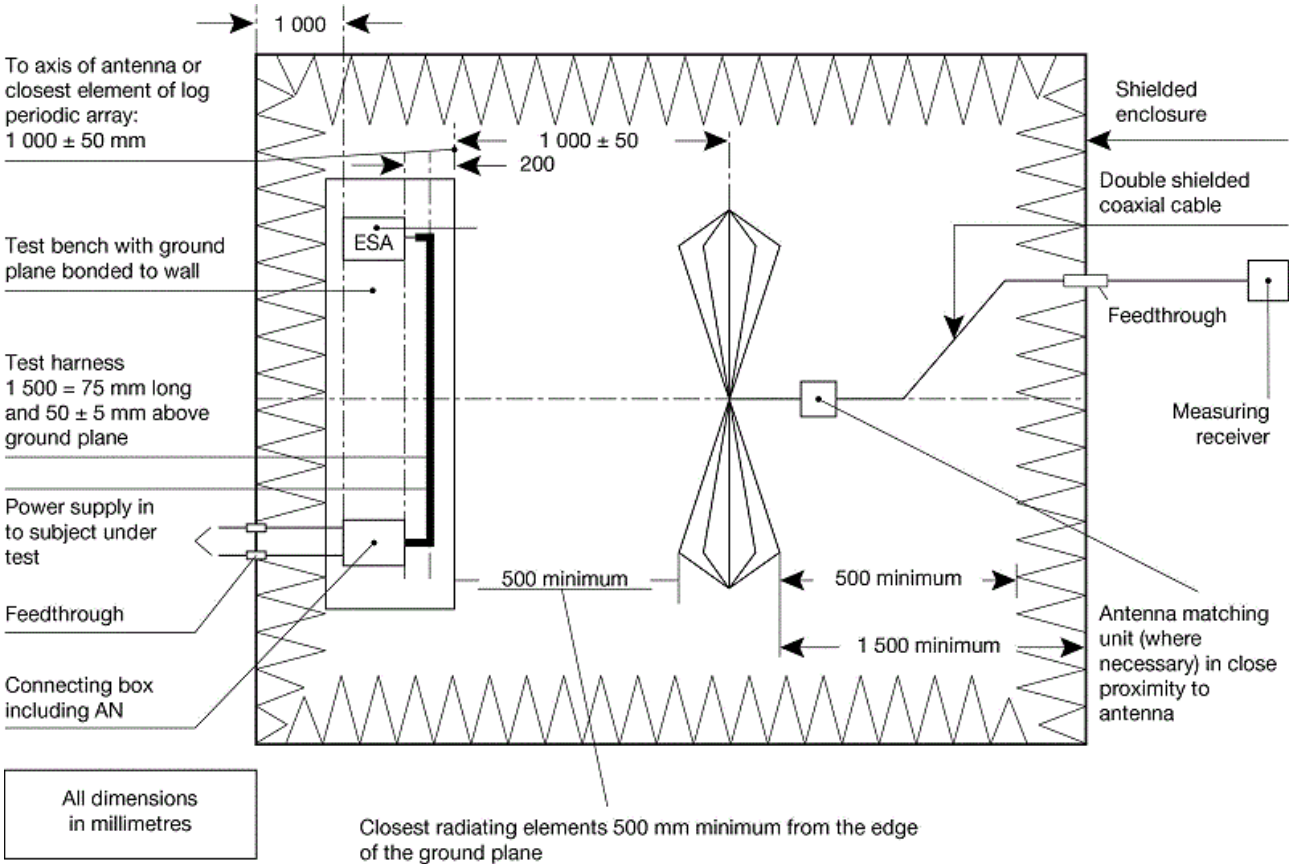


Figure 8

Test layout (general plan view)

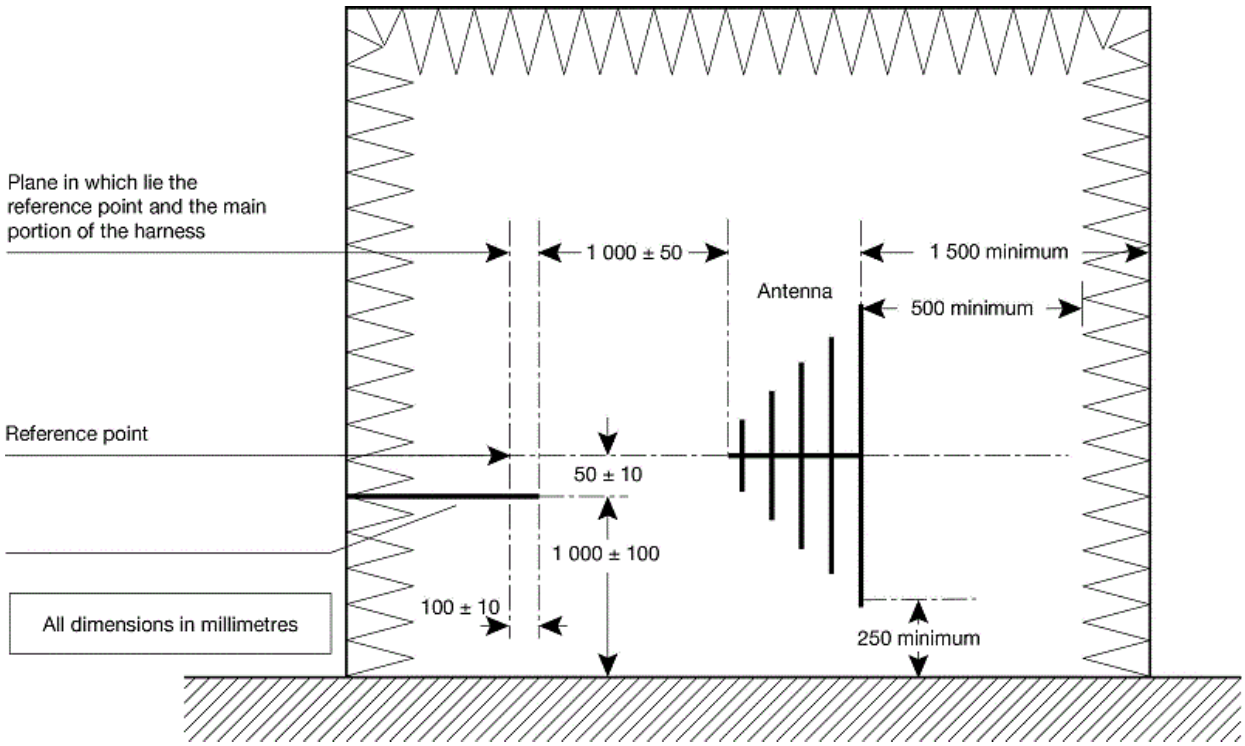


Figure 9

View of test bench plane of longitudinal symmetry

PART 9

Manufacturers may choose whether to apply either the requirements of Parts 2 to 8 or the requirements of UNECE Regulation No 10 as referenced in Annex I or the requirements of ISO 14982: 1998.

ANNEX XVI
Requirements on audible warning devices

1. The audible warning device shall be granted component type-approval according to the requirements for N-category vehicles in the UNECE Regulation No 28 as referenced in Annex I.

2. Characteristics of the audible warning device when fitted to the tractor

2.1. Acoustic tests

When a tractor is type approved, the characteristics of the warning device fitted to that type of tractor shall be tested as follows:

2.1.1. The sound pressure level of the device when fitted to the tractor shall be measured at a point 7 metres in front of the tractor, at a site which is open and as level as possible. The engine of the tractor shall be stopped. The effective voltage shall be that laid down in paragraph 6.2.3. of UNECE Regulation No 28 as referenced in Annex I.

2.1.2. Measurements shall be made on the 'A' weighting scale of the IEC (International Electrotechnical Commission) standard.

2.1.3. The maximum sound pressure level shall be determined at a height between 0.5 and 1.5 metres above ground level.

2.1.4. The maximum value for the sound-pressure level shall be at least 93 dB(A) and at the most 112 dB(A).