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Limits and Methods of Measurement of Radio Disturbance Characteristics of Components and Modules for the Protection of Receivers used on Board Vehicles

This document is technically equivalent to the component portion of IEC CISPR 25 1st Edition.

1. ***Scope***—This SAE Standard contains limits[1] and procedures for the measurement of radio disturbances in the frequency range of 150 kHz to 1000 MHz. The standard applies to any electronic/electrical component intended for use in vehicles and large devices. Refer to International Telecommunications Union (ITU) Publications for details of frequency allocations. The limits are intended to provide protection for receivers installed in a vehicle from disturbances produced by components/modules in the same vehicle.[2]

The receiver types to be protected are: sound and television receivers[3], land mobile radio, radio telephone, amateur and citizens' radio. For the purpose of this document, a vehicle is a machine which is self-propelled. Vehicles include (but are not limited to) passenger cars, trucks, agricultural tractors, and snowmobiles.

The limits in this document are recommended and subject to modification as agreed between the vehicle manufacturer and the component supplier. This document shall also be applied by manufacturers and suppliers of components and equipment which are to be added and connected to the vehicle harness or to an on-board power connector after delivery of the vehicle.

This document does not include protection of electronic control systems from radio frequency (RF) emissions, or from transient or pulse type voltage fluctuations. These subjects are included in other parts of SAE J1113.

Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, this document defines multiple limit levels. The level class to be used (as a function of frequency band) shall be agreed upon between the vehicle manufacturer and the component supplier.

The World Administrative Radiocommunications Conference (WARC) lower frequency limit in Region 1 was reduced to 148.5 kHz in 1979. For vehicular purposes, tests at 150 kHz are considered adequate. For the purposes of this document, test frequency ranges have been generalized to cover radio services in various parts of the world. Protection of radio reception at adjacent frequencies can be expected in most cases.

1. Only a complete vehicle test can be used to determine the component compatibility with respect to a vehicle's limit.
2. Adjacent vehicles can be expected to be protected in most situations.
3. Adequate television protection will result from compliance with the levels at the mobile service frequencies.

It is assumed that protection of services operating on frequencies below 30 MHz will most likely be provided if the limits for services above 30 MHz are observed.

2. *References*

References—The following standards contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated as follows. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1 Applicable Publications

2.1.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components

SAE J1752-3—Electromagnetic Compatibility Measurement Procedures for Integrated Circuits—Integrated Circuit Radiated Emissions Measurement Procedure 150 kHz to 1000 MHz TEM Cell

SAE ARP958—Electromagnetic Interference Measurement Antennas; Standard Calibration Methods

2.1.2 ANSI Publication—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI C63.5-1988—Electromagnetic Compatibility Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration of Antennas

2.1.3 CISPR Publications—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

CISPR 12: 1990—Limits and methods of measurement of radio interference characteristics of vehicles, motor boats, and spark-ignited engine driven devices

CISPR 16-1: 1993—Specification for radio disturbance measuring apparatus and methods—Part 1: Radio disturbance and immunity measuring apparatus

CISPR 20: 1990—Limits and methods of measurement of immunity characteristics of sound and television broadcast receivers and associated equipment

CISPR 25—Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on-board vehicles

3. *Definitions*

Definitions—See SAE J1113-1 for definitions.

For this document, Equipment under test (EUT) and Device under test (DUT) are used interchangeably.

4. *Requirements for Component/Module Emissions Measurement*

4.1 General Test Requirements and Test Plan

4.1.1 Test Plan—A test plan shall be established for each item to be tested. The test plan shall specify the frequency range to be tested, the emissions limits, the disturbance classification (broadband, long or short duration or narrowband), antenna types and locations, test report requirements, supply voltage, and other relevant parameters.

4.1.2 Determination of Conformance With Limits—If the type of disturbance is unknown, tests shall be made to determine whether measured emissions are narrowband and/or broadband to apply limits properly as specified in the test plan.

Figure 1 outlines the procedure to be followed in determining conformance with limits.

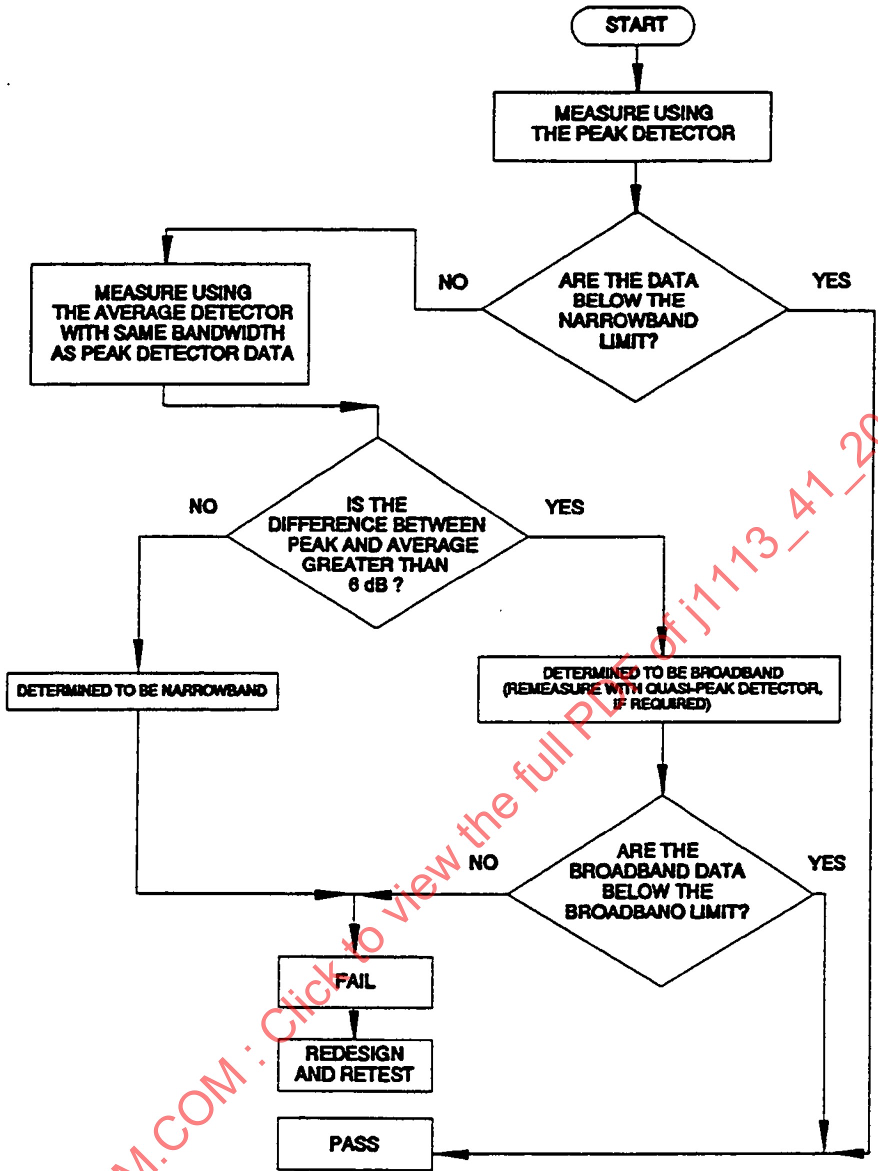


FIGURE 1—METHOD OF DETERMINATION OF CONFORMANCE OF RADIATED/CONDUCTED DISTURBANCE

4.1.3 CATEGORIES OF DISTURBANCE SOURCES (AS APPLIED IN THE TEST PLAN)—Electromagnetic disturbance sources can be divided into three types:

a. Continuous/long duration broadband and automatically actuated short duration equipment
b. Manually actuated short duration broadband
c. Narrowband

NOTE—For examples, see 4.1.4 and 4.1.5 and Table 1.

4.1.4 Examples of Broadband Disturbance Sources

NOTE—The examples in Table 1 are intended as a guide to assist in determining which limits to use in the test plan.

TABLE 1—EXAMPLES OF BROADBAND DISTURBANCE SOURCES BY DURATION

Continuous	Long Duration[1]	Short Duration[1]
Ignition system	Wiper motor	Power antenna
Active ride control	Heater blower motor	Washer pump motor
Fuel injection	Rear wiper motor	Door mirror motor
Instrument regulator	Air conditioning compressor	Central door lock
Alternator	Engine cooling	Power seat

1. As defined in the test plan.

4.1.5 Narrowband Disturbance Sources—Sources employing microprocessors, digital logic, oscillators or clock generators, etc., can cause narrowband emissions.

4.1.6 Operating Conditions—When performing component/module tests, the equipment under test (EUT) shall be exercised using typical loads and conditions which simulate installation and operation in the vehicle.

4.1.7 Test Report—The report shall contain the information agreed upon by the customer and the supplier.

4.2 Measuring Equipment Requirements—All equipment shall be calibrated on a regular basis to assure continued conformance of equipment to required characteristics. The measuring equipment noise floor shall be at least 6 dB less than the limit specified in the test plan.

4.3 Shielded Enclosure—The ambient electromagnetic noise levels shall be at least 6 dB below the limits specified in the test plan for each test to be performed. The shielding effectiveness of the shielded enclosure shall be sufficient to assure that the required ambient electromagnetic noise level requirement is met.

NOTE—Although there will be reflected energy from the interior surfaces of the shielded enclosure, this is of minimal concern for the measurement of conducted disturbances because of the direct coupling of the measuring instrument to the leads of the EUT. The shielded enclosure may be as simple as a suitably grounded bench top screened cage.

4.4 Absorber-Lined Shielded Enclosure (ALSE)—For radiated emission measurements, however, the reflected energy can cause errors of as much as 20 dB. Therefore, it is necessary to apply RF absorber material to the walls and ceiling of a shielded enclosure that is to be used for radiated emissions measurements. No absorber material is required for the floor. The following ALSE requirements shall also be met for performing radiated RF emissions measurements:

4.4.1 Size—For radiated emission tests, the shielded enclosure shall be of sufficient size to ensure that neither the EUT nor the test antenna shall be closer than (a) 2 m from the walls or ceiling, and (b) 1 m to the nearest surface of the absorber material used.

4.4.2 Reflection Characteristics—The reflection characteristics of the ALSE shall be such that the maximum error caused by reflected energy from the walls and ceiling is less than 6 dB in the frequency range of 70 to 1000 MHz.

4.4.3 OBJECTS IN ALSE—In particular, for radiated emissions measurements the ALSE shall be cleared of all items not pertinent to the tests. This is required in order to reduce any effect they may have on the measurement. Included are unnecessary equipment, cable racks, storage cabinets, desks, chairs, etc. Personnel not actively involved in the test shall be excluded from the ALSE.

4.5 Receiver—Scanning receivers which meet the requirements of CISPR 16-1 are satisfactory for measurements. Manual or automatic frequency scanning may be used. Special consideration shall be given to overload, linearity, selectivity, and the normal response to pulses.

NOTE—Spectrum analyzers and scanning receivers are particularly useful for disturbance measurements. Special consideration shall be given to overload, linearity, selectivity, and the normal response to pulses. The peak detection mode of spectrum analyzers and scanning receivers provides a display indication which is never less than the quasi-peak indication for the same bandwidth. It may be convenient to measure emissions using peak detection because of the faster scan possible than with quasi-peak detection.

When quasi-peak limits are being used, any peak measurements above the limit shall be measured using the quasi-peak detector.

4.5.1 MINIMUM SCAN TIME—The scan rate of a spectrum analyzer or scanning receiver shall be adjusted for the CISPR frequency band and detection mode used. The minimum sweep time/frequency, (i.e., most rapid scan rate) is listed in Table 2:

TABLE 2—MINIMUM SCAN TIME

Band[1]		Peak Detection	Quasi-peak Detection
A	9–150 kHz	Does not apply	Does not apply
B	0.15–30 MHz	100 ms/MHz	200 s/MHz
C,D	30–1000 MHz	1 ms/MHz or 100 ms/MHz[2]	20 s/MHz

1. Band definition from CISPR 16-1.
2. When 9 kHz bandwidth is used, the 100 ms/MHz value shall be used.

NOTE—Certain signals (e.g., low repetition rate or intermittent signals) may require slower scan rates or multiple scans to insure that the maximum amplitude has been measured. For the measurement of pure broadband emission, scanning steps greater than the measurement bandwidth are permitted; thus accelerating the measurement of the emission spectrum

4.5.2 MEASURING INSTRUMENT BANDWIDTH—The bandwidth of the measuring instrument shall be chosen such that the noise floor is at least 6 dB lower than the limit curve. The bandwidths in Table 3 are recommended.

NOTE—When the bandwidth of the measuring instrument exceeds the bandwidth of a narrowband signal, the measured signal amplitude will not be affected. The indicated value of impulsive broadband noise will be lower when the measuring instrument bandwidth is reduced.

TABLE 3—MEASURING INSTRUMENT BANDWIDTH (6 dB)

Frequency Band MHz		Broadband Peak and quais-Peak	Narrowband Peak and Average
0.15–30		9 kHz	9 kHz
30–1000	FM Broadcast	120 kHz	120 kHz
30–1000	Mobile Service	120 kHz	9 kHz

If a spectrum analyzer is used for peak measurements, the video bandwidth shall be at least three times the resolution bandwidth.

For the narrowband/broadband discrimination according to Figure 1, both bandwidths (with peak and average detectors) shall be identical.

4.6 Power Supply—The EUT power supply shall have adequate regulation to maintain the supply voltage within the limits specified: 13.5 V ± 0.5 V for 12 V systems, 27 V ± 1.0 V for 24 V systems, unless otherwise specified in the test plan.

The power supply shall also be adequately filtered such that the RF noise produced by the power supply is at least 6 dB lower than the limits specified in the test plan.

4.7 Battery—When specified in the test plan, a vehicle battery shall be connected in parallel with the power supply.

4.8 Ground Plane—The ground plane shall be made of 0.5 mm thick (minimum) copper, brass or galvanized steel of the size specified in Figures 5 through 10 for the measurement of conducted or radiated emissions.

The ground plane shall be bonded to the shielded enclosure such that the DC resistance shall not exceed 2.5 mΩ. In addition, the bond straps shall be placed at a distance no greater than 0.9 m apart.

4.9 Test Equipment Unique to Conducted Emissions Measurements

4.9.1 ARTIFICIAL MAINS NETWORK (AN)

4.9.1.1 AN Impedance Characteristics—The AN shall have a nominal 5 µH inductance and shall meet the impedance characteristics of CISPR 16-1. A suggested schematic is shown in Appendix E. The measuring port of all AN's shall be terminated with a 50 Ω load (either a measuring instrument or a resistor). For the purpose of this document, the AN may be used to 108 MHz.

4.9.1.2 AN Connection—For the emissions tests of Sections 7 and 9, a standard AN according to 4.9.1.1 shall be used. For the TEM cell emissions test of Section 9, an AN with a coaxial connector will facilitate connection to the TEM cell EUT power connector.

4.9.2 CURRENT PROBE—The current probe shall be selected considering the following: the size of the harness to be measured, the frequency range required by the test plan, and the sensitivity of the probe necessary to measure signals at the limit level.

NOTE—Typically, a current probe is a transducer which converts current to voltage. As such, its calibration factor is often called a transfer impedance curve and is given in Ω or dB(Ω). (See Appendix B.)

4.10 Equipment Unique to Component/Module Radiated Measurements

4.10.1 ANTENNA SYSTEMS—The limits shown in Tables 8 and 9 are listed in decibels relative to 1 µV/m, and thus theoretically any antenna can be used, provided that it has adequate sensitivity, the antenna correction factor is applied, and the antenna provides a 50 Ω match to the measuring receiver. For the purposes of this standard, the limits shown in Tables 8 and 9 are based upon the following antennas:

a. 0.15 to 30 MHz—1 m vertical monopole (where this is not 50 Ω, a suitable antenna matching unit shall be used).
b. 30 to 200 MHz—A biconical antenna used in vertical and horizontal polarization.
c. 200 to 1000 MHz—A log-periodic antenna used in vertical and horizontal polarization.

Commercially available antennas with known antenna correction factors may be used. The cable loss factor can be determined in accordance with CISPR 12, Appendix A.

NOTE— A method for determining antenna factor is described in SAE ARP958.

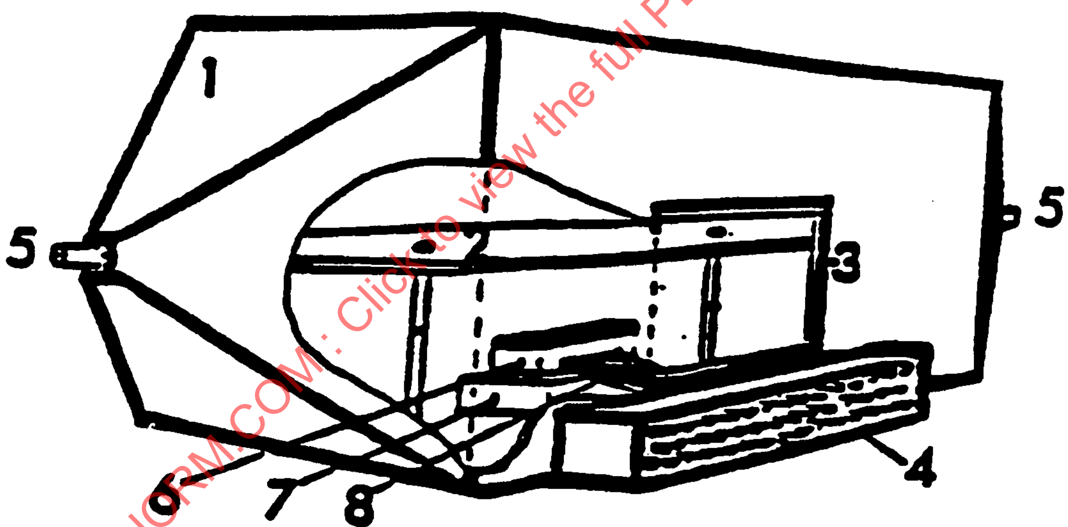
4.10.2 Antenna Matching Unit—Correct impedance matching between the antenna and the measuring receiver of 50 Ω must be maintained at all frequencies. There shall be a maximum SWR of 2:1. Appropriate correction shall be made for any attenuation/gain of the antenna system from the antenna to the receiver.

NOTE 1—Care should be taken to ensure input voltages do not exceed the pulse input rating of the unit or overloading may occur. This is particularly important when active matching units are used.

NOTE 2—Biconical antennas usually have a SWR of up to 10:1 in the frequency range of 30 to 80 MHz. Therefore an additional measurement error may occur when the receiver input impedance differs from 50 Ω. The use of an attenuator (3 dB minimum) at the receiver input (if possible) will keep this additional error low.

4.11 Equipment Unique to the TEM Cell Method

4.11.1 TEM Cell Size—An example of a TEM cell is shown in Figure 2. Information relating to the size and construction of a TEM cell for component measurement is given in Appendix D.



1. Outer shield
2. Septum (inner conductor)
3. Access door
4. Connector panel
5. Coaxial connectors
6. EUT
7. Dielectric equipment support
8. Artificial harness

FIGURE 2—TEM CELL (EXAMPLE)

4.11.2 TEM Cell Test Setup (EUT With Leadframe)

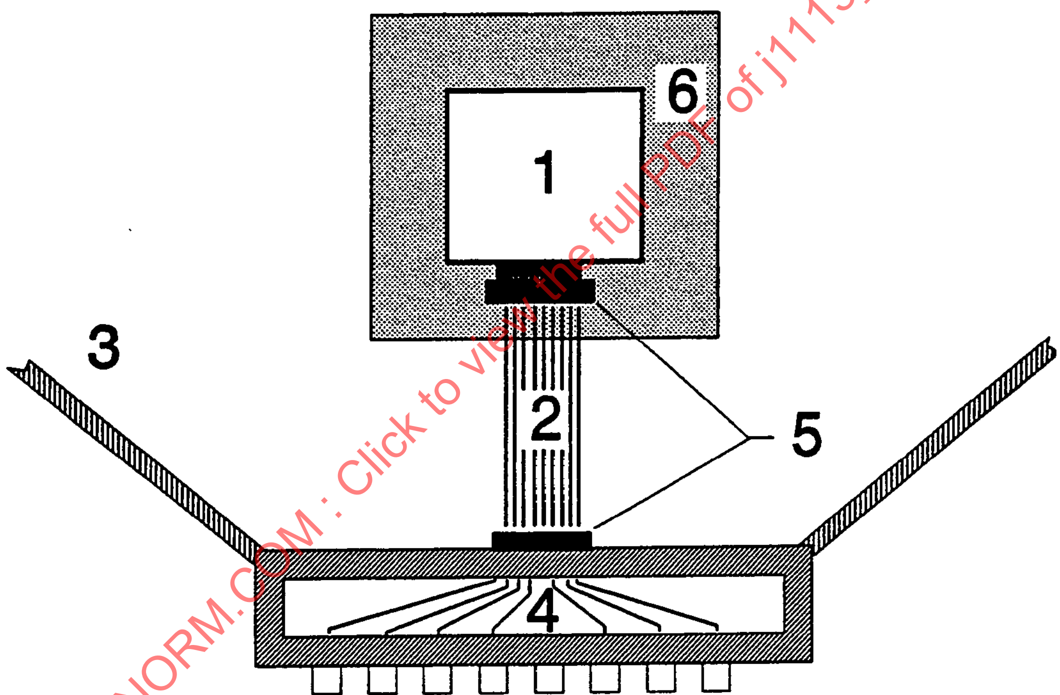
4.11.2.1 TEM Cell—For the purpose of these tests, the septum of the TEM cell functions in a similar way to a receiving antenna.

4.11.2.2 Supply and Signal Leads—The TEM cell shall have a connector panel connected as close as possible to a plug connector (see Figure 3).

All supply and signal leads from the EUT are directly connected to the artificial harness (e.g., a leadframe). The plugs at the connector panel, which are not required must be sealed so that they are RF-tight.

The connection of the positive power lead shall be through the AN (see 4.9.1.2), direct at the connector panel.

It is not permitted to ground the EUT to the TEM cell floor. The grounding shall be done at the connector panel.



1. EUT
2. Artificial Harness (e.g., printed leadframe)
3. TEM cell wall
4. Connector panel
5. Connector

FIGURE 3—EXAMPLE OF ARRANGEMENT OF LEADS IN THE TEM CELL AND TO THE CONNECTOR PANEL

4.11.3 TEM CELL TEST SETUP (EUT WITHOUT LEADFRAME)

4.11.3.1 The test setup is similar to the method shown previously, except that the leads to the EUT are positioned and shielded to minimize electromagnetic radiation from the leads. This is accomplished by positioning the leads flat across the bottom of the TEM cell and bringing them vertically to the EUT. The use of a sealed battery and shielded wiring in the TEM cell will further reduce the electromagnetic radiation from power and signal leads. To minimize the radiation from the wiring further, shielding foil tape can be applied over the leads.

4.12 Special Test for Integrated Circuits—Methods are under development in Europe and in North America for directly measuring the emissions from integrated circuits using a TEM cell or other equipment. The intent is to minimize extraneous effects of leads and test circuitry mask changes. See SAE J1752/3.

5. Conducted Emissions Component/Module

5.1 General—Emissions on power leads are to be measured using an artificial mains network (voltage measurement). Emissions on control/signal leads are to be measured using a current probe.

NOTE—Conducted emissions will contribute to the radiated emissions measurements because of radiation from the wiring in the test setup. Therefore, it is advisable to establish conformance with the conducted emissions requirements before performing the radiated emissions test.

5.2 Test Procedure

5.2.1 VOLTAGE MEASUREMENTS—Voltage measurements on all power leads shall be made relative to the case of the EUT (when the case provides the ground return path) or the ground lead as close to the EUT as practical.

For EUT with return line remotely grounded, the voltage measurements shall be made on each lead (supply and return) relative to the ground plane.

The test harness shall be spaced 50 mm above the ground plane.

5.2.2 CURRENT PROBE MEASUREMENTS—Current probe measurements shall be made on the control/signal leads as a single cable or in subgroups as is compatible with the physical size of the current probe. The test harness length shall be nominally 1.5 m long (or as specified in the test plan), spaced 50 mm above the ground plane. The test harness leads shall be nominally parallel and adjacent unless otherwise defined in the test plan.

Position the current probe 50 mm from the EUT connector and measure the emissions. To assure that the maximum level is measured at frequencies above 30 MHz, position the current probe in the following additional positions:

a. 0.5 m from the EUT connector
b. 1 m from the EUT connector
c. 50 mm from the AN terminal

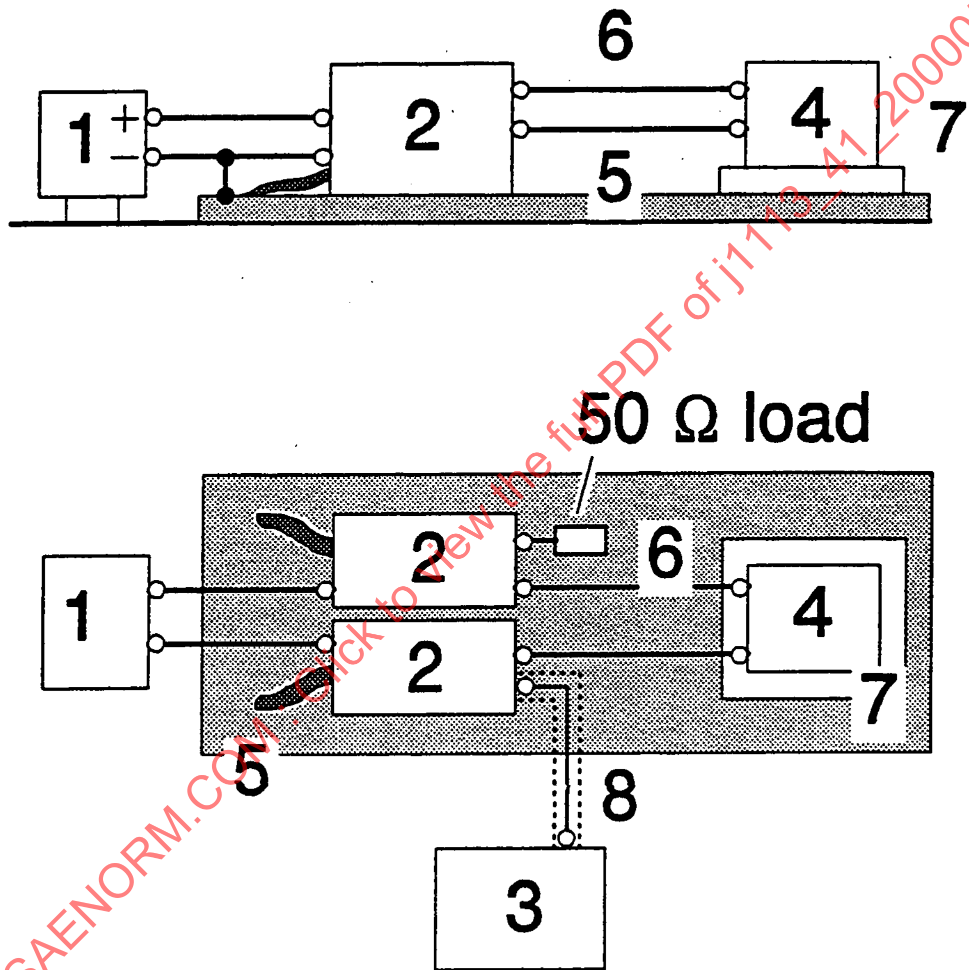
In most cases, the position of maximum emission will be as close to the EUT connector as possible. Where the EUT is equipped with a metal shell connector, the probe shall be clamped to the cable immediately adjacent to the connector shell, but not around the connector shell itself. The EUT and all parts of the test setup shall be a minimum of 100 mm from the edge of the ground plane.

5.2.3 Equipment Arrangement—For voltage measurements, the arrangement of the EUT and measuring equipment shall be as shown in Figures 4, 5, and 6 depending on the intended EUT installation in the vehicle:

a. EUT—Remotely Grounded (Power Return Line Longer Than 200 mm)—Use Figure 4.
b. EUT—Locally Grounded (Power Return Line 200 mm or Shorter)—Use Figure 5.
c. Alternators and Generators—Use Figure 6.

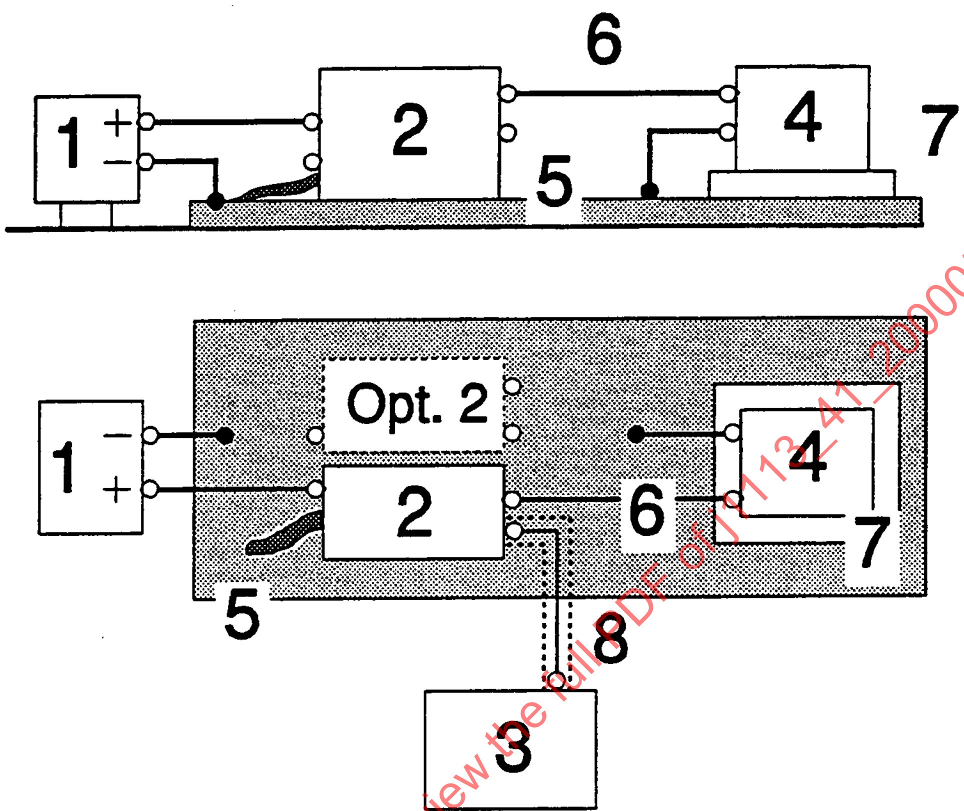
Remote versus local grounding, the use of an insulating spacer, and the electrical connection of the EUT case to the ground plane shall simulate the actual vehicle configuration and be specified in the test plan.

For current measurements, the measuring equipment shall be as shown in Figure 7.



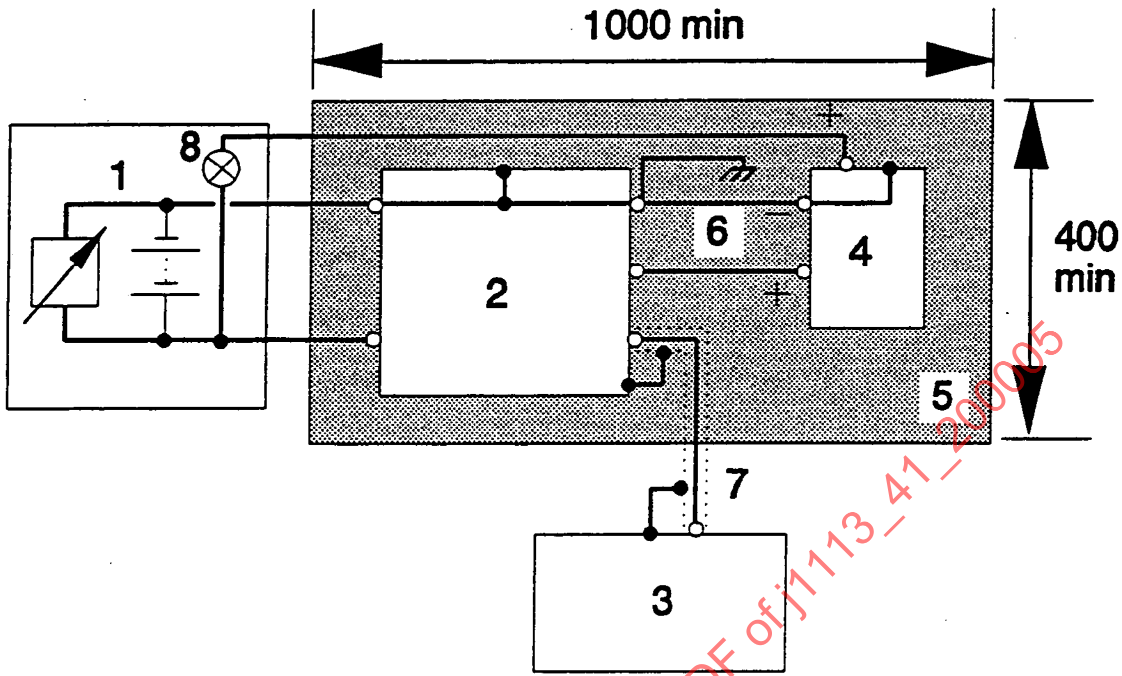
1. Power supply
2. Artificial mains network (two units)/ control box / loads
3. Measuring instrument
4. EUT
5. Ground plane
6. Test harness (Power leads 200 mm maximum length)
7. Insulating spacer (50 mm thick), when required in test plan
8. Double shielded or solid shielded coaxial cable (50 Ω)

FIGURE 4—CONDUCTED EMISSIONS—EUT WITH POWER RETURN LINE REMOTELY GROUNDED



1. Power supply
2. Artificial mains network (one unit, second optional)/ control box/loads
3. Measuring instrument
4. EUT
5. Ground plane
6. Test harness (power leads 200 mm maximum length)
7. Insulating spacer (50 mm thick), when required in test plan
8. Double shielded or solid shielded coaxial cable (50 Ω)

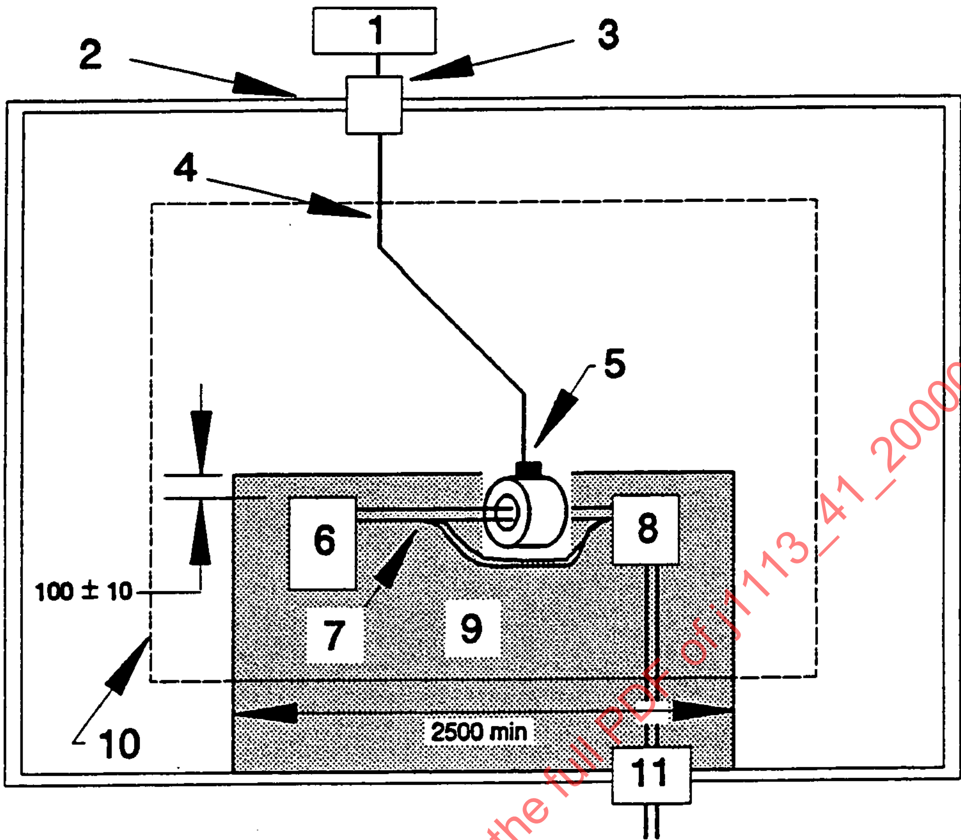
FIGURE 5—CONDUCTED EMISSIONS—EUT WITH POWER RETURN LINE LOCALLY GROUNDED



Dimensions in millimeters

1. Load (battery and resistor)
2. Artificial mains network
3. Measuring equipment
4. EUT
5. Ground plane
6. Test Harness (Power leads 200 mm maximum length)
7. Double shielded or solid shielded coaxial cable (50 Ω)
8. Indicator lamp/control resistor (where applicable)

FIGURE 6—CONDUCTED EMISSIONS—TEST LAYOUT FOR ALTERNATORS AND GENERATORS



Dimensions in millimeters

1. Measuring instrument (allowed in shielded enclosure if ambient requirement is met)
2. Shielded enclosure
3. Bulkhead connector
4. Double shielded or solid shielded coaxial cable (50 Ω)
5. Current probe for signal/control line test
6. EUT
7. Test harness (1500 mm ± 75 mm) long or as specified up to 2000 mm length (50 mm ± 5 mm) above ground plane.
8. Artificial network
9. Test bench - 2500 mm long by 900 mm high
10. Typical RF absorber (optional)
11. Filter to power supply

FIGURE 7—CONDUCTED EMISSIONS—EXAMPLE OF TEST LAYOUT FOR CURRENT PROBE MEASUREMENTS

5.2.4 TEST PROCEDURE FOR GENERATORS/ALTERNATORS—Generators/alternators shall be loaded with a battery and parallel resistor combination, and connected to the artificial mains network in the manner shown in Figure 6. The load current, operating speed, harness length, and other conditions shall be defined in the test plan.

6. *Limits for Component Conducted Disturbances*

6.1 Limits for Power Leads—For acceptable radio reception in a vehicle, the conducted noise shall not exceed the values shown in Tables 4 and 5, broadband and narrowband limits, respectively. Refer to Footnote 1) Scope for statement on limits.

6.2 Limits for Control/Signal Lines—The limits for RF currents on control/signal lines are given in Table 6 (broadband) and Table 7 (narrow band).

TABLE 4—LIMITS FOR BROADBAND CONDUCTED DISTURBANCES ON POWER INPUT TERMINALS (PEAK OR QUASI-PEAK DETECTOR)

Class	Levels in dB (µV) 0.15-0.3 MHz P	Levels in dB (µV) 0.15-0.3 MHz QP	Levels in dB (µV) 0.53-2.0 MHz P	Levels in dB (µV) 0.53-2.0 MHz QP	Levels in dB (µV) 5.9-6.2 MHz P	Levels in dB (µV) 5.9-6.2 MHz QP	Levels in dB (µV) 30-54 MHz P	Levels in dB (µV) 30-54 MHz QP	Levels in dB (µV) 70-108 MHz P	Levels in dB (µV) 70-108 MHz QP
1	113	100	95	82	77	64	77	64	61	48
2	103	90	87	74	71	58	71	58	55	42
3	93	80	79	66	65	52	65	52	49	36
4	83	70	71	58	59	46	59	46	43	30
5	73	60	63	50	53	40	53	40	37	24

For short duration disturbances, add 6 dB to the levels shown in the table.

NOTE—All values listed in this table are valid for the bandwidths specified in Table 3.

TABLE 5—LIMITS FOR NARROWBAND CONDUCTED DISTURBANCES ON POWER INPUT TERMINALS (PEAK DETECTOR)

Class	Levels in dB (µV) 0.15-0.13 MHz	Levels in dB (µV) 0.53-2.0 MHz	Levels in dB (µV) 5.9-6.2 MHz	Levels in dB (µV) 30-54 MHz	Levels in dB (µV) 70-108 MHz
1	90	66	57	52	42
2	80	58	51	46	36
3	70	50	45	40	30
4	60	42	39	34	24
5	50	34	33	28	18

For 87 - 108 MHz add 6 dB to the level shown in the table.

TABLE 6—LIMITS FOR BROADBAND CONDUCTED DISTURBANCES ON CONTROL/SIGNAL LINES (PEAK OR QUASI-PEAK DETECTOR)

Class	Levels in dB (μA) 0.15-0.3 MHz P	Levels in dB (μA) 0.15-0.3 MHz QP	Levels in dB (μA) 0.53-2.0 MHz P	Levels in dB (μA) 0.53-2.0 MHz QP	Levels in dB (μA) 5.9-6.2 MHz P	Levels in dB (μA) 5.9-6.2 MHz QP	Levels in dB (μA) 30-54 MHz P	Levels in dB (μA) 30-54 MHz QP	Levels in dB (μA) 70-108 MHz P	Levels in dB (μA) 70-108 MHz QP
1	100	87	92	79	74	61	74	61	68	55
2	90	77	84	71	68	55	68	55	62	49
3	80	67	76	63	62	49	62	49	56	43
4	70	57	68	55	56	43	56	43	50	37
5	60	47	60	47	50	37	50	37	44	31

For short duration disturbances, add 6 dB to the levels shown in the table.

NOTE—All values listed in this table are valid for the bandwidths specified in Table 3.

TABLE 7—LIMITS FOR NARROWBAND CONDUCTED CURRENT DISTURBANCES ON CONTROL/SIGNAL LINES (PEAK DETECTOR)

Class	Levels in dB (μA) 0.15-0.13 MHz	Levels in dB (μA) 0.53-2.0 MHz	Levels in dB (μA) 5.9-6.2 MHz	Levels in dB (μA) 30-54 MHz	Levels in dB (μA) 70-108 MHz
1	80	66	57	52	52
2	70	58	51	46	46
3	60	50	45	40	40
4	50	42	39	34	34
5	40	34	33	28	28

For 87 - 108 MHz add 6 dB to the level shown in the table.

7. *Radiated Emissions*—Component/Module

7.1 General

NOTE—Conducted emissions will contribute to the radiated emissions measurements because of radiation from the wiring in the test setup. Therefore, it is advisable to establish conformance with the conducted emissions requirements before performing the radiated emissions test.

Measurements of radiated field strength shall be made in a ALSE to eliminate the high levels of extraneous disturbance from electrical equipment and broadcasting stations.

The reflection characteristics of the shielded enclosure shall be checked by performing comparative measurements in an open field test site and in the ALSE. The difference of results shall comply with 4.4.2. For further details, see Appendix A. For restrictions on size, see 4.4.1.

NOTE— Disturbance to the vehicle on-board receiver can be caused by direct radiation from one or more leads in the vehicle wiring harness. This coupling mode to the vehicle receiver affects both the type of testing and the means of reducing the disturbance at the source.

Vehicle components which are not effectively grounded to the vehicle by short ground leads, or which have several harness leads carrying the disturbance voltage, will require a radiated emissions test. This has been shown to give better correlation with the complete vehicle test for components installed in this way.

Examples of component installations for which this test is applicable include, but are not limited to:

a. Electronic control systems containing microprocessors
b. Two speed wiper motors with negative supply switching
c. Suspension control systems with strut-mounted actuator motors
d. Engine cooling and heater blower motors mounted in plastic or other insulated housings

7.2 Test Procedure—The general arrangement of the disturbance source, and connecting harnesses, etc., represents a standardized test condition. Any deviations from the standard test harness length, etc., shall be agreed upon prior to testing, and recorded in the test report. The harness (power and control/signal lines) shall be supported 50 mm above the ground plane by nonconductive, low dielectric constant material, and arranged in a straight line (see Figures 8 and 9).

The EUT shall be made to operate under typical loading and other conditions as in the vehicle such that the maximum emission state occurs. These operating conditions must be clearly defined in the test plan to ensure supplier and customer are performing identical tests. Depending on the intended EUT installation in the vehicle:

a. EUT With Power Return Line Remotely Grounded—Two artificial networks are required—one for the positive supply line and one for the power return line.

a. EUT With Power Return Line Locally Grounded—One artificial network is required for the positive supply line.

The EUT shall be wired as in the vehicle (see Figures 5 and 6). The measuring port of the artificial mains network shall be terminated with a 50 Ω load.

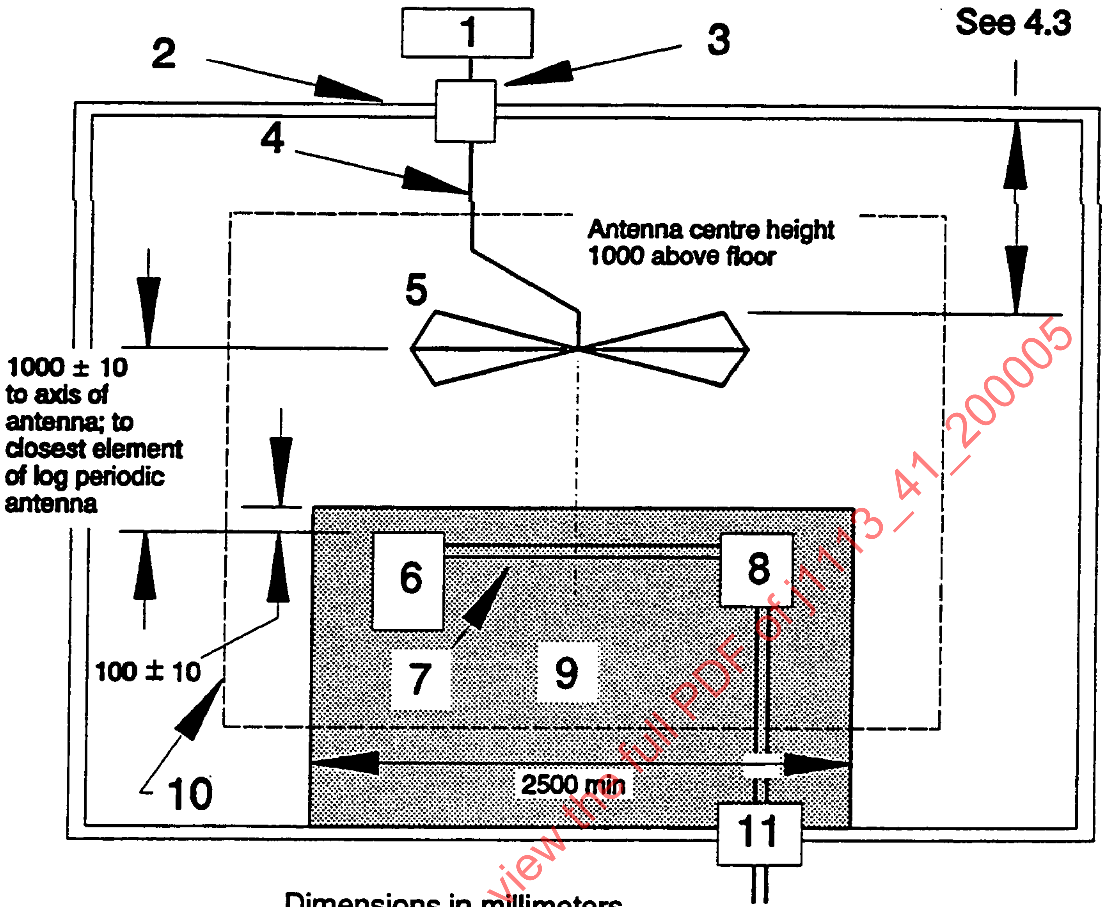
The face of the disturbance source causing the greatest RF emission shall be closest to the antenna. Where this face changes with frequency, measurements shall be made in three orthogonal planes, and the highest level at each frequency shall be noted in the test report.

NOTE—If the EUT is small in comparison to the wavelength, orientation in three planes may be omitted.

At frequencies above 30 MHz, the antenna shall be oriented in horizontal and vertical polarization to receive maximum indication of the RF noise level at the measuring receiver. See Figures 10 and 11 for further test requirements. The distance between the wiring harness and the antenna shall be 1000 mm ± 10 mm. This distance is measured from the center of the wiring harness to:

a. The vertical monopole element or
b. The midpoint of the biconical antenna or
c. The nearest part of the log periodic antenna

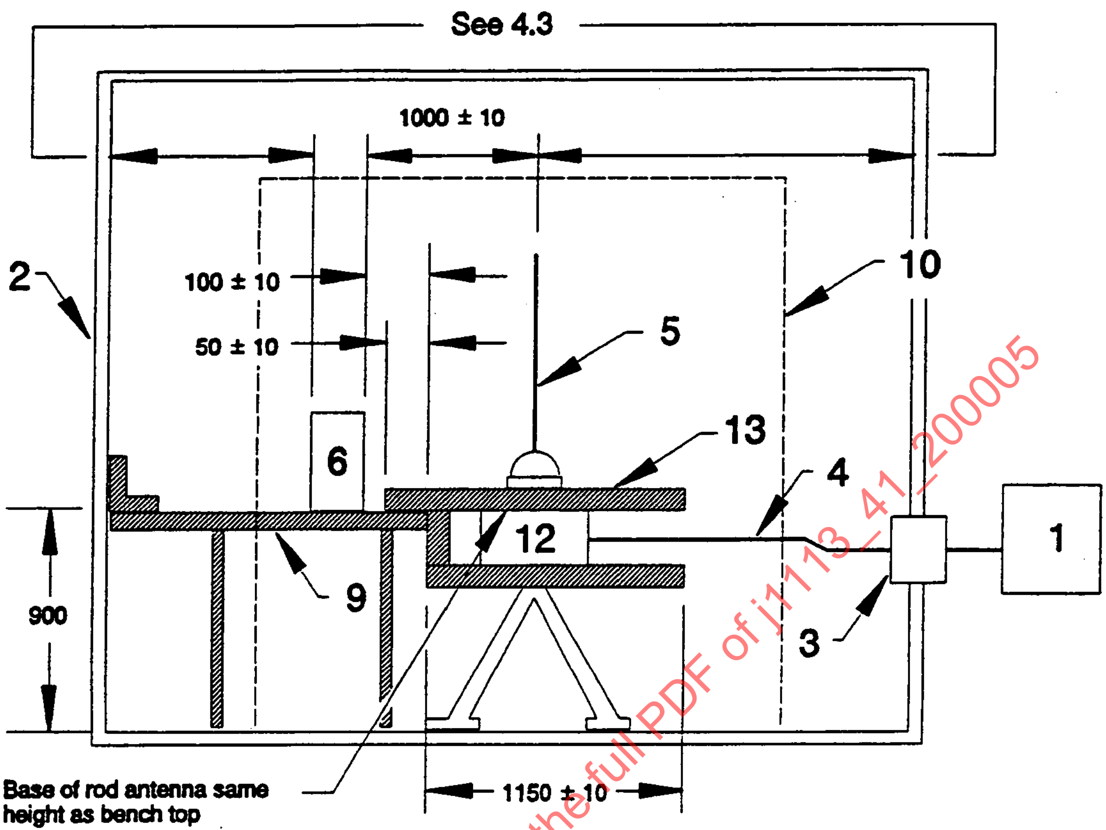
The EUT shall be mounted 100 mm ± 10 mm from the edge of the test bench as shown in Figure 9.



Dimensions in millimeters

1. Measuring receiver
2. ALSE
3. Bulkhead connector
4. Double shielded or solid shielded coaxial cable (50 Ω)
5. Antenna (see 4.10.1)
6. EUT
7. Test harness (1500 mm ± 75 mm) long (or as specified up to 2000 mm long) (50 mm ± 5 mm) above ground plane.
8. Artificial network(s)
9. Test bench - 2500 mm long by 900 mm high
10. Typical RF absorber
11. Filter to power supply

FIGURE 8—RADIATED EMISSIONS—EXAMPLE OF TEST LAYOUT
(GENERAL PLAN VIEW)



Dimensions in millimeters

1. Measuring receiver
2. ALSE
3. Bulkhead connector
4. Double shielded or solid shielded coaxial cable (50 Ω)
5. Antenna (see 4.10.1)
6. EUT
9. Test bench - 2500 mm long by 900 mm high
10. Typical absorber material
12. Antenna matching unit
13. Counterpoise - 600 mm by 600 mm typical with full width bond to ground plane

NOTES

1. The preferred location for antenna matching unit is below the counterpoise. As an alternative, the matching unit may be above the counterpoise, but the base of the antenna rod shall be at the height of the bench ground plane.
2. Numbers 7, 8, and 11 not used to maintain numbering scheme in Figure 8.

FIGURE 9—RADIATED EMISSIONS—EXAMPLE FOR TEST LAYOUT
(SIDE VIEW WITH MONOPOLE ANTENNA)

8. ***Limits for Component Radiated Disturbances***—Some disturbance sources are continuous emitters and require a more stringent limit than a disturbance source which is only on periodically or for a short time. The limits in Tables 8 and 9 have been adjusted to take account of this fact. Levels in Tables 8 and 9 were established by the application of engineering judgment to empirical values obtained from multinational testing during 1990. Measurements need only be performed with one detection type. Refer to Footnote 1) Scope for statement on limits.

TABLE 8—LIMITS FOR COMPONENT BROADBAND RADIATED DISTURBANCE (PEAK OR QUASI-PEAK DETECTOR)

Class	Levels in dB (μV/m) 0.15-0.3 MHz P	Levels in dB (μV/m) 0.15-0.3 MHz QP	Levels in dB (μV/m) 0.53-2.0 MHz P	Levels in dB (μV/m) 0.53-2.0 MHz QP	Levels in dB (μV/m) 5.9-6.2 MHz P	Levels in dB (μV/m) 5.9-6.2 MHz QP	Levels in dB (μV/m) 30-54 MHz P	Levels in dB (μV/m) 30-54 MHz QP	Levels in dB (μV/m) 70-108 144-172 420-512 820-960 MHz P	Levels in dB (μV/m) 70-108 144-172 420-512 820-960 MHz QP
1	96	83	83	70	60	47	60	47	49	36
2	86	73	75	62	54	41	54	41	43	30
3	76	63	67	54	48	35	48	35	37	24
4	66	53	59	46	42	29	42	29	31	18
5	56	43	51	38	36	23	36	23	25	12

For short duration disturbances, add 6 dB to the levels shown in the table.

NOTE—All values listed in this table are valid for the bandwidths specified in Table 3.

TABLE 9—LIMITS FOR NARROWBAND COMPONENT RADIATED DISTURBANCE (PEAK DETECTOR)

Class	Levels in dB (μV/m) 0.15-0.13 MHz	Levels in dB (μV/m) 0.53-2.0 MHz	Levels in dB (μV/m) 5.9-6.2 MHz	Levels in dB (μV/m) 30-54 MHz	Levels in dB (μV/m) 70-108 144-172 420-512 820-960 MHz
1	61	50	46	46	36
2	51	42	40	40	30
3	41	34	34	34	24
4	31	26	28	28	18
5	21	18	22	22	12

For 87 - 108 MHz add 6 dB to the level shown in the table.

9. *Radiated Emissions*—Component/Module; TEM Cell Method

9.1 General—Measurements of radiated field strength shall be made in a shielded enclosure to eliminate the high levels of extraneous disturbance from electrical equipment and broadcast stations. The TEM cell works as a shielded enclosure. For further details, see Appendix D.

The TEM cell method of emission measurements is more suited to narrowband measurements than broadband.

NOTE—The upper frequency limit of this test method is a direct function of the TEM cell dimensions, the component/module dimensions (arrangement included), and the RF filter characteristic. Measurements shall not be made in the region of the TEM cell resonances.

A TEM cell is recommended for testing automotive electronic systems in the frequency range of 150 kHz to 200 MHz. The TEM cells boxed in Figure D3, Appendix D, are typical of those used in automotive work.

In order to achieve reproducible test results, the EUT and the test harness shall be placed in the TEM cell in the same position for each repeated measurement.

9.2 Test Procedure—The general arrangement of the EUT, the harness, the filter system at the TEM cell's wall, etc., represents a standardized test condition. Any deviations from the standard test configuration shall be agreed upon prior to testing and recorded in the test report.

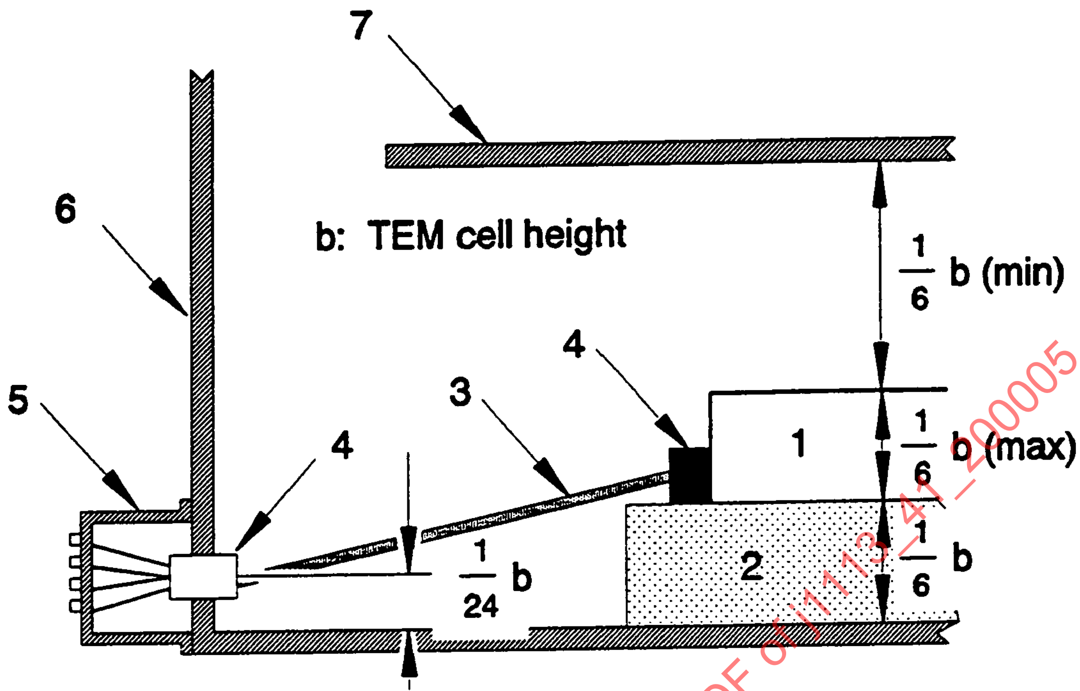
The EUT shall be supported b/6 (see Figure 10) above the TEM cell floor by nonconductive material ($\varepsilon_r \leq 1.4$) in the allowed working region. The length of the artificial harness (e.g., a lead frame) shall be 450 mm and positioned as shown in Figure 3.

The electrical loop between EUT and the connector panel shall not be influenced by the connector system at the EUT as far as possible. Variations of the loop can be balanced with transfer measurements. Care shall be taken, if the size of the EUT and the allowed working region is nearly the same. In such case, special definitions between the users are necessary.

The EUT shall be installed to operate under typical loading and other conditions as in the vehicle in such a way that the maximum emission state occurs. These operating conditions must be defined in the test plan to ensure supplier and customer are performing identical tests.

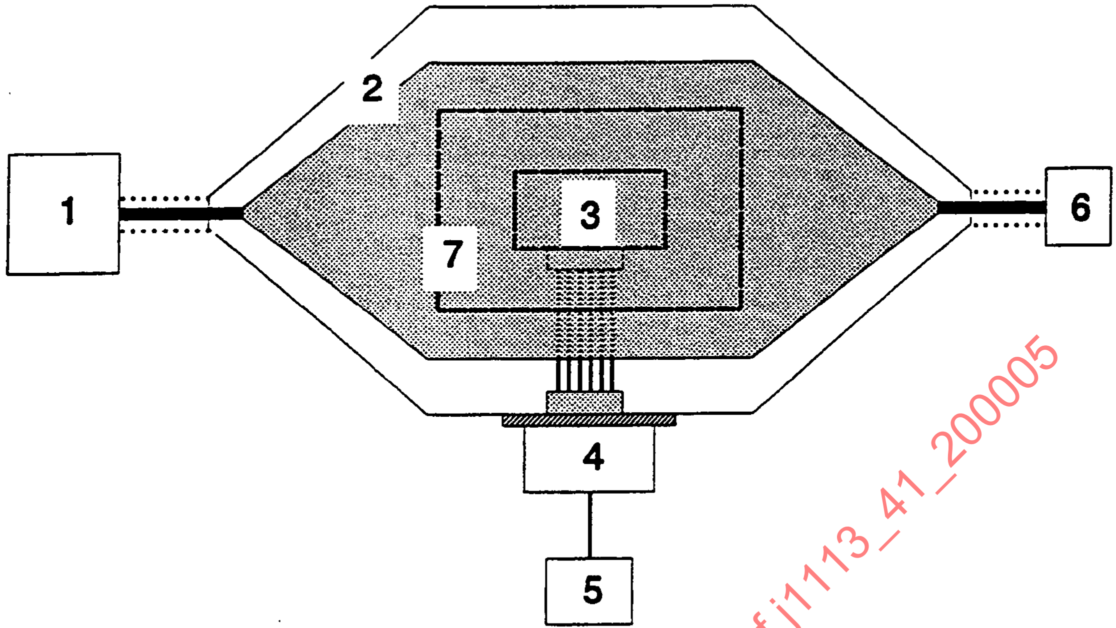
The positive supply line shall have an RF filter at the TEM cell input. The artificial network (AN) of 4.9.1.2 shall be used as the filter. The AN shall be connected directly to the TEM cell and shall be screened, so that the negative supply line is grounded at the connector panel.

Figure 11 shows a typical example of a TEM cell method test layout.



1. EUT
2. Dielectric equipment support ($\varepsilon_r \leq 1.4$)
3. Artificial harness (e.g., leadframe)
4. Connectors
5. Connector panel (optional)
6. TEM cell wall
7. Septum

FIGURE 10—EXAMPLE OF THE ARRANGEMENT OF THE CONNECTORS, THE LEADFRAME AND THE DIELECTRIC SUPPORT



1. Measuring instrument
2. TEM cell
3. EUT
4. AN (see 4.9.1)
5. Power supply
6. 50 Ω termination resistor
7. Dielectric equipment support

FIGURE 11—EXAMPLE OF THE TEM CELL METHOD TEST LAYOUT

10. ***Limits for Component Radiated Disturbances; TEM Cell Method (Both the Leadframe and EUT and the EUT Only Methods)***—Some disturbance sources are continuous emitters and require a more stringent limit than a disturbance source which operates only periodically and/or for a short time.

The limits of the radiated electromagnetic energy may be different for each disturbance source and arrangement (coupling between antenna and electronic device in the vehicle). The class from Table 10 for each applicable band in Table 11 shall be selected by the vehicle manufacturer and the component supplier, and documented in the test plan. For continuous emitters, it is recommended to use class 5 in bands E and F. The class 6 and 7 limits are used for special protection cases.

TABLE 10—DISTURBANCE LIMITS(1)(2)(3)(4)

Class	Levels-dB (μV)
0	user defined
1	60
2	50
3	40
4	30
5	20
6	10
7	0

1. The limits in Table 10 are for narrowband measurements (peak-and quasi-peak detector) and continuous emitters.
2. For broadban measurements with quasi-peak detector, add 10 dB and with peak detector, add 23 dB to the levels In Table 10.
3. For short duration broadban measurements with quasi-peak detector, add 16 dB to the levels in Table 10, for similar peak detector measurements, add 29 dB.
4. Levels in Table 10 were established by application of engineering judgment to empirical values obtained from national testing.

TABLE 11—FREQUENCY BANDS

Band	Frequency-MHz
A	0.15 - 0.3
B	0.53 - 2.0
C	5.90 - 6.2
D	30.0 - 54.0
E	70.0 - 108.0
F	144.0 - 172.0
G	user defined
H	user defined

11. ***Limits for Integrated Circuit Radiated Disturbances***—TEM Cell Method—See SAE J1752/3.

PREPARED BY THE SAE EMR STANDARDS COMMITTEE

APPENDIX A

CALIBRATION PROCEDURE FOR COMPONENT SHIELDED ENCLOSURE (INFORMATIVE)

A.1 Shielded Enclosure Reflection Test and Calibration Procedure—The following test procedure is recommended for calibration of any shielded enclosure of dimensions not less than 7.0 m x 6.5 m x 4.0 m (L x W x H) for radiated emissions measurements.

A.2 Standard Noise Source—A standard noise source with defined output characteristics shall be used for calibration purposes. A calibration curve shall be obtained with the standard noise source for field strength at 1 m distance in an open field test site, using the same test setup, i.e., antennas, calibration harness, artificial mains network, etc.

A.3 Standard Noise Source Characteristics—The standard noise source shall have a stable output amplitude spectrum throughout the frequency range of interest.

A.4 Calibration Procedure—Arrange the standard noise source in place of the EUT in the test setup shown in Figures 8 and 9. The noise source shall be attached to the artificial mains network by the standard 1500 mm harness lead supported 50 mm above the ground plane.

Measurements shall be made at the same frequencies and with the same antennas as will be used for the subsequent testing of the EUT. A plot of field strength versus frequency shall be produced.

The difference between the open test site curve and that taken in the ALSE shall be used to check whether the reflection characteristics of the ALSE comply with 4.4.2, but they cannot be used as a calibration factor.

To ensure uniformity of testing, steps shall be taken to reduce any reflections in the shielded enclosure which may cause variations in measured levels.

NOTE—Radio frequency absorbent material, properly applied, will reduce reflections at the higher frequencies.