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Part 3

Test Methods and Limits for Equipment and Sub Systems

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Foreword

AMENDMENT RECORD

Amdt No	Date	Text Affected	Signature and Date
1		The following clauses have been updated: Clause 6.1, 6.2, 6.3.1, 6.4, 6.7.2, 6.18, 9.5, 9.7, 9.11, 9.12, 9.15, 9.16, 9.19, A.2.3, A.5.5, B.4, B.11.3, B.13, B.18.5, B.20, C.2.1, C.2.2, C.6, C.7.2, & C.8.4. Figure 3 deleted remainder renumbered. The following figures have been updated: 14, 15, 17, 34, 36, 49, 53, 62, 94, 98, 108, 115, 116, 117 & 126. New Table 2 remainder renumbered. The following Tables have been updated: 5, 13 & 25 References to "DCSA DE3A" have changed to "DE&S DE3A"	

REVISION NOTE

This part of the standard is raised to Issue 1 Amendment 1 to update its content. The sponsor of this standard should be consulted for a full description of the changes.

HISTORICAL RECORD

This standard supersedes the following:

Defence Standard 59-41 Part 3 Section 1 Issue 2 Published 5 April 1999

Defence Standard 59-41 Part 3 Section 2 Issue 2 Published 5 April 1999

Defence Standard 59-41 Part 3 Section 3 Issue 1 Published 16 May 2003

Defence Standard 59-41 Part 5 Issue 3 Published 5 February 2003

Defence Standard 59-411 Part 3 Issue 1 Addendum 1 31 August 2007

a) This standard provides requirements for Ministry of Defence (MOD) Project Officers and defence contractors to assist them in the specification and selection of Electromagnetic Compatibility (EMC) Test Methods and Limits for Sub Systems to limit the propagation and coupling of unintentional electromagnetic energy whether conducted or radiated.

b) This standard has been produced on behalf of the Defence Material Standardization Committee (DMSC) by Defence Equipment & Support (DE&S) Defence Electromagnetic Environment Effects Authority (DE3A).

c) This standard has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc. and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, UK Defence Standardization (DStan) shall be informed so that a remedy may be sought.

d) Any enquiries regarding this standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

e) Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.

f) This standard has been devised solely for the use of the Ministry of Defence (MOD) and its contractors in the execution of contracts for the MOD. To the extent permitted by law, the MOD hereby excludes all liability whatsoever and howsoever arising (including, but without limitation, liability resulting from negligence) for any loss or damage however caused when the standard is used for any other purpose.

Introduction

Electromagnetic compatibility is an essential feature of any specification for military electrical equipment and is defined as the ability of electrical and electronic equipment, sub-systems and systems to share the electromagnetic spectrum and perform their desired functions without unacceptable degradation from or to the specified electromagnetic environment.

The contractor shall take into account the EMC characteristics of all proprietary equipment being procured by MOD, to ensure that it complies with the EC EMC Directive 89/336/EEC. (Note from 20 July 07 will be EMC Directive 2004/108/EC) Where equipment needs to operate in a military environment, then Defence Standard 59-411 shall be invoked and the appropriate test methods and limits identified in order to ensure acceptable equipment performance in their intended environment.

Although EMC measurements are usually specified in terms of absolute units, precise measurement is often difficult, the result depending on the method used. In the interests of repeatability, therefore, the preferred methods should be used. Alternative measurement techniques to those prescribed in this Standard may be permitted but only if their equivalence can be demonstrated to the satisfaction of the Procuring Authority. Any deviations from the practices laid down in this Standard shall be recorded and included with the test results.

The tests described in Annexes A and B are not intended to be regarded as production tests although they may in certain circumstances be suitable for this purpose.

This part of the Defence Standard also contains:

An Annex C which gives the mandatory performance specifications for certain specialised items of test equipment required to carry out certain tests within this part of the Standard. Equipment specified in this part of the Defence Standard is restricted to those specialised items listed in the test methods of Annexes A and B which are either conceptually new or would require an unwarranted amount of text to be detailed in the particular test method.

The nomenclature associated with a particular item of test equipment e.g. Type X, is purely for identification purposes and does not refer to any specific manufacturer.

This part of the Defence Standard is to be read in conjunction with the following parts in the Def Stan 59-411 series:

Def Stan 59-411 Part 1: Management and Planning

Def Stan 59-411 Part 2: The Electric, Magnetic and Electromagnetic Environment

Def Stan 59-411 Part 4: Platform and System Test and Trials

Def Stan 59-411 Part 5: Code of Practice for Tri-Service Design and Installation

Electromagnetic Compatibility - Part 3 - Test Methods and Limits for Equipment and Sub Systems

1 Scope

This part of the Defence Standard defines the preferred techniques to be used for the measurement of the electromagnetic compatibility characteristics to limit the propagation and coupling of unintentional electromagnetic energy whether conducted or radiated. It covers the following types of equipment procured by the Ministry of Defence for all three Services. Man Worn, Man Portable Equipment, Line Replacement Unit (LRU) and Sub-Systems and Support Equipment Requirements. It also covers any specialised EMC Test Equipment Requirements.

The procedures and limits outlined within this part of the Defence Standard are generally more stringent than those evoked by the European Directive 89/336/EEC (Note from 20 July 07 this will be EMC Directive 2004/108/EC). These reflect the harsher environment in which military equipment will operate. It is not permissible or acceptable to compare or cross reference test results from Euro Norms or Commercial Specifications with the procedures and limits contained within.

1.1 Man Worn / Man Portable Equipment

Annex A describes the preferred techniques to be used for the measurement of the electromagnetic compatibility characteristics of Man Worn and Man Portable electrical and electronic equipment.

1.2 Line Replacement Units and Sub Systems

Annex B describes the tests that are applicable to Line Replacement Units (LRUs) and Sub-Systems to limit the propagation of unintentional electromagnetic energy whether conducted or radiated internally or externally to a weapon platform, military vehicle, ship or aircraft. To limit any susceptibility to the internal or external operational electromagnetic environments of the weapon platform, in which the equipment will be fitted.

1.3 Support Equipment

See Part 1 of this Standard.

1.4 Performance Specification for Specialised EMC Test Equipment

Annex C specifies mandatory specifications for certain specialised items of test equipment as follows:

a) Performance requirements for transient and pulse generators.

b) Performance requirements for injection probes needed to couple generator output into equipment under test.

c) Performance requirements for calibration jigs needed to verify generator performance.

d) Information for the requirements of special voltage probes and their calibration.

e) Impedance/frequency compliance requirements for the Line Impedance Stabilising Network (LISN) called up in the tests described in this part of the Defence Standard. Some non-mandatory constructional information and a LISN calibration procedure are provided.

f) Methods of damping a screened room, the damping performance of the screened room and the verification procedures for measuring the screened room's performance.

g) Design of a twin-T filter to be used with the voltage probe when performing DCE03 and DCS01 measurements.

1.5 This Part of the Defence Standard also includes:

a) Some simulated NEMP, lightning strike and electrostatic discharge tests.

b) Information for individual tests is included under the clause ‘Detailed Test Requirements and Rationale’. This includes rationale for requirements, guidance in applying the requirements, and lessons learned from platform and laboratory experience. This information should help users understand the intent behind the requirements. In addition it should aid the procuring activity in tailoring emission and susceptibility requirements as necessary for particular applications and help users develop detailed test procedures in the Test Plan based on the general test procedures in this Part of the Defence Standard. This background information is provided for guidance purposes and as such, should not be interpreted as providing contractual requirements.

2 Warning

The Ministry of Defence (MOD), like its contractors, is subject to both United Kingdom and European laws regarding Health and Safety at Work. All Defence Standards either directly or indirectly invoke the use of processes and procedures that could be injurious to health if adequate precautions are not taken. Defence Standards or their use in no way absolves users from complying with statutory and legal requirements relating to Health and Safety at Work.

3 Related Documents

3.1 Related publications referred to in the text of this Standard are detailed in Part 1 Annex A of this Standard.

3.2 Reference in this standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

3.3 In consideration of **Clause 3.2** above, users shall be fully aware of the issue and amendment status of all related documents, particularly when forming part of an invitation to tender or contract. Responsibility for the correct application of standards rests with users.

3.4 DStan can advise regarding where related documents are obtained from. Requests for such information can be made to the DStan Helpdesk. How to contact the helpdesk is shown on the outside rear cover of Def Stans.

4 Abbreviations and Definitions

4.1 Abbreviations

AAMTU	Automatic Antenna Matching and Tuning Unit
AC	Alternating Current
ACF	Antenna Calibration Factor
AF	Audio Frequency
AM	Amplitude Modulated
ANA	Automatic Network Analyser

BCI	Bulk Current Injection
BS EN	British Standard (Euronorm)
CAT	Category
CCF	Chamber Calibration Factor
CFC	Carbon Fibre Composite
CLF	Chamber Loading Factor
CNE	Comparison Noise Emitter
COTS	Commercial Off The Shelf
CRT	Cathode Ray Tube
CW	Continuous Wave
DB	decibels
DC	Direct Current
DEC	Director Equipment Capability
DEF STAN	Defence Standard
DTI	Department of Trade and Industry
DRWG	Double Ridged Waveguide
EC	European Community
ECM	Electronic Counter Measures
EHT	Extra High Tension
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
ESD	Electrostatic Discharge
EUT	Equipment Under Test
f	Frequency
GHz	Giga Hertz
GTEM	Gigaherz Transverse Electro Magnetic
GSE	Ground Support Equipment
Hz	Hertz

kA	kilo Amps
kV	kilo Volts
LEMP	Lightning Electromagnetic Pulse
LF	Low Frequency
LISN	Line Impedance Stabilising Network
MAD	Magnetic Anomaly Detection
MHz	Mega Hert
M	metres
mm	milli metre
ms	milli seconds
NEMP	Nuclear Electromagnetic Pulse
NSIL	Normalised Site Insertion Loss
NWA	Network Analysers
OUT	Optical Transmitter Unit
PRF	Pulse Repetition Frequency
RAM	Radio Frequency Absorbent Material
RF	Radio Frequency
RMS	Root Mean Square
TEM	Transverse Electromagnetic
TNSIL	Theoretical Normalised Site Insertion Loss
UHF	Ultra High Frequency
UKAS	United Kingdom Accreditation Services
Vpk	Voltage (peak)
W	Watts
Ω	Ohms
μF	micro Farad
μs	micro seconds

4.2 Definitions

For the purpose of this standard the definitions in ISO/IEC Guide 2 ‘Standardization and Related Activities – General Vocabulary’ and in Part 1 Annex B of this Standard will apply.

5 Format

The test methods specified in this Standard are designated by an alpha-numeric identification scheme:

a) DCE Defence Conducted Emission

b) DCS Defence Conducted Susceptibility

c) DRE Defence Radiated Emission

d) DRS Defence Radiated Susceptibility

Each method has subsections of Purpose, Applicability, Test Layout, Test Method and Limits together with illustrations as necessary.

NOTE An additional letter is placed after each test method in Annexes A and B to signify that the test is only applicable to that particular annex of DEF STAN 59-411 and not to any other annex.

6 General Test Requirements

6.1 Introduction

The following requirements are applicable generally but in some instances extra detail is given for some tests in the relevant annex.

The laboratory shall for all tests performed, produce an estimate of the uncertainty of its measurements in accordance with UKAS documents M3003 The Expression of Uncertainties and Confidence in Measurements, LAB12 The expression of Uncertainty in Testing and LAB 34 The Treatment of Uncertainties in EMC Testing. It is not a requirement of this standard to include measurement uncertainty when making compliance statements or decisions. Uncertainty budgets should be held on file by the test house.

Reference to **Part 1 Clause 6.5** of this Standard is also required for Quality Assurance.

NOTE Unless otherwise stated the tolerance on all dimensions is ± 5%.

6.2 Test Sites

Tests shall be performed in a suitable test environment.

6.3 Screened Rooms / Reverberation Chamber

6.3.1 Screened Room

All Radiated Electric-Field Emission qualification tests shall be made in a screened room, which meets the Normalised Site Insertion Loss (NSIL) requirements. See **Annex C Clauses C.7** and **C.8**. It needs to provide an RF quiet zone free from broadcast and other transmitting sources, and in which high RF fields can be generated without causing interference to other users of the RF spectrum.

The screened room shall be of sufficient size to accept the equipment under test (EUT) and measuring antenna without sacrificing accuracy or required deviation from the methods specified in this document.

The screening effectiveness to electromagnetic fields shall be sufficient to provide ambient electromagnetic noise levels at least 6 dB below the limit curve of each test to be performed in the enclosure.

The test area shall be cleared of all items not pertinent to the tests in order to avoid the effect they may have on the measurement. All equipment other than the EUT should be housed in another area and coupled to the EUT by an access panel fitted with bulkhead coaxial connectors and filters as shown in **Figures 1** and / or **2**. Observation of the EUT can then be made using a suitably RF hardened TV camera coupled via a fibre optic link to a monitor.

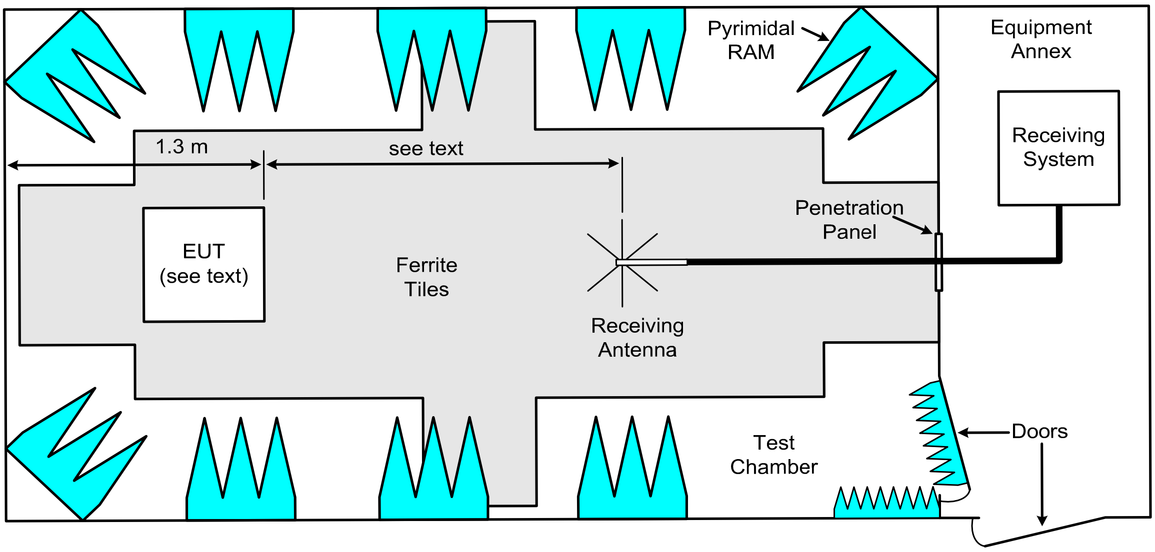

Figure 1 Screen Room Layout for Man Worn / Man Portable Equipment

NOTE 1 For Antenna EUT Separation distance see applicable test in Annex A.

NOTE 2 A separation distance of at least 0.3 m must be maintained between any equipment (including antenna) and absorber material

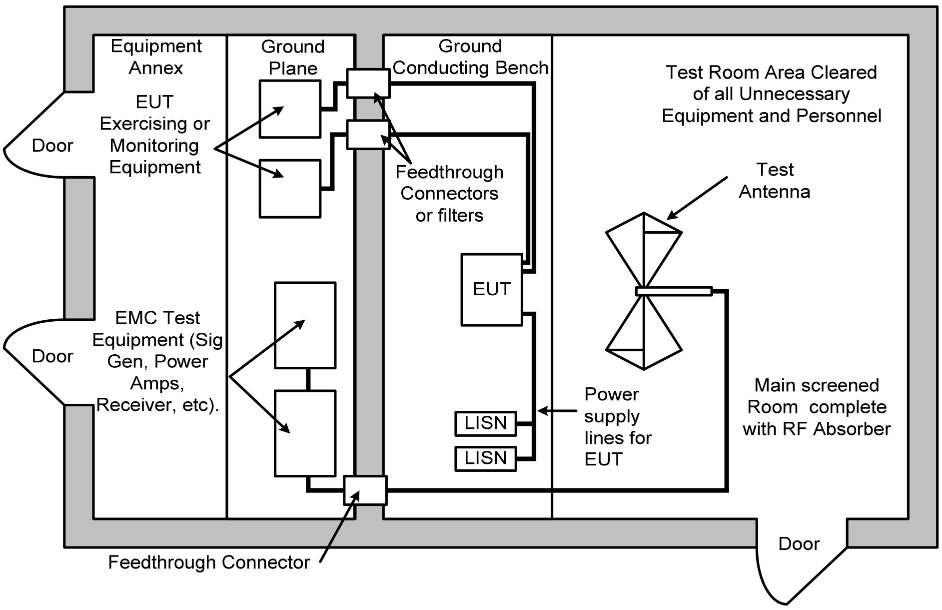

Figure 2 A Typical Layout for a Screen Room with a Ground Conducting Bench

6.3.2 Reverberation Chamber

As an alternative for performing Radiated Susceptibility Tests, a Reverberation Chamber may be used. See **Clause 9.19.1** and **Annex B**, **Clause B.19** for details.

6.4 Ground Conducting Bench

In order to provide a reference plane, the equipment under test shall normally be mounted on a solid copper ground conducting bench having a minimum thickness of 0.25 mm. Other conductive materials such as brass or aluminium (non-preferred because of oxidation) may be used but in a minimum thickness (mm) given by 0.25 x (resistivity of chosen material relative to that of copper).

The minimum area of the ground conducting bench outside of the absorber material shall be 2.25 m^2 with a minimum side of 0.75 m. The longer side of the ground conducting bench shall be bonded to the walls, solid sheet copper bonds being preferred, the bonds being not more than 0.9 m apart. If a shorter side of the ground conducting bench runs close and parallel to the enclosure wall, bonding of that side is also required. The bond thickness shall be not less than 0.30 mm with a length to width ratio not exceeding 3. The height of the ground conducting bench above the RAM level on the floor will be 0.9 m ± 0.05 m.

The maximum resistance between the ground conducting bench and the walls shall not exceed 2.5 mΩ when measured with a low current 4 wire bond resistance meter.

For large equipment mounted in a metal rack or cabinet, the metal rack or cabinet shall be considered a part of the ground conducting bench for testing purposes and shall be bonded to the ground conducting bench or floor of the screen room (which ever is the shorter) by the rack or cabinet bonding arrangements.

NOTE 1 The ground conducting bench shall be removed from the enclosure for Man Worn equipment measurements and replaced with a non conducting 0.45 m ± 0.05 m for Man Portable equipment measurements (**Annex A**). If it is not possible to remove the ground conducting bench due to it being welded or soldered in place to minimize bond impedances then covering the ground conducting bench with Radio Frequency Absorbent Material is an acceptable alternative providing the screened room still meets the Normalised Site Insertion Loss (NSIL) requirements. See **Annex C Clauses C.7** and **C.8**.

NOTE 2 Ground connections are not normally applicable to Man Worn / Man Portable Equipment Measurements (**Annex A**) but see **Clause 6.9** for further details.

NOTE 3 If equipment has dual purpose however it shall be tested in both configurations

6.5 Power Supply Filtering

Filtering of the power supply must be such that the resulting voltage at the EUT is at the nominal value throughout the load variation of the EUT. The degree of filtering must reduce any potential interference in the circuit under test to at least 6 dB below the test limit. Filtering of instrumentation power supplies for screened rooms shall ensure that any electromagnetic noise entering the room by this path is 6 dB below the limit in the test circuit.

6.6 Power Supply Impedance

The level of interference current generated by an EUT and fed back into its external power supply, will depend on the output impedance of that supply. In order to provide a defined impedance relatively independent of the impedance of different power sources, a Line Impedance Stabilising Network (LISN) shall be used in series with each conductor of the power supply. The LISN offers a defined impedance between its EUT terminal and earth, provided a discrete 50 Ω resistive impedance is connected between the LISN case and the measuring terminal provided for the purpose. This resistor should be a coaxial terminating resistor with a VSWR of <1.25.

The required impedance/frequency characteristics of the LISN (between EUT terminal and earth, with the line terminal left open-circuit) are specified in **Annex C Clause C.6** together with information on the special measures to be taken when using the LISN with DC supplies. Some non-mandatory constructional guidance is also given.

The LISN is also used in immunity tests when interference current must be injected into the power supply of the EUT. In this event care must be taken that the power rating of the 50 Ω termination is adequate. For example in test DCS02 a 50 W termination may be required.

The LISN is housed in a metal screening case provided with a supply terminal, an EUT terminal and a 50 Ω bulkhead RF connector mounted on the case, for connection of the external 50 Ω termination. It should be noted that the design impedance/frequency characteristic of the LISN is only realised when a short metal strap earths the case to the ground conducting bench (defined in **Clause 6.4**) or to the wall / floor of the screen room where there is no ground conducting bench.

6.7 Layout of EUT

To facilitate EMC measurement repeatability in a screened room, the physical layout of an EUT and its associated connecting cables must be specified.

For all EUT's a pre-scan is encouraged to identify which face or faces of the EUT appear to emit the highest level of emissions. Consideration should be given to the cables and the individual faces of the EUT or each EUT in the case of multiple units. A suggested method of pre-scanning is given below:

Pre-scans are best implemented by using a spectrum analyser and either antennas to cover the frequency range or small loop probes or near field probes to individually investigate the emissions in close proximity to the EUT. It must be understood that the amplitudes measured will not correlate readily with any emissions found during the final emission measurements but the relative amplitudes measured can indeed be a good indication of the 'hot' cables or faces of the EUT. The separation distance of the loop or probe from the LRU or cable will be critical in comparing emissions.

Ideally the frequency range of interest will be subdivided into a number of smaller ranges that will enable many scans to take place during any 15 to 20 second pre-scan operation and using a bandwidth no more than 3 times the specified measurement bandwidth in Table 1 for the frequency range being scanned, this will ensure that relevant emissions occurring more frequently than once every 15 seconds will be captured.

Where the Spectrum analyser has the facility, it is often a good idea to configure it such that trace A is in 'Clear Write' and trace B is in max hold, with practice the relative amplitudes of emissions around the EUT can be analysed and an indication gained of which cables and faces of the EUT are the source of the highest emissions.

Using this technique a diagram can be produced indicating which cables and EUT faces were emitting the strongest signals and from this the optimum test configuration can be derived. Where possible it may be practical to still measure the EUT in several configurations, this however can be very time consuming and the need should be considered with the application and use of the equipment. Where an EUT is not the subject of a pre-scan, mitigation for its omission and the defined EUT configuration shall be included in the Test Plan or Report.

NOTE If an EUT has cables attached, the cables should be considered part of the EUT because often, especially below 200 MHz, they radiate more than the EUT body. Therefore it is possible that the cables could make the EUT larger than 1 m^3.

6.7.1 Man Worn Equipment

The use of a full size adult (1.8 m nominal) non conducting manikin complete with limbs is required and the EUT shall be position on the manikin to simulate its position in use. See applicable test methods in **Annex A**.

6.7.2 Man Portable Equipment

The equipment shall be placed on a 0.45 m high non-conducting bench. See applicable test methods in **Annex A**.

NOTE Some man worn / man portable equipment maybe dual purpose, i.e. it can be connected to the mains or host equipment by a conductive multi-core cable. In this case its needs to be tested in accordance with the test methods in **Annex B** and **Clause 6.7.3**.

6.7.3 LRU's and Sub Systems

The EUT and the 50 Ω termination face of the LISN's used shall be positioned 100 mm ± 20 mm from and parallel to the front edge of the ground conducting bench subject to allowances for providing adequate room for cable arrangements as shown in **Figure 3**. This requirement also applies to EUT, which are multi unit, if the actual positions relative to each other in their installation are known then that arrangement shall take precedence. If an EUT is normally rack mounted then the rack if available should be utilised for the test.

Cables should be arranged at a distance of 100 mm back from the front edge of the ground conducting bench for as much of their length as possible, ignoring any cable that for reasons of the connectors and harnesses design protrude from the equipment in differing directions, these should be positioned to maximise the length of cable situated at the 100mm point.

The separation distance from EUT to the nearest LISN terminal shall be 1m ± 100 mm. This LISN shall for AC and DC supplies be connected to all phase lines and neutral. Any deviations shall be documented in the Test Plan.

Figure 3 shows typical layouts for multiple EUT units on a ground conducting bench.

Photographs or detailed sketches of the test layout shall be included in the EMC Test Report, including dimensions and cable lengths. Marking the ground conducting bench with a 100mm square grid is also encouraged as this will aid repeatability. See **Part 1 Clause 11** of this Standard.

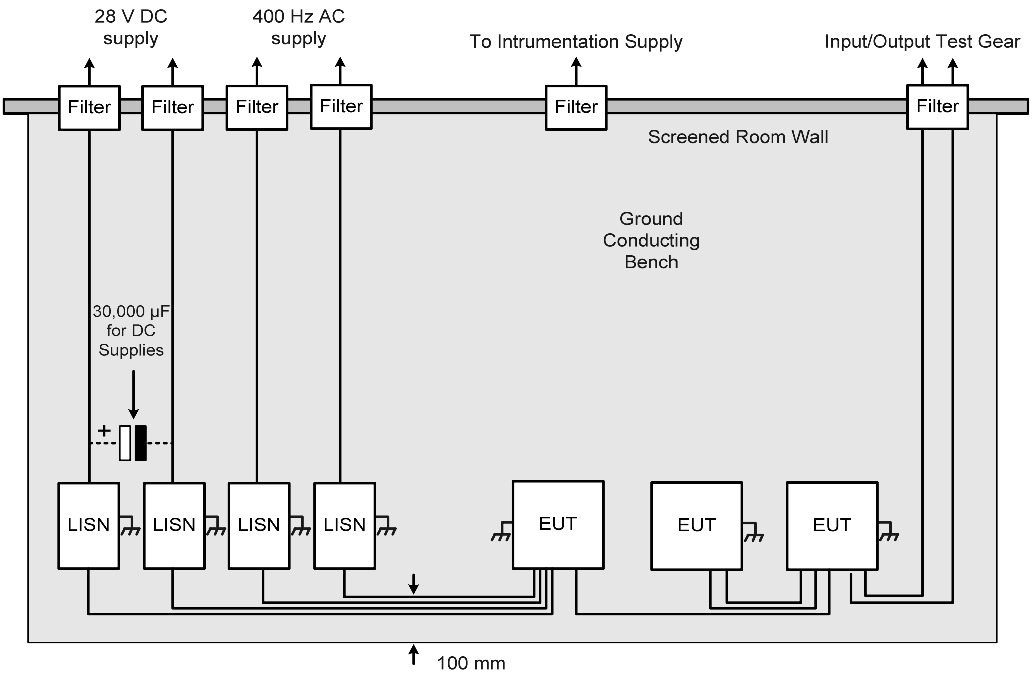

Figure 3 Suggested Multiple EUT Layout for Screen Room WITH a Ground Conducting Bench

6.8 Length and Arrangement of Connecting Leads to EUT

The EUT interconnecting cable-forms shall whenever possible, be of length, type and layout representative of the practical installation, and ideally actual cable-forms shall be used.

6.8.1 Man Worn / Man Portable Equipment (Annex A)

Interconnecting cables should be positioned as near as possible to simulate the operational scenario. Wherever possible the actual cable harnesses normally deployed should be used.

All monitoring cables to antennas/current probes shall be taken horizontally to the nearest wall and then dressed around the room to the penetration panel.

6.8.2 LRUs & Sub Systems (Annex B)

The EUT interconnecting cable-forms shall be supported above the ground conducting bench on 50 mm insulated stand-offs in order to simulate a typical ground current loop area. If the leads were located directly on the ground conducting bench this would result in lower magnetic-field emissions or reduced susceptibility and hence give more favourable test results. This requirement relates to the fact that normal installations cannot always allow wiring harnesses or cables to be clamped directly to the installation/vehicle structure over the whole of the cable length.

In circumstances where the length of the cable form is not known, control and signal cable lengths shall be 2m ± 100 mm. Primary power leads from LISN to EUT shall be 1m ± 100 mm. The test house mains supply cable from enclosure filter to LISN input, shall be routed in contact with the ground conducting bench, and by the shortest possible path.

Some installations require very long cable runs, which cannot be accommodated on the test bench. In these cases, the maximum length of interconnecting test cable-forms shall be 15m ± 1m or as specified in the Test Plan.

When the length of an interconnecting cable-form between two items of an EUT is greater than 2m, the leads must be deployed in a certain manner. I.e. the cable-form shall be arranged as shown in **Figure 4** with the excess length zigzagged at the back of the test bench on 50 mm supports. This method is preferred to that of coiling the cable which could increase the cable inductance by as much as ten times for a very long cable-form, thus reducing the conducted emissions. Ideally the run of cable should follow the front edge of the test bench at a distance of 100 mm from the edge for at least 1 m. However this will not always be possible due to the relative positions of the front face of the EUT and connector dispositions.

NOTE The position and length of cables must be recorded in the Test Report (see **Part 1 Clause 11** of this Standard).

6.9 Bonding of EUT

Bonding is not applicable for Man Worn equipment. However if Man Portable equipment has dual purpose, e.g. it can be connected to an external power supply and/or control harness or antenna (such as may connect a man-pack radio to a vehicle power, control and/or antenna system) then it shall be tested in both configuration for compliance. Such EUT's will be tested without a bond connection to the ground conducting bench, unless when installed in the field a bond is normally added. Where the sole earth to the EUT is via its power cable, this will be connected to the ground conducting bench at the non-EUT end of the cable.

The bonding provisions included in the design of the EUT and specified in the installation instruction shall be used:

a) To bond the items of the EUT together, such as equipment case and mount,

and/or

b) To bond the EUT to the ground conducting bench.

When used, bonding jumpers and routing shall be as close as possible to those specified for the installation including the method of connection.

Equipment intended to be grounded through a third wire should be grounded by that method unless a special installation requires otherwise. When this method is used the test item shall be placed on insulating 50mm stand-offs.

When EUT's are secured to mounting bases having shock or vibration isolators, bonding straps when furnished with mounting bases shall be connected to the ground conducting bench. If bonding straps are not specified none shall be fitted.

When an external terminal lug, stud or connector pin is available for a ground connection on the EUT, it shall be used if normal installation so indicates. Where known, the connection shall be made with a cable similar in type and dimension to that used in service. The EUT shall be mounted on insulating 50 mm stand-offs so as not to create additional earth paths.

Details of the EUT bonding shall be included along with the results of the measurements of the bond resistance in the Test Report (see **Part 1 Clause 11** of this Standard).

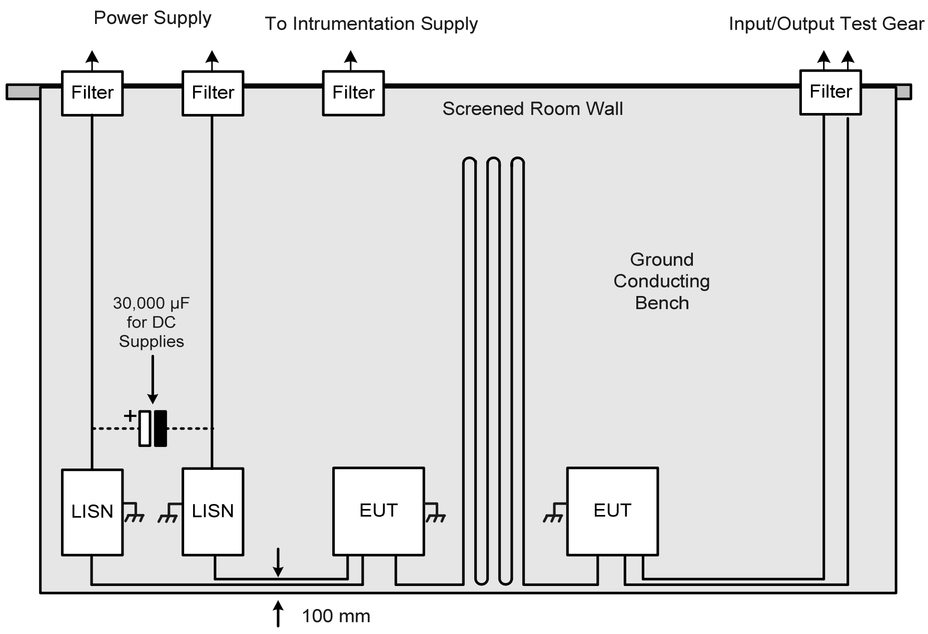

Figure 4 Arrangement for Long Interconnecting Cables (Annex B measurements)

6.10 Ambient Electromagnetic Noise Levels

If the equipment emissions are more than 6 dB below the applicable limit line then ambient measurements are not required. The number of ambient noise measurements made may be reduced if several tests are made consecutively. The ambient noise levels shall be included in the Test Report whenever measured emissions are within 6dB's of the relevant limit (see **Part 1 Clause 11** of this Standard).

The ambient noise levels shall be measured in the following ways:

1 For methods involving the measurement of conducted emissions on EUT power leads, the power leads shall be disconnected from the EUT and reconnected via 10 µF to the ground conducting bench on each lead plus a resistive load. The value of this load shall be such that at least the same current is drawn from the power source as when the EUT is connected.

2 For methods involving the measurement of conducted emissions on interconnecting cable-forms, the EUT shall be de-energised and the monitoring equipment/test set shall be energised.

3 For methods involving the measurement of radiated fields, the EUT shall be de-energised and any support monitoring and test equipment/test set shall be energised.

Ambient levels in the screened room may be reduced by housing all the support, monitoring and test equipment other than the EUT in another area coupled by an access panel fitted with a bulkhead connector for the measuring cable and bulkhead filtering of the input/output signal leads. Where ever possible fibre optic cables should be used and care must be taken to ensure that these do not affect the ambient conditions.

6.11 Ground Loop Currents in Measuring Leads

Care must be taken to ensure that the measurement arrangements do not introduce noise signals in the ground loop formed by the measuring lead and the ground conducting bench. The effect, which is commonly encountered at low frequencies, can be checked by replacing the sensor head by a 50 Ω resistor and earthing the coaxial cable at the sensor earth point; then any signals recorded must be at least 6 dB below the test limit. With some arrangements an isolating power transformer with Faraday screen should be used to reduce the coupling. In most cases if the instrumentation power supply is properly filtered problems of this nature will not occur.

NOTE This is not applicable to Man Worn or Man Portable Equipment, unless it is dual purpose.

6.12 Input / Output Connections to the Equipment Under Test

Ideally the EMC tests should be performed on a complete subsystem but, where part of a subsystem is unavailable, input and output signals or loads may have to be simulated.

Where parts of a system are being simulated by test equipment and are likely to be susceptible or generate interference they should be housed in a separate area from the EUT and receiving equipment. Any connecting leads must not significantly affect the emissions or susceptibility performance of the EUT. The connecting leads will be filtered at the screened room wall. Where the EUT is part of a system and the rest of the system is represented by a test box with many connections, some of which carry digital signals and filtering cannot be installed, there is no satisfactory method by which results can be identified as pertinent to the EUT alone.

Wherever possible loads i.e. lamps, meters, relays or solenoids should remain inside the screened room. Where this is not practicable they must be filtered where they exit the screen room. Where 15 m long cables simulate long cables (see **Clause 6.8.2**) no further RF loading other than the load simulation is considered necessary.

It is desirable that EUT cables are terminated in their normal load but where this not possible the simulated load shall be representative.

Antenna feeders are outside the scope of this standard.

Details of the test set-up Input and Output connections must be included in the test report (see **Part 1 Clause 11** of this Standard).

6.13 Modes of Operation of Equipment Under Test

Attention must be paid to the operation of the EUT as some equipment have many modes of operation. The modes of operation likely to cause the highest levels of emission and those likely to give the most susceptible condition shall be selected.

Transient emissions of electromagnetic energy occurring infrequently at a rate of not more than once every 15 seconds are not subject to limits except those of exported transients.

6.14 Test Frequency Selection

Automatic swept frequency techniques shall be used for measurement purposes but where the electromagnetic noise arises from infrequent switching operations and is discontinuous in nature i.e. where the transient emissions are < 15 seconds, fixed frequency measurements must be made with at least 3 frequencies per octave in addition to swept frequency measurements.

6.15 Measurement Bandwidth / Detector Function

One of the most troublesome areas in EMC testing is the classification of measured electromagnetic emissions as either narrow or broadband, and this is related to the fact that for any given signal (other than perhaps in simple terms an unmodulated CW carrier) it is only narrow or broadband as a function of the bandwidth in which it is measured. This means that the test receiver settings determine whether the signal being measured is appearing as a narrowband or broadband signal. This could cause a possible error in the measured amplitude of the signal. Therefore each signal would need to be analysed before its correct amplitude could be determined.

Ideally the receiver bandwidths to be used would be such that at any given frequency a broadband signal at the broadband limit will develop the same voltage in the receiver pass band as a narrowband signal at the narrowband limit. This is not practical so in this standard there is no distinction between broadband and narrowband signals for limit purposes and the receiver 6 dB (impulse) bandwidths to be used are defined for particular frequency ranges.

Peak detector function only shall be used for all measurements apart from DRE01.B (Land Class A) where an average detector is also required.

The bandwidths to be used are specified in **Table 1**.

Table 1 Measurement Bandwidths

Frequency Band	**6dB Impulse Bandwidth**
20 Hz 1 kHz	10 Hz ± 5 Hz
1 kHz 10 kHz	100 Hz ± 50 Hz
10 kHz 150 kHz	1 kHz ± 100 Hz
150 kHz 30 MHz	10 kHz ± 1 kHz
30 MHz 1 GHz	100 kHz ± 10 kHz
Above 1 GHz	1 MHz ± 100 kHz
* 1.6 MHz 30 MHz	1 kHz ± 100 Hz
** 30 MHz 450 MHz	10 kHz ± 1 kHz
NOTE * Applicable to: DRE03.A Land Service Class A DRE03.B Land Services Class A and B	
NOTE ** Applicable to: DRE01.A (88 MHz – 450 MHz) Land Service Class A DRE03.A (30 MHz – 88 MHz) Land Service Class A DRE01.B (30 MHz – 450 MHz) Land Service Classes A & B	
NOTE For the receiver, Impulse Bandwidth takes precedence and must comply with the values shown under the heading of '6 dB Impulse Bandwidth'	

The use of these bandwidths is to be confirmed in the Test Report. See **Part 1 Clause 11** of this Standard.

6.16 Sweep Speeds and Plot Charts

Only automated sweep techniques are permissible (see also **Clause 6.14**). The frequency step size shall be 0.5 times the bandwidth and the minimum detector dwell time shall be 20 ms. Longer dwell times are to be used when the operation of the EUT with slow repetition frequencies is such that peak emissions may not be recorded across the test frequency range.

Plot charts used to record emissions from the EUT shall incorporate as a minimum:

a) Frequency graduations.

b) Amplitude graduations (at least every 10 dB).

c) Specification limit or equivalent specification limit.

d) EUT mode of operation and lead under test, as applicable.

e) Date of test.

f) Title of EUT.

g) Test method.

h) Test point.

NOTE d, f and h may be abbreviated if space is limited on the chart.

The following shall be included in the Test Report. Detector dwell time, frequency step size, sensors or probes used, including their frequency range. See **Part 1 Clause 11** of this Standard.

6.17 Measuring Receiver Accuracy

The limits set down in this Standard take into account the uncertainty of the measuring equipment provided that the following parameters are within the tolerances described:

1) The required accuracy for frequency is ± 2 %.

2) The required accuracy for bandwidth is specified in **Table 1**.

3) The required accuracy for current or voltage is ± 2 dB.

The manufacturers' specifications for the receiver are to be confirmed by calibration to provide confidence in the measurement performance of the receiver. Manufacturers' specification figures will be used in the estimation of the measurement uncertainty with the exception of VSWR which must be measured for 0 dB attenuation.

Calibration shall be by an approved calibration laboratory with the required parameters traceable to National/International Standards.

NOTE EMC receiver peak detectors shall be calibrated in terms of the RMS value of a sine wave.

6.18 Susceptibility Criteria

In order that the test engineer can determine the threshold during conducted or radiated susceptibility testing the criteria for malfunction must be stated in the Test Plan or agreed in writing prior to testing based on the following performance criteria.

Performance Criterion A:

The equipment shall continue to operate as intended during and after each test. No degradation of performance or loss of function or unwanted operation is allowed, when the equipment is used as intended.

Performance Criterion B:

The equipment shall continue to operate as intended after the disturbance is removed. After the test, no degradation of performance or loss of function or unwanted operation is allowed, when the apparatus is used as intended. During each test, degradation of performance is allowed. However, there shall be no change to the actual operating state or to stored data at the end of test. Any such loss of performance during testing shall be recorded in the Test Report together with the conditions of test under which the degradation occurred.

Performance Criterion C:

Temporary loss of function is allowed during each test, provided the function is automatically self recoverable at the end of the test within an acceptable timescale. The allowable loss of function and timescale shall be stated in the EMC Test Plan. Any such loss of function during testing shall be recorded in the Test Report.

Performance Criterion D:

Loss of function is allowed during each test provided the function can be restored by the manual operation of the controls at the end of the test and no permanent damage occurs. The allowable loss of function shall be stated in the EMC Test Plan. Any such loss of function during testing shall be recorded in the Test Report.

Table 2 provides the default performance criteria to be applied dependent on the criticality of the equipment function. The equipment function criticality category is determined during the system safety assessment. The definitions of criticality are given in **Part 1 Annex B** of this Standard.

Table 2 Default Performance Criteria Guide

Susceptibility Test	Safety Critical / Safety Related Function	Mission Critical Function	Non-safety Critical (Non-essential) Function[1]
DCS01	A	A	A
DCS02	A	A	A
DCS03	A	A	A
DCS04	A	A	C
DCSO5 (Switching)	A	A	C
DCS05 (NEMP)	A	C	D
DCS06	A	A	C
DCS08	A	C	C
DCS09	A	C	D
DCS10	A	B	B
DCS12	A	C	D
DRS01	A	A	A
DRS02	A	A	A
DRS03	A	A	A

[1] Performance Criteria A is specified for non-safety critical functions where the interference conditions may be continuously present.

If the threshold level differs between raising and lowering of the interference signal, the upper and lower level threshold shall be recorded (Hysteresis effect).

When auxiliary test instrumentation is used for monitoring EUT e.g. oscilloscopes or digital voltmeters, steps must be taken to exclude the RF test signal induced into the output leads of the EUT from the monitoring circuit so that the output signal can be monitored without disturbance. Where ever possible fibre optic cables should be used. The method used for correct monitoring of the EUT output shall be detailed in the Test Plan / Report. See **Part 1 Clauses 10** and **11** of this Standard.

Following transient susceptibility testing a check shall be made to ensure that no damage to filters or other components has been made which would affect DCE01.B results. As a minimum therefore DCE01.B shall be performed after all transient susceptibility testing has been completed.

6.19 Susceptibility Test Stimuli

6.19.1 Modulation Requirements

Analysis of an EUT which contain one or more amplifiers or sensitive circuits which are not communications / electronics receivers will usually reveal that the equipment is likely to be more sensitive to one kind of modulation than another. The modulation most likely to have the greatest effect on the EUT shall be specified in the EMC Test Plan (see **Part 1 Clause 10** of this Standard) provided that this modulation frequency shall not exceed 0.2 x F_o (where F_o is the lowest frequency over the range being swept).

The amplitudes associated with test levels are based on the peak of the RMS envelope over the complete modulation period as shown in **Figure 5**. Amplitude measurements shall be made in a manner which clearly establishes the peak amplitude of the modulated waveform. This instrument must have a fast enough time response to respond to signal amplitude variations. The detection, resolution, and video bandwidths of the measuring instrument must be wider than the modulating frequency. The measurement bandwidth shall be increased until the amplitude of the measured signal does not change by more than 1 dB for a factor of three changes in bandwidth. This bandwidth setting shall then be used for the test. At the proper setting, the individual modulation sidebands will not be resolved.

The modulation requirements for susceptibility tests should demonstrate that the EUT does not suffer unacceptable performance degradation when exposed to the full range and intensity of the likely EM Environment that the EUT shall encounter over its operational life. This requires that the Operational Scenario and EM Environment be as accurately defined as possible (see **Part 2** of this Standard), especially with regard to safety and mission critical systems and that appropriate types of modulation are used.

In addition, consideration should be given to types of modulation which are likely to cause susceptibilities based upon the technology used within the EUT i.e. clock speed etc.

As a minimum requirement the following types of modulation shall be applied to both radiated and conducted susceptibility tests unless the Test Plan details specific alternatives.

The output level of the signal generator (or forward power) will in general be reduced to compensate for the addition of each of the modulating signals on the peak carrier amplitude in order to maintain the same Peak level under all conditions.

If modulation applied, peak levels will increase and amplitude to be rechecked

NOTE The limits for each of the relevant test in Annexes A and B specify the applicable frequency range for each type of modulation.

6.19.1.1 Ship and Land Service Use

a) 20 Hz – 50 kHz CW

b) 50 kHz – 1 GHz

- i) CW
- ii) AM >90% square wave or 80% sine at a frequency in the range 100 Hz – 10 kHz.
- iii) AM 100% square at 1 Hz.

c) 200 MHz – 18 GHz Pulsed CW, pulse length 1 μs, pulse repetition frequency 1 kHz (DRS02 only)

NOTE 1 In the 50 kHz -1 GHz range (ii) and (iii) may be applied simultaneously as shown in **Figure 5**.

NOTE 2 The selection of either >90% square wave modulation or 80% sine should be considered with respect to the equipment or system under test. Generally, >90% square wave modulation should be applied to equipment with a predominately digital architecture e.g. computers, whereas 80% sine should be applied to systems with a predominantly analogue architecture e.g. radio systems. The modulation frequency should be selected in cases where particular frequencies of interest, between 100 Hz and 10 kHz, exist within the equipment or system to be tested. If no frequencies of particular interest exist, then a modulation frequency of 1 kHz shall be used by default

6.19.1.2 Air Service Use

a) 20 Hz – 50 kHz CW

b) 50 kHz – 400 MHz

- i) CW.
- ii) AM >90% square wave at 1 kHz prf.

iii) 300 Hz to 3 kHz square wave amplitude modulation of depth >90% with a superimposed 1 Hz square wave modulation of at least 90% depth. The frequency is linearly swept from 300 Hz to 3 kHz during the on period of the 1 Hz square wave and reset in the off period. Ensure that sweeping and/or frequency stepping is suspended during the «off» period of the 1 Hz modulation.

c) 150 MHz – 225 MHz and 400 MHz – 18 GHz

i) 1 kHz pulse modulation. The pulse width shall be 20 µS. This signal should in addition be switched on and off at a rate of 1 Hz to simulate the effect of rotational radar.

ii) 1 kHz square wave amplitude modulation of at least 90% depth.

iii) CW.

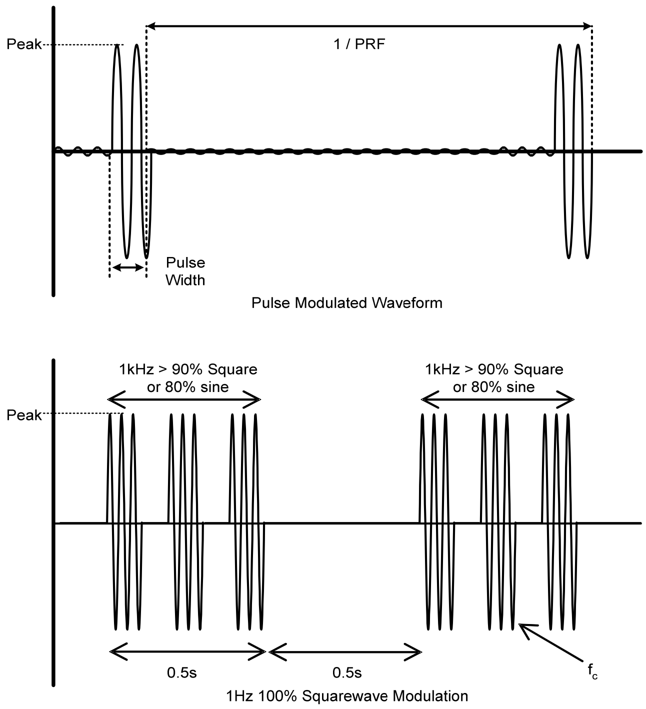

Figure 5 Amplitude Measurements for Susceptibility Testing

6.19.2 Frequency Sweep Rates

In susceptibility testing the entire frequency range for each applicable test shall be swept, while the EUT is exercised in each of its appropriate operating modes.

The frequency sweep rates shall not exceed those values listed in **Table 3**.

Analogue sweeps refer to signal generators, which are continuously tuned. Stepped sweeps refer to signal generators, which are sequentially tuned to discrete frequencies. Stepped sweeps shall dwell at each tuned frequency consistent with the EUT cycle time (polling time) and equipment reporting time. This shall be specified in the Test Plan. A minimum of 100 steps per decade shall be used.

For Safety Critical Systems there is a need to check for 'window effects'

"Window Effects" is the name given to a susceptibility that has been observed during immunity testing of some systems which occurs at a certain test level but then apparently disappears at a higher level. An example of this is a system which utilizes a solid state switch and the upset is defined as inadvertent operation of the switch. As the level of applied RF is increased, a threshold level is reached where the controlling circuitry changes state, thus operating the switch. At higher levels, the controlling circuitry is saturated, thus no longer changing the state of the switch. If in this case the test level was just applied at the higher level then the susceptibility would not have been found. Safety critical and safety related equipment shall be reviewed for circuits having a safety function which may exhibit “window effects” to determine the necessity to conduct window effect tests. Where identified, the requirement to perform "window effects testing" shall be included within the relevant susceptibility test procedures of the Test Plan.

The review shall address both CW and transient conditions. "Window effects" may be observed in equipment containing non-linear transient protection devices.

To check for "window effects" the signal source should be programmed to reduce its output by 20 dB at a minimum of 5 frequencies per decade, logarithmically spaced. At these frequencies, the output is then increased in 5 dB steps to the pass/fail level. If it is intended to sweep across the frequency band at the test level, to reduce test time it should be demonstrated that "window effects" are not applicable to the system under test.

Table 3 Frequency Sweep Rates

Sweep Frequency Range	Frequency Span	Max Sweep Rate	Sweep Time (minutes)
20 Hz 100 Hz	80 Hz	0.6 Hz/s	2.25
100 Hz 1 kHz	900 Hz	2.0 Hz/s	7.5
1 kHz 10 kHz	9 kHz	20 Hz/s	7.5
10 kHz 100 kHz	90 kHz	200 Hz/s	7.5
100 kHz 1 MHz	900 kHz	2 kHz/s	7.5
1 MHz 30 MHz	29 MHz	30 kHz/s	16.2
30 MHz 100 MHz	70 MHz	150 kHz/s	7.8
100 MHz 1 GHz	900 MHz	500 kH/s	30.0
1 GHz 18 GHz	17 GHz	5 MHz/s	57.0

6.20 Operating Frequency of Equipment Under Test

When testing communications equipment the measurements shall be performed with the EUT tuned according to the following rules:

Where the EUT has only one tuneable band (without band switching) or a single range of fixed channels, tests shall be performed with the EUT tuned to frequencies or channels not more than 5 % removed from the lower and upper tuneable frequency limits.

If these selected frequencies are of a ratio greater than 2:1, tests shall also be performed with the EUT tuned to the centre frequency of the tuneable band or range.

For the EUT with multiple tuning bands or ranges of fixed channels, tests shall be performed with the EUT tuned to frequencies 5 % from the extremes of each band or range. Where this would involve more than six tests, the tests shall be performed with the EUT tuned to the centre frequency of each band or range only.

6.21 Current Probes

6.21.1 Emission Testing

The current probes used for the tests described in this Standard must have adequate sensitivity i.e. transfer impedance and also must be capable of carrying the rated DC or power frequency current without saturation. The probe winding shall be electro-statically screened and isolated from the ground. All current probes are required to be calibrated to methods traceable to national standards.

6.21.2 Susceptibility Testing (RF)

The injection probes used for the tests described in this Standard must comply with the appropriate requirements for each test method as defined in **Annex C**, **Table 29**. During the high level RF injection tests, prolonged excitation will cause a significant temperature rise of the probe and due care must be exercised to avoid damage to the cable under test as well as the probe itself.

NOTE The probe should be positioned with cable at the centre and should not be in physical contact with the cable under test, the max induced current should limit the cable getting too hot.

6.21.3 Susceptibility Testing (Transients)

Reference should be made to **Annex C**, **Table 29** to identify the performance requirements of injection probes to be used for specific tests.

NOTE Applicable to **Clauses 6.21.2** and **6.21.3**. When calibrating for high level Bulk Current Injection (BCI) and also while conducting the test, the linearity of the probe must be checked. I.e. if the input power is increased by 3 dB then the output power should be increased by 3dB

6.21.4 Test Jigs

The injection probes referred to in **Clauses 6.21.2** and **6.21.3** are intended for use with particular test jigs, when validating the performance required of certain generators used for susceptibility testing. Test jig performance requirements are specified in **Annex C Clause C.4.3**.

6.22 Antennas

The types of antennas and field strength probes used for measurement of radiated emissions and for radiated susceptibility testing are specified below for each test application. Except for the CNR whip antennas, all antennas and field strength probes are required to be calibrated to methods traceable to national standards.

Receive antennas shall have nominal impedance of 50 Ω. The antenna element shall not be closer than 0.3 m to any part of the absorbing material.

Antennas for E-Field measurements are situated at a stipulated separation distance of 1 metre from the closest surface of the EUT (apart from the 2.4 m whip used in DRE03.A) to the antenna depending on the antenna type. For the 41" rod and the CNR whip antennas it will be the centre of the rod or whip element, for Biconical antennas it will be the centre line of the elements, for Log Periodic Antennas it will be the tip of the Antenna and for Double Ridge Guide and Horn antenna it will be the front face.

The closest point on the EUT does not include any cables that are unavoidably closer to the Antenna for a short distance prior to being established at their specified position in the test set-up. If due to the design of the EUT and the cable connections a significant problem is experienced with these cables consideration should be given to repositioning the EUT. This should be discussed and accommodated in the Test Plan.

6.22.1 Antenna Calibration

a) Magnetic Field Search Coils: These shall be calibrated using a TEM cell or other alternative methods.

b) 41 inch Rod Antenna: These shall be calibrated using the methods specified in the current issue of CISPR 16-1-4, Annex B.

c) CNR Whip Antennas: These do not require calibration but the tuner units and antenna bases used with these antennas require checks to confirm their performance meets their operating specifications for bandwidth and sensitivity over the frequency band.

d) Biconical Antennas: These are to be calibrated for their “free space” antenna factors.

e) Double Ridged Guide and Horn Antennas: These shall be calibrated using the ARP 958 method or the NPL 3 antenna method for 1 metre separation. As described in A National Measurement Good Practice Guide No 73.

f) Log Periodic Dipole Antennas (LPDA): These are to be calibrated for their “free space” antenna factors (AFfs), corrected for use with a separation of 1 m between the EUT and the tip of the antenna. The required corrections will vary according to the physical size and frequency coverage of the particular antenna. When the antenna is calibrated it is necessary to request that the AFfs is corrected to give the field strength at the tip of the antenna. If the correction has not been provided on the antenna calibration certificate then a correction needs to be made. This is explained in **Annex C Clause C.10**.

g) Field Strength Probes: These shall be calibrated using combinations of TEM cells and anechoic chambers.

6.22.2 Emission Testing Nominal Frequency Range 20 Hz – 250 kHz H Field Radiation

A calibrated search coil shall be used, having 36 turns wound on a circular section former of diameter 133 mm. The coil shall be bunch or layer wound, with the winding cross section dimensions not exceeding 5 mm, using stranded wire comprising 7 strands of insulated wire, each of approximately 0.11 mm diameter. The coil shall be electro-statically screened and terminated on a co-axial connector with the screen connected to the screen of the connector. For location and orientation of the coil see **Figure 6**.

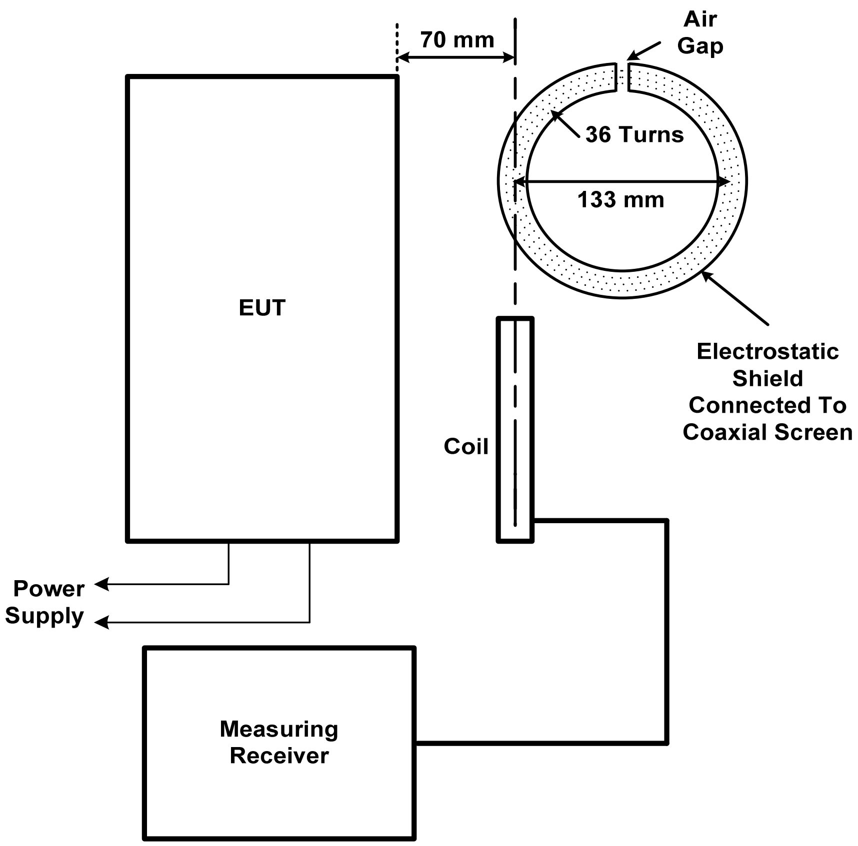

Figure 6 Coil Arrangement for Magnetic Emissions (20 Hz - 250 kHz) Test DRE02

6.22.3 Emission Testing Nominal Frequency Range 14 kHz – 30 MHz, E Field Radiation

An active 41” vertical rod antenna or a 41” vertical rod antenna with a passive matching-unit may be used. This monopole antenna shall be used with an earth plane or counterpoise not less than 600 mm square for screened room use bonded to the ground conducting bench. For antenna separation from the nearest face of the EUT, For LRU’s and Sub Systems see **Annex B, Figure 86**.

NOTE Great care should be exercised when using an active rod antenna to damp out resonances which may cause overload. See **Clause 6.30**.

6.22.4 Emission Testing Frequency Range 1.6 MHz – 30 MHz Tuned Antenna (Land Service)

A HF CNR whip antenna in conjunction with a HF antenna base and AAMTU (The specific antenna is a 2.4 m Clansman whip antenna in conjunction with a HF antenna base and AAMTU). See **Annex A Figures 30** and **31** for further details on Man Worn, Man Portable equipment and **Annex B**, **Figures 97** and **98** for LRU’s and Sub Systems.

NOTE Manual measurement techniques can be used only for indication purposes and are deemed non-compliant with the requirements of this specification.

6.22.5 Emission Testing Frequency Range 30 MHz – 88 MHz Tuned Antenna (Land Service)

A VHF CNR whip antenna in conjunction with a VHF antenna base. See **Annex A Figures 32** and **33** for further details on Man Worn, Man Portable equipment. The specific antenna of use is the 4000-900 VHF End Fed as detailed:-

VHF Whip Upper Part No 4000-107-01 NSN 5985-99-225-8192

VHF Whip Lower Part No 4000-108-01 NSN 5985-99-968-3485

Base Assembly Part No 4000-104-01 NSN 5985-99-359-4394

6.22.6 Emission Testing Nominal Frequency Range 25 MHz – 300 MHz E Field Radiation

A bi-conical antenna shall be used with a balun or matching unit. For Antenna position see **Annex A Figures 20** and **21** for Man Worn, Man Portable Equipment and **Annex B Figure 89** for LRU’s and Sub Systems. The antenna will be placed alternatively in the horizontal and vertical plane.

6.22.7 Emission Testing Nominal Frequency Range 200 MHz – 1 GHz E Field Radiation

Log-periodic or Double Ridged Wave Guide antennas shall be used. For Antenna position see **Annex A Figures 22** and **23** for Man Worn, Man Portable Equipment and **Annex B Figure 90** for LRU’s and Sub Systems. The antenna shall be orientated alternatively horizontal and vertical.

6.22.8 Emission Testing Nominal Frequency Range 1 GHz – 18 GHz E Field Radiation

Waveguide or double ridged wave guide horns shall be used. For Antenna position see **Annex A Figures 24** and **25** for Man Worn Man, Portable Equipment and **Annex B Figure 91** for LRU’s and Sub Systems. The antenna shall be placed alternately in the horizontal and vertical plane.

6.22.9 Susceptibility Testing, Nominal Frequency Range 20 Hz – 150 kHz H Field Radiation

A test coil shall be used, having between 10 and 20 turns wound on a circular section former of diameter 120 mm. The coil shall be single layer wound to a winding length between 14 mm and 28 mm, using enamelled solid copper wire of 1.35 mm diameter.

The coil former shall incorporate a non-metallic spacer to permit accurate separation of the coil from the faces of the EUT. The separation from the centre of the coil to the nearest face of the EUT shall be 50 mm. Determination of the current necessary in this coil, to produce the specified field, shall be made by using the calibrated emission search coil defined at **Clause 6.22.2**. With the two coils arranged co-axially and spaced

50 mm between their centres, the current in the susceptibility test coil, required to produce the specified field in the calibrated emission search coil, shall be recorded and then used as the test limit.

6.22.10 Susceptibility Testing, Nominal Frequency Range 14 kHz – 30 MHz E Field Radiation

A parallel plate or long wire transmission line shall be used over this frequency range. Alternative antennas are however permitted, particularly for the testing of large equipment or extended systems. If alternative antennas are used, it shall be demonstrated that the prescribed field strengths are achieved by the strategic placement of field sensors. Details of the antenna used shall be included in the Test Report. In both cases their respective characteristic impedance must terminate the transmission lines. Because errors may occur due to standing wave, voltage monitoring difficulties and variations due to the EUT it is required that a small sensor adjacent to the EUT (vertical polarisation only) shall monitor the field strength. Care should be taken that the sensor accuracy is not affected by the close proximity of the EUT and a separation of 0.15 m between them should be maintained while keeping both within the main body of the field being generated.

An example arrangement of the parallel plate line is shown in **Figure 7** and of the long wire antenna in **Figure 8**. Distortion of the field within the transmission line must be minimised by restricting the dimensions of the EUT to 0.4 times the height, 0.7 times the length and 0.6 times the width of the transmission line. A typical design of parallel plate can be found in ISO 11452-5.

6.22.11 Susceptibility Testing, Nominal Frequency Range, 30 MHz – 18 GHz, E Field Radiation

A number of radiating antennas may be used within this frequency range, e.g. a wide band short un-terminated transmission line, bi-conical, dipole, log-periodic and double ridged wave guide horn. However the choice of antenna will depend upon the field strength required and it must be capable of handling the power for the highest field strength requirements. The position of the antenna shall not be closer to the EUT than 1 metre. The antennas shall be polarised alternately in the horizontal and vertical plane. See **Annex A Clause A.8** and **Annex B Clauses B.18** and **B.19** (which is an alternative test method using a reverberation chamber).

6.22.12 Field Strength Monitoring

During radiated susceptibility testing the field strength shall be monitored at the EUT. Ideally the field sensor should be placed close to the most susceptible part of the EUT; however, in most cases the location cannot be established with certainty. One method, which can be used to locate and identify areas of low immunity on the EUT, is to energise a small sensor which is then passed over the EUT. The sensor shall be energised by signals at frequencies selected as being likely to cause disturbance to the EUT. This procedure is limited in that the areas of low immunity may vary considerably with frequency and it would be difficult to make an exhaustive survey. However, at low radio frequencies, transfer of interfering signals is likely to be dominated by cable coupling. At higher frequencies and in the microwave region, conduction via cables is very poor so that interfering signals are only likely to impinge on internal circuit boards via discontinuities in the screening of equipment cases, i.e. numerical displays, CRT screens, meters, waterproof gaskets or terminal housings etc. In general, placing the field monitor near the equipment case close to the known discontinuities in the screening or near to cable entries will be closest to the area of maximum susceptibility. Care should be taken that the sensor accuracy is not affected by the close proximity of the EUT and a separation of 0.15 m between them should be maintained while keeping both within the main body of the field being generated. The height of the sensor should be typically 0.3 m above the ground conducting bench.

The field monitoring equipment should have a dimensionally small sensor and ideally be self-contained using a fibre optic link to allow remote monitoring of the field strength away from the EUT. When modulated fields are being measured some sensor characteristics will require correction factors in order that the peak field strength can be obtained.

NOTE Care should be taken when using broadband field probes that the indicated field strength pertains to the indicated frequencies rather than any harmonic or resonance caused by the equipment set up.

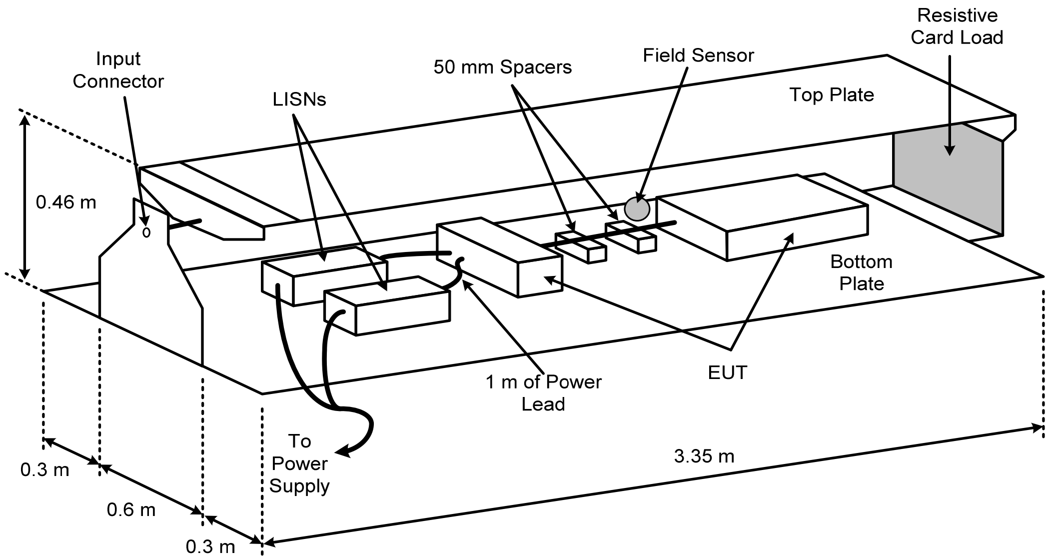

Figure 7 Example of a Parallel Plate Line for Susceptibility Testing

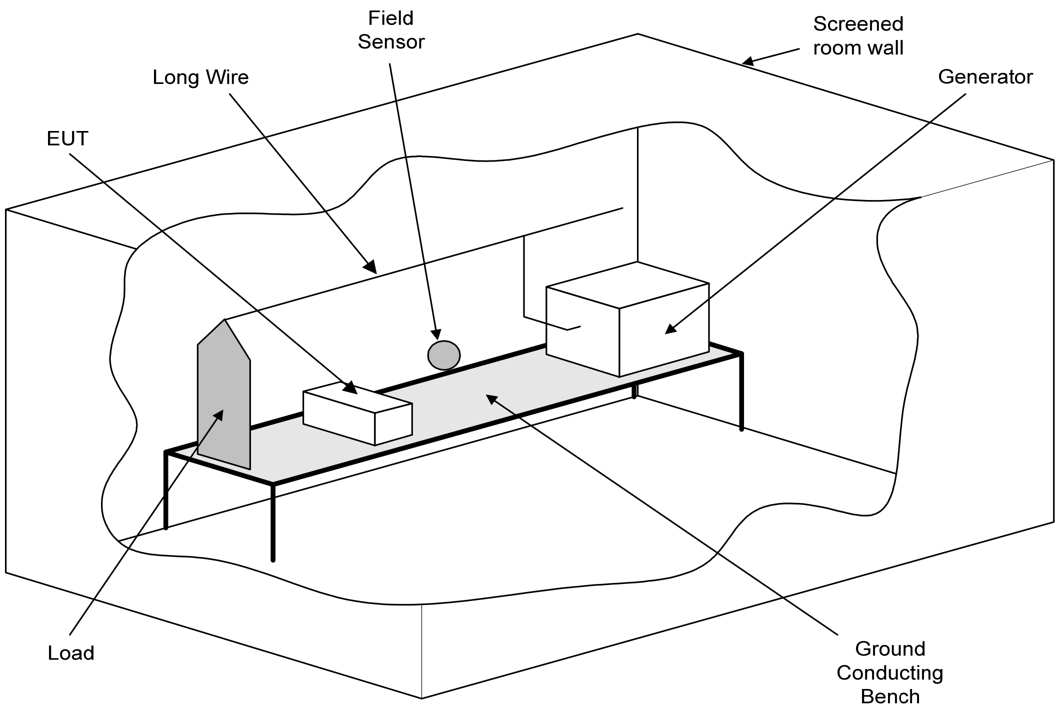

Figure 8 Example of a Long Wire Antenna Arrangement for Susceptibility Testing

6.23 Measuring Sets

The nominal input impedance of the measuring sets used in this Standard shall be 50 Ω. The bandwidth/detector function requirements are detailed in **Clause 6.15**.

Fast Fourier Transform equipment can be used for Land and Ship System tests only over the frequency range 20 Hz - 100 kHz provided that it is fitted with signal overload indication.

The use of spectrum analysers at frequencies below 1 GHz is restricted to susceptibility testing due to overload problems which may arise from the lack of front end pre-selection. If adequate front-end tracking pre-selection can be provided use for emission testing is permitted providing it has adequate sensitivity, subject to the agreement of the MOD Project Manager.

The measuring set shall have the means to provide the necessary outputs such that an X-Y plot can be obtained for inclusion in the Test Report.

6.24 Measuring Cables

The coaxial measuring cables should be of the double-screened high quality type to minimise errors due to loop currents. The cables shall be calibrated and their loss characteristics used in correcting the results.

6.25 Oscilloscope

The oscilloscope used for tests described in this Part of the Standard shall have the capability to record either by storage, by camera or by print out and where necessary, have dual inputs for differential measurements of line-to-line potential.

The oscilloscope bandwidths, and sampling rates where appropriate, shall be at least twice the bandwidth of the signal being measured to achieve the required accuracy.

These parameters are usually measured via a probe whose output is delivered to an oscilloscope, possibly through a high impedance probe or via a 50 Ω line to a 50 Ω oscilloscope input. The probes shall be calibrated and have adequate bandwidth (see above) so that the signal parameters indicated by the oscilloscope output can be corrected to yield results of adequate accuracy.

The oscilloscope probe should be compensated and have their calibration verified using a calibration source. Where differential probes are used these should be adjusted to minimise their common mode rejection ratio and calibration verified.

6.26 Signal Sources/Power Amplifiers

The signal source used for susceptibility testing must be capable of modulation as described in **Clause 6.19**. A series switch between the signal generator and the power amplifier can achieve the low frequency square wave modulation.

The harmonic content of the signal source/power amplifier can cause erroneous results and care should be taken to minimise harmonics. Individual harmonics must be >15 dB below the fundamental. Where particular difficulty is experienced, band-pass and/or low pass filters may have to be used in the power amplifier output.

6.27 Transient Generators

The performance requirements for the various transient generators needed to execute these tests are specified in **Annex C Clause C.2**.

6.28 Injection Transformers

The low frequency transformer used in test method DCS01 (**Annex B Clause B.4**) shall be capable of carrying the power line current and injected interference signal without saturation. The output impedance of the transformer shall be less than or equal to 0.5 Ω when coupled to the amplifier, which supplies the power.

6.29 Presentation of Results

This Clause deals briefly with the way electrical quantities are described in this Standard and the manner in which, they should be reported. The following comments are particularly relevant to the use of logarithmic units and are intended only for those unfamiliar with them.

Electrical quantities are usually specified by a number followed by a symbol representing the unit in which the quantity is measured e.g. a current of one ampere will be designated by "1 A". Multiples or sub-multiples of the unit are often used for convenience so the same current might be reported as "1000 mA".

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Many of the tests in this Standard require the measurement of quantities varying over a wide range of values and some limits are quoted in logarithmic or dB units. Specifically for the quantities voltage, current and field strength (both electric and magnetic) the relationship between the number, n, of logarithmic units corresponding to N basic units is given by: -

$$n = 20*\log_{10}N$$

$$\text{and} \qquad N = 10^{(n/20)}$$

To express a quantity in logarithmic units write "ndBX" where X is the symbol for the unit measured and takes account of whether a multiple or sub-multiple is used. **Table 4** gives examples of the relationship between basic and logarithmic units and their reporting styles.

Table 4 Examples of Basic and Logarithmic Unit Relationships

Quantity	Basic Unit Symbol	Example number of units (N)	Equivalent logarithmic description
Current	A mA	1 1000	0 dBA 60 dBmA
Voltage	V µV	1 1000000	0 dBV 120 dBµV
Electric Field	V/m µV/m	100 100000000	40 dBV/m 160 dBµV/m
Magnetic Field	pT	100000	100 dBpT

Magnetic fields should properly be expressed in A/m. However it is common practice at low frequencies to express the field in terms of the equivalent flux density, Tesla, in air. This practice is followed in the present Standard.

6.30 Overload Precautions

Measurement receivers and transducers are subject to overload, especially receivers without pre-selectors and active transducers. Periodic checks shall be performed to assure that an overload condition does not exist. Instrumentation changes shall be implemented to correct any overload condition.

Overloads can easily go unnoticed if there is not an awareness of the possibility of an overload or active monitoring for the condition. The usual result is a levelling of the output indication of the receiver.

Two types of overloads are possible. A narrowband signal such as a sinusoid can saturate any receiver or active transducer. Typical procedures for selecting attenuation settings for measurement receivers place detected voltages corresponding to emission limits well within the dynamic range of the receiver. Saturation problems for narrowband type signals will normally only appear for a properly configured receiver if emissions are significantly above the limits. Saturation can occur more readily when receivers are used to monitor susceptibility signals due to the larger voltages involved.

Overload from impulsive type signals with broad frequency content can be much more deceptive. This condition is most likely to occur with devices without a tuneable bandpass feature in the first stage of the signal input. Examples are pre-amplified rod antennas and spectrum analyzers without pre-selectors. The input circuitry is exposed to energy over a large portion of the frequency spectrum. Pre-selectors include a tuneable tracking filter which bandwidth limits the energy applied to the receiver front end circuitry.

6.30.1 Measurement Receivers

Measurement receiver overload to both narrowband and impulsive type signals can be evaluated by applying an additional 10dB of attenuation in the first stage of the receiver (before mixer circuitry) or external to the receiver. If overload is not present, the observed output will uniformly decrease by 10 dB.

6.30.2 Active Antennas

Overload conditions for active antennas are normally published as part of the literature supplied with the antenna. For narrowband signals, the indicated level in the data can be reviewed with respect to the literature to evaluate overload. Levels are also published for impulsive type signals; however, these levels are not very useful since they usually assume that a flat field exists across the useable range of the antenna. In reality, the impulsive field will vary significantly with frequency and the antenna circuitry sees the integration of the spectral content of this field over its bandpass. The primary active antenna used is an active rod antenna. Overload can be evaluated by collapsing the rod and observing the change in indication. If overload is not present, the indicated level should drop approximately 8 dB (rod at 30% of its original height). The actual change for any particular manufacturer's product will depend on the telescoping design and can be determined by radiating a signal to the antenna that is within its linear range.

6.31 RF Safety of Personnel

The performance of the susceptibility test described in this Standard involves the use of RF power covering a wide frequency range. In principle the preferred arrangement for susceptibility tests is that the operator should be outside the screened room in which the test is in progress and that monitoring and control should be done on a remote basis through filtered cables or fibre optic links. Although it is considered unlikely that hazards to personnel will arise, it is recognised that remote operation is not always possible and that guidance should be provided as to the field strength or power density levels which are regarded as non-hazardous.

The UK authority on matters of personnel safety is the Health and Safety Executive who take guidance from the Health Protection Agency – Radiation Protection Division.

NOTE Reference can also be made to JSP 375 Leaflet 22.

7 Classification of Equipment and Limits

7.1 Introduction

Classification of equipment and the introduction of different classes or grades of limits are essential if economic suppression measures are to be achieved. Extensive suppression and/or screening, essential when the source of disturbance is closely coupled to sensitive receiving equipment, would not be cost effective if it were required to be applied to all installed equipment. Thus limits must be graded and tailored on the basis of probable coupling, for example, between receiving antennas and the location of the source of disturbance. An equipment classification will determine the applicability of the test procedures.

Communications antennas are necessarily mounted outside the structure of the platform on which they are carried, while most of the associated equipment will be installed internally. Although the equipment-to-antenna coupling will vary greatly between installations there is often a common metallic boundary in ships, vehicles and aircraft, (e.g. the hull or fuselage) which can provide significant screening. Special consideration must be given when the screening effect may be reduced temporarily for operational reasons (such as opening a hatch, window or door), where the structure is largely non metallic or where equipment are mounted external to the structure.

Furthermore, the type of equipment will determine the range of tests required. Motors, relays, heating equipment etc are unlikely to be disturbed by RF signals or noise and hence may not be subject to requirements for susceptibility.

The range of tests may be broadly subdivided into two groups for the control of emissions and susceptibility. All equipment should be subject to emission testing but only equipment incorporating electronics should be subject to susceptibility tests.

At low frequencies there are no intentional transmitting and receiving antennas but circuits and wiring can behave as both source and receiver. The spacing of such circuits is relatively small within hull or fuselage and hence a single grade of limits may be appropriate.

7.2 Equipment Types

Equipment under test may be divided into three types: -

Type 1 Equipment Containing Electronic Components

Type 2 Motors, Generators and Electromechanical Units (excluding items under Type 3).

These types of equipment are generally non-susceptible to EMI therefore only conducted and radiated emissions and exported and imported transient test methods need to be considered. If electronic control forms part of the EUT however it shall be considered as Type 1 equipment.

Type 3 Relays, Solenoids and Transformers.

These types of equipment are generally immune to most forms of EMI and do not cause continuous interference hence only imported and exported transient tests apply. It is advisable however that Type 3 equipment fed with ac power be also subjected to the low frequency magnetic field test DRE02 (at power frequency only) to determine whether a minimum separation distance needs to be enforced.

7.3 Test Method Selection

Table 5 shows the general applicability of test methods to the three types of equipment just defined.

Table 5 Applicability of Test Methods to Equipment Type

Applicability	Type 1	Type 2	Type 3
All Test Methods	Yes	No	No
All Emission and Imported Transient Test Methods	No	Yes	No[a]
Imported and Exported Transient Test Methods only	No	No	Yes

[a] If the Type 3 EUT is fed with AC power then the test method DRE02.B (**Annex B**, **Clause B.15**) is required and the measurements are restricted to those at the power frequency only.

Small self-contained and self-powered units or systems will normally require only radiated emission and radiated susceptibility tests. E.g. Man Worn Man Portable, only equipment which may be connected to host equipment by conductive cable need be subjected to conducted emission or susceptibility tests.

Should the Project Manager find difficulty in specifying the appropriate range of test methods for any equipment, specialist advice should be sought.

Further guidance on the selection of tests is given in **Part 1 Clause 13** of this Standard.

7.4 Grading of Limits

7.4.1 Air Service Use

Generally there is only one grade for most tests although tests DCS02.B, DCS09.B and DCS10.B categorise EUT's depending on safety and mission critical considerations and the degree of environmental protection.

7.4.2 Sea Service Use

Two grades are required for ship use, 'Below decks' and 'Above decks'.

'Below deck' limits apply to equipment fitted in areas on the vessel which are surrounded by a closed metallic structure, or an area which provides significant attenuation to electromagnetic radiation, such as the specialised screened rooms described in **Annex C** of this Standard.

'Above deck' limits apply to equipment fitted in all other areas which are not considered ‘below deck’ as defined above. This includes areas on the exposed upper-deck, compartments in non-metallic ships (except in specialised screened rooms), bridge and hangar areas and the space between the pressure hull and the outer casing of a submarine.

For land based sea services the limits shown in **Table 6** should be used

Table 6 Land Based Sea Service Limits

Test Ref	Test Description	Limit
DCE01.B	Conducted Emission on Primary Power Lines	Def Stan 59-411 Sea Service Below Decks 500 Hz to 100 MHz
DCE02.B	Conducted Emission on Control, Signal and Secondary Power Lines	Def Stan 59-411 Sea Service Below Decks 500 Hz to 100 MHz
DCE03.B	Exported Transients, Power Lines	Land Service Limit for 240 V AC single phase equipment or for 415 V 3 phase AC equipment. Ship use limit for 115 V single phase AC equipment
DCS01.B	Conducted Susceptibility, Primary Power Lines	Def Stan 59-411 20 Hz to 50 kHz
DCS02.B	Conducted Susceptibility, Power, Control & Signal Lines	Def Stan 59-411 Sea Service Below Decks 50 kHz to 400 MHz
DCS03.B	Conducted Susceptibility, Control & Signal Lines	Optional for EUT with low LF or audio systems. Def Stan 59-411 20 Hz to 50 kHz
DCS05.B	Externally Generated Transients (Land & Sea Systems) (*Local switching and NEMP onto power, signal & control lines)*	Land & Sea systems switching simulation NEMP not applicable
DCS06.B	Imported Long Transient Susceptibility (Land & Sea systems) (*Group switching power lines*)	Land Service 240 V AC supply or 415 V AC supply Ship use limit for 115 V single phase AC equipment
DCS10.B	Electrostatic Discharge (ESD)	DCS10 or BS EN 61000-4-2, 4 kV (contact) 8 kV (air)
DRE01.B	Radiated Emissions, E-Field	Modified Def Stan 59-411 Sea Service Below Decks 14 kHz to 1 GHz 14 kHz to 50 MHz, 80.5 to 44 dBμV/m 50 MHz to 1 GHz, 44 to 77 dBμV/m
DRE02.B	Radiated Emission H Field	Optional for EUT in a magnetically sensitive environment Def Stan 59-411 20 Hz to 100 kHz
DRS01.B	Radiated Susceptibility H Field	Optional for EUT with magnetic components Def Stan 59-411 Sea Service 20 Hz to 100 kHz
DRS02.B	Radiated Susceptibility E Field	For sites with transmitters derived environment levels apply, otherwise for sites without transmitters use Def Stan 59-411 Sea Service Below Decks 150 kHz to 10 GHz

7.4.3 Land Service Use

The land services presently employ a system of segregation of logistic and communications equipment with a differential system of EMC limits. The following classification has been rationalised from the existing Land Service requirements. The separation distances designated for equipment include the equipment and its associated cables.

7.5 Land Service Classifications

Land service equipment is classified according to its potential to suffer electromagnetic interference from nearby transmitters of RF energy or to cause interference to nearby receivers. Classification depends on the intended proximity of the equipment to the nearest antenna. Minimum separation likely from such antennas can normally be established from the "EMC scenario" as defined in the User Requirements Document (URD) prepared by the Director Equipment Capability (DEC) or other equipment sponsor for new equipment.

NOTE Different class limits may apply in different frequency bands.

7.5.1 Class A limits

These are the most stringent limits applying to equipment which must operate at a distance of less than 2 m from the nearest RF antenna and where there is no scope for increasing that separation. Equipment internal to a well screened structure however (e.g. metal hulled vehicle) can use Class B limits noting the caveat at **Clause 7.1** that special consideration must be given when the screening effect may be reduced temporarily for operational reasons (such as opening a hatch, window or door). This relaxation should only be considered when either the metal hull is always closed or when the risk to installed antenna performance is considered minimal (i.e. physical separation of the open hatch and installed antenna).

Types of equipment which, are automatically subject to the Class A limits include:

a) Man Worn Man / Portable Equipment.

b) Equipment installed on the exterior of any vehicle, which bears an RF antenna.

c) Equipment which itself bears an RF antenna - except that such equipment is exempt from this Standard for tests associated with the intentional transmission and/or reception of RF energy by that antenna.

7.5.2 Class B limits

Applicable to equipment which, is to operate at a separation, distances between 2 m and 15 m of the nearest RF antenna. This Class includes equipment, which may be sited closer to such an antenna but is simple to move away e.g. a vehicle, which is not itself equipped with radio but is likely to be sited next to another, which is so equipped.

7.5.3 Class C limits

Applicable to equipment which, is to operate at a separation, distances between 15 m and 100 m of the nearest RF antenna.

7.5.4 Class D limits

Applicable to equipment which, is to operate only at separation, distances exceeding 100 m from the nearest RF antenna. This classification includes commercial equipment, which is intended for use only in non-critical areas. When such equipment complies with current statutory EMC requirements (e.g. the EMC Directive) it may, at the discretion of the Project Manager, be exempted from testing.

7.5.5 Differential Classifications

The frequency range of interest in a particular EMC scenario is likely to be covered by several RF antennas in different frequency bands, at different separations. The use of separate antennas for the purposes of transmission and reception is not uncommon. In these circumstances the Project Manager may decide to introduce a differential classification for different frequency bands and/or conditions of use.

For example, an EUT which is deployed within 2 m of a transmitting antenna but over 100 m from the nearest receiving antenna might be defined as Class A for radiated susceptibility but Class D for radiated and conducted emission tests.

Alternatively, consider an EUT which, is installed within 2 m of a VHF antenna but 20 m from the nearest HF antenna. The EUT might be defined as Class A at VHF, Class C at HF and Class D at all other frequencies.

Further guidance on the selection of limits is given in **Part 1 Clause 14** of this Standard.

8 Applicability Requirements

This section specifies and details the test applicability requirements. **Tables 7** and **8** list the test reference, test description, service applicability and the Annexes in which the test method is detailed. All results of tests performed to demonstrate compliance with the requirements are to be documented in the Test Report.

The applicability of individual requirements in **Tables 7** and **8** for a particular equipment or subsystem is dependent upon where the item will be used. The electromagnetic environments present together with potential degradation modes of electronic equipment items play a major role regarding which requirements are critical to an application. For example, emissions requirements are tied to protecting antenna-connected receivers on platforms. The operating frequency ranges and sensitivities of the particular receivers on-board a platform therefore, influence the need for certain requirements.

The Control Plan, Test Plan and Test Report are important elements in documenting design efforts for meeting the requirements of this standard. These documents also determine the approach to testing, interpret the generalised test procedures in this Standard and report on the test results obtained. The Control Plan is a mechanism instituted to help ensure that contractors analyse equipment design for EMI implications and include necessary measures in the design for compliance with requirements. Approval of the document does not indicate that the procuring activity agrees that all the necessary effort is stated in the document. It is simply recognition that the design effort is addressing the correct issues.

Table 7 Man Worn / Man Portable Equipment Test Methods

Test Ref	Test Description	Service Applicability	Annex A
DCE02.A	Conducted Emissions, Control, Signal and Power Lines 500 Hz – 150 MHz	Land	A1
DCS02.A	Conducted Susceptibility, Control and Signal lines 50 kHz – 400 MHz	Land	A2
DCS10.A	Electrostatic Discharge (ESD)	Land	A3
DRE01.A	Radiated Emissions E Field 88 MHz – 18 GHz.	Land	A4
DRE02.A	Radiation Emissions H Field 500 Hz – 250 kHz	Land	A5
DRE03.A	Radiated Emissions E Field Tuned Antenna 1.6 MHz – 88 MHz	Land	A6
DRS01.A	Radiated Susceptibility H Field 500 Hz – 50 kHz	Land	A7
DRS02.A	Radiated Susceptibility E Field 50 kHz – 18 GHz	Land	A8

Table 8 EUT and Sub System Test Methods

Test Ref	Test Description	Service Applicability	Annex B
DCE01.B	Conducted Emissions, Primary Power Lines 20 Hz – 150 MHz	Air Land Sea	B1
DCE02.B	Conducted Susceptibility, Control and Signal and Secondary Power lines 20 Hz – 150 MHz	Air Land Sea	B2
DCE03.B	Exported Transients, Primary Power Lines	Air Land Sea	B3
DCS01.B	Conducted Susceptibility, Primary Power Lines, 20 Hz - 50 kHz	Air Land Sea	B4
DCS02.B	Conducted Susceptibility, Control, Signal and Power Lines, 50 kHz - 400 MHz	Air Land Sea	B5
DCS03.B	Conducted Susceptibility, Control and Signal Lines, 20 Hz - 50 kHz	Air Land Sea	B6
DCS04.B	Imported Transient Susceptibility (Air Services)	Air	B7
DCS05.B	Externally Generated Transients (Land and Sea Services	Land Sea	B8
DCS06.B	Imported Long Transient Susceptibility AC and DC Systems (Land and Sea Services	Land Sea	B9
DCS08.B	Externally Generated Transients (Air Services)	Air	B10
DCS09.B	Imported Lightning Transient Susceptibility (Air Services)	Air	B11
DCS10.B	Electrostatic Discharge (ESD)	Air Land Sea	B12
DCS12.B	Imported Low Frequency Transient Susceptibility Power Lines	Sea	B13
DRE01.B	Radiated Emissions E Field 10 KHz – 18 GHz.	Air Land Sea	B14
DRE02B	Radiation Emissions H Field 20 Hz – 200 kHz	Air Land Sea	B15
DRE03.B	Radiated Emissions E Field Tuned Antenna 1.6 MHz – 30 MHz	Land	B16
DRS01.B	Radiated Susceptibility H Field 20 Hz – 100 kHz	Air Land Sea	B17
DRS02.B	Radiated Susceptibility E Field 10 kHz – 18 GHz	Air Land Sea	B18
	Radiated Susceptibility E Field - Alternative Method	Air	B19
DRS03.B	Magnetic Field (DC) Susceptibility	Land Sea	B29

9 Test Methods and Limits

9.1 Introduction

Individual emission and susceptibility requirements are grouped together in the following clauses and should be read in conjunction with the clause specifying the applicability of the test, the test layout and test methods together with the test limits in the appropriate Annex to this part of the standard. Each clause is intended to be read in conjunction with the general requirements specified in **Clause 6** and **Annex C**, in particular information about LISN, antenna selection, antenna position and modulation, etc. The applicable frequency range and limit of many emission and susceptibility requirements varies depending on the particular platform or installation. The test procedures included in the annexes are valid for the entire frequency range specified in the procedure, however testing only needs to be performed over the frequency range specified for the particular platform or installation.

9.2 DCE01 Conducted Emission, Primary Power Lines 20 Hz – 150 MHz

This requirement is applicable to Primary Power Lines to ensure that the differential mode conducted emissions to the EUT are controlled to appropriate limits in order to provide adequate protection to radio reception and to minimise disturbances to any sensitive electronic equipment.

For AC applications, this requirement is applicable starting at the second harmonic of the EUT power frequency.

Test Procedures: When using current probes care should be taken to make sure the cable under test passes through the centre of the internal aperture so that measurements are more repeatable. When placing current probes on cables minimise the effect of neighbouring cable harnesses by maintaining the maximum separation distances to them

Current probes should be positioned at a point 50 mm from each LISN terminal stud on each power lead tested. Supplies and their returns should be tested separately (common mode) and not as pairs (differential mode).

Ambient measurements are made on power leads prior to EUT testing with the EUT replaced by a resistive load drawing the same steady state current.

The limits are in terms of current because of the difficulty in controlling the power source impedance in test facilities at lower frequencies. This type of control would be necessary to specify the limits in terms of voltage. Emission current levels will be somewhat independent of power source impedance variations as long as the impedance of the emission source is large relative to the power source impedance.

NOTE This test shall be repeated once all transient susceptibility tests have been completed to demonstrate that no damage has occurred to the filter.

9.3 DCE02 Conducted Emission, Control, Signal Lines and Secondary Power Lines 20 Hz – 150 MHz

This requirement is applicable to all signal and control leads and secondary power leads connected to an EUT that are greater than 500 mm in length. Particular attention should be given to leads that are installed in the same conduit, trunking or cable bundles as those of other systems fitted to the same platform where cross coupling can readily occur. Where internal EUT cables interface between different component parts of the EUT only and no part of the installation cabling is closer than 15 cm to external cabling then these may be excluded from this test.

This requirement is performed to control the levels of conducted interference appearing on EUT cabling which could couple to adjacent cabling from other systems installed on the same platform.

Test Procedures: When using current probes care should be taken to make sure that the cable under test passes through the centre of the internal aperture so that measurements are more repeatable. This can most easily be achieved with the use of a non-ferrous former of some kind that holds the cable in place. When placing current probes on cabling minimise the effect of neighbouring cable harnesses on the measurement by maintaining the maximum separation distance to them.

Current probes should be positioned 50 mm from the EUT connector back shell of each signal and control lead being tested. Where signal or control leads are longer than 1 m then testing is required at both ends of the cable at frequencies above 30 MHz.

Ambient measurements on signal and control lines are performed at the same location as the EUT measurement but with the EUT switched off. All EUT exercising equipment must be fully functional and connected in circuit during all ambient measurements, although it is understood that in some circumstances full functionality may not be achievable due to required interaction with the EUT. Care should be taken not to introduce additional interference from exercising equipment and wherever possible this should be of a passive nature or filtered to minimise interference levels.

For the purpose of the test the EUT should be powered and in its normal mode of operation throughout and some means of indication should be present to establish its correct operation.

9.4 DCE03 Exported Transients, Primary Power Lines

Contactor switching transients are generated by switching the EUT on and off using an external supply contactor of the type to be used in its final installation. If the contactor type is not known or unavailable, then an alternative of suitable type and current rating may be used. The alternative shall be supplied by the manufacturer.

Functional switching transients are generated by switching the EUT on and off using the power switch on the EUT, if fitted. Additionally, functional switching transients may be generated by operation of the EUT, i.e. while operating the EUT over its normal operating sequence and exercising the EUT through its full range of functions.

Test Procedures: The purpose of this test is to measure the amplitude and duration of transients appearing on primary power lines caused by the normal operation of the EUT and also as a result of switching on and off the power supply to the EUT. These transient emissions may couple via conduction and radiation from the power lines to other potentially susceptible equipment in the actual installation.

For AC supplies, a twin ‘T’ notch filter may be used to filter the power supply frequency. With the power frequency filtered, any transients shown on the oscilloscope are relative to the AC waveform when measured between the transient's peak and the oscilloscope’s reference level.

The accurate measurement of transient amplitude in conducting this test may sometimes be prejudiced by the high amplitude response at the power supply frequency. **Annex C**, **Clause C.9** describes the design of a twin-T filter, tuned to the supply frequency, which is connected at the oscilloscope input, in tandem with a voltage probe, which attenuates the power supply frequency response by at least 30 dB.

Alternatively, a fast acquisition digital oscilloscope may be used to store the data. Although the power supply frequency is not filtered, measurement of all transient types can be made with reference to the AC waveform. This is achieved by reducing the time base, effectively zooming in on the transient using the data stored within the oscilloscope.

It should be noted that different limits may apply for systems operating at power line frequencies or voltages other than those specified in this section. In these cases the Procuring Authority may adjust the limits accordingly.

Prior to performing the test the contactor shall be validated. To ascertain that transient levels consistent with contact bounce do not mask those caused by the EUT, the test house shall ensure that the contactor meets the following validation. The set up shall be based on that given in **Annex B**, **Figures 55** and **56**. The difference being that a resistive load substitutes the EUT with a 10 μF capacitor on each lead to the ground conducting bench and the oscilloscope probes connected directly onto either side of the contactor. The value of the load shall be such that the same current is drawn from the power source as when the EUT is connected.

NOTE The origin for this test was Mil Std 461C and TS1527

Limits: The limits are based upon measurements made on behalf of the MOD in the 1970s and 1980s.

9.5 DCS01 Conducted Susceptibility, Primary Power Lines 20 Hz – 50 KHz

The requirement is applicable to power input leads that obtain power from other sources that are not part of the EUT. There is no requirement on power output leads. The basic concern is to ensure that equipment performance is not degraded from ripple voltages associated with allowable distortion of power source voltage waveforms.

The series injection technique in the test procedure results in the voltage dropping across the impedance of the EUT power input circuitry. The impedance of the power supply wiring is normally insignificant with respect to the EUT Impedance over most of the frequency range. In addition to this differential mode voltage, a common mode voltage will be developed across the common mode filter relative to the ground plane. Where the power return is earthed to the ground plane, this common mode voltage will be effectively the differential mode voltage. The common mode voltage is measured in this test. The additional capacitance across the power source provides very low impedance in this frequency range.

Rather than having a separate curve for each possible power source voltage, only one curve is specified. The voltage amplitude specified is approximately 6 dB above typical power quality limits, although the limit has been somewhat generalised to avoid complex curves.

Test Procedures: Earlier EMI standards introduced a circuit for a phase shift network, which was intended to cancel out AC power waveforms and allow direct measurement of the ripple present across the EUT. While these devices very effectively cancel the power waveform, they return the incorrect value of the ripple and are not acceptable for use. The networks use the principle of inverting the phase of the input power waveform, adding it to the waveform (input power plus ripple) across the EUT, and presumably producing only the ripple as an output. For a clean power waveform, the network would perform properly. However, the portion of the ripple that drops across the power source impedance contaminates the waveform and gets recombined with the ripple across the EUT resulting in an incorrect value.

9.6 DCS02 Conducted Susceptibility, Control, Signal and Power Lines 50 kHz – 400 MHz

This test is applicable to all power, control and signals leads connected to the EUT. Cables, which include power supply leads together with control and signal leads, are also subject to this test and shall be tested as a bundle.

In most equipment installations, cables connecting to an EUT present the easiest coupling path for interference signals and as such represent one of the major risks associated with controlling the level of interference that the EUT is subjected to. This is particularly true at RF frequencies up to 400MHz, in this frequency range cables can inadvertently act as receiving antennas from radiated emission sources due to the wavelengths involved or a coupling path for RF signals conducted on cables that are installed alongside.

Normally this test is not applied to cables shorter than 0.5 m in length but for some sensitive EUT's it may be necessary to test shorter cables where they will be installed in a hostile environment or a known susceptibility problem exists. Particular attention should be made to cables that interface to external equipment or EUT's as susceptibility issues may have a secondary affects on devices not part of the EUT test set up.

The purpose of this test is to ensure that EUT's are not susceptible to RF frequency interference signals coupled onto equipment cable looms from adjacent cabling or radiated sources.

Calibration Procedure: Prior to the test being performed the levels of power applied to the injection probe are determined in a 100 Ω calibration fixture. The input power to the injection probe is increased until the correct RF current is induced in the calibration fixture; this is maintained across the whole frequency range.

Test Procedures: Generally a monitor probe is placed 50 mm from the EUT connector of the cable being tested and the injection probe is placed at a separation distance of 50 mm from that. The susceptibility signal is swept across the frequency range at the levels previously determined in the calibration fixture. This procedure is repeated for each cable and each branch of the cable in turn being tested.

The monitor and injection probe shall be clamped around the cable under test such that the cable is located in the centre of both of the probes apertures. The cable bundle under test shall be mounted on 50 mm non-conducting spacers with respect to the ground conducting bench.

The test signal shall consist of an un-modulated carrier wave and an amplitude modulated carrier wave applied sequentially to each cable being tested. Where the EUT is found to be susceptible, the susceptibility threshold is determined by replacing the injection probe back in the calibration fixture, replicating the level of power applied to EUT and measuring the induced current.

A safety level for induced current is specified during the test so that the EUT is not subjected to unrealistic levels caused by cable resonances or EUT input impedance. Limits have been derived from empirical measurement on military installations.

Limits: The limits for this test are representative of those typically found in most military installations and have been derived by empirical measurements. The procuring authority should give consideration to tailoring the limits at frequencies where specific interfering RF signals or known installation problems exist.

9.7 DCS03 Conducted Susceptibility, Control and Signal Lines 20 Hz – 50 kHz

The purpose of this test is to confirm that audio frequency currents which are likely to be flowing in cables adjacent to the EUT control and signal lines do not cause malfunction of the EUT.

The effective coupling between cables is dependent upon length and separation. Electromagnetic radiation is produced by conductors in which currents or voltages are changing. In the near field (i.e. at distances less than $\lambda/2\pi$ at the relevant frequency) the induction components are dominant but these components decrease rapidly with distance (proportional to $1/d^2$ or $1/d^3$ at a distance d). In the far field (i.e. at distances greater than $\lambda/2\pi$) the radiation field, which varies as 1/d, is dominant.

Test Procedures: The test wire shall be closely coupled to the cable form to be tested by wrapping an insulated current carry wire spiralling at a two turn per metre equally spaced and running the whole of the cable bundle to within 15 cms of each end connector.

The test wire shall be energized with the specified current over the required frequency range and monitored by means of a suitable method and device. The cable bundle under test shall be mounted on 50 mm non-conducting spacers with respect to the ground conducting bench.

The test signal shall consist of an un-modulated carrier wave and shall be maintained at the test limit current across the test frequency range. Measurement of the current in the test wire can be made using a suitable measurement instrument in peak mode, but calibrated in RMS.

Limits: The limits for this test are representative of those typically found in most military installations and have been derived by empirical measurements. The procuring authority should give consideration to tailoring the limits at frequencies where high-level ripple is expected. For the airside, the frequency range of the enhanced limit (146 dBµA), may need to be adjusted depending on the frequency range of the aircraft's ac power system e.g. if the equipment is installed on aircraft whose primary power is variable over a frequency range of 350 Hz – 800 Hz then the enhanced limit should cover this band.

9.8 DCS04 Imported Transient Susceptibility (Air Services)

The purpose of the test is to ensure that equipment/load-switching transients induced on power supply lines and interconnecting bundles of the aircraft systems will not cause damage or malfunction.

The test is to be applied to all electrical cables interfacing with each EUT enclosure, and also individually on each power lead. Two Transient types are to be applied:

a) Type 1 2 MHz to 30 MHz

Transients are damped sinusoidal waveforms over the frequency range 2 MHz to 30MHz. These types of transient are commonly found on aircraft, and tend to be caused by heavy inductive loads switching on and off. During this switching, significant transients have been measured that are caused by the excitation of resonances by arc initiation and quenching of contactors and switches.

b) Type 2 100 kHz

Transients are voltage spikes which can be found during switching of large groups of equipments which are connected directly to the power distribution systems i.e. both positive and negative lines for DC supplies and Live and Neutral for AC supplies and each phase of a 3 phase + Neutral supply. The test is applicable to power lines only.

The transient results were characterised from the test data gathered during the1970's and 1980's by the Royal Aircraft Establishment (RAE) and the Transient Survey Team attached to the Aircraft and Armament Experimental Establishment (A&AEE). From this data it became evident that there were several constituent components to the transient waveform. The test waveforms are a simplified form aimed at simulating the main components and as such are "idealised" derivations from complex waveform measurements. The test limits are based on the results of the aircraft transient surveys conducted by the RAE and A&AEE and from literature surveys of other aircraft transient studies conducted outside the UK.

The frequencies used for the test are the default frequencies of 100 kHz (Type 1) and 2, 3, 5, 7, 10, 15, 20, 25 and 30 MHz (Type 2). Additional frequencies are also applied and they are determined from two sources:

a) By establishing the minimum and maximum impedances of the cable under test.

b) From the most susceptible DCS02 frequencies.

The rationale for frequency selection is to test the most vulnerable condition. A number of frequencies are required as the actual frequency of the transient that would be found on the aircraft is unknown especially as default cable lengths are used in the test and these will have different impedance characteristics.

If test DCS08.B is to be applied, only Type 2 transients need to be applied with this test as DCS08.B is a more severe requirement covering Type 1 transients.

9.9 DCS05 Externally Generated Transients (Land and Sea Services)

The purpose of the test is to ensure that equipment/load-switching transients induced on power supply and interconnecting cable bundles of land or sea platform systems will not cause damage or malfunction. It also covers the transients induced on power supply and interconnecting cable bundles of land or sea platform systems as a result of the Platform's exposure to a Nuclear Electromagnetic Pulse (NEMP).

The test is to be applied to all electrical cables interfacing with each EUT enclosure including each power supply cable bundle (common mode). It is also applied to the EUT's ground bonds.

The Type 1N transients applied are damped sinusoids over the frequency range 0.5 MHz to 50 MHz. These types of transient are commonly found on large platforms, and tend to be caused by heavy inductive loads switching on and off. During this switching, significant transients have been measured that are caused by the excitation of resonances by arc initiation and quenching of contactors and switches. These types of transient will also be induced on the cable bundles as a result of the interaction of an NEMP with the platform. In this case, the resulting induced frequencies are a function of the physical dimensions of the platform and the cable lengths.

Many of the transient types were monitored during trials on ships, submarines and land vehicles during the early 1980's by the MoD. Additionally, a full ship electrical system was set up to enable transients over a range of electrical load configurations to be measured. From these results, the Type 1 transient type was derived to replicate specific components of the transients observed during the trials. The test waveforms are a simplified form aimed at simulating the main components and as such are "idealised" derivations from complex waveform measurements.

Limits: NEMP test requirements for Land and Sea Systems define two generic default levels of severity which depend on the predominant location of the equipment cabling. The more severe limits apply where the cables are afforded little protection by the platforms' structure or where the equipment and wiring is in the open (electromagnetically). The test level shall be specified in the Test Plan based upon the System Requirements Document.

The default severe NEMP limits for Land and Sea Systems may be modified for the given installation by analysis of predicted or measured coupling from the free field environment at the resonant length of installation cabling.

9.10 DCS06 Imported Long Transient Susceptibility AC and DC Systems (Land and Sea Services)

The purpose of the test is to ensure that transients typical to those produced by Group Switching of equipment on the power supply lines will not damage individual equipments.

The test DCS06 (which now incorporates the previous DCS11 requirements) is to be applied to all power cables interfacing with the EUT. Only one transient type is applied:

Type 2 100 kHz

Type 2 Transients are Voltage Spikes which can be found during switching of large groups of equipments which are connected directly to the power distribution systems i.e. both positive and negative lines for DC supplies and Live and Neutral for AC supplies and also each phase of a 3 phase + Neutral supply. The test is applicable to power lines only.

Many of the transient types were monitored during trials on ships, submarines and land vehicles, during the early 1980’s by the MoD. Additionally a full ship electrical system was set up to enable variable electrical load configurations to be measured. From these results the type 2 transient type was derived because it became apparent that there was a predominant 100 kHz component present.

The test waveform is an “idealised” derivation from complex waveform measurements that were derived using Fast Fourier Transforms (FFT) and Harmonic Analysis.

9.11 DCS08 Externally Generated Transients (Air Services)

The purpose of the test is to ensure that transients induced on power supply lines and interconnecting bundles of the aircraft systems during exposure of the aircraft to a high altitude nuclear electromagnetic pulse (HEMP) or the high frequency transients induced by direct lightning attachment will not cause damage or malfunction.

The test is to be applied to all electrical cables interfacing with each EUT enclosure, and also individually on each power lead.

Type 1 2 MHz to 30 MHz

Type 1 Transients are damped sinusoidal waveforms over the frequency range 2 to 50 MHz. This test simulates the ring induced cable current waveforms found on Aircraft system wiring when the Aircraft is subjected to a High Altitude Electromagnetic Pulses (HEMP) or a direct lightning strike.

When an aircraft is subjected to HEMP large currents are induced in the skin of the aircraft and these will excite resonances in the aircraft structure and cable bundles. The induced cable bundle current waveforms are damped sinusoid in shape with frequencies a function of the physical dimensions of the platform and the cable lengths. Similar waveforms are induced by the airframe currents flowing as a result of a direct lightning strike to the aircraft. In this case other transient waveforms of a double exponential wave shape are also induced but these are covered by DCS09.B.

The transient results were characterised from the test data gathered during the, 1980’s by the Royal Aircraft Establishment during whole Aircraft lightning and EMP testing on Tornado. Often the induced wave shape contains more than one frequency component however for the purposes of the test; single frequencies are injected at a time separately. Thus the test waveforms are “idealised” derivations from complex waveform measurements.

The frequency range covers most variations of systems installed on Aircraft, but due consideration should be given for deployment of long wire towed arrays or decoys as the coupled frequencies may be lower than 2 MHz because of the overall length of the aircraft and the towed array.

Selection of Transient Test Frequencies

During injection tests, transients shall be injected at frequencies according to the following criteria.

a) The most susceptible frequencies in the range 2 to 50 MHz found from any previous continuous wave (CW) bulk current injection EMC testing; or

b) The frequencies at which maxima and minima cable impedances occur.

Over the frequency range 2 to 50 MHz inclusive not less than 50 frequencies such that any resonances in the EUT internal circuitry are excited, so subjecting any active or passive devices to maximum voltage or current threat. These frequencies shall be spaced evenly with a logarithmic increment. The approximate frequency of each injection is obtained by the use of the following equation:

Test frequency (MHz) = $10^{(0.3 + 0.028k)}$

Where k = 0, 1, 2, 3 to 50 for 50 frequencies

9.12 DCS09 Imported Lightning Transient Susceptibility (Air Services)

This test is applicable to aircraft equipment, which may be considered flight safety critical for aircraft operations. A direct lightning strike to an aircraft will result in electrical transients induced on equipment wiring, including equipment ground bonding straps. Other types of equipment shall be considered with regard to their function and vulnerability.

This test method requires the application of idealised waveforms to verify that the equipment is capable of withstanding the effects of lightning induced transients. The criteria for equipment performance while being subjected to lightning transients shall be defined in terms of equipment function and criticality. Flight safety critical systems are required to continue to function without manual intervention after the application of a lightning transient.

This test may not cover all aspects of lightning induced transients and interaction effects on equipment, particularly when incorporated into a system. Additional tests such as simultaneous cable bundle injection, multiple stroke/multiple burst and/or multiple frequency may be required to achieve equipment qualification. Because there is a close connection between the design requirements for protection against lightning Group Indirect Effects (GIE) and those covering EMC and Nuclear Electromagnetic Pulse (NEMP) considerations, the Lightning Protection Plan shall take account of EMC Requirements, and also of NEMP requirements if applicable. Lightning requirements shall be co-ordinated with these other requirements and any conflict of requirements in particular instances shall be noted in the Risk Assessment and proposals included for resolving the conflict.

There are various coupling modes between the lightning current or fields and the internal wiring, each of which tends to produce a transient of a particular waveform. Thus the total transient may be a complex composite of several waveforms, and transient testing of equipment needs to include a variety of voltage and current waveforms selected to cover the principal coupling modes. The purpose of such tests is to determine whether the equipment can experience a given level of transient (of representative waveform) without damage or functional upset.

The test levels applied to equipment are derived from the locations and positions of the installed equipment. The maximum amplitudes for the test waveforms are chosen according to equipment categories A - D (electromagnetic (EM) environments of the equipment) and E (criticality of equipment). See **Clause B.11.10** for the categories.

9.13 DCS10 Electro Static Discharge (ESD)

9.13.1 Purpose

The purpose of this test is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges, which may occur from personnel to objects near vital equipment.

In service, electrostatic discharges result from charges built up by friction between materials, such as clothing, and inadvertently transferred to equipment by personnel, either directly or indirectly

This test simulates the above process by the use of a high voltage generator, charge storage capacitor and discharge probe to determine whether electrostatic discharges transferred to equipment by personnel contact will damage the EUT or lead to the malfunctioning and degradation of its performance.

It is not intended to specify the tests to be applied to a particular apparatus or system. The main aim is to give a general basic reference. The procuring agency or users of the equipment, remains responsible for the appropriate choice of test and the severity level to be applied to the EUT.

9.13.2 Applicability

This test applies to all Air equipment fitted with electronic and active components, particularly non-linear items such as transistors or integrated circuits etc, and Land and Sea Systems equipment if operated in an air-conditioned or protected environment.

The test method is similar to that described in BS EN 61000-4-2: 1995 but the following differences should be noted:

a) The applied levels and equipment classifications from this document should be used instead of those given in BS EN 61000-4-2: 1995.

b) The contact discharge method shall be used wherever possible but the rounded discharge tip described within the test method shall be substituted for that shown in BS EN61000-4-2: 1995.

c) When the air discharge method is used on non-conducting surfaces an additional test level of 15 kV shall be applied to all test points.

Discharges are normally directed to points on the front panel of the EUT, e.g. keyboards, knobs, switches, buttons and indicators, LED's, slots, grilles, connectors and any metallic parts on the outside of the EUT electrically isolated from ground, specific points shall be detailed in the Test Plan (see **Part 1 Clause 10** of this Standard). Equipment shall withstand discharges as specified in **Clause 9.13.5** at charging voltages appropriate to the Category of the equipment, without malfunction or disturbance.

NOTE An external calibration laboratory would normally performed the Calibration of the ESD generator. The test laboratory however is responsible for verifying the ESD waveform prior to application of the test.

9.13.3 Test Equipment

The ESD generator is intended to simulate the current pulse, which arises when a person carrying an electric charge dissipates that charge on contact with the equipment under test (EUT). For convenience the characteristics of the ESD generator from BS EN 61000-4-2:1995 are reproduced below.

The basic design circuit of the generator is shown in **Figure 9**. A capacitor (Cs) can be charged to a specified voltage and then discharged through the series resistor (Rd) and discharge tip using either the “contact” or “air” discharge methods. In the contact discharge method the discharge tip is held in contact with the EUT and the discharge actuated by the discharge switch within the generator. In the air discharge method the charged electrode of the generator is brought close to the EUT and the discharge actuated by a spark to the EUT. The discharge tip geometry for the air discharge method is shown in **Figure 10**.

Output waveform: The output current waveform, when the generator is discharged through a 2 Ω calibration resistance (see **Annex C Clause C.4.2**), is defined by the rise time to peak. The current, as a percentage of the peak value, shall be measured 30 ns from the start of the waveform and then 60 ns from start. A typical waveform is shown in **Figure 11**. The rise time (10% to 90% of peak amplitude) is in the range 0.7 ns to 1.0 ns, the current at 30 ns is nominally 53 % of peak amplitude and at 60 ns, 27 % of peak amplitude. The generator performance verification procedure is described in BS EN 61000-4-2:1995. The generator output waveform will be dependent, to some extent, on the inductance of the generator earthing lead. For this reason the same physical lead, in as far as possible the same physical configuration shall be used both for verifying generator performance and for testing the equipment. It is important that the test oscilloscope (recommended bandwidth 1 GHz) is adequately shielded from energy radiated by the electrostatic discharge and from energy conducted into its power supply.

Performance characteristics **Figure 12** shows a typical ESD calibration arrangement although generators compatible with that described in BS EN 61000-4-2:1995 will be suitable for the DCS10 test. The required output current characteristics, using contact discharge and calculated from the voltage measured across the 2 Ω resistor, are shown in **Table 9** for four test voltages.

Table 9 ESD Generator Output Requirements

Required Charging Voltage (kV)	1st Peak Discharge Current (A ± 10%)	Current (A ± 10%) after 30 ns	Current (A ± 10%) after 60 ns
2	7.5	4	2
4	15.0	8	4
6	22.5	12	6
8	30.0	16	8
NOTE The required rise time (10% to 90% of peak current) shall be in the range 0.7ns to 1.0ns for all charging voltages.			

The general outline technical characteristics of the generator shall be compliant with **Table 10**.

Table 10 Outline Technical Characteristics of ESD Generator

Characteristic	Performance Requirement
Discharge storage capacitor	150 pF ± 10%
Discharge Resistor	330 Ω ± 10%
EHT output	Up to 15 kV DC
EHT metering	2 kV to 12 kV ± 5%
Output polarity	Positive and negative (switchable)
Holding time	The ESD generator shall be able to hold its charge for at least 5 s without falling below 90% of its pre-set value
Discharge Modes	(a) Single discharge (b) Repetitive discharge (c) Contact discharge
Output Current	The output current waveform developed in the 2 Ω calibration resistor shall be as shown in Figure 12

9.13.4 Test Method

In order to minimize the impact of environmental parameters on test results, the tests shall be carried out with the following laboratory conditions;

a) Ambient Temperature: 15ºC to 35ºC

b) Relative Humidity: 30 % to 60 %

A typical test configuration is shown in **Figure 13**.

The tests shall be conducted by applying discharges to each of the specified application points listed in the Test Plan, using the charging voltage sequence 2, 4, 6 and 8 kV until the limit for the EUT category is reached. For each charging voltage, five discharges shall be applied at each point for each polarity, allowing a 10s interval between discharges. The tests shall be repeated for each mode of operation of the EUT and all malfunctions and disturbances, whether temporary or permanent, shall be recorded.

NOTE Reference must also be made to BS EN 61000-4-2:1995.

9.13.5 Limits

Equipment shall withstand discharges as specified above at charging voltages appropriate to the Category of the equipment, without malfunction or disturbance.

For Air Services the tests shall be applied at one of two severity levels, depending on the category of the equipment:

a) Category A - Safety Critical in that the safety of personnel or third parties is placed at risk either directly or indirectly from malfunctioning of the equipment (and hence subsequently the materiel).

b) Category B - Mission Critical in that malfunctioning or upset of the equipment functions that reduces, damages or prevents the materiel from performing its mission.

ESD testing of Air service equipment not in either of these categories is not normally required but it is at the discretion of the Project Manager.

Table 11 shows which set of charging voltages shall be applied to Category A or B equipment.

Table 11 Application of Charging Voltages by Equipment Category

Charging Voltage (kV)	Category A Safety Critical	Category B Mission Critical
2	No	Yes
4	Yes	Yes
6	Yes	Yes
8	Yes	No

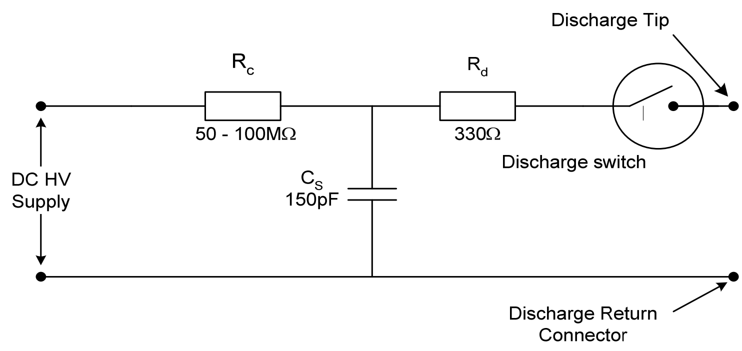


Figure 9 DCS10 – Simplified Diagram of the ESD Generator

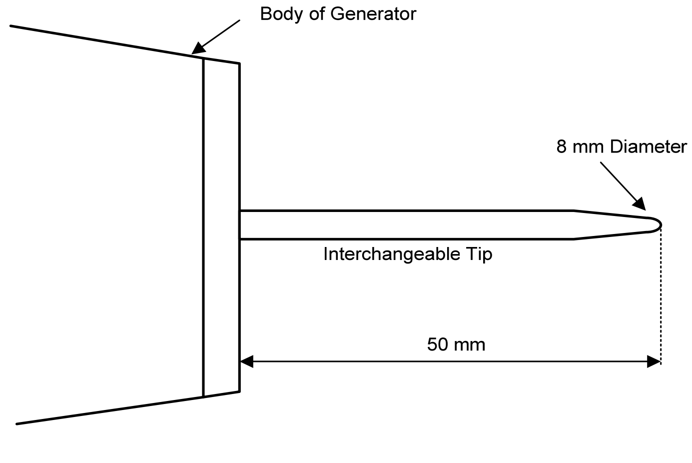


Figure 10 DCS10 – ESD Generator Discharge Tip Geometry

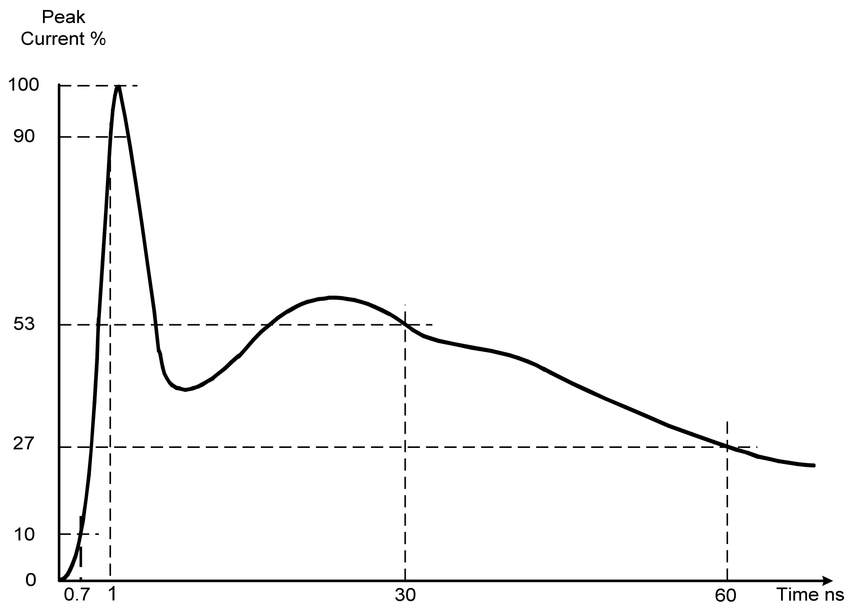


Figure 11 DCS10 – Typical Type 4 ESD Generator

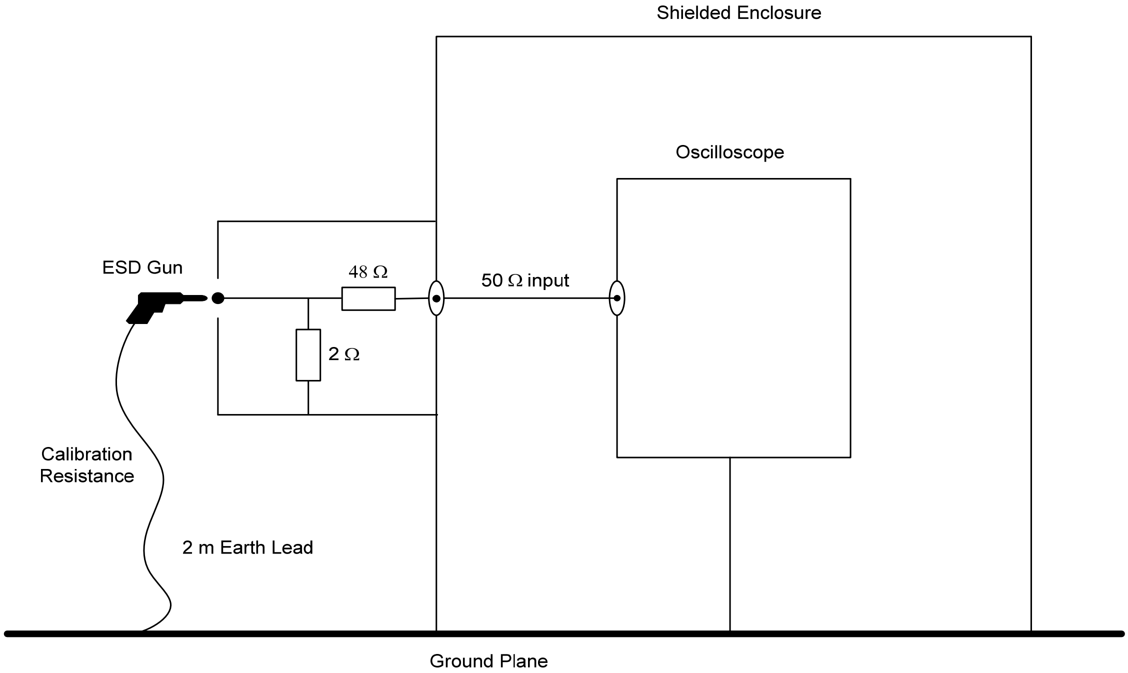


Figure 12 DCS10 – ESD Calibration Arrangement

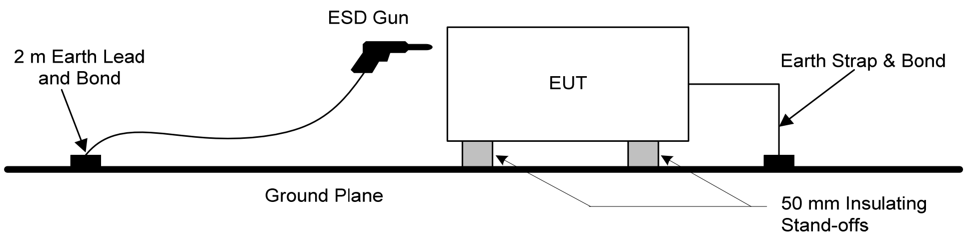


Figure 13 DCS10 – Typical Test Configuration

9.14 DCS12 Imported Low Frequency Transient Susceptibility Power Lines (Sea Services)

The purpose of this test is to confirm that the EUT will withstand imported low frequency transients imposed upon its power supply lines. This test simulates the effect of voltage transients observed due to switching of machines and other loads on ship and submarine power supply systems.

This test is applicable to all equipment in use in the Sea Systems environment connected to ship and submarine power supplies. The test subjects the EUT to high-energy transients, typically 6 Joules for the 750 V limit and 18 Joules for the 2500 V limit. In common with other transient tests the test relies on the attenuation effect of the power input filter to protect the EUT but it also exercises transient suppressors (if present) by applying levels above their clamping voltage. In addition determining EUT susceptibility the test assesses the robustness of the input filter, which if damaged by high-energy transients could lead to higher emission levels and reduced protection against all forms of susceptibility. Typical occurrences of filter damage are capacitor dielectric breakdown or damage to transient suppressors of insufficient rating. Positive-going and negative-going, damped sinewave transients between 10 to 16 kHz, are to be applied to individual supply leads of an EUT, for both AC and DC incoming supplies. Battery operated equipment which may be connected to a platform supply, for example, during battery charging, shall also be subjected to this test.

The limits for this test have been derived from empirical measurements made of typical transients on DC and AC supplies.

During each transient application, the EUT shall be monitored for degradation of performance, damage or malfunction as defined in the Test Plan. When testing digital systems it may be necessary to apply a greater number of transients to ensure detection of any malfunction. In this case, the Test Plan shall include some guidance to ensure capture of a malfunction during test.

9.15 DRE01 Radiated Emissions Electric (E) Field 10 kHz – 18 GHz

The requirements are applicable to electric field emissions from the EUT and associated cables. The basic intent of the requirement is to protect sensitive receivers from interference coupled through the antennas associated with the receiver. Many tuned receivers have sensitivities in the order of one microvolt and are connected to an intentional aperture (the antenna), which are constructed for efficient reception of energy in the operating range of the receiver. The potential for degradation requires relatively stringent requirements to prevent platform problems especially in land applications.

There is no implied relationship between this requirement and DRS02 that addresses radiated susceptibility to electric fields. Attempts have been made quite frequently in the past to compare electric field radiated emission and susceptibility type requirements as a justification for deviations and waivers. While DRE01 is concerned with potential effects with antenna-connected receivers, DRS02 simulates fields resulting from antenna-connected transmitters and from external transmitters.

Often, the same equipment item will be involved in influencing both requirements. A 30 watt VHF-AM radio with a typical blade antenna operating at 150 MHz can easily detect a 40 dBµV/m electric field (approximately -81 dBm developed at receiver input) while in the receive mode. When this same piece of equipment transmits at the same 150 MHz frequency, it will produce a field of approximately 150 dBµV/m (32 volts/metre) at a 1 metre distance. The two field levels are 110 dB apart.

The limit curves are based on experience with platform-level problems with antenna-connected receivers and the amount of shielding typically between antennas and equipment and associated wiring.

The limit curves for equipment in internal installations on air platforms are not designed to take into account intentionally shielded volumes that are effective across the frequency range of the test. Some minimal shielding can be expected from the platform.

In the past EUT's have been found to be susceptible to ripple voltages when fitted to platforms and hence must be tested to avoid problems when subjected to low frequency radiated fields which can couple onto interconnecting cabling. Although relatively inefficient, coupling to cabling at lower frequencies has been demonstrated innumerable times in EMI testing.

Test Procedures: Specific antennas are required by this test procedure for standardisation reasons. The intent is to obtain consistent results between different test facilities.

In order for adequate signal levels to be available above the receiver noise floor to drive the measurement receivers, physically large antennas are necessary. Due to shielded room measurements, the antennas are required to be relatively close to the EUT, and the radiated field is not uniform across the antenna aperture. For electric field measurements below several hundred megahertz, the antennas do not measure the true electric field.

The 41 inch rod antenna has a theoretical electrical length of 0.5 metres and is considered to be a short monopole with an infinite ground plane. It would produce the true electric field if a sufficiently large counterpoise were used to form an image of the rod in the ground plane. However, there is not adequate room. The requirement to bond the counterpoise to the shielded room or earth ground, as applicable, is intended to improve its performance as a ground plane.

The antenna positioning requirements in this procedure are based on likely points of radiation and antenna patterns. At frequencies below several hundred MHz, radiation is most likely to originate from EUT cabling. The 41” rod biconical and Log Periodic antennas have wide pattern coverage. The double ridge horns have narrower beamwidths. However, the shorter wavelengths above 200 MHz will result in radiation from EUT apertures and portions of cabling close to EUT interfaces. The requirements for antenna positioning above 200 MHz are based on including EUT apertures and lengths of cabling at least one quarter wavelength.

All the specified antennas are linearly polarised. Above 30 MHz, measurements must be performed to measure both horizontal and vertical components of the radiated field. Measurements with the 41” rod are performed only for vertical polarisation. This antenna configuration is not readily adapted for horizontal measurements.

For equipment or subsystems that have enclosures or cabling in various parts of a platform, data may need to be taken for more than one configuration. For example, in an aircraft installation where a pod is located outside of the aircraft structure and its associated cabling is internal to structure; two different limits may be applicable. Different sets of data may need to be generated to isolate different emissions from the pod housing and from cabling. The non-relevant portion of the equipment would need to be protected with appropriate shielding during each evaluation.

Limits:

For Man Worn / Man Portable Equipment the frequency range is 88 MHz to 18 GHz whereas for Land LRU's and sub Systems the frequency range is 1.6 MHz to 18 GHz.

The limit for surface ships is based on numerous documented incidents of case and cable radiation coupling to receiver antennas. The use of hand-held type transceivers below deck within a ship is increasing resulting in excessive levels of interference below deck.

Possible tailoring by the procuring activity for contractual documents is as follows. The limits could be adjusted based on the types of antenna-connected equipment on the platform and the degree of shielding present between the equipment, associated cabling, and the antennas.

NOTE For Electronic Countermeasure (ECM) applications reference should be made to the tailored limits in the following DSTL documents: DSTLI/PL15013 or DSTL/TR/249848.

9.16 DRE02 Radiated Emissions Magnetic (H) Field 20 Hz – 250 kHz

This requirement is specialised and is intended primarily to control magnetic fields for applications where equipment is present in the installation, which is potentially sensitive to magnetic induction at lower frequencies. The most common example is a tuned receiver that operates within the frequency range of the test.

DRS01 is a complimentary requirement imposed on equipment to ensure compatibility with the anticipated magnetic fields. The DRS01 limits are the same (except for power frequencies) however the measurement distance is more stringent at 50 mm instead of 70 mm.

NOTE The limit does not take into account magnetic effects from equipment such as magnetic launchers, magnetic guns and the like.

An estimate can be made of the types of induced levels that will result in circuitry malfunction from the limits. Magnetic fields act by inducing voltages into loop areas in accordance with Faraday's law ($V = -d\phi/dt$). For a uniform magnetic field perpendicular to the loop area, the induced voltage from Faraday's law reduces to $V = -2\pi fBA$.

f = Frequency of Interest

B = Magnetic Flux Density

A = Loop Area

Test Procedures: A 13.3 centimetre loop is specified for the test.

Typical points of magnetic field emissions leakage from EUT enclosures are CRT yokes, transformers and switching power supplies.

A possible alternative measurement tool in this frequency range is wave analyser using a Fast Fourier Transform algorithm. Use of this type of instrumentation requires specific approval by the procuring activity.

A correction factor curve to convert from the voltage indicated by the measurement receiver to the magnetic field in dBpT is required. Manufacturers use different construction techniques that cause the actual factor to vary somewhat.

NOTE For Electronic Countermeasure (ECM) applications reference should be made to the tailored limits in the following DSTL documents: DSTLI/PL15013 or DSTL/TR/249848.

9.17 DRE03 Radiated Emissions Electric (E) Field Tuned Antenna (Land Service) 1.6 MHz – 88 MHz

This test is intended to mimic the use of equipment in close proximity to Combat Net Radio (CNR) installations used by the Army and as such it utilises CNR antennas and tuning units as detailed in **Clauses 6.22.4** and **6.22.5**. This test is specific to CNR HF and VHF radios and is used to measure the amount of interference that would appear at the radio's input terminals and not the electric field strength generated by that interference. Although a guide to what level of interference may be present to affect other radio installations it should not be considered representative of non-CNR set-ups.

The use of a HF tuner unit means that the HF CNR whip antenna is matched to the 50 Ω measuring receiver input and signals outside the measuring bandwidth are excluded. This results in a much more sensitive measurement where out of band signals cannot overload the receiver input and give rise to false measurements.

The current VHF CNR whip is a broadband antenna and therefore does not require a tuner unit.

Because of the widespread use throughout the British Army of the HF and VHF CNR a number of different test scenarios are considered to mimic different deployment roles. These are as follows:

a) The man worn/man portable scenario covered in **Annex A** is concerned with EUTs that are carried and used by soldiers and the limits and test techniques take into account interactions between radios and man portable radios attached to the soldier's combat webbing. This scenario requires the DRE03.A measurement to be performed over the CNR VHF band using the antenna as detailed in **Clause 6.22.5** at a separation of 0.1 m from the face of the EUT.

b) General equipment used by the Army is covered under the tests included for LRUs in **Annex B** and this should be used for all equipment deployed in a frontline or support role where Clansman HF CNRs are also deployed. There is no requirement to perform the DRE03.B measurement over the CNR VHF band in this scenario as it is covered by the DRE01.B measurements.

c) The last group of equipments covers vehicles fitted with CNRs or large EUTs which may be subjected to the "passing scenario" where a Fitted For Radio (FFR) vehicle or fixed CNR installation will operate adjacent to a large EUT. This scenario is covered under platform testing in **Part 4** of this Standard.

Empirical measurements have determined limits that represent an acceptable level of permissible interference allowable at the radio input terminals. These limits are based upon interference causing degradation to the minimum discernable input signal of a CNR radio (0.5 µV). Limits and frequency ranges are specific to CNR radio installations and where other radios are being considered these should be tailored appropriately.

Large emission levels appearing at the measurement receiver input will correspond to a large degradation of wanted signal and a break down of radio communication resulting in severe CNR range reduction. For a given scenario this may render the radio installation less effective or even useless.

Because this test specifies limits in terms of emissions appearing at the CNR's input terminals care should be taken when making a comparison with electric field measurements of the EUT made over the same frequency range using normal broadband EMC antennas as these will not be directly comparable.

9.18 DRS01 Radiated Susceptibility Magnetic (H) Field 20 Hz – 100 kHz

This requirement is specialised and intended primarily to ensure that performance of equipment potentially sensitive to low frequency magnetic fields is not degraded. DRE02 is a complimentary requirement governing the radiated magnetic field emissions from equipment and subsystems. The DRE02 discussion is also applicable to this requirement.

Land has maintained the basic relationship of the DRS01 and DRE02 limits having the same shape.

The primary test procedure requires that testing be performed at each electrical interface connector. On some small size EUTs, connectors may be closely spaced such that more than one connector can be effectively illuminated for a particular loop position. The Test Plan shall address this circumstance.

9.19 DRS02 Radiated Susceptibility Electric (E) Field 10 kHz – 18 GHz

The requirements are applicable to both the EUT enclosures and EUT associated cabling. The basic concern is to ensure that equipment will operate without degradation in the presence of electromagnetic fields generated by antenna transmissions both onboard and external to the platform.

The EUT is subjected to lower frequency radiated fields (down to 10 kHz) to determine its vulnerability to emissions generated within the EUT's normal installation by other electronic/electrical components, such as those associated with switch mode power supplies.

There is no implied relationship between this requirement and DRE01. The DRE01 limit is placed primarily to protect antenna-connected receivers while DRS02 simulates fields resulting from antenna transmissions.

The limits specified for different equipment are simply based on levels expected to be encountered during the service life of the equipment. They do not necessarily represent the worst-case environment to which the equipment may be exposed. RF environments can be highly variable, particularly for emitters not located on the platform. The limits are placed at levels that are considered to be adequate to cover most situations.

In the past EUTs have been found to be susceptible to ripple voltages when fitted to platforms and hence must be tested to avoid problems when subjected to low frequency radiated fields.

An example, which demonstrates the variability of environments for ground installations and the need for effective tailoring of requirements, is the installation of equipment in a large ground-based radar facility. Some of these facilities transmit power levels over one megawatt and the back lobes from the antennas can be substantial. Suitable design levels for equipment that will be used in the facility or nearby need to be imposed.

For aircraft and ships, different limits are specified depending on whether the equipment receives protection from platform structure. In the case of air the limits are based upon typical external environments with allowances for limited attenuation (10-12 dB) in line with typical aircraft bays. However they should be tailored for each application, in many cases they will be to low. This distinction is not made for Army ground systems, such as tanks, because the same equipment used inside a structure is often used in other applications where protection is not available.

Possible tailoring by the procuring authority for contractual documents is to modify the required levels and required frequency ranges based on the emitters on and near a particular installation. Actual field levels can be calculated from characteristics of the emitters, distances between the emitters and the equipment, and intervening shielding. Part 2 of this Standard provides information on land, air, and sea based RF emitters, both hostile and friendly, which contribute to the overall electromagnetic environment. The possible use of the equipment in other installations and the potential addition or relocation of RF emitters needs to be considered. Other possible tailoring is to change from the standard 1 kHz, square wave modulation or use additional modulations based on actual platform environments.

NOTE For Electronic Countermeasure (ECM) applications reference should be made to the tailored limits in the following DSTL documents: DSTLI/PL15013 or DSTL/TR/249848.

Test Procedures: Test facilities are permitted to select appropriate electric field generating apparatus. Any electric field generating device such as antenna, long wire, TEM cell, reverberating chamber (using mode tuned techniques) or parallel strip line capable of generating the required electric field may be used. Fields should be maintained as uniform as possible over the test set-up boundary. Above 30 MHz, both horizontally and vertically polarised fields must be generated. This requirement may limit the use of certain types of apparatus. Only vertically polarised measurements are required below 30 MHz due to the difficulty of orienting available test equipment for horizontal measurements.

Monitoring requirements emphasise measuring true electric field. While emission testing for radiated electric fields does not always measure true electric field, sensors with adequate sensitivity are available for field levels generated for susceptibility testing. Physically small and electrically short sensors are required so that the electric field does not vary substantially over the pickup element resulting in the measurement of a localised field. Broadband sensors not requiring tuning are available.

The use of more than one sensor is acceptable provided all sensors are within the beamwidth of the transmit antenna. The effective field is determined by taking the average of the readings. For example, if the readings of three sensors are 30, 22, and 35 volts/metre, the effective electric field level is (30 + 22 + 35)/3 = 29 volts/metre.

Different sensors may use various techniques to measure the field. At frequencies where far-field conditions do not exist, sensors must be selected which have electric field sensing elements. Sensors that detect magnetic field or power density and convert to electric field are not acceptable. Under far-field conditions, all sensors will produce the same result. Correction factors must be applied for modulated test signals for equivalent peak detection. A typical procedure for determining the correction factor for these sensors is as follows:

a) Generate a field at a selected frequency using an unmodulated source.

b) Adjust the field to obtain a reading on the sensor display near full scale and note the value.

c) Modulate the field as required and ensure the field has the same peak value. A measurement receiver with the peak detector selected and receiving antenna can be used to make this determination.

d) Note the reading on the sensor display.

e) Divide the first reading by the second reading to determine the correction factor (Subtract the two readings if the field is displayed in terms of dB).

f) Repeat the procedure at several frequencies to verify the consistency of the technique.

Above 1 GHz, radiated fields usually exhibit far-field characteristics for test purposes due to the size of typical transmit antennas, antenna patterns, and distances to the EUT. Therefore, a double-ridged horn together with a measurement receiver will provide true electric field. Similarly, the particular sensing element in an isotropic sensor is not critical, and acceptable conversions to electric field can be made.

For equipment or subsystems that have enclosures or cabling in various parts of a platform, data may need to be taken for more than one configuration. For example, in an aircraft installation where a pod is located outside of aircraft structure and its associated cabling is internal to structure; two different limits may be applicable. Different sets of data may need to be generated to evaluate potential pod susceptibility due to coupling through the housing versus coupling from cabling. The non-relevant portion of the equipment would need to be protected with appropriate shielding.

9.19.1 Alternative Method Using Reverberation Chamber (Air Services)

Reverberating chambers, using mode-tuned techniques, have been popular for performing shielded effectiveness evaluations and, in some cases, have been used for radiated susceptibility testing of equipment and subsystems. The concept used in reverberating chambers is to excite available electromagnetic wave propagation modes to set up variable standing wave patterns in the chamber. A transmit antenna is used to launch an electromagnetic wave. An irregular shaped tuner is rotated to excite the different modes and modify the standing wave pattern in the chamber. Any physical location in the chamber will achieve same peak field strength at some position of the paddle wheel.

Reverberation chambers have the advantage of producing relatively higher fields than other techniques for a particular power input. Also, the orientation of EUT enclosures is less critical since the all portions of the EUT will be exposed to the same peak field at some paddle wheel position. The performance of a particular reverberation chamber is dependent upon a number of factors including dimensions, Q of the chamber, number of available propagation modes, and frequency range of use.

Some issues with reverberation chambers are as follows. The field polarisation and distribution with respect to the EUT layout are generally unknown at a point in time. If a problem is noted, the point of entry into the EUT may not be apparent.

Reverberation chambers are sometimes treated as a good tool to determine potential problem frequencies with conventional antenna procedures being used to evaluate areas of concern.

The performance of each chamber must be reviewed to determine the suitability of its use for reverberation testing over a particular frequency range.

Reverberation chambers should be constructed in accordance with the following guidance in order to function properly.

a) A tuner should be constructed of metal and installed with appropriate positioning equipment to allow the tuner to be rotated 360^0 in at least 200 evenly spaced increments. The tuner should be constructed to be asymmetric with the smallest dimension of the tuner being at least λ/3 of lowest frequency to be tested and the longest dimension of the tuner being approximately 75 % of the smallest chamber dimension.

b) The enclosure shall be free of any materials that might exhibit absorptive properties such as tables, chairs, wood floors, sub-floors, shelves, and such. Support structures should be constructed from high density foam.

c) Transmit and receive antennas should be at least 1.0 metre (λ/3 is the actual limitation) from any wall or object and should be positioned to prevent direct alignment between the main lobes of the two antennas or between the EUT and the main lobe of either antenna.

d) The lower frequency limit is dependent on chamber size. To determine the lower frequency limit for a given chamber, use one of the following methods:

   1) Using the following formula, determine the number of possible modes (N) which can exist at a given frequency. If, for a given frequency, *N* is less than 100 then the chamber should not be used at or below that frequency.

$$N = \frac{8\pi}{3} abd \frac{f^3}{c^3}$$

where: *a, b*, and *d* are the chamber internal dimensions in metres

f is the operation frequency in Hz

c is the speed of propagation (3×10^8 m/s)

2) Use the methods detailed in RTCA DO-160, section 20.6, for determining the lowest useable frequency based on field uniformity

e) In order to assure that the time response of the chamber is fast enough to accommodate pulsed waveform testing (other than the 1 kHz, 50% duty cycle, waveform specified), determination of the chamber time constant must be accomplished using the following procedure:

1) Calculate the chamber Q using:

$$Q = \left(\frac{16\pi^2 V}{\eta_{Tx}\eta_{Rx}\lambda^3} \right) \left(\frac{P_{ave\ rec}}{P_{forward}} \right)$$

Where η_{Tx} and η_{Rx} are the antenna efficiency factors for the Tx and Rx antennas respectively and can be assumed to be 0.75 for a log periodic antenna and 0.9 for a horn antenna.

V is the chamber volume (m3), λ is the free space wavelength (m) at the specific frequency.

$P_{ave\ rec}$ is the average received power over one tuner rotation.

$P_{forward}$ is the forward power input to the chamber over the tuner rotation at which was measured.

2) Calculate the chamber time constant, τ, using:

$$\tau = \frac{Q}{2\pi f}$$

Where *Q* is the value calculated above, and *f* is the frequency (Hz)

3) If the chamber time constant is greater than 0.4 of the pulse width of the modulation waveform, absorber material must be added to the chamber or the pulse width must be increased. If absorber material is added, repeat the measurement and the Q calculation until the time constant requirement is satisfied with the least possible absorber material. A new Q must be defined if absorber material is required.

f) Prior to using the chamber, the effectiveness of the tuner should be evaluated at the upper and lower frequencies to be used and at points between the endpoints not to exceed 1 GHz spacing. To evaluate the stirring effectiveness, inject a CW signal into the chamber at the desired frequency and record the net received power at 200 positions of the tuner evenly spaced over a 360 degree rotation of the tuner. Determine the correlation coefficient between the original set of received power and subsequent sets obtained by rotating the last data point of the original set to the position of the first point and then shifting all the other points to the right as depicted below.

Original data	D1, D2, D3, D4, D5, . . . D200
Shifted data (1)	D200, D1, D2, D3, D4, . . . D199
Shifted data (2)	D199, D200, D1, D2, D3, . . . D198
Shifted data (3)	D198, D199, D200, D1, D2, . . . D197
Shifted data (4)	D197, D198, D199, D200, D1, . . . D196
Shifted data (5)	D196, D197, D198, D199, D200, D1, . . . D195

The correlation coefficient should drop to below 0.36 within five shifts of the data. This will ensure that the tuner is operating properly. If the tuner fails this test, then the tuner needs to be made either larger or more complex, or both.

g) National Bureau of Standards Technical Note 1092. “Design, Evaluation, and Use of a Reverberation Chamber for Performing Electromagnetic Susceptibility/Vulnerability Measurements” and National Institute of Standards and Technology Technical Note 1508, “Evaluation of the NASA Langley Research Center Mode-Stirred Chamber Facility,” should be used as a guide in preparing a shielded room for reverberation measurements.

9.20 DRS03 Magnetic Field (DC) Susceptibility

This requirement is specialised and intended primarily to ensure that performance of equipment potentially sensitive to DC magnetic fields is not degraded. EUTs may be required to operate in areas that are subjected to large fields either intentionally or unintentionally generated.

This requirement is performed to prove that equipment continues to function correctly on board a Ship where deperming and degaussing of the ship’s hull takes place on a regular basis. It should be noted that the amount of field that the EUT will be subjected to will be dependant upon its location on the ship and the level applied should be adjusted accordingly, for this reason the procuring authority should define actual levels before testing commences.

This test procedure should be used when EUTs have components that are sensitive to magnetic fields such as CRTs, Hall effect circuitry, compasses or generating/sensing loops.

Test Procedures: A slewed DC magnetic field must be applied to all equipment operating on submarines and surface ships.

This test should be applied to each axis of the EUT for a continuous time period to establish that the EUT has suffered no detrimental effects. The field should be increased up to the desired test level at a rate of 1600 A/m/s and then maintained at this level for at least 5 seconds before being allowed to decay back to 0 A/m. This process should be repeated a sufficient number of times to establish that the EUT has not been adversely effected. This process should then be repeated with the field in the opposite direction, this is accomplished by reversing the connections to the coil.

Care must be taken to keep the EUT in the uniform portion of the field produced within the centre of the coil. The area of uniform field is dependant upon the physical size of the Helmholtz coil being used and no EUT tested should have any dimension greater than 1.1 x the radius of that coil.

For EUT (or units of a system) greater than $1m^3$ or weighing more than 100 kg it is considered generally impractical to apply the standard test method. For these equipment types, a localised test method shall be applied to all the areas of the equipment considered most likely to be susceptible. However it should be stressed that the normal method be used wherever possible and that the localised method be limited to exceptional circumstances.

For the purpose of the test, the EUT should be powered and in its normal mode of operation throughout and some means of indication should be present to establish its correct operation.

Annex A
Test Methods and Limits for Man Worn / Man Portable Equipment

Introduction:

This Annex describes the preferred techniques to be used for the measurement of the electromagnetic compatibility characteristics of Man Worn and Man Portable electrical and electronic equipment to be procured by the Ministry of Defence.

A.1 DCE02.A Conducted Emissions Control, Signal and Power Lines 500 Hz – 150 MHz

A.1.1 Purpose

The purpose of this test is to ensure that the common mode conducted emissions on all control, signal and power lines to the equipment under test (EUT) are controlled to the appropriate limits in order to provide adequate protection to radio reception and to minimise disturbance to any co-located sensitive electronic equipment for land based applications.

A.1.2 Applicability

This test is only applicable to EUTs with cables. This test is not applicable to co-axial antenna feeders or cables less than 500 mm in length. All branches of the EUT harnesses are subject to this test. The Test Plan must indicate which of the control and signal lines are grouped together in a typical installation. The Test report will indicate the groupings and layout used. See **Part 1 Clause 11** of this Standard.

Reference should also be made to **Clause 9.3**.

NOTE If the Man Portable equipment is dual purpose then reference **to Clause 6.7** and **6.9** is also required.

A.1.3 Test Layout

Typical EUT test layouts are shown in **Figures 14** and **15** but reference is also required, to **Clauses 6.7**, **6.8** and **6.12.**

Some harnesses may contain cables conducting power supplies generated within one EUT of the system to another EUT of the system, i.e. secondary power supplies. These power supply cables will be measured together with all other cables in that particular cable harness branch.

A.1.4 Test Method

The current shall be measured using current probes. The probe shall be positioned 50 mm from the connectors on the EUT. For looms longer than 1 metre between two units, measurements will be made at both ends for all frequencies greater than 30 MHz. Reference is also required, to **Clauses 6.10**, **6.13**, **6.15**, **6.16** and **6.21.2**.

A.1.5 Limits

Limits are shown in **Figure 16** for Man Worn, Man Portable Land Based Equipment.

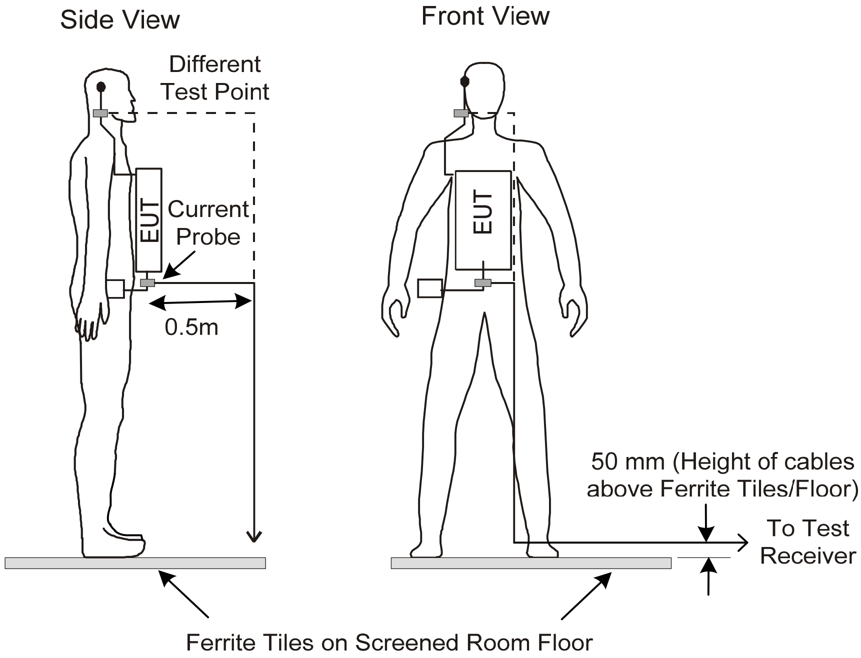
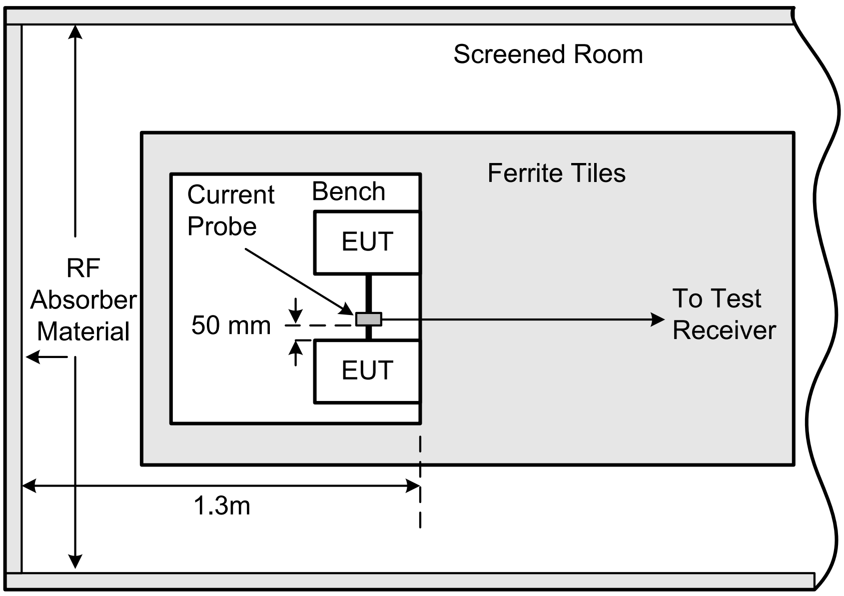


Figure 14 DCE02.A – Typical Test Configuration for Man Worn Scenario



NOTE The cable from the probe drops vertically to the floor first then to the test receiver as shown in Figure 15

Figure 15 DCE02.A – Typical Test Configuration for Man Portable Scenario

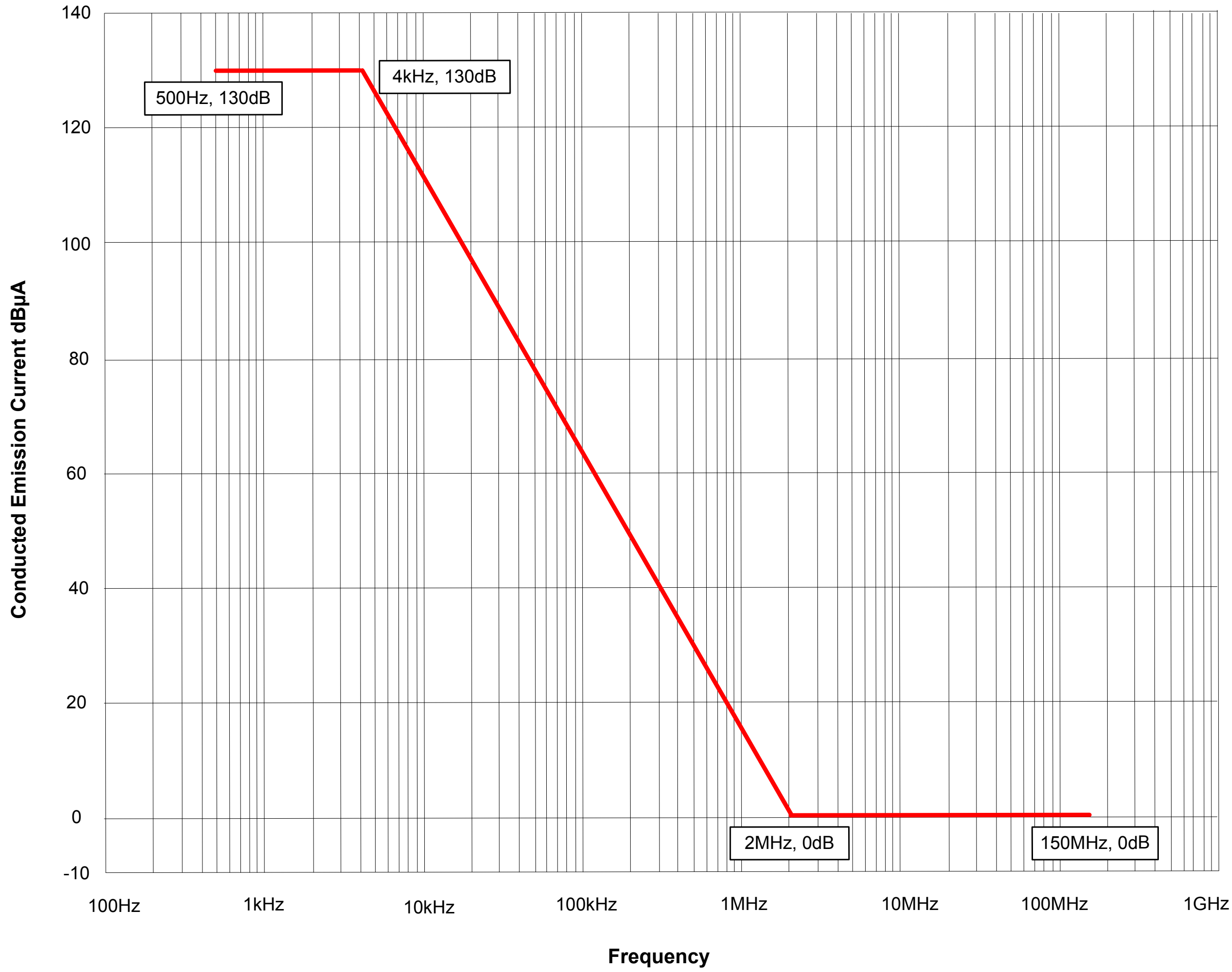


Figure 16 DCE02.A – Class A Limit for Man Worn, Man Portable Land Based Equipment

A.2 DCS02.A Conducted Susceptibility Control, Signal and Power Lines 50 kHz – 400 MHz

A.2.1 Purpose

The purpose of this test is to confirm that RF signals in the range 50 kHz to 400 MHz, when coupled on to the interconnecting cable looms and power supply lines of an EUT, will not cause degradation of performance. In addition this test will provide an amplitude / frequency malfunction signature for the system which, when compared with the levels of current on the looms (or cables) caused by adjacent or nearby transmitting sources measured during system acceptance trials, will assist in the establishment of adequate safety margins.

A.2.2 Applicability

Cable looms that connect the EUT to other equipments in the total system (including primary power lines) and those interconnecting units of the EUT are subject to this test. Cable looms can be tested as a whole or individual wires can be tested. The looms or individual wires to be tested will be defined in the equipment test plan but some basic ground rules are:

a) All looms shall be tested as a whole, connector by connector.

b) On some EUTs (including sub-systems responsible for the control and/or initiation of electro-explosive devices) individual wires and/or branch looms may be selected for testing in addition to a) above as defined by the Project Manager.

Reference should also be made to **Clause 9.6**.

NOTE For a system with built in redundancy the Project Manager may require simultaneous injections on several looms.

A.2.3 Test Layout

Before commencement of test **Clause 6.21.2** should be studied. **Figures 17** and **18** show typical layouts for the man worn and man portable tests respectively.

The probes used for these tests should have the following characteristics when driving current into the 100 Ω calibration jig defined in **Annex C.4**.

a) The insertion loss should be within the limits shown in **Annex C.3 Table 28**. The empirically established performance specifications for bulk current injection probes, driven in the CW mode are presented in **Annex C.3 Table 28**. These specifications are based on normal drive conditions in which probe cores are NOT driven into magnetic saturation. Test engineers are cautioned to ensure that measurements are NOT taken under core saturation conditions, during either calibration or equipment testing.

b) The probes shall be capable of delivering the jig currents shown in **Figure 19**.

A.2.4 Test Method

The test method has two main elements:

a) Calibration of the current injection probes, which must be done prior to each equipment test or series of consecutive tests detailed in **Clause A.2.5**.

b) The equipment test detailed in **Clause A 2.6**.

NOTE Modulation requirements are specified in **Clause 6.19**.

NOTE 2 The injection probes required for this test are designed to operate in the linear portion of their characteristics for the levels stipulated. If non-linear effects are observed during calibration, i.e. if a 1 dB increase in forward power does not produce a corresponding 1 dB increase in the current flowing in the jig, then the power amplifier or the injection probe is approaching saturation. If this effect is observed then non-recoverable damage may occur to the probe and investigative action must be taken.

A.2.5 Calibration

The following calibration procedure shall be performed prior to the equipment test(s) using the same test equipment layout and probes as will be used for those tests. The injection probe shall be installed in the 100 Ω calibration jig described in **Annex C Clause C.4**. The calibration jig shall be terminated in a 50 Ω, 50 W (minimum) RF coaxial load at one end and by a 50 Ω measuring system (spectrum analyser or RF voltmeter) at the other. A 20 dB power attenuator of 50 W minimum rating will be required to protect the input of the measuring system. The VSWR of the terminations at both ends of the calibration jig shall be less than 1.2:1 over the frequency range of the test. The injection probe is fed with power from the signal source via the power amplifier. The limits specified for this test method are in terms of current induced in the calibration jig.

The test signal supplied to the injection probe shall be increased until the voltmeter or spectrum analyser indicates that the level of current shown in the limit curve is flowing in the calibration jig. The forward power flow to the probe shall be recorded. These measurements are to be made over the frequency range 50 kHz to 400 MHz at sufficient intervals to ensure that amplitude variations are less than 1 dB between each measurement point.

The calibration curves shall be shown in the test report. The forward powers to the current injection probes to give the level of current shall become the `test level' for the equipment test.

NOTE This procedure needs to be repeated for every modulation applied.

A.2.6 Equipment Test

This test may be applied to whole cable looms or individual conductors, those to be tested being defined in the equipment test plan.

As a minimum requirement, the injection probe shall be connected around the complete cable loom and subsequently around any branches of that loom. Wherever practical the current monitor probe shall be connected around the complete cable loom 50 mm from the connector, in cases where this is not possible the monitor position shall be noted in the test report. If the overall length of the connector and backshell exceeds 50 mm, the monitor probe shall be placed as close to the connector's backshell as possible. This may not always be possible where harnesses are integral to items of clothing, under these conditions record probe position.

The current injection probe shall be fitted around the loom or conductor under test such that the separation to the monitor probe is 50 mm. Where the injection probe is placed around cable loom branches, the monitor probe shall be retained at the position 50 mm from the connector.

Radio frequency power applied to the injection probe shall be swept over the test frequency range and the parameters of induced current and forward power recorded. Recordings are required at the test level if no malfunctions occur or at the threshold condition if malfunctions do occur. Care must be taken not to overheat the cable under test as the injection probe reaches a high temperature with prolonged excitation. To avoid damage to the EUT wiring the induced current shall be limited to the values shown in **Table 12**. The EUT is deemed to have passed the test criterion if no malfunction occurs at the induced current levels shown in **Table 12** before the forward power levels required for the test assessment are reached.

Table 12 Limits for Induced Current on Man Worn, Man Portable EUT Wiring

Frequency Range (MHz)	Maximum induced current levels (A)
0.05 - 2.0	0.4
2.0 - 400	2.0

At frequencies where the test sample is susceptible, the signal amplitude shall be reduced until a threshold of susceptibility is determined. Check for hysteresis in signal amplitudes by decreasing and then increasing through the susceptibility threshold. The lower of the two values shall be recorded.

A.2.7 Limits

The limits in terms of current in the calibration jig are shown in **Figure 19** for Man Worn, Man Portable Land Based Equipment.

NOTE The limits are in peak values and apply to each of the modulation characteristics specified in **Clause 6.19**.

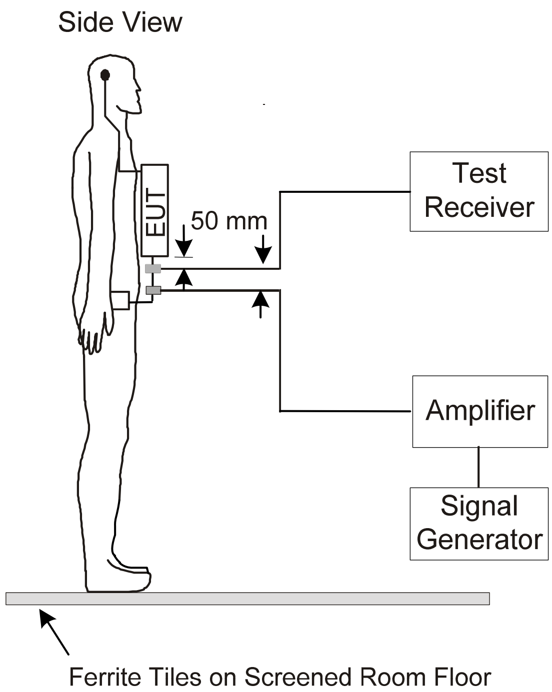


Figure 17 DCS02.A – Typical Test Configuration for Man Worn Scenario

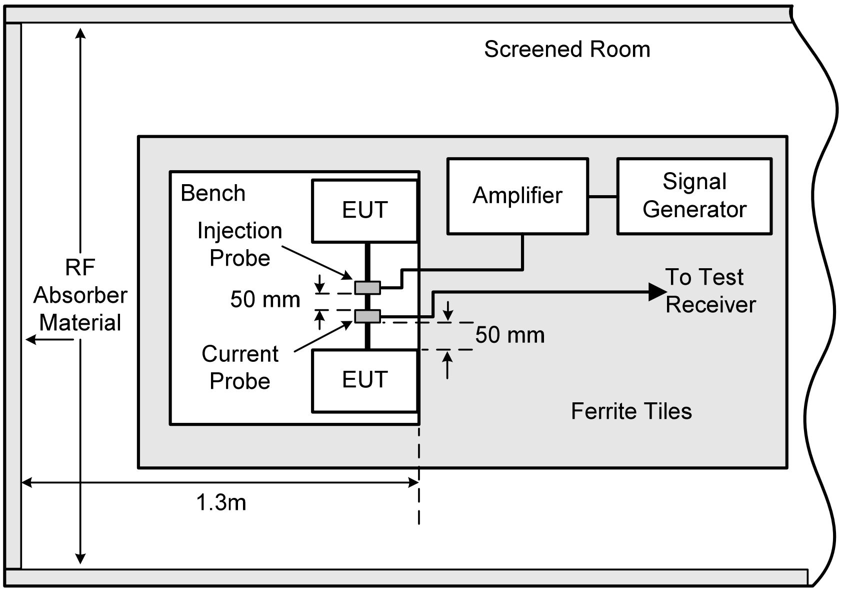


Figure 18 DCS02.A – A Typical Test Configuration for Man Portable Scenario

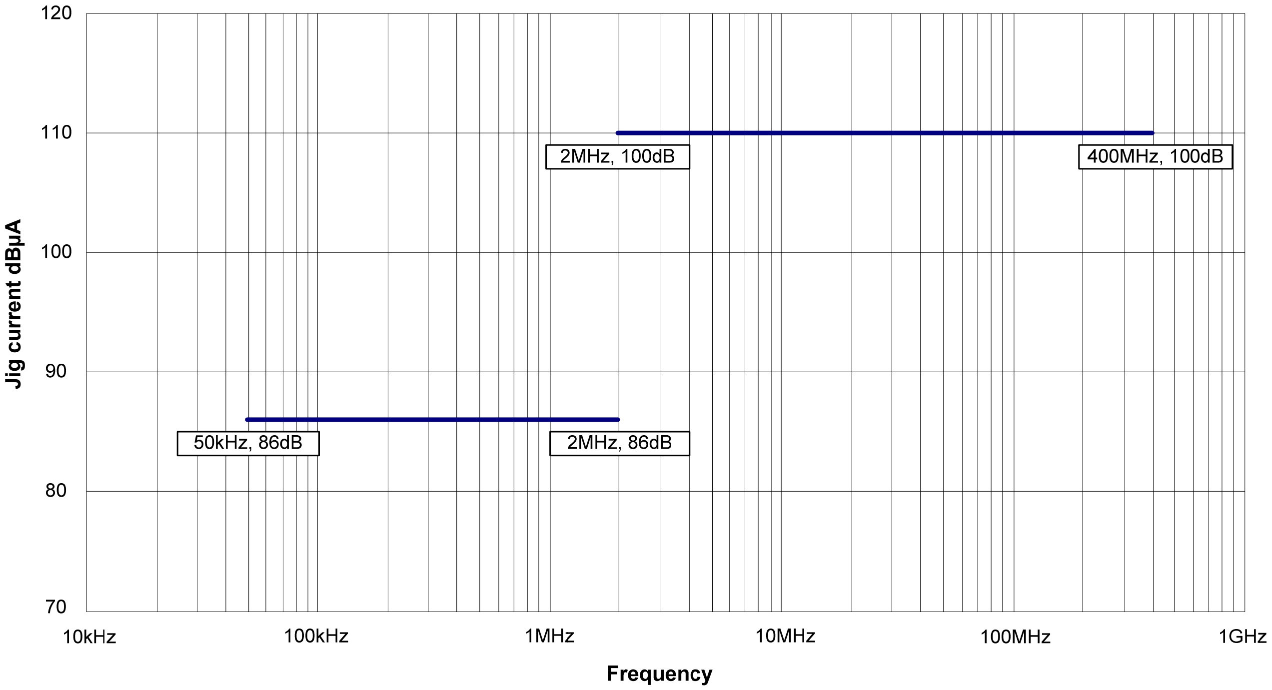


Figure 19 DCS02.A – Limits in Terms of Current to be Induced in Calibration Jig for Man Worn, Man Portable Land Based Equipment

A.3 DCS10.A Electro Static Discharge (ESD)

A.3.1 Purpose

See **Clause 9.13** for all details relating to this test.

A.4 DRE01.A Radiated Emissions E Field 88 MHz – 18 GHz

A.4.1 Purpose

The purpose of this test is to confirm that the E Field emissions have been controlled to the required limits to ensure that the performance of the most sensitive equipment (communications receivers etc.) is not impaired.

A.4.2 Applicability

This test is applied to the EUT, and its connecting harness.

Transmissions from antennas are not subject to the limit of this test but are subject to the performance specification requirements. Equipments for test which are normally connected to antennas shall for this test be fitted with a screened dummy antenna where possible and be subject to the limits of this test. The limit at the fundamental frequency of transmission may be relaxed at the discretion of the Project Manager.

Reference should also be made to **Clause 9.15**.

A.4.3 Test Layout

Typical EUT test layouts are shown in **Figures 20** to **25**. Reference must also be made to **Clauses 6.7**, **6.8** and **6.12**.

A.4.4 Test Method

The radiated emissions are monitored using the specified antennas for each mode defined in the Test Plan. See **Part 1 Clause 10** of this Standard. For small test samples the monitoring antennas shall be positioned opposite the test sample. Reference to **Clauses 6.10**, **6.15**, **6.1**6 and **6.22** is also required.

Bi-conical, Log-Periodic or Double Ridge Waveguides and Horn antennas are mounted at a height of 1 m from the screened room floor on a non-conductive antenna stand and 1 metre from the closest face of the EUT.

For man worn equipments the EUT is mounted on a manikin in a position that mimics the normal layout on the man as close as is practically possible. The manikin itself stands on the floor of the screened room. For man portable equipment the EUT is sited on a non-conducting bench above the ferrite tiles.

A.4.5 Limits

The recommended limit and frequency range is shown in **Figure 26** for Man Worn, Man Portable Land Based Equipment.

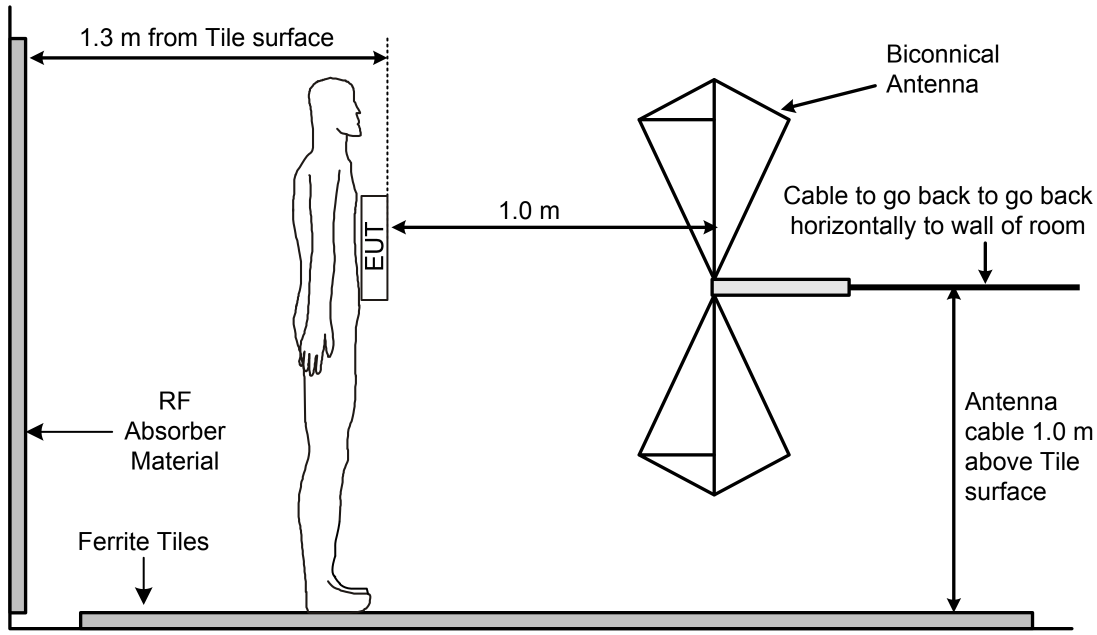


Figure 20 DRE01.A – Typical Test Configuration for Man Worn Scenario (88 MHz - 300 MHz)

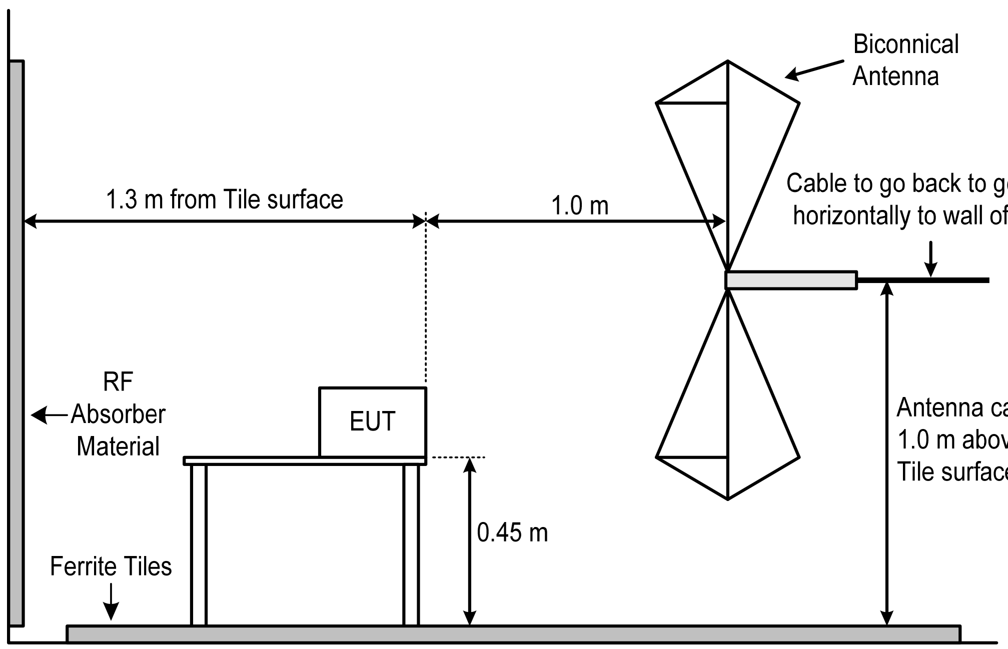
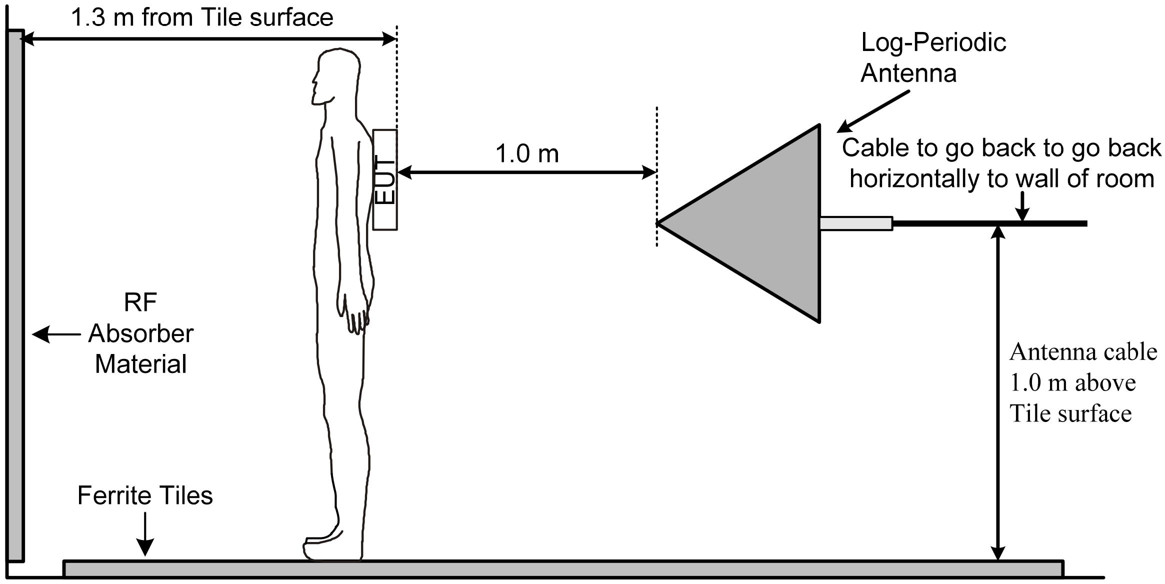
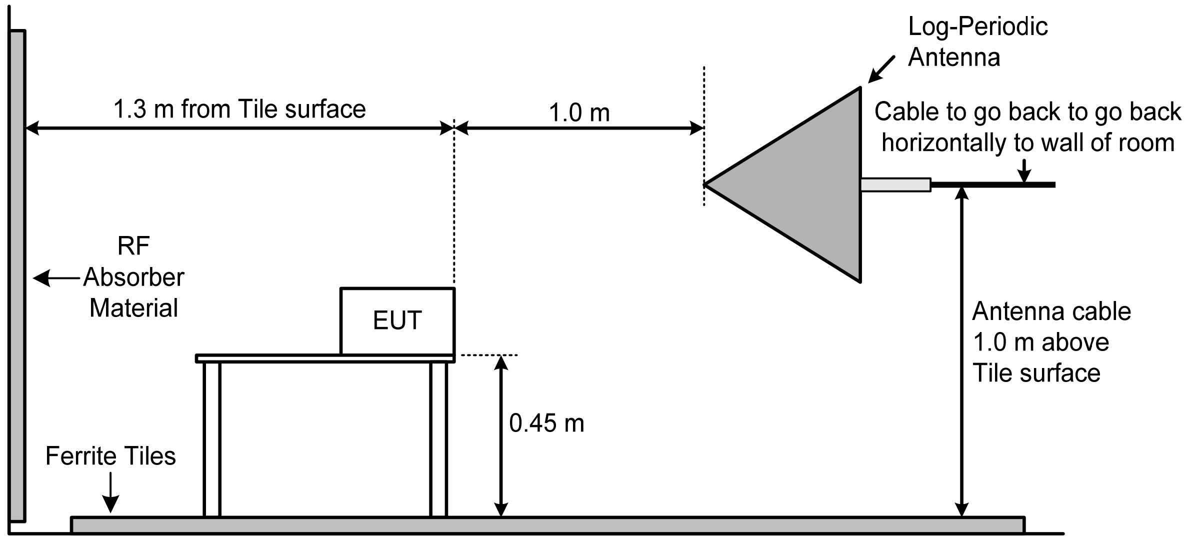


Figure 21 DRE01.A – Typical Test Configuration for Man Portable Scenario (88 MHz - 300 MHz)



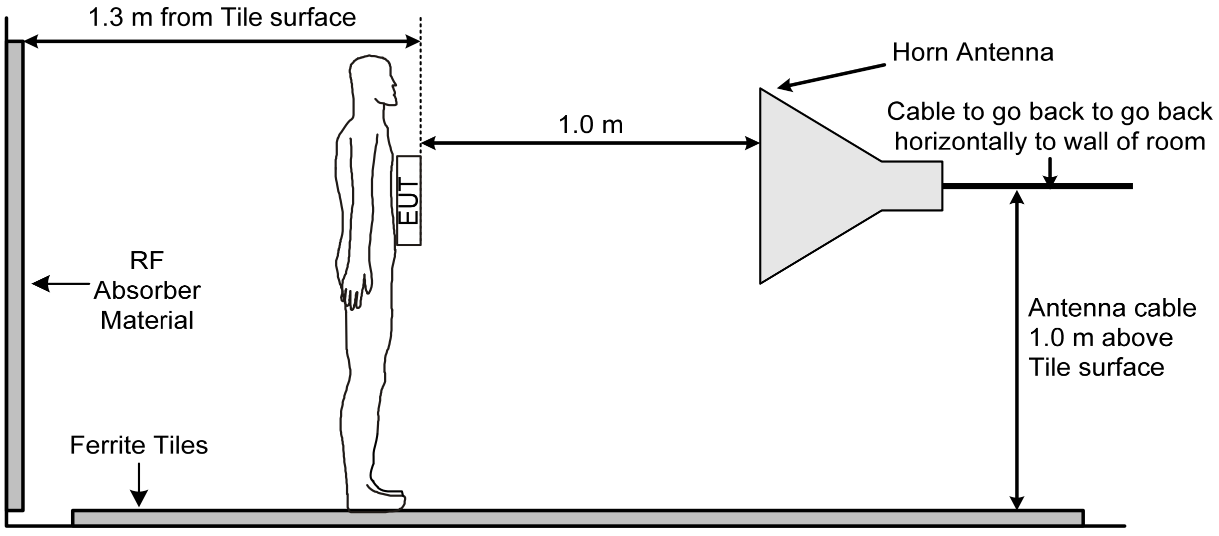
NOTE A Double Ridge Wave Guide Antenna may also be used

Figure 22 DRE01.A – Typical Test Configuration for Man Worn Scenario (200 MHz - 1 GHz)



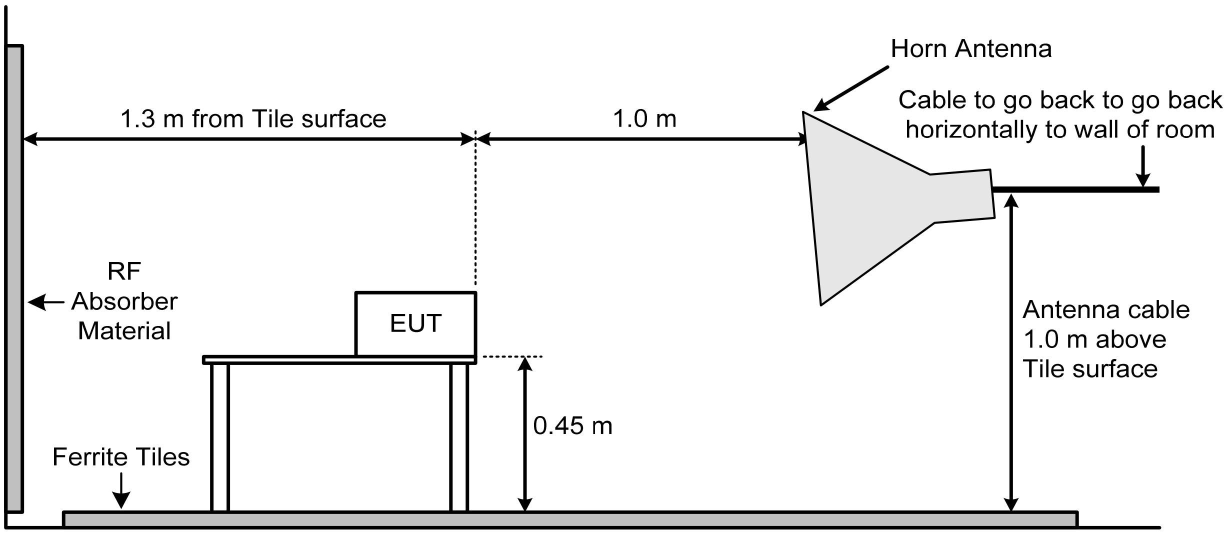
NOTE A Double Ridge Wave Guide Antenna may also be used

Figure 23 DRE01.A – Typical Test Configuration for Man Portable Scenario (200 MHz - 1 GHz)



NOTE The Horn antenna may need to be angled upwards or downwards depending on position of EUT

Figure 24 DRE01.A – Typical Test Configuration for Man Worn Scenario (1 GH - 18 GHz)



NOTE The Horn antenna may need to be angled downwards depending on size of EUT

Figure 25 DRE01.A – Typical Test Configuration for Man Portable Scenario (1 GHz - 18 GHz)

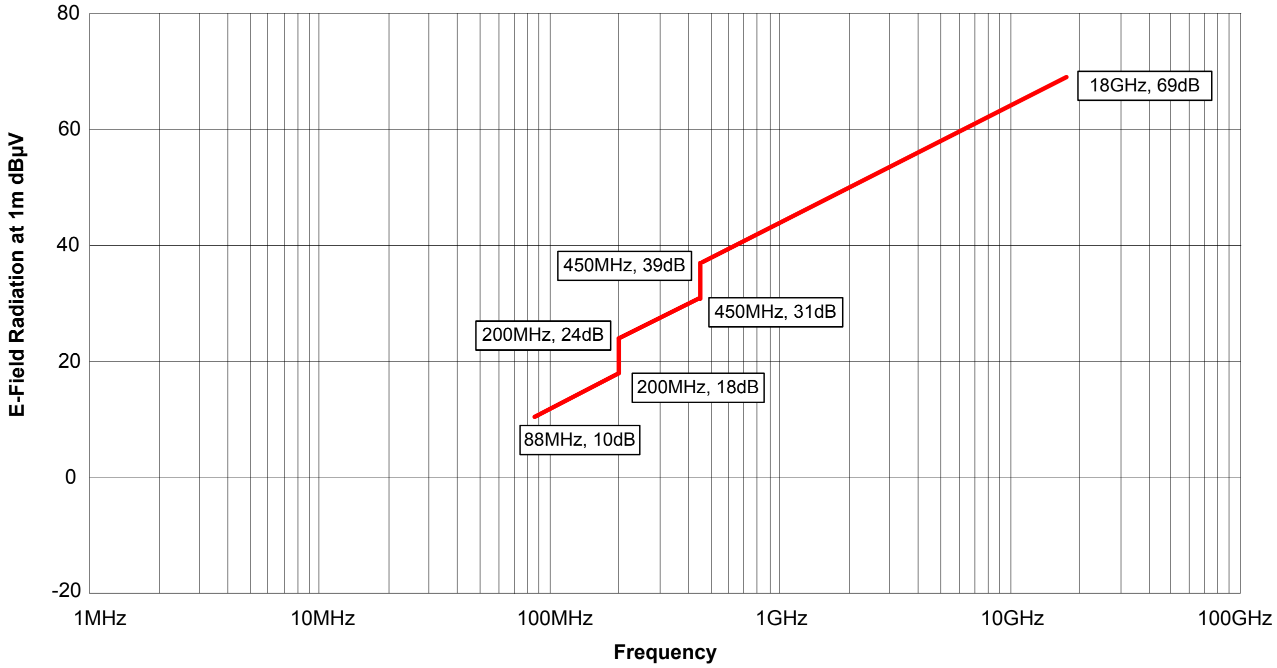


Figure 26 DRE01.A – Class A Limit for Man Worn, Man Portable Land Based Equipment

A.5 DRE02.A Radiated Emissions Magnetic (H) Field 500 Hz – 250 kHz

A.5.1 Purpose

In order to achieve compatibility between modern equipments operating together, limitations on emissions and control of susceptibility must be clearly defined. The levels of H field related to both emissions and susceptibility have been formulated from composite measurements taken within the confines of military platforms and an average level of emissions established.

Since these levels are realistic, equipment should be designed to operate satisfactorily in this environment. It may be found impracticable to meet the emission limits for some equipment in which case if the distance is established at which the amplitude limit level is met for the equipment under test, segregation by that distance from other equipment or cabling may offer a realistic alternative.

The frequency range and limit has been derived from the necessity to protect against intra-equipment operability.

A.5.2 Applicability

All EUT units and associated cables are subject to this test.

Reference should also be made to **Clause 9.16**.

A.5.3 Test Equipment

The search coil shall be electro-statically screened and terminated on a coaxial connector with the screen connected to the screen of the connector.

The location and orientation of the coil with respect to the EUT is shown in **Figure 6**.

A.5.4 Test Layout

Typical EUT test layouts are shown in **Figures 27** and **28** but reference to **Clauses 6.7**, **6.8** and **6.12** is also required.

NOTE Ferrite Tiles on the floor of the screen room are optional for this test.

A.5.5 Test Method

A field measuring device in the form of a multi-turn loop shall be placed 70 mm from each face of the EUT and its associated cables. The plane of the loop shall be parallel to each face of the test sample and a search made for the maximum emission level at each measurement frequency. Measurements are made with the plane of the loop both parallel and at right-angles to each face of the test sample and along the associated cable harnesses. Particular attention should be given to the critical frequencies of the test sample.

In the event of the unit under test exceeding the specified limit at 70 mm, the distance and position at which compliance is achieved shall be declared.

Reference to **Clauses 6.10**, **6.15**, **6.16** and **6.22** is also required.

NOTE Where a physical dimension of the EUT is less than 70 mm it is only necessary to measure one of the opposing sides. If one of man worn EUT dimensions is greater than 70 mm, then the test may need to be performed on the bench since it will not be possible to access the opposing side of the EUT due to the manikin.

A.5.6 Limits

Limit for Man Worn, Man Portable Land Based Equipment are shown in **Figure 29**.

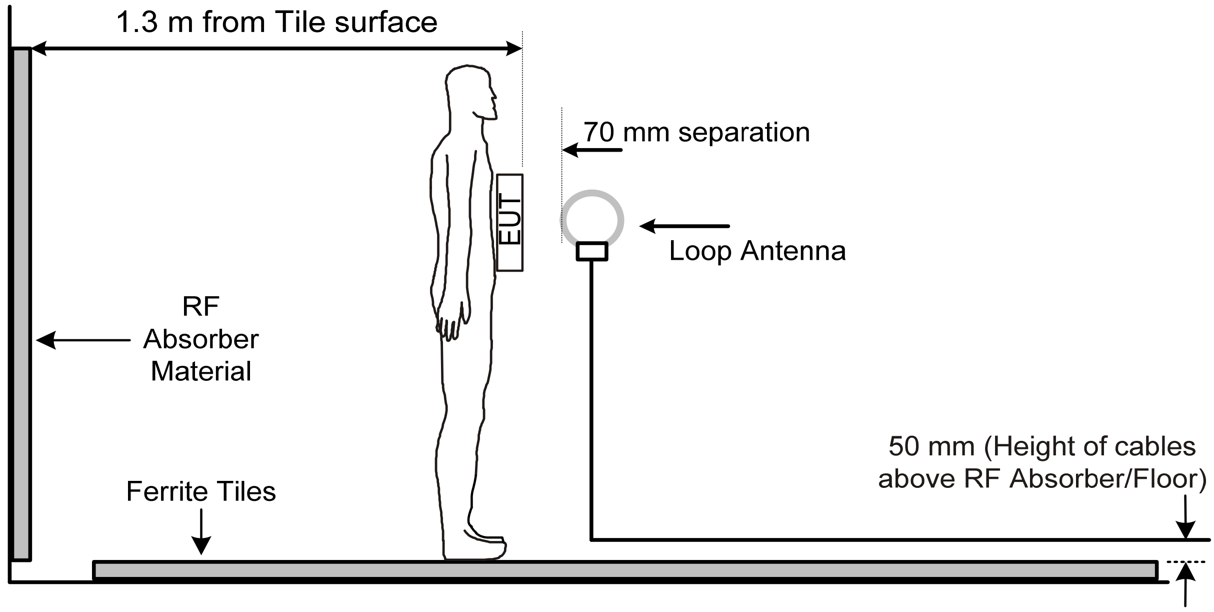


Figure 27 DRE02.A – Typical Test Configuration for Man Worn Scenario

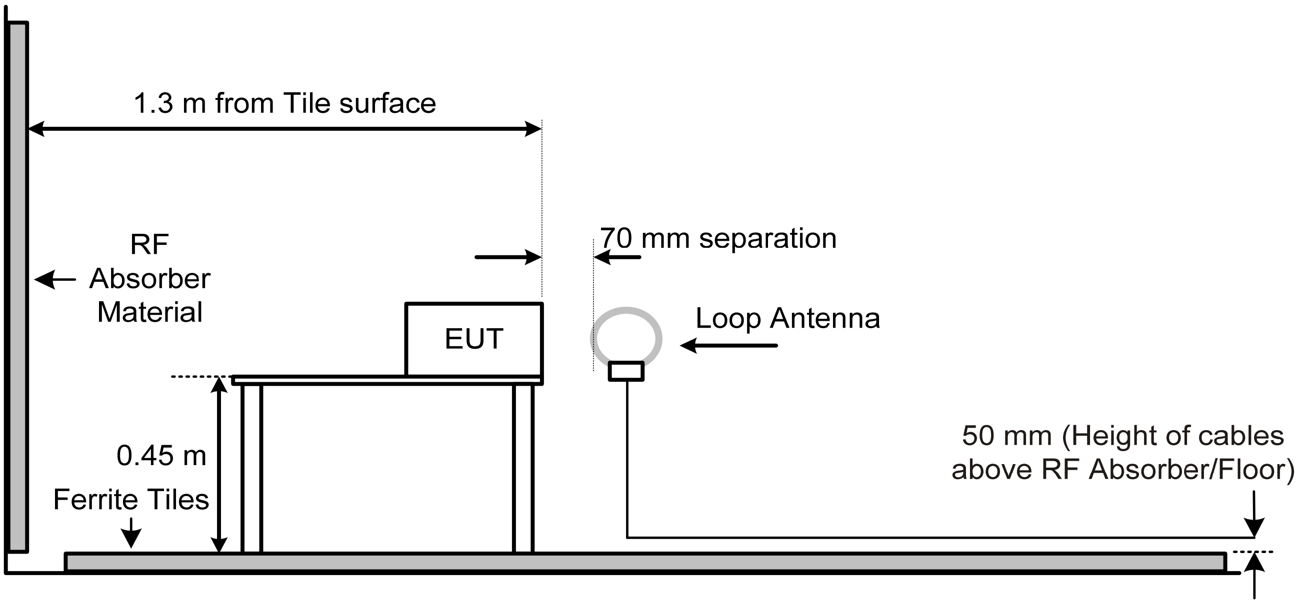


Figure 28 DRE02.A – Typical Test Configuration for Man Portable Scenario

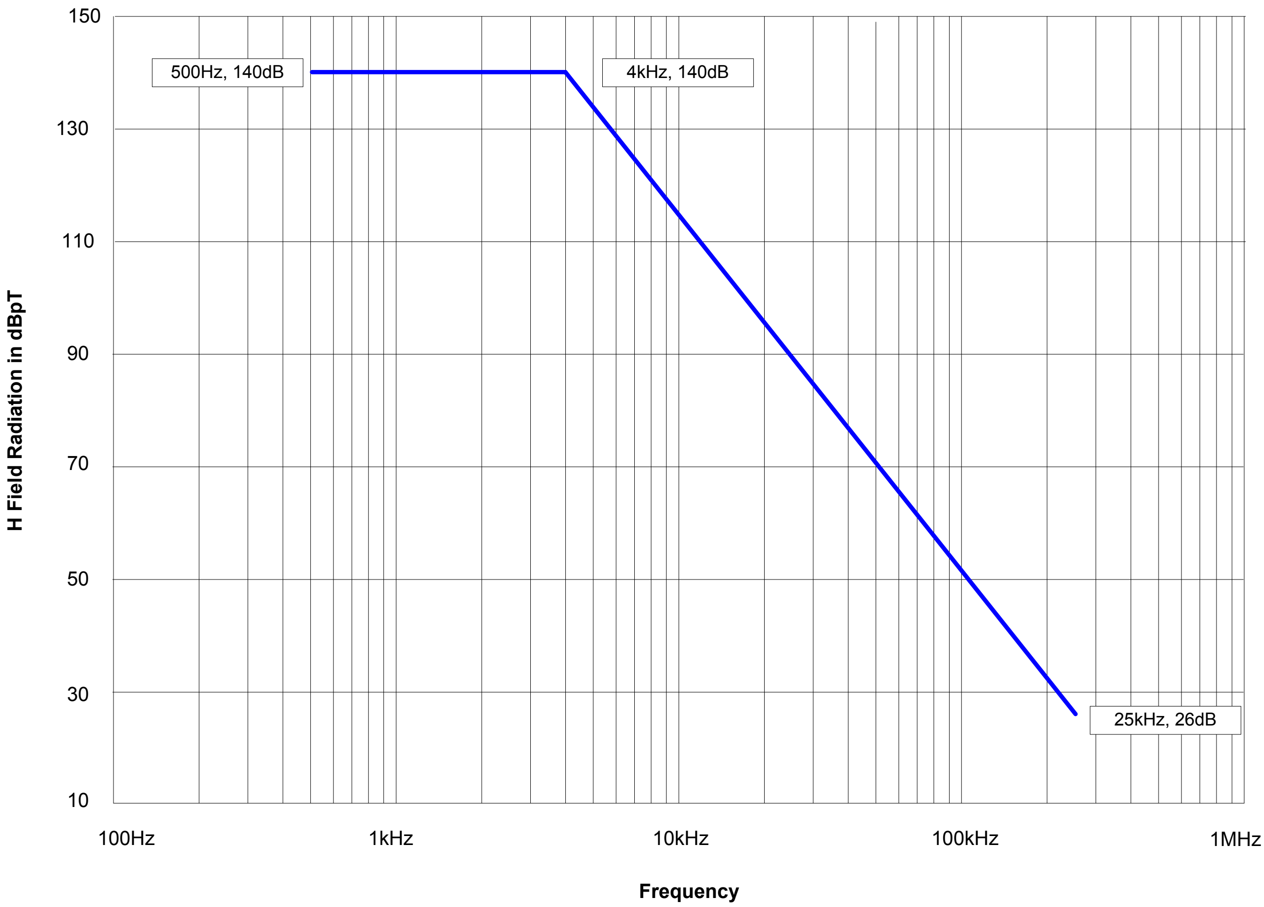


Figure 29 DRE02.A – Limit for Man Worn, Man Portable Land Based Equipment

A.6 DRE03.A Radiated Emissions Electric (E) Field (Land Services) Tuned Antenna 1.6 MHz – 88 MHz

A.6.1 Purpose

The purpose of this test is to confirm that the E field emissions have been controlled to the required limit, so that the receive performance of radio communications equipment in the nearby operational environment is not impaired. This test method employs both CNR tuned and broadband antenna systems, which are significantly more sensitive than the broadband antennas used in Test Method DRE01.A.

A.6.2 Applicability

This test is applied to an EUT and its associated harnesses when it is co-located with any Army equipment and with a receiving antenna operating in the frequency range 1.6 MHz to 88 MHz deployed in the man worn or man portable scenario.

Transmissions from antennas are not subject to the limits of this test but are subject to the performance specification requirements. An EUT, which is normally connected to an antenna, shall be fitted with it for this test. The limit at the fundamental frequency of transmission may be relaxed at the discretion of the Project Manager.

Reference should also be made to **Clause 9.17**.

A.6.3 Test Equipment

The antenna system(s) to be used for measuring emissions in this test shall have similar sensitivities to those deployed operationally near the EUT. They will therefore usually incorporate automatic tuning to each operational frequency. More than one antenna system may be needed to cover the required frequency range. It is the contractor's responsibility to ensure the availability of these antenna systems when required for testing purposes.

The output voltage from the test antenna system shall be measured across a nominal impedance of 50Ω.

To achieve the required sensitivity bandwidths of 1 kHz in the frequency range 1.6 MHz to 30 MHz and 10 kHz in the frequency range 30 MHz to 88 MHz shall be used. These bandwidths shall also be used where the Project Manager agrees any relaxation or tightening on the specification limit. All testing shall be performed using a normal peak detector.

A.6.4 Test Layout

Typical test layouts are shown in **Figures 30** to **33**. Reference must be made to **Clauses 6.7**, **6.8** and **6.12**.

NOTE It may not be possible to perform this test in a small screened room due to the length of the whip antennas required. See **Annex C Clause C.7.4**.

A.6.5 Test Method

A.6.5.1 Automatic Tuning

Where a CNR HF tuning unit is part of the operational fit, an AAMTU (Automatic Antenna Matching and Tuning Unit) can be fitted in its place; with appropriate test equipment, the limitations of manually tuning a Clansman Turf (Tuner Unit RF) are avoided and swept measurements are possible even over the HF band.

Manual measurement techniques can be used only for indication purposes and are deemed non-compliant with the requirements of this specification.

Before testing commences a check shall be made for correct tuning of the measuring system. This is performed at the extremities and centre of the tuneable frequency range. A signal generator is connected to a calibrated antenna at a distance of 1m from the antenna and a small signal applied, the signal propagated should be within 2 dB of the specified limit.

If the automated measuring system fails to tune at any frequency then the test engineer must either perform another automatic sweep over that part of the frequency range or check using a manual technique that no emissions are present.

A.6.5.2 CNR HF Frequency Range (1.6 MHz to 30 MHz)

The test technique requires a 2.4 m whip antenna and an AAMTU and is equally suitable for man worn or man portable applications.

The antenna shall be set up at a separation of 1 m from the face of the EUT in configurations similar to those shown in **Figures 30** and **31**. The HF antenna base is mounted on the floor of the screened room and connected to the AAMTU via its short HT lead a coaxial cable connects the AAMTU to the rest of the receiving system. Both the antenna base and the AAMTU shall be bonded to the floor of the screened room.

A.6.5.3 VHF Frequency Range (30 MHz to 88 MHz)

The test technique allowed for in this annex requires a 2.4 m whip antenna and is equally suitable for man worn or man portable applications.

The antenna shall be set up at a separation of 0.1 m from the face of the EUT in configurations similar to those shown in **Figures 32** and **33** this is to achieve the required sensitivity. The VHF antenna base mounted on the floor of the screened room and connected to the receiving system. The antenna base shall be bonded to the floor of the screened room.

The manikin itself may need to be rotated about its vertical axis until a maximum amount of EUT and associated harnesses are facing the antenna, i.e. where an EUT is mounted on the back of the manikin this should be the side facing to the antenna. Where an EUT is sited across a large amount of the manikin’s body surface it may be necessary to make measurements in more than one position.

A.6.6 Limits

Limits for Man Worn, Man Portable Land Based Equipment are shown in **Figure 34**.

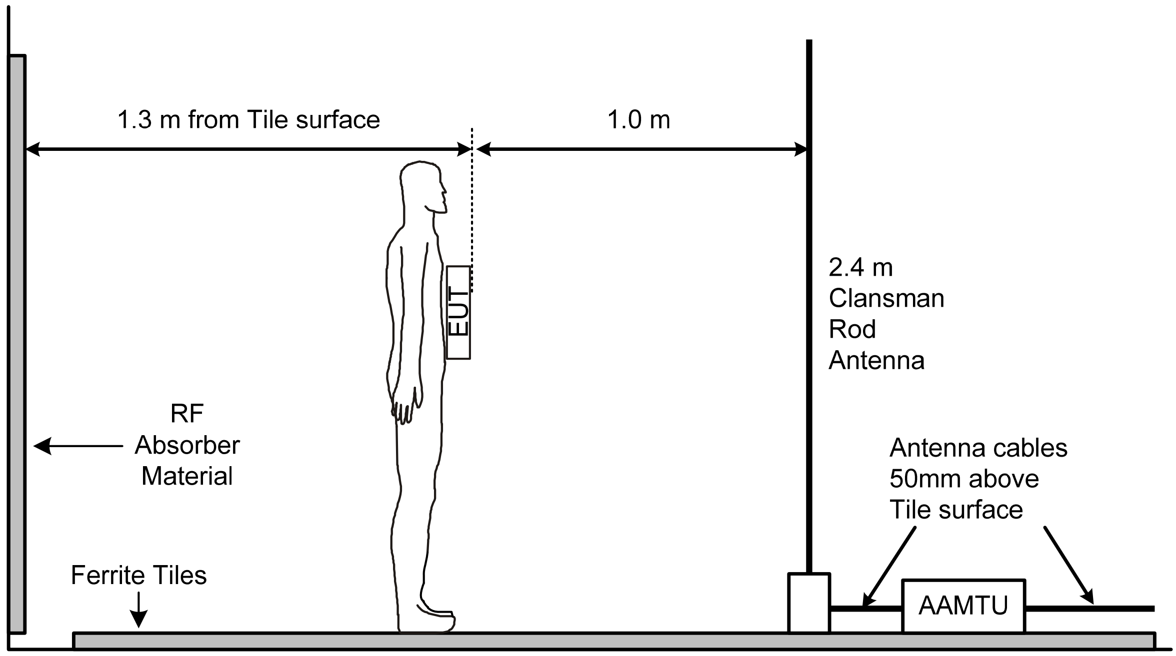


Figure 30 DRE03.A – Typical Test Configuration for Man Worn Scenario (1.6 MHz - 30 MHz)

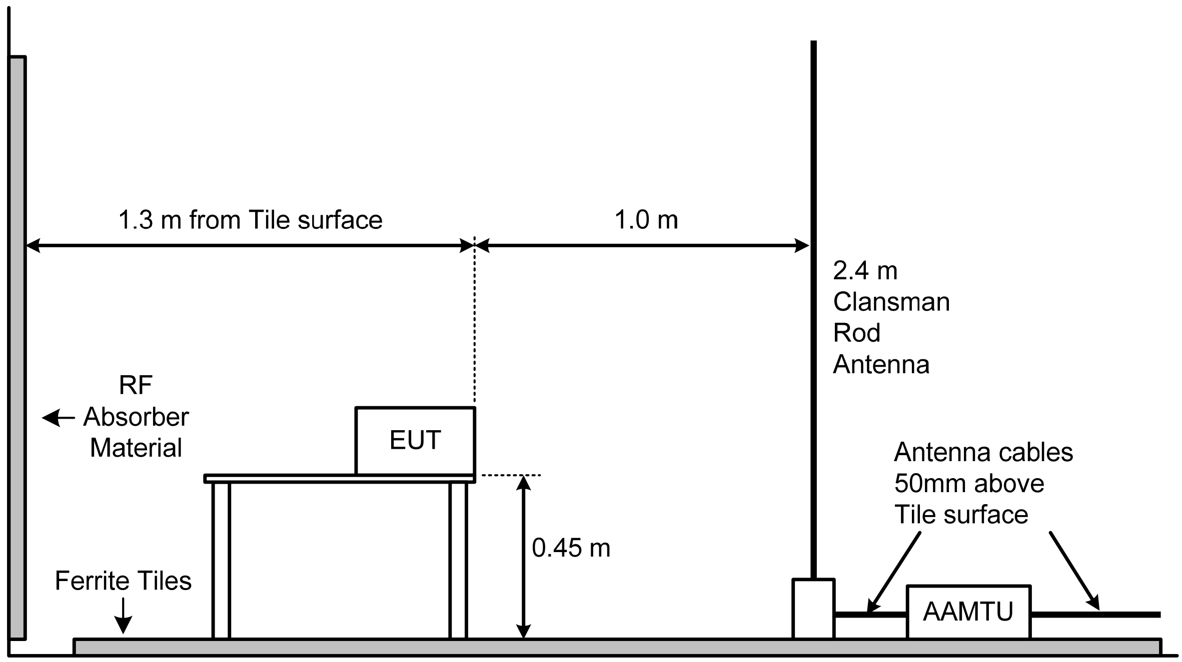


Figure 31 DRE03.A – Typical Test Configuration for Man Portable Scenario (1.6 MHz - 30 MHz)

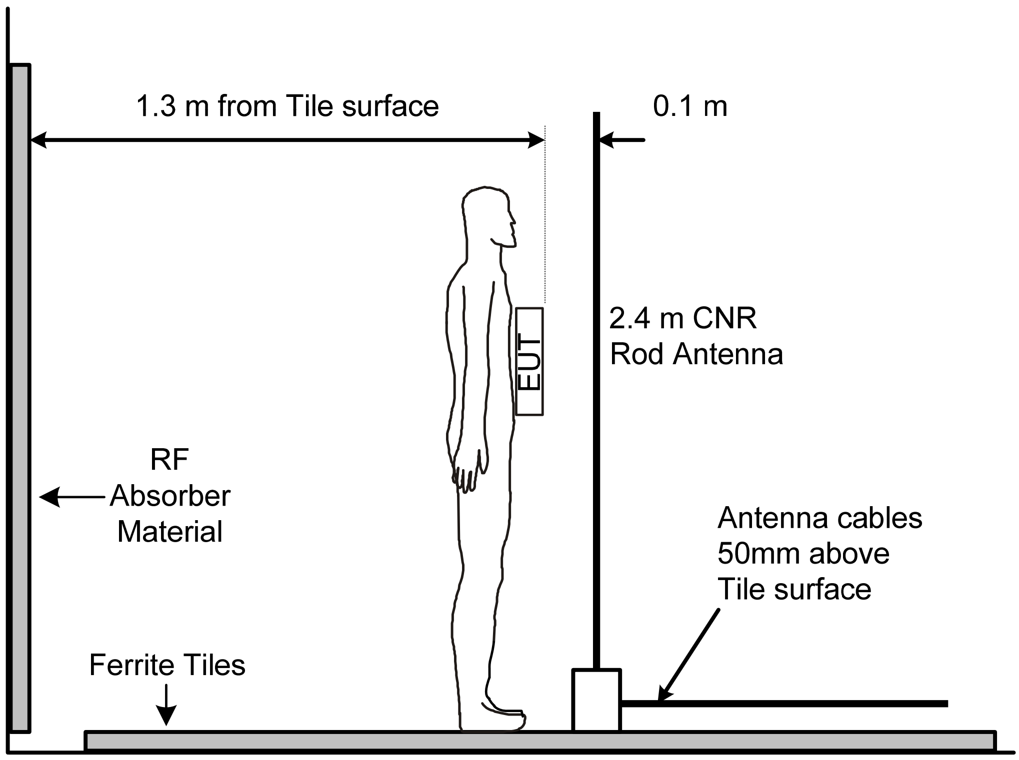


Figure 32 DRE03.A – Typical Test Configuration for Man Worn Scenario (30 MHz - 88 MHz)

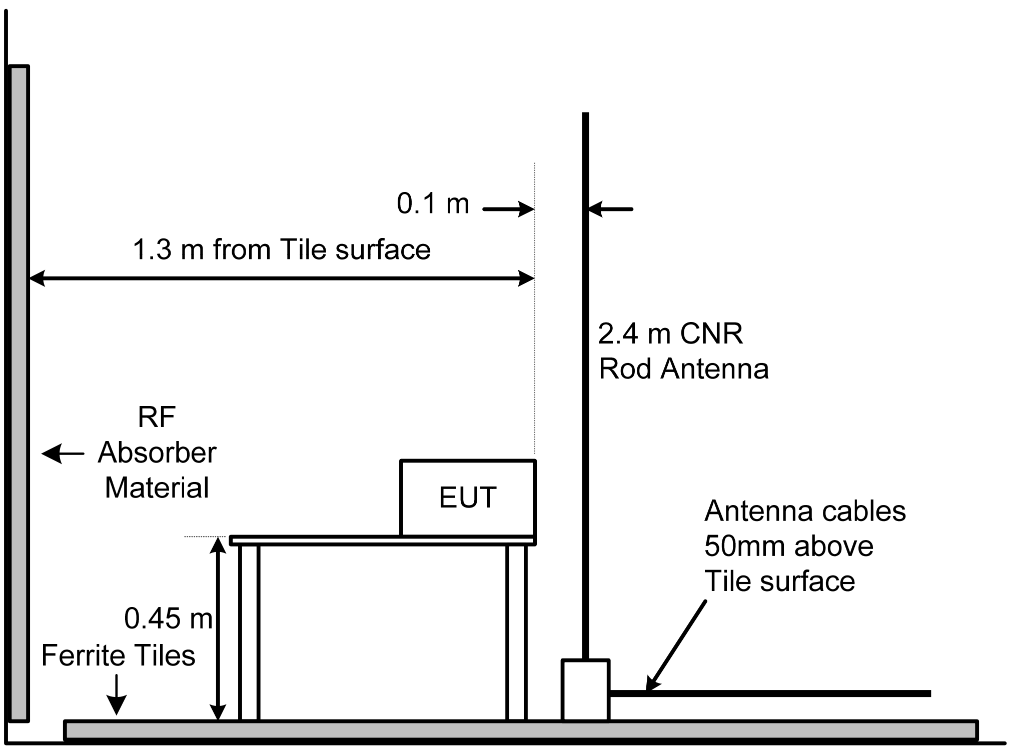


Figure 33 DRE03.A – Typical Test Configuration for Man Portable Scenario (30 MHz - 88 MHz)

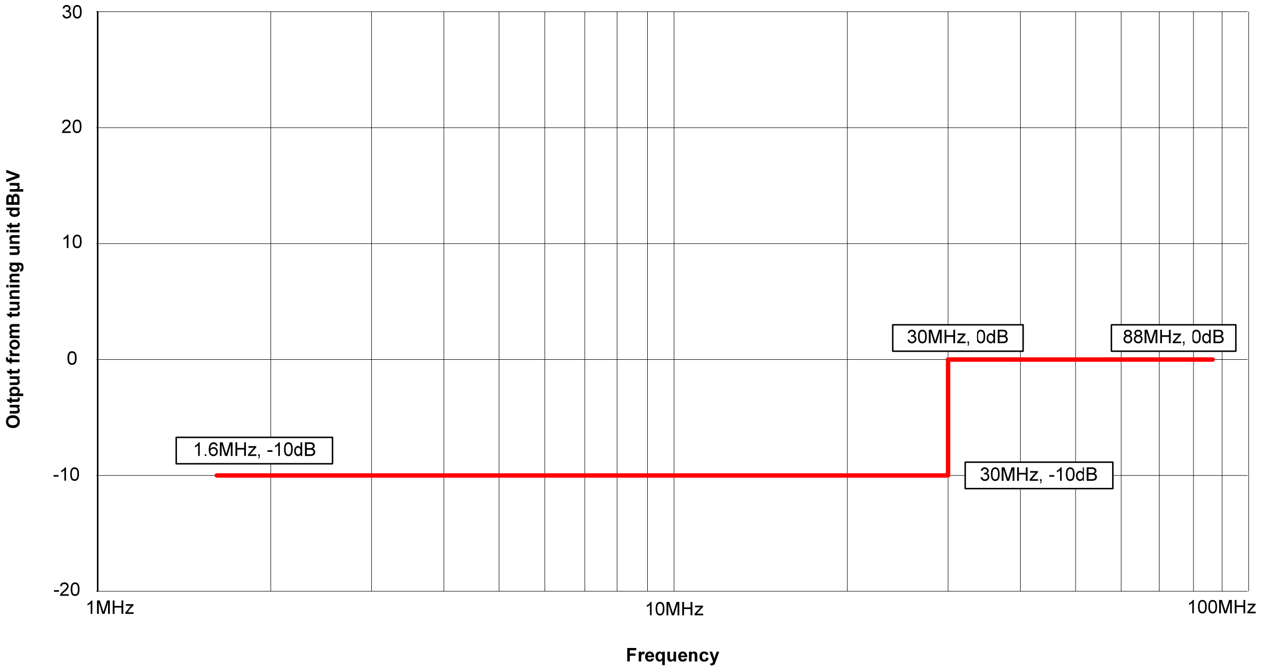


Figure 34 DRE03.A – Class A Limit for Man Worn, Man Portable Land Based Equipment 1.6 MHz - 88 MHz Peak Detector

A.7 DRS01.A Radiated Susceptibility Magnetic (H) Field 500 Hz – 100 kHz

A.7.1 Purpose

In order to achieve compatibility between modern equipments operating together limitations on emissions and susceptibility must be clearly defined. The levels of H Field related to both emissions and susceptibility have been derived from those already contained in other parts of this Standard.

Since these levels are realistic, equipment should be designed to operate satisfactorily in this environment. It may be found impracticable to meet the susceptibility requirements for some equipments in which case if the distance is established at which the amplitude limit level is met for the equipment under test, segregation by that distance from other equipment may offer a realistic alternative.

A.7.2 Applicability

All EUT units, i.e. boxes, cases or cabinets are subject to this test.

Reference should also be made to **Clause 9.18**.

A.7.3 H Field Calibration

The H field produced by the radiating loop during the test is equal to the H field received in a loop antenna (the loop antenna is specified in test method DRE02.A). The spacing between the centres of the loops is 50 mm and the loops must be on the same mechanical axis as shown in **Figure 35.** From this set-up the current required to produce the desired signal, at each frequency, is observed, this can be achieved by a suitable current measuring device (RMS ammeter, standard resistor and RMS voltmeter or a current probe and receiver). Reference to **Clauses 6.10**, **6.15**, **6.16** and **6.22** is required.

NOTE Where a 50 mm spacer forms part of the radiating loop it may be necessary to perform the calibration with the receiving loop on the opposite side of the one that has the spacer so that the correct separation distance is obtained.

A.7.4 Test Layout

Typical test layouts are shown in **Figures 36** and **37**. Reference to **Clauses 6.7**, **6.8** and **6.12** is also required. This test comprises two parts. The H field applied is first calibrated using a measuring loop antenna to produce the known current in the energized radiating loop, with respect to frequency. These levels of current are then applied to the radiating loop during the test.

NOTE Ferrite Tiles on the floor of the screen room are optional for this test.

A.7.5 Test Method

A circular radiating loop as defined in **Clause 6.22.9** shall be used. The energized loop shall be moved over each face of the equipment and any interconnecting harnesses under test at a constant spacing of 50 mm between the centre of the loop and the equipment face or harness while the equipment is being continuously monitored for malfunction. Particular attention should be given to the potentially critical frequencies of the EUT. In the event of the unit under test failing to meet the specified limits at a loop spacing of 50 mm, the distance at which compliance is achieved shall be recorded. The coil current should be as near sinusoidal as possible to avoid harmonic problems and adjusted to the prescribed level monitored by a suitable current measuring device. This current is defined by measuring the H-field see **Clause A.7.3.**

NOTE Where a physical dimension of the EUT is less than 50 mm it is only necessary to measure one of the opposing sides. If one of man worn EUT dimensions is greater than 50 mm, then the test may need to be performed on the bench since it will not be possible to access the opposing side of the EUT due to the manikin.

A.7.6 Limits

Limits for Man Worn Man Portable Land Based Equipment are shown in **Figure 38**.

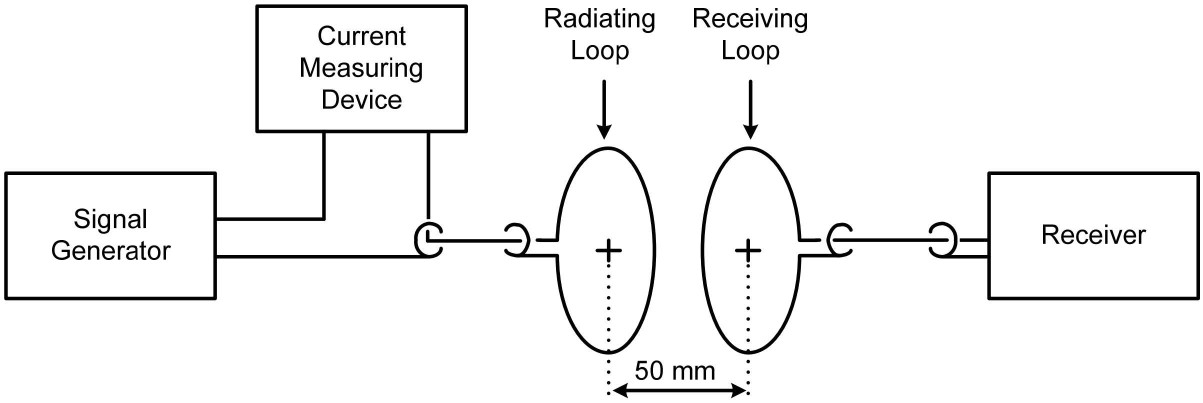


Figure 35 DRS01.A – Typical Arrangement of Equipment for Calibrating H Field Radiation

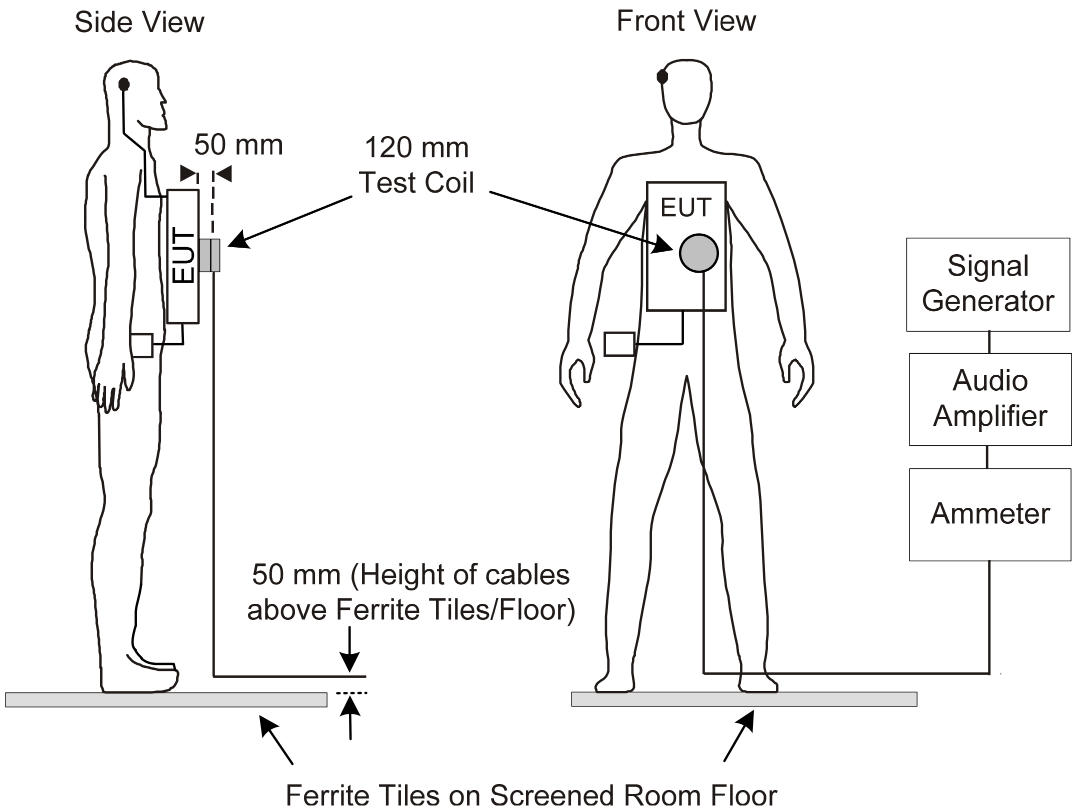


Figure 36 DRS01.A – Typical Test Configuration for Man Worn Scenario

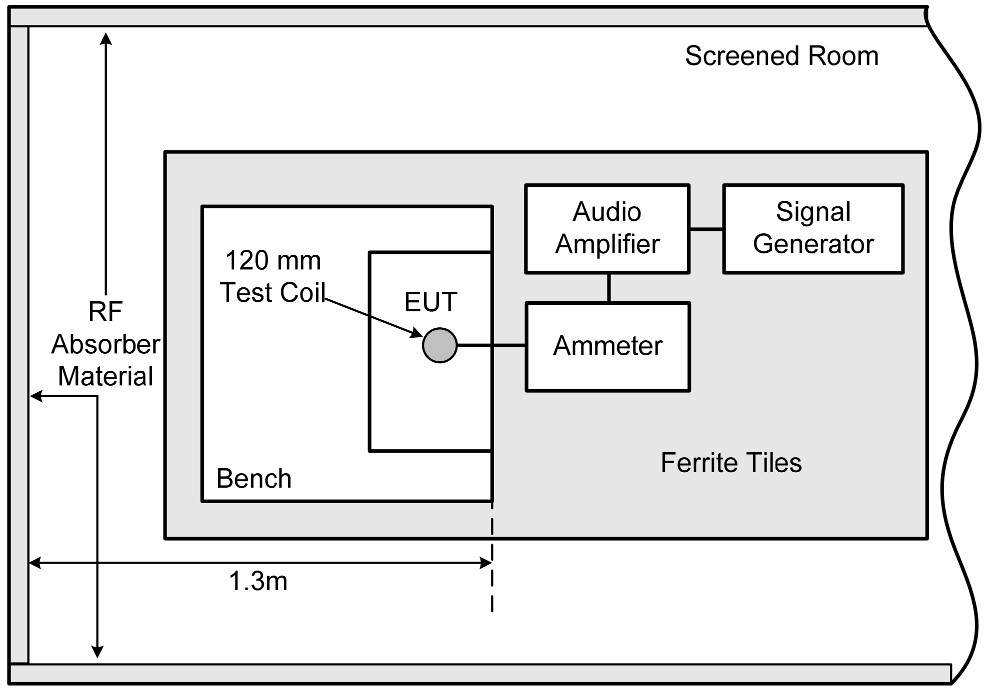


Figure 37 DRS01.A – Typical Test Configuration for Man Portable Scenario

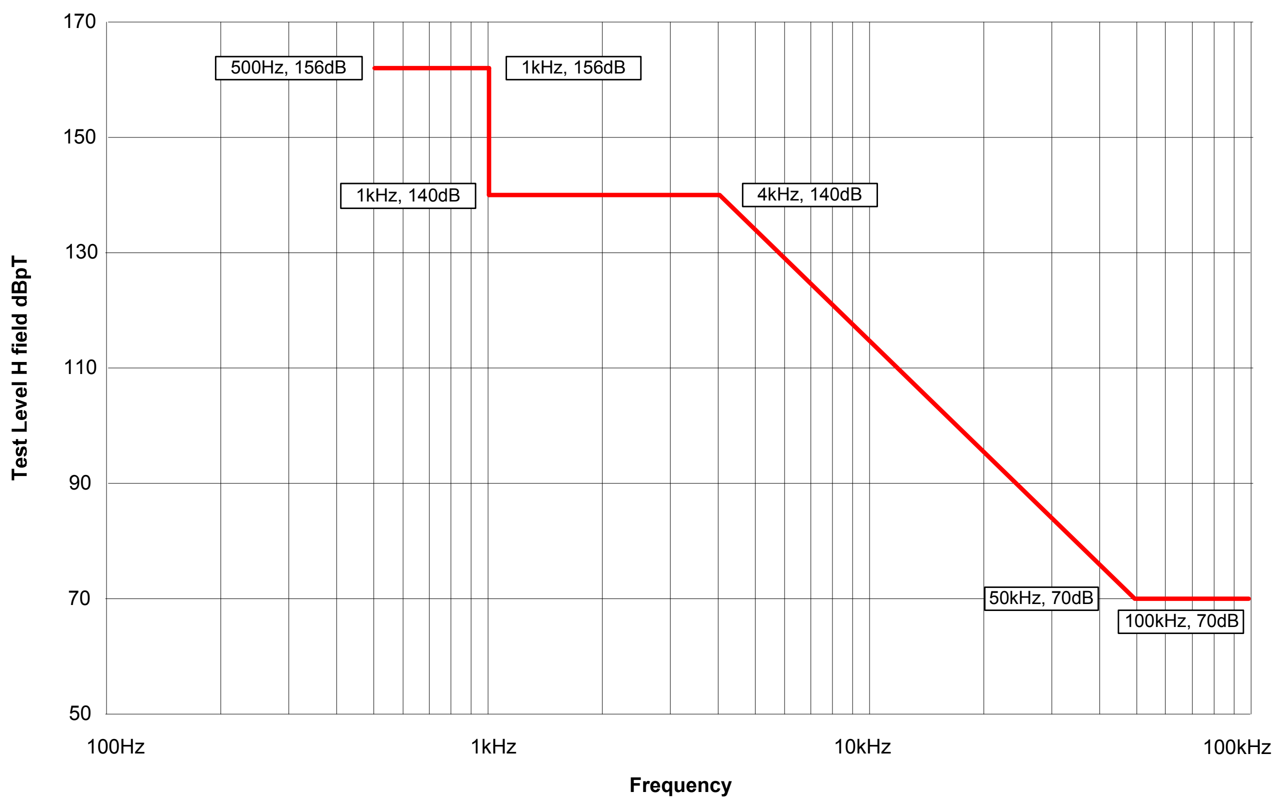


Figure 38 DRS01.A – Limit for Man Worn, Man Portable Land Based Equipment

A.8 DRS02.A Radiated Susceptibility Electric (E) Field 50 kHz – 18 GHz

A.8.1 Purpose

The purpose of this test is to confirm that the EUT will perform without malfunction when subject to high-level RF fields from transmitting sources.

A.8.2 Applicability

This test is applicable to the EUT together with its wiring harness.

Reference should also be made to **Clause 9.19**.

A.8.3 Test Layout

Typical layouts are shown in **Figures 39** to **44**. Reference to **Clauses 6.7**, **6.8** and **6.12** is also required.

A.8.4 Test Method

The specified transmitting antenna shall be energized so that field strengths in excess of the test limit are produced. If a malfunction occurs when sweeping through the frequency range then the signal strength shall be reduced to establish the threshold level.

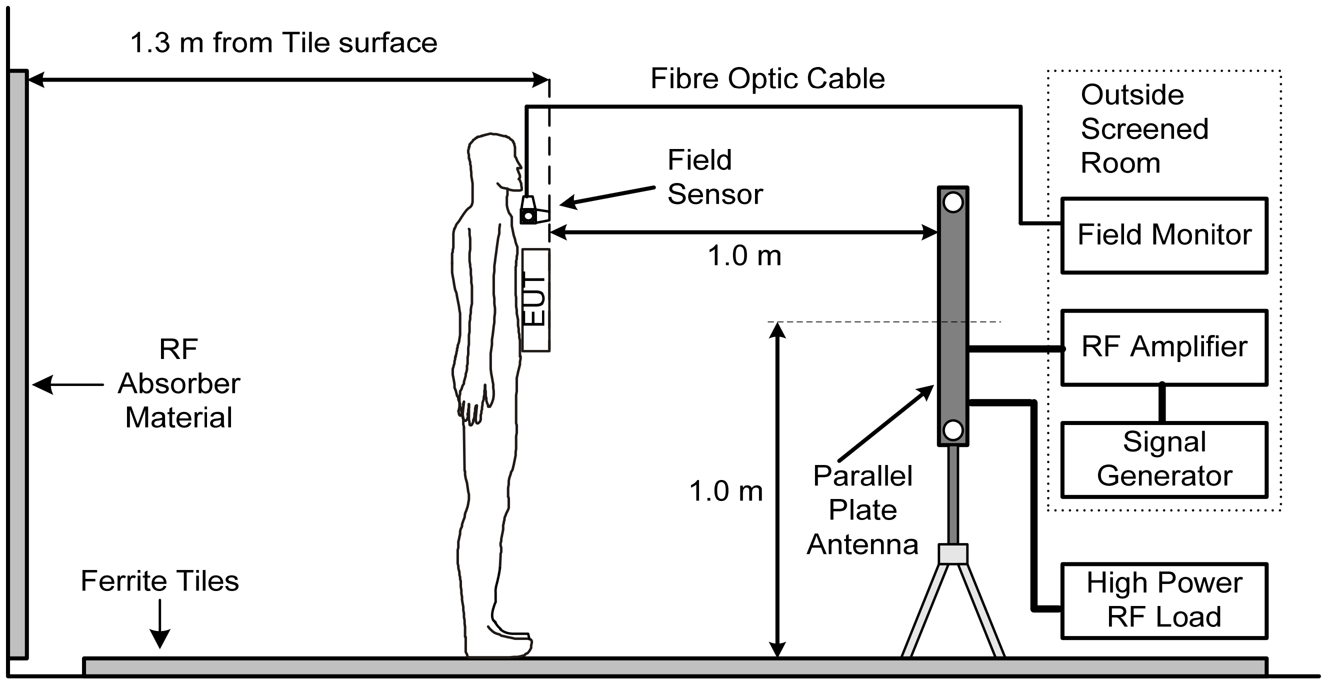
The RF field produced shall be monitored adjacent to the EUT. Reference to **Clauses 6.19**, **6.22** and **6.29** is required.

At frequencies above 1 GHz discontinuities in the screening of the EUT shall be presented to the transmitting antenna directly, i.e. turn the EUT so that numerical displays, CRT screens, LRU connectors etc. are normal to the main beam of energy from the transmitter antenna. The illuminating beam from horn antennas is very narrow and the EUT may require a number of antenna positions to illuminate the whole EUT.

A.8.5 Limits

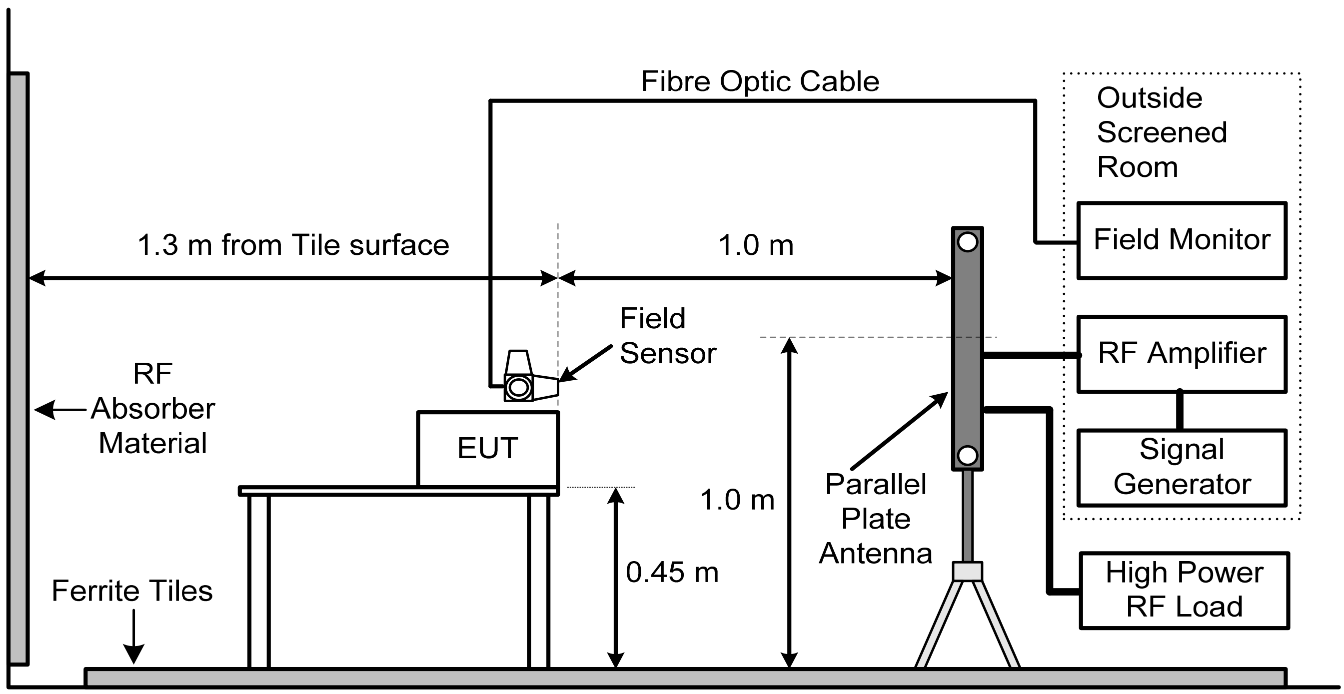
Limits are shown in **Figure 45** for Man Worn, Man Portable Land Based Equipment.

NOTE The limits are shown in peak values and apply to each of the modulation characteristics specified in **Clause 6.19**.



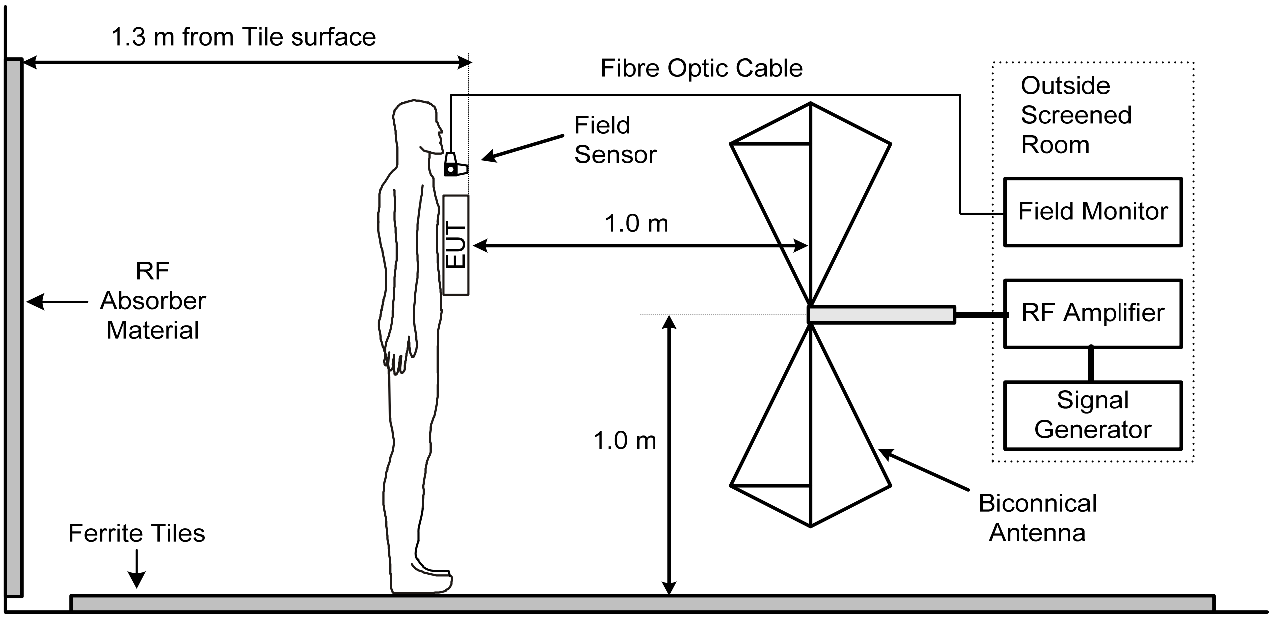
Note: Field Sensor should be placed 50 mm from the EUT

Figure 39 DRS02.A – Typical Test Configuration for Man Worn Scenario (50 kHz - 30 MHz)



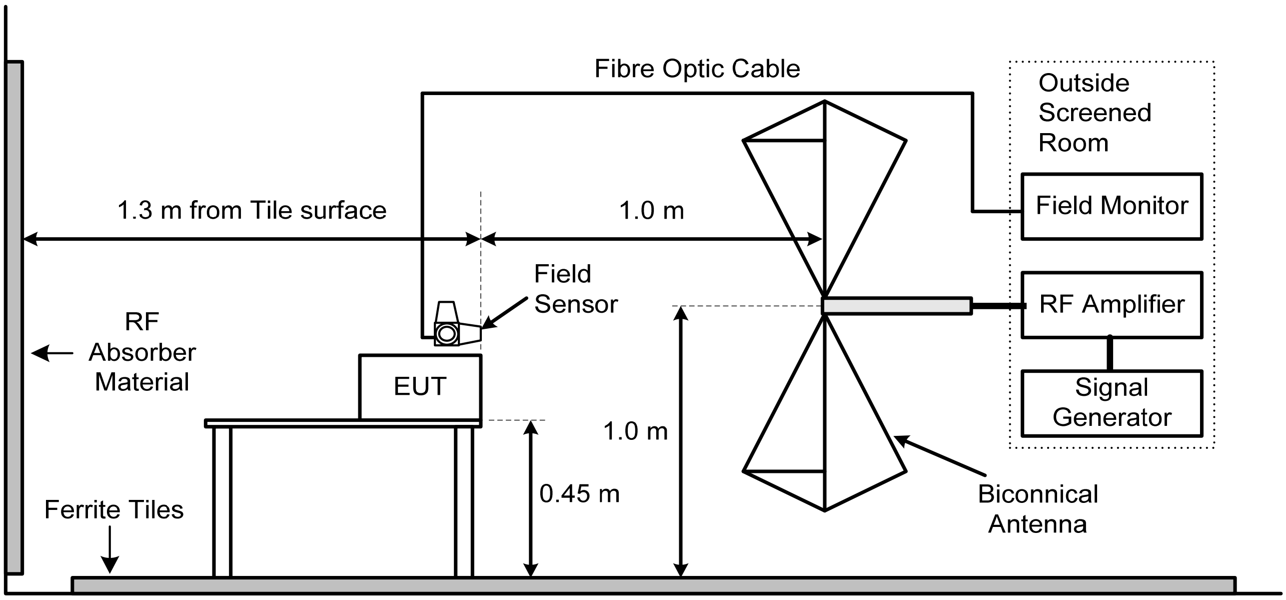
Note: Field Sensor should be placed 50 mm from the EUT

Figure 40 DRS02.A – Typical Test Configuration for Man Portable Scenario (50 kHz - 30 MHz)



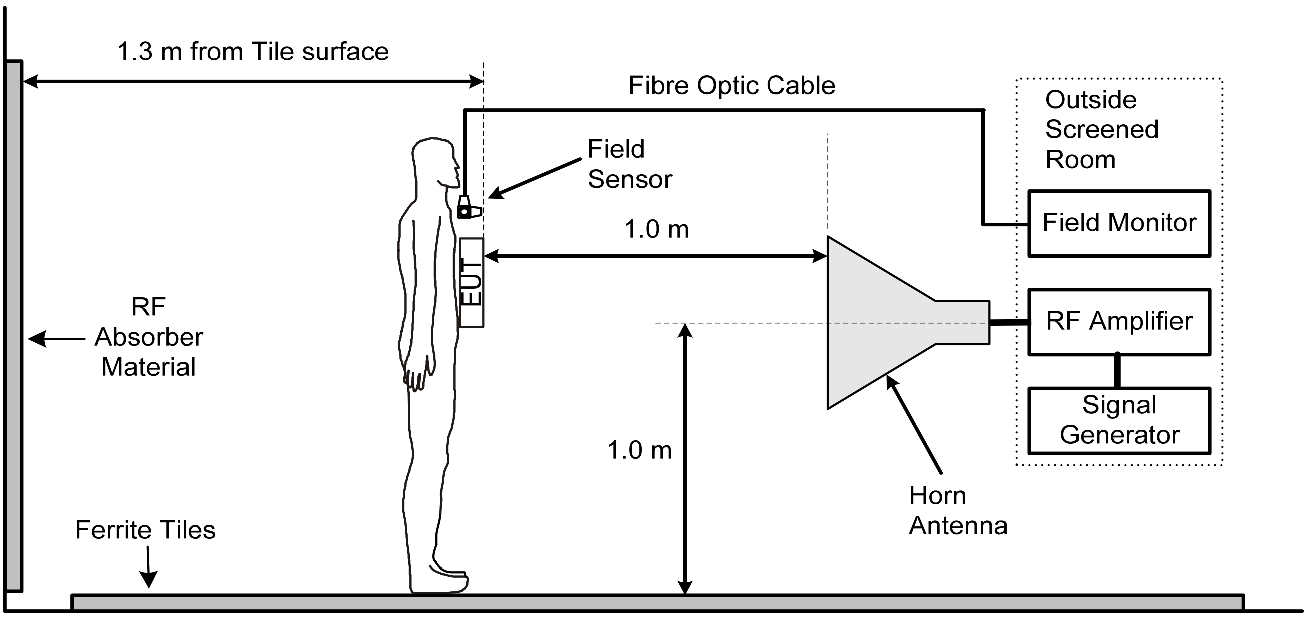
Note: Field Sensor should be placed 50 mm from the EUT

Figure 41 DRS02.A – Typical Test Configuration for Man Worn Scenario (30 MHz - 300 MHz)



Note: Field Sensor should be placed 50 mm from the EUT

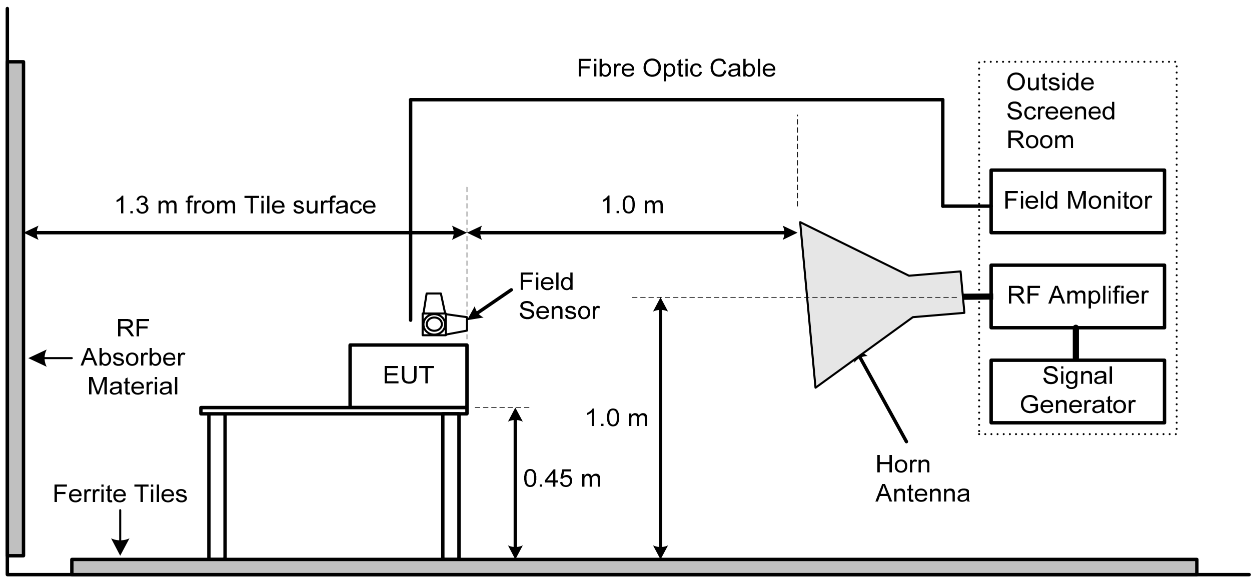
Figure 42 DRSO2.A – Typical Test Configuration for Man Portable Scenario (30 MHz - 300 MHz)



Note: Field Sensor should be placed 50 mm from the EUT

NOTE The Horn antenna may need to be angled upwards or downwards depending on position of EUT

Figure 43 DRS02.A – Typical Test Configuration for Man Worn Scenario (200 MHz - 18 GHz)



Note: Field Sensor should be placed 50 mm from the EUT

NOTE The Horn antenna may need to be angled downwards depending on the size of EUT

Figure 44 DRS02.A – Typical Test Configuration for Man Portable Scenario (200 MHz - 18 GHz)

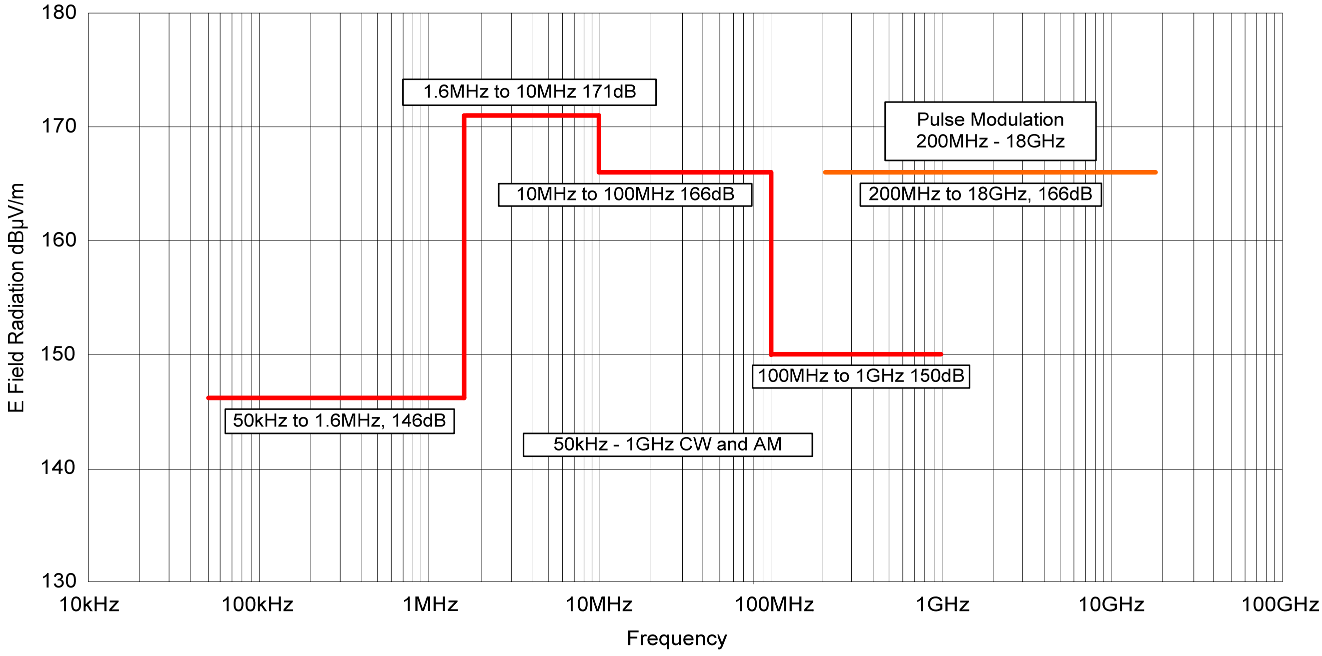


Figure 45 DRS02.A – Limit for Man Worn, Man Portable Land Based Equipment

Annex B
Test Methods and Limits for LRU and Sub Systems

Introduction:

This annex describes the methods of test to be applied and where appropriate the limits required to be met when measuring the electromagnetic compatibility of LRU's and Sub System equipment for Ministry of Defence use.

B.1 DCE01.B Conducted Emissions on Primary Power Lines 20 Hz - 150 MHz

B.1.1 Purpose

The purpose of this test is to ensure that the differential mode conducted emissions on all primary power lines to the equipment under test (EUT) are controlled to the appropriate limits in order to provide adequate protection to radio reception and to minimise disturbance to any sensitive electronic equipment.

B.1.2 Applicability

The test is applicable to all power supply lines connected from the bus-bars to the EUT or power outlets from the EUT connected to the bus-bars, i.e. primary power lines, including power returns or neutral lines.

Reference should also be made to **Clause 9.2**.

B.1.3 Test Layout

A typical equipment layout is shown in **Figure 46** but reference should also be made to **Clauses 6.7**, **6.12** and **Annex C.6**.

B.1.4 Test Method

The current shall be measured using current probes positioned 50 mm from the LISN terminal. Tests shall be made in as many modes of operation as specified in the Test Plan (see **Part 1 Clause 10** of this Standard). Reference to **Clause 6** is also required especially sub **Clauses 6.8**, **6.10**, **6.15**, **6.16** and **6.21.1**.

B.1.5 Limits

Recommended limits and frequency ranges are shown in **Figures 47**, **48** and **50** for Air Service, Sea Services and Land Service use respectively.

NOTE For Land Based Sea Services the Ship Below Deck Limit should be Used.

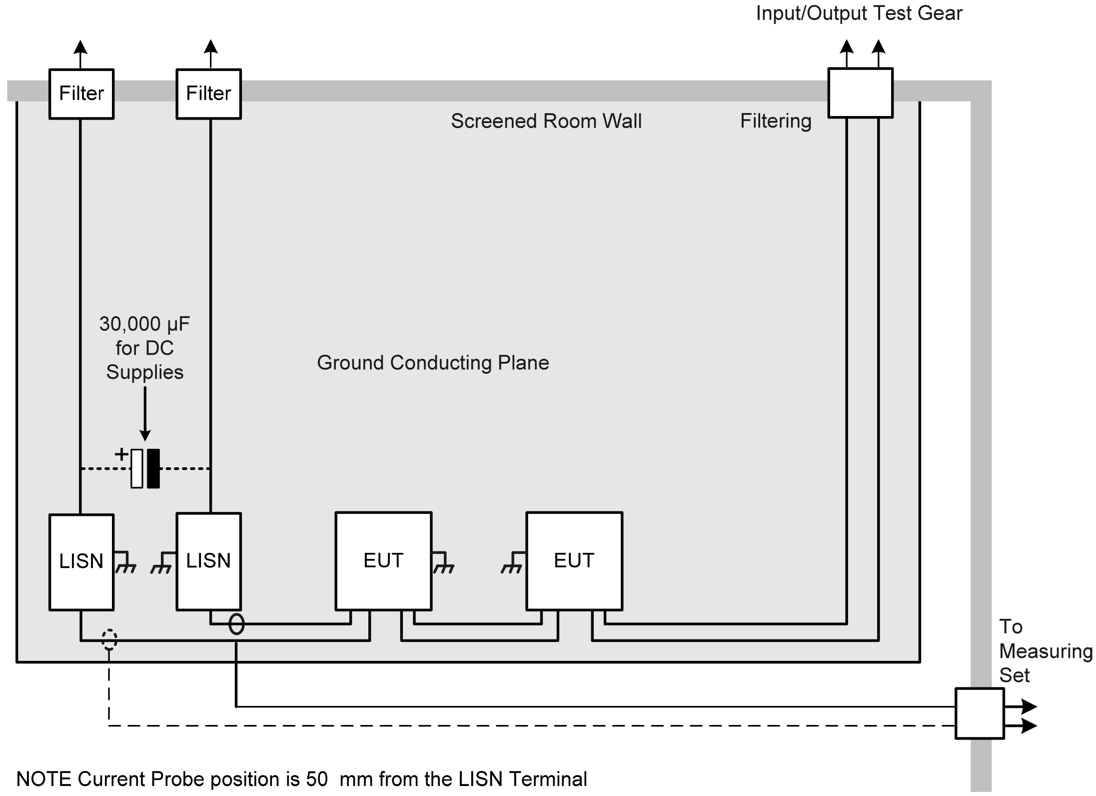


Figure 46 DCE01.B – Typical Test Configuration

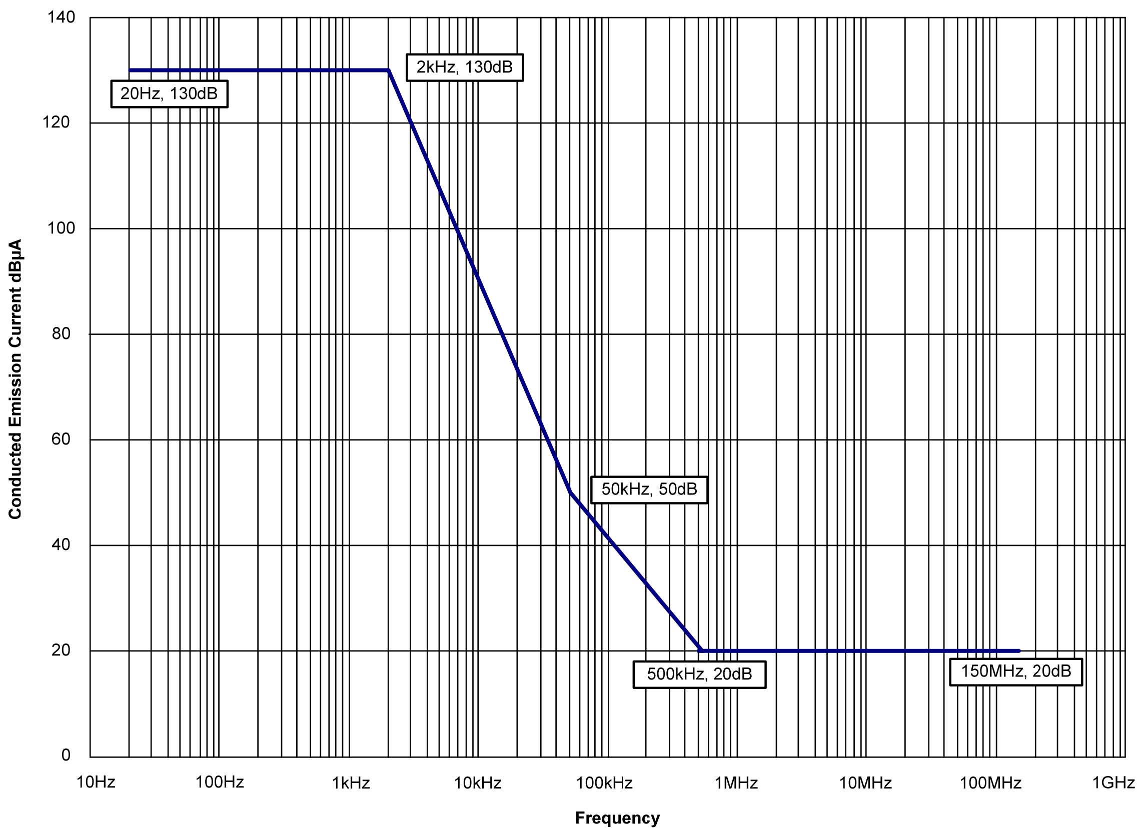


Figure 47 DCE01.B – Limit for Air Service Use

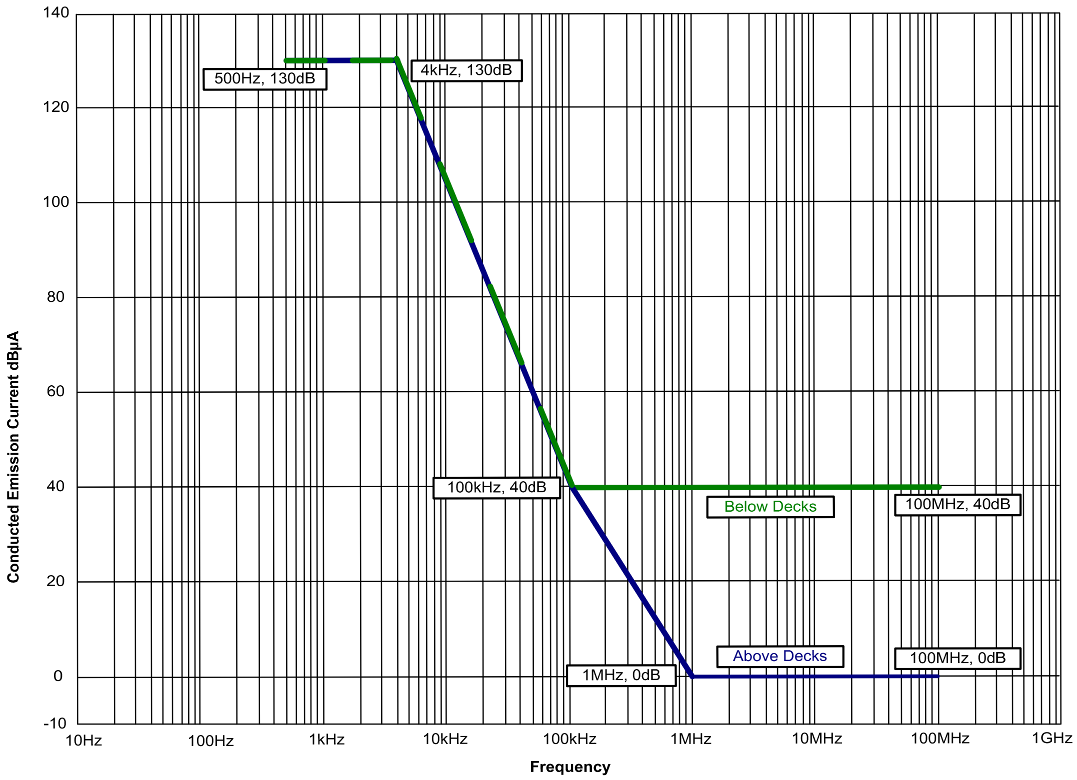
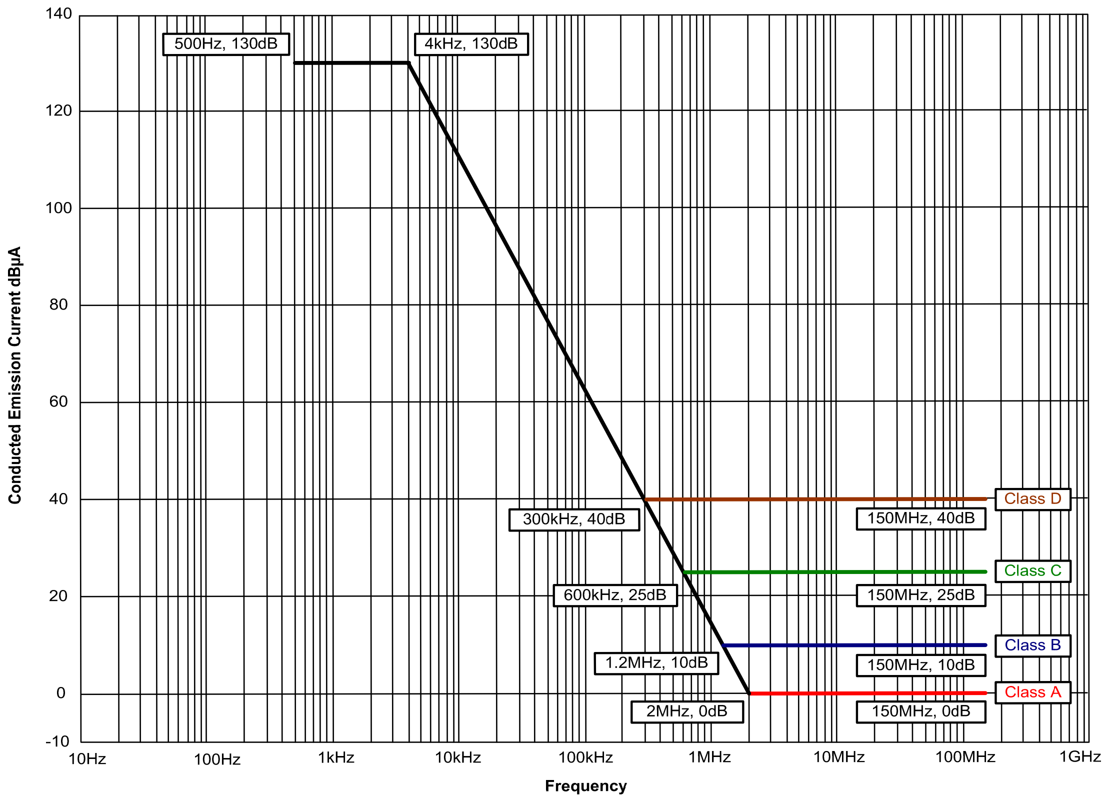


Figure 48 DCE01.B – Limits for Sea Service Use



NOTE See **Clause 7.5** for Classification of limits.

Figure 49 DCE01.B – Limits for Land Service Use

B.2 DCE02.B Conducted Emissions Control, Signal and Secondary Power Lines 20 Hz – 150 MHz

B.2.1 Purpose

The purpose of this test is to ensure that the common mode conducted emissions on all control, signal, secondary power lines and safety earths to the equipment under test (EUT) are controlled to the appropriate limits in order to provide adequate protection to radio reception and to minimise disturbance to any sensitive electronic equipment.

B.2.2 Applicability

All branches of the EUT harnesses are subject to this test. This test is not applicable to co-axial antenna feeders. Neither is it applicable to cables between units of the EUT which are shorter than 500 mm. In addition, earth lines exceeding a length of 500 mm shall also be subject to this test. The Test Plan must indicate which of the control, signal and power lines are grouped together in a typical installation. The Test report will indicate the groupings and layout used. See **Part 1 Clause 10** of this Standard.

Reference should also be made to **Clause 9.3**.

B.2.3 Test Layout

A typical equipment layout is shown in **Figure 50** but reference should also be made to **Clauses 6.7**, **6.8**, **6.12** and **Annex C.6**.

Some harnesses may contain cables including power supplies generated within one EUT of the system to another EUT of the system, i.e. secondary power supplies. These power supply cables will be measured together with all other cables in that particular cable harness branch but shall not be connected to a LISN.

B.2.4 Test Method

The current shall be measured using current probes placed 50 mm from the EUT connectors. For equipment with a loom between two units measurements will be made at both ends for all frequencies greater than 30 MHz. Reference to **Clause 6** is also required especially sub **Clauses 6.10**, **6.13**, **6.15**, **6.16** and **6.21.1**.

Where cable looms split into more than one branch, then each branch shall be tested separately at a position of 50 mm from the connector at its end. Testing is required at all connectors from a frequency of 30 MHz.

B.2.5 Limits

Limits are shown in **Figures 51**, **52** and **53** for Air Service, Sea Services and Land Service Use respectively.

NOTE For Land Based Sea Services the Ship Below Deck Limit should be Used.

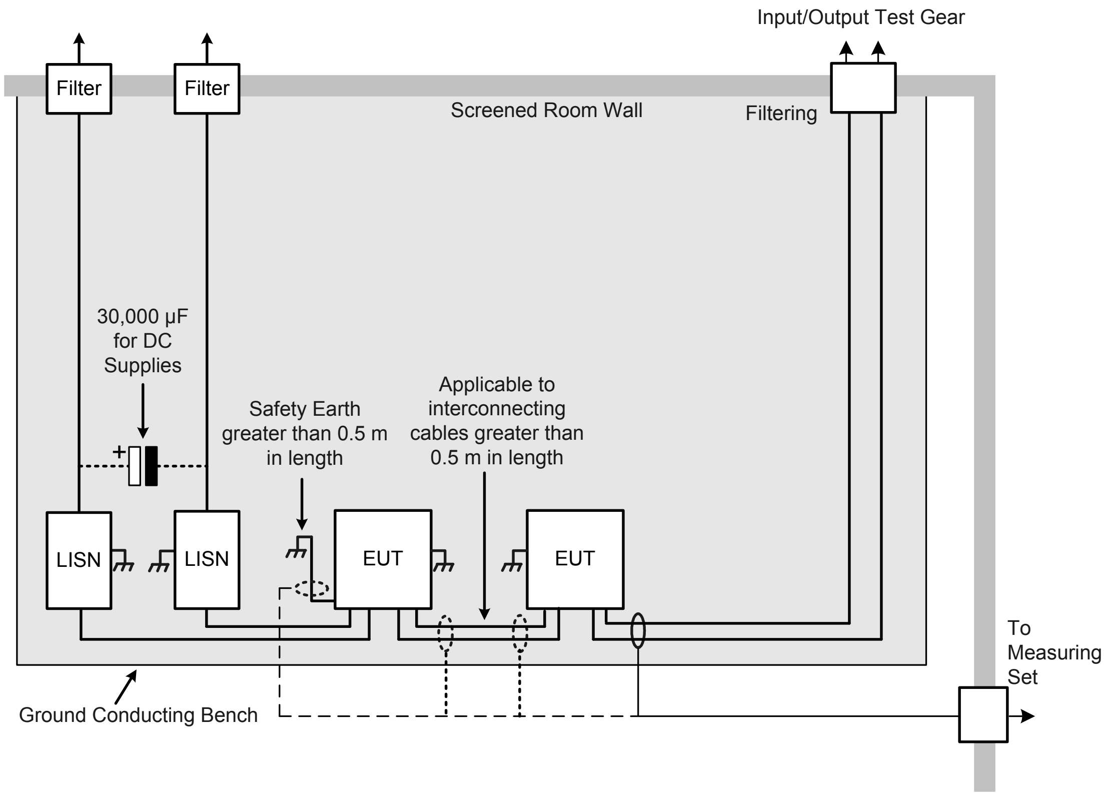


Figure 50 DCE02.B – Typical Test Configuration

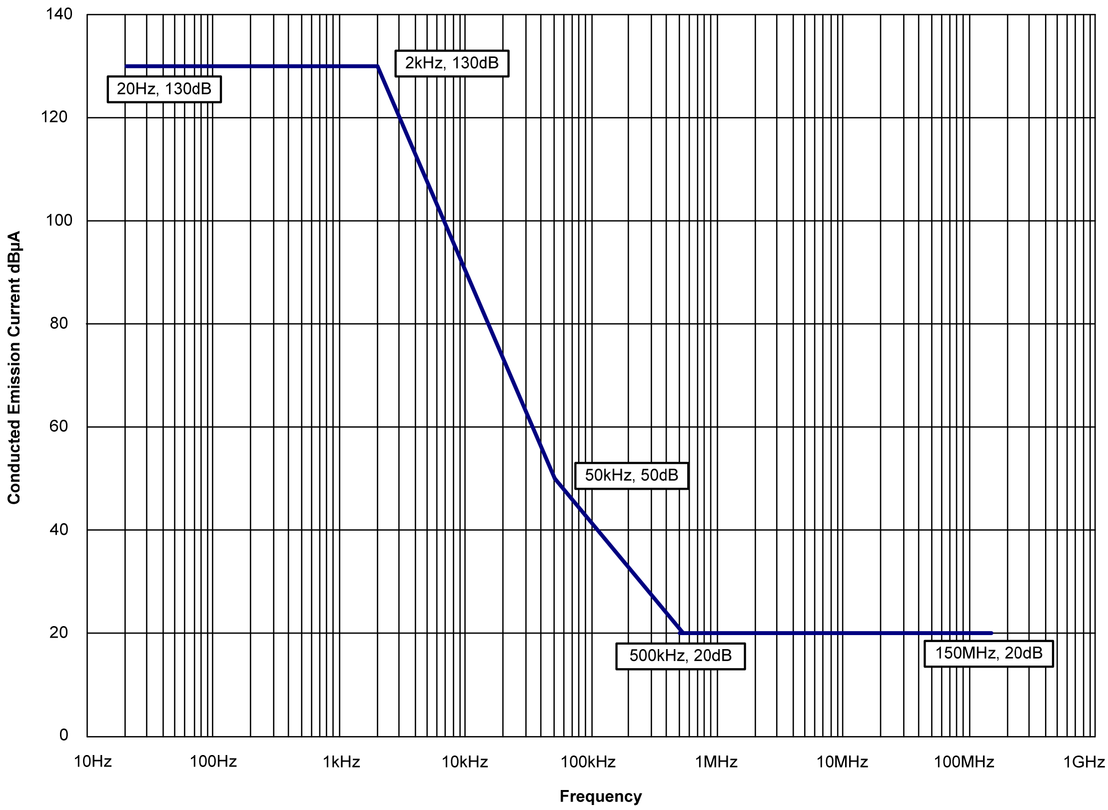


Figure 51 DCE02.B – Limit for Air Service Use

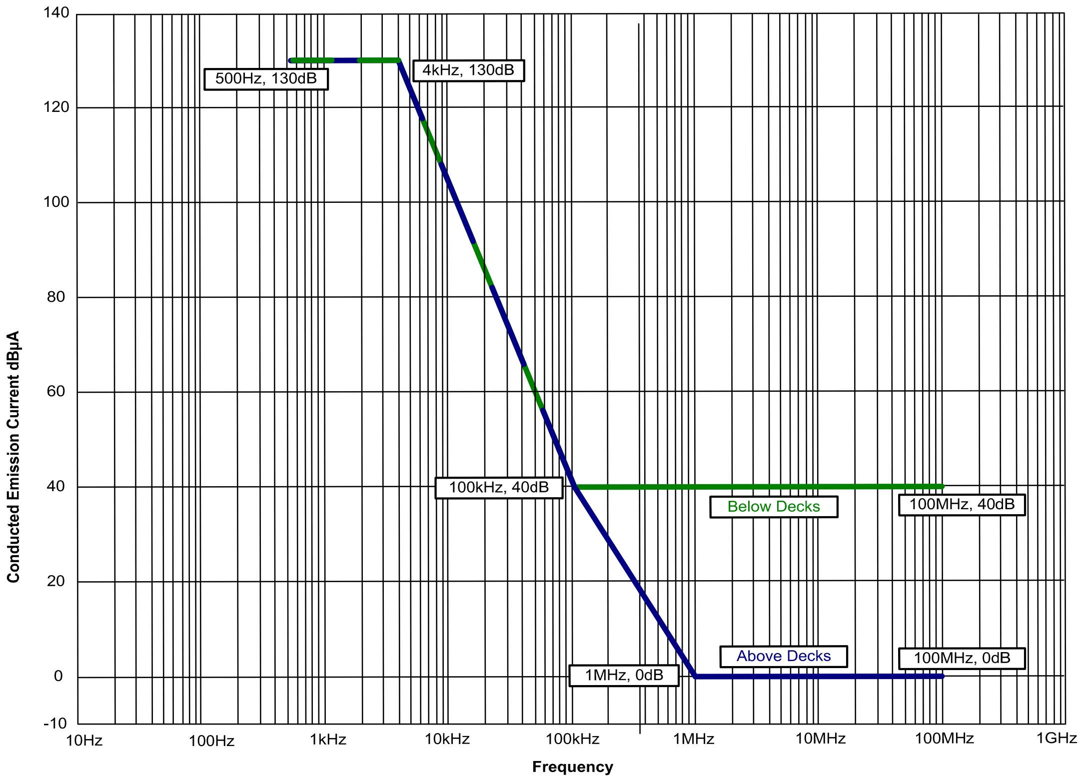
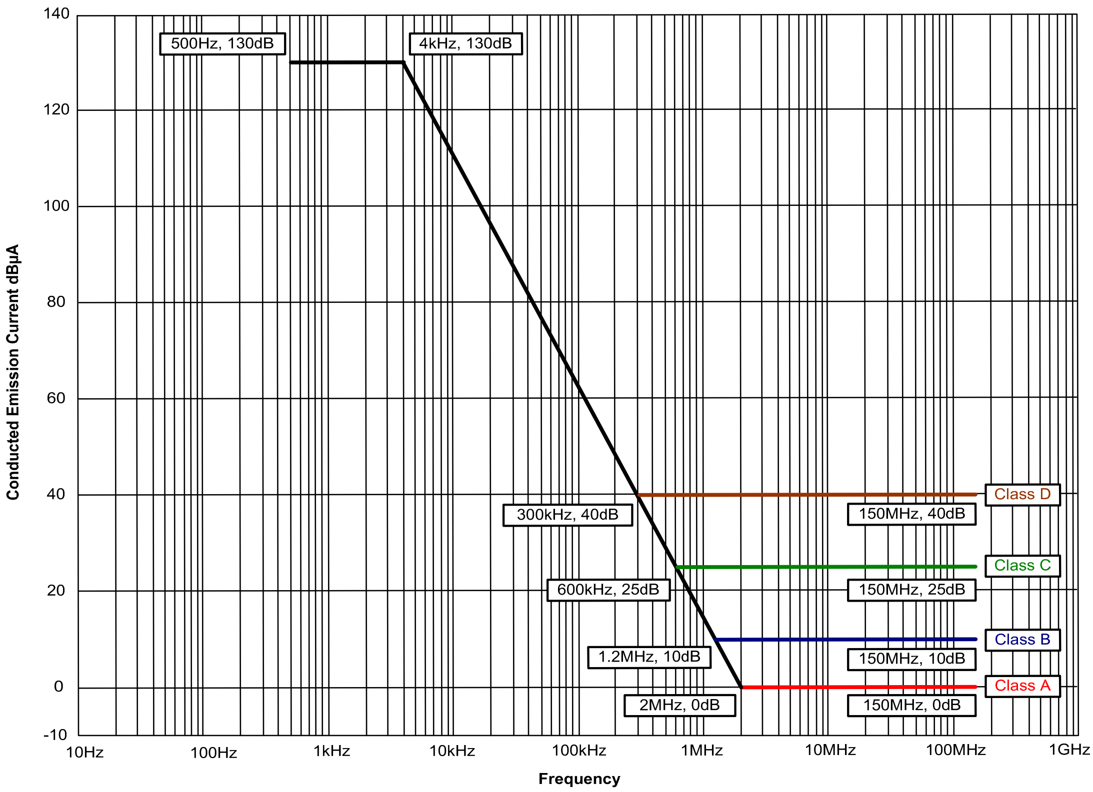


Figure 52 DCE02.B – Limits for Sea Service Use



NOTE See **Clause 7.5** for Classification of limits.

Figure 53 DCE02.B – Limits for Land Service Use

B.3 DCE03.B Exported Transients Primary Power Lines

B.3.1 Purpose

The purpose of this test is to measure the amplitude and duration of transients appearing on primary power lines caused by the normal operation of the EUT and also as a result of switching on and off the power supply to the EUT. These transient emissions may couple via conduction and radiation from the power lines to other potentially susceptible equipment in the actual installation.

B.3.2 Applicability

AC and DC power cables which interface with bus-bars are subject to this test method.

Reference should also be made to **Clause 9.4**.

B.3.3 Test Layout

Before commencement of this test **Clause 6.25** should be studied which, defines the oscilloscope and oscilloscope probe parameters. Reference to **Annex C.9** should also be made. **Figure 54** shows a typical test layout for this test method.

B.3.4 Test Method

For all EUTs, a switch or contactor of the type normally intended to control the supply to the EUT shall be connected into the power lines. If the contactor is not part of the EUT and its type is not known or available then an alternative, of suitable type and current rating may be used. The contactor shall be inserted at the LISN end of the lines. Oscilloscope probe connections shall be made to the power lines at a distance of 50mm from the EUT connector and LISN. **Figures 55** and **56** show typical test layouts for DC and AC lines respectively.

For AC supplies, filtering of the power supply frequency may be required to aid measurement of the transient. The test report (see **Part 1 Clause 11** of this Standard) should give details of the filtering used showing how the input impedance requirements of **Clause 6.25** have been met.

It should be noted that different limits may apply for systems operating at power line frequencies or voltages other than those specified in this section. In these cases the Project Manager may adjust the limits accordingly.

B.3.5 Contactor Validation

To ascertain that transient levels consistent with contact bounce do not mask those caused by the EUT, the test house shall ensure that the contactor meets the following test.

The set up shall be based on that given in **Figures 55** and **56** except that the EUT is substituted by a resistive load with a 10µF capacitor on each lead to the ground conducting bench and the oscilloscope probes connected directly onto either side of the contactor. The value of the load shall be such that the same current is drawn from the power source as when the EUT is connected.

At least 10 operations with the contactor making and breaking shall be monitored, 5 with the oscilloscope +ve triggered and 5 –ve. The worst case transient shall be used to assess whether the contactor is suitable for purpose.

The maximum excursion of the transient caused by the contactor bounce shall not exceed 50% of the appropriate test limit.

B.3.6 Tests for Land Service Use (DC and AC Systems)

The differential transient voltage appearing between the various power lines shall be measured as follows:

a) For DC lines the transient voltage shall be measured between the positive line and the ground conducting bench and also between the zero volt return line and the ground conducting bench.

b) For single-phase supplies the transient voltage shall be measured between the phase line and ground conducting bench, the neutral line and ground conducting bench and between phase and neutral lines.

c) For three-phase AC supplies the transient voltage shall be measured between phases, A to B, A to C, B to C and between each phase line and ground conducting bench. Where a neutral line is present, additional measurements will be made between neutral and each phase and neutral and ground conducting bench.

B.3.6.1 Test Limits For Land Service Use (28 Volt DC Systems)

B.3.6.1.1 Contactor Switching:

The maximum voltage excursion of the superimposed exported transient relative to the steady state voltage prior to disconnection when measured at 50 mm from the EUT shall not exceed:

a) ± 250 V peak.

b) ± 150 V peak for a period of longer than 10 µs

c) ± 100 V peak for a period of longer than 5 ms

B.3.6.1.2 Functional Switching:

The maximum voltage excursion of the superimposed exported transient, relative to the steady state voltage, when measured at the LISN, shall not exceed ± 30 V peak during functional switching of the EUT.

B.3.6.2 Test Limits For Land Service Use (240 Volt AC Systems)

B.3.6.2.1 Contactor Switching (Measurement at the EUT)

The maximum voltage excursion of the superimposed exported transient relative to the supply voltage waveform shall not exceed:

a) ± 2000 V peak for 415 V three-phase AC equipment

b) ± 1100 V peak for 240 V single-phase AC equipment

The period for which any individual voltage excursion of the transient exceeds:

c) ± 1300 V peak for 415 V three-phase AC equipment

d) ± 730 V peak for 240 V single-phase AC equipment

Shall not exceed 10 µs

The period for which the voltage excursion of the transient exceeds:

e) ± 1000 V peak for 415 V three-phase AC equipment

f) ± 550 V peak for 240 V single-phase AC equipment

Shall not exceed 5 ms (measured from the time the voltage exceeds these limits to the time it returns to, and remains within, the limits).

B.3.6.2.2 Functional Switching (Measurements at the LISN)

The maximum superimposed voltage excursion of the exported transient relative to the supply voltage waveform shall not exceed:

a) ± 200 V peak for 415 V three-phase AC equipment

b) ± 110 V peak for 240 V single-phase AC equipment

B.3.7 Tests for Sea Services Use (DC and AC)

NOTE For Land Based Sea Service Use **Table 6** should be consulted.

The differential transient voltage appearing between the various power lines shall be measured as follows:

a) For DC lines the transient voltage shall be measured between the positive line and zero volt return line, between the positive line and the ground conducting bench and also between the zero volt return line and the ground conducting bench.

b) For single-phase AC lines the transient voltage shall be measured between the lines and between each line and the ground conducting bench.

c) For three-phase AC lines the transient voltage shall be measured between each of the phase lines and between each phase line and the ground conducting bench.

NOTE The supply voltage for test purposes may be 50 Hz instead of 60 Hz where the EUT can operate at this frequency.

B.3.7.1 Test Limits for Sea Services Use (DC Systems)

B.3.7.1.1 Contactor Switching (Measurement at the EUT)

The maximum voltage excursion of the superimposed exported transient relative to the supply voltage waveform shall not exceed:

a) ± 2000 V peak for 720 V DC equipment

b) ± 960 V peak for 355 V DC equipment

c) ± 480 V peak for 28 V DC equipment

The period for which any individual voltage excursion of the transient exceeds:

d) ± 1300 V peak for 720 V DC equipment

e) ± 640 V peak for 355 V DC equipment

f) ± 320 V peak for 28 V DC equipment

Shall not exceed 10 µs

The period for which the voltage excursion of the transient exceeds:

g) ± 1000 V peak for 720 V DC equipment

h) ± 500 V peak for 355 V DC equipment

i) ± 250 V peak for 28 V DC equipment

Shall not exceed 5 ms (measured from the time the voltage exceeds these limits to the time it returns to, and remains within, the limits).

B.3.7.1.2 Functional Switching (Measurements at the LISN)

The maximum superimposed voltage excursion of the exported transient relative to the supply voltage waveform shall not exceed:

a) ± 200 V peak for 720 V DC equipment

b) ± 96 V peak for 355 V DC equipment

c) ± 48 V peak for 28 V DC equipment

B.3.7.2 Test Limits for Sea Services Use (AC Systems)

Contactor Switching (Measurement at the EUT)

The maximum voltage excursion of the superimposed exported transient relative to the supply voltage waveform shall not exceed:

a) ± 2000 V peak for 440 V three-phase AC equipment

b) ± 600 V peak for 115 V single-phase AC equipment

The period for which any individual voltage excursion of the transient exceeds:

c) ± 1300 V peak for 440 V three-phase AC equipment

d) ± 400 V peak for 115 V single-phase AC equipment

Shall not exceed 10 µs

The period for which the voltage excursion of the transient exceeds:

e) ± 1000 V peak for 440 V three-phase AC equipment

f) ± 300 V peak for 115 V single-phase AC equipment

Shall not exceed 5 ms (measured from the time the voltage exceeds these limits to the time it returns to, and remains within, the limits).

B.3.7.2.1 Functional Switching (Measurements at the LISN)

The maximum superimposed voltage excursion of the exported transient relative to the supply voltage waveform shall not exceed:

a) ± 200 V peak for 440 V three-phase AC equipment

b) ± 60 V peak for 115 V single-phase AC equipment

B.3.8 Tests for Air Services Use (DC and AC)

The differential transient voltage appearing between the various power lines shall be measured as follows:

a) For DC lines the transient voltage shall be measured between the positive line and zero volt return line, between the positive line and the ground conducting bench and also between the zero volt return line and the ground conducting bench.

b) For single-phase AC lines the transient voltage shall be measured between the phase line and the neutral line, between the phase line and the ground conducting bench and also between the neutral line and the ground conducting bench.

c) For three-phase AC lines the transient voltage shall be measured between each of the phase lines, between each phase line to the ground conducting bench, between each phase line to the neutral line and also between the neutral line and the ground conducting bench.

B.3.8.1 Test limits for Air Services Use (28 Volt DC Systems)

B.3.8.1.1 Contactor Switching (Measurement at the EUT)

The maximum voltage excursion of the superimposed exported transient relative to the supply voltage waveform shall not exceed:

a) ± 100 V peak.

The period for which any individual voltage excursion of the transient exceeds:

b) ± 90 V peak

Shall not exceed 10 µs

The period for which the voltage excursion of the transient exceeds:

c) ± 80 V peak

Shall not exceed 5 ms (measured from the time the voltage exceeds these limits to the time it returns to, and remains within, the limits).

B.3.8.1.2 Functional Switching (Measurements at the LISN)

The maximum superimposed voltage excursion of the exported transient relative to the supply voltage waveform shall not exceed:

a) ± 30 V peak

B.3.8.2 Test limits for Air System Use (400 Hz AC Systems)

B.3.8.2.1 Contactor Switching (Measurement at the EUT)

The maximum voltage excursion of the superimposed exported transient relative to the supply voltage waveform shall not exceed:

a) ± 300 V peak for 200 V Line to Line measurements

b) ± 300 V peak for 115 V Line to Neutral measurements

The period for which any individual voltage excursion of the transient exceeds:

c) ± 200 V peak for 200 V Line to Line measurements

d) ± 200 V peak for 115 V Line to Neutral measurements

Shall not exceed 10 µs

The period for which the voltage excursion of the transient exceeds:

e) ± 160 V peak for 200 V Line to Line measurements

f) ± 95 V peak for 115 V Line to Neutral measurements

Shall not exceed 5 ms (measured from the time the voltage exceeds these limits to the time it returns to, and remains within, the limits).

B.3.8.2.2 Functional Switching (Measurements at the LISN)

The maximum superimposed voltage excursion of the exported transient relative to the supply voltage waveform shall not exceed:

a) ± 160 V peak for 200 V Line to Line measurements

b) ± 90 V peak for 115 V Line to Neutral measurements

NOTE These latter limits for measurements at the LISN should be tailored for individual project requirements to take into account the aircraft primary power supply characteristics.

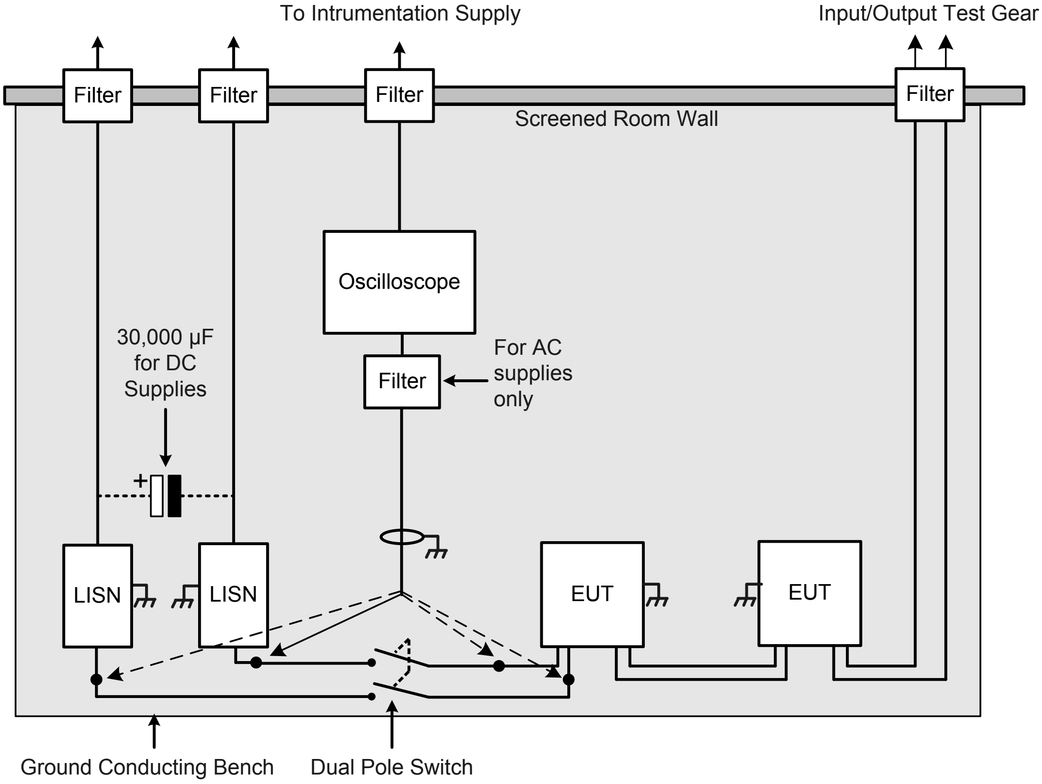


Figure 54 DCE03.B – Typical Test Configuration

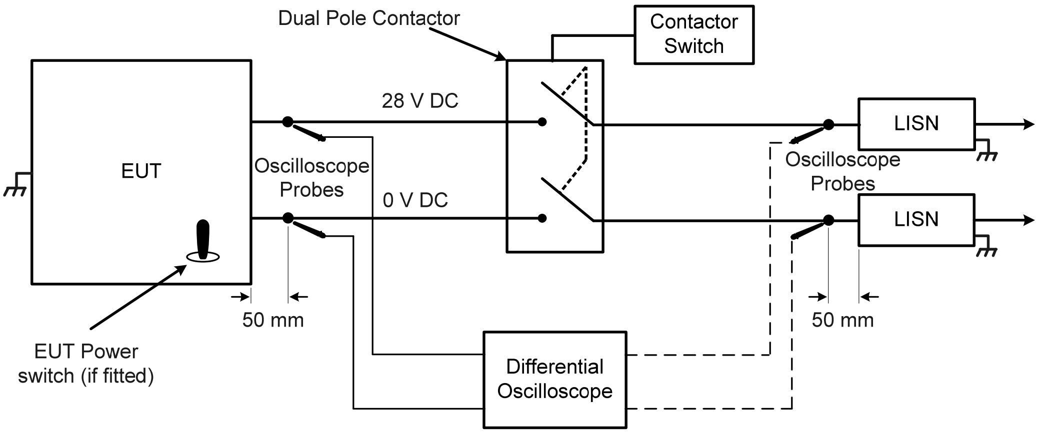


Figure 55 DCE03.B – Typical Test Configuration - DC Supply Lines

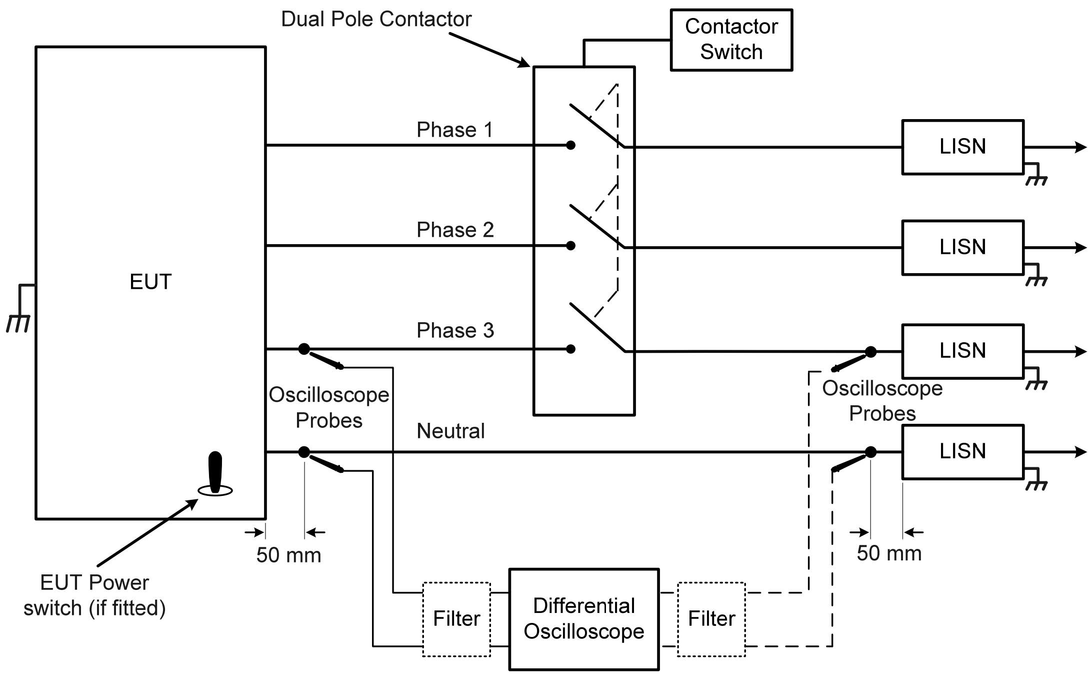


Figure 56 DCE03.B – Typical Test Configuration - AC Supply Lines

B.4 DCS01.B Conducted Susceptibility Primary Power Lines 20 Hz – 50 kHz

B.4.1 Purpose

The purpose of this test is to confirm that the EUT will withstand ripple voltages imposed upon its power lines. The limits have been set taking into account levels likely to occur on power supplies.

B.4.2 Applicability

This test is applied to all primary power input supply lines which are connected to supply bus-bars including power returns but not to secondary power lines, e.g. active sensors supplied from main unit.

This test is not intended to be applied to power output lines e.g. generators, power conversion equipment and regulated supplies.

Reference should also be made to **Clause 9.5**.

B.4.3 Test Layout

A typical test layout is shown in **Figure 57** but reference is also required to **Clauses 6.7**, **6.8**, **6.12** and **Annex C.6**.

B.4.4 Test Method

B.4.4.1 Calibration

b) Configure the equipment as shown in **Figure 58**.

c) Set the signal generator to the lowest test frequency.

d) Increase the applied signal until the oscilloscope indicates the voltage level corresponding to the maximum required power level specified for the limit in **Figure 59**. Verify the output waveform is sinusoidal.

e) Record the setting of the signal source.

f) Scan the required frequency range for testing and record the signal source setting needed to maintain the required power level.

B.4.4.2 EUT Testing

The test signal shall be swept through the frequency range at a level slightly above the test limit. If malfunctions are detected, then the test signal level shall be reduced until an acceptable condition is restored. Check for hysteresis in signal amplitudes by decreasing and then increasing through the susceptibility threshold. The lower of the two values shall be recorded.

Care must be taken to ensure that the isolation transformer has adequate ratings; the maximum current required by the EUT must be less than that required to cause core saturation or an unacceptable line voltage drop. Reference to **Clause 6** is also required especially sub **Clauses 6.13**, **6.18**, and **6.28**.

WARNING — Warning: When the test is applied to power lines carrying high currents the isolation transformer will back transform the voltage developed across the secondary winding to appear across the output of the power amplifier, which may damage the amplifier.

B.4.5 Limits

Limits for Air, Ship and Land service use are shown in **Figure 60**.

NOTE When the loop impedance of power supply and EUT is low, high and possibly damaging power would be required to achieve the test limit. The maximum power to be used for this test is therefore limited. The test limit is deemed to have been met if the voltage conditions cannot be achieved when the test generator power settings produce 50 watts into a 0.5 Ω load, substituted for the EUT circuit at the transformer secondary.

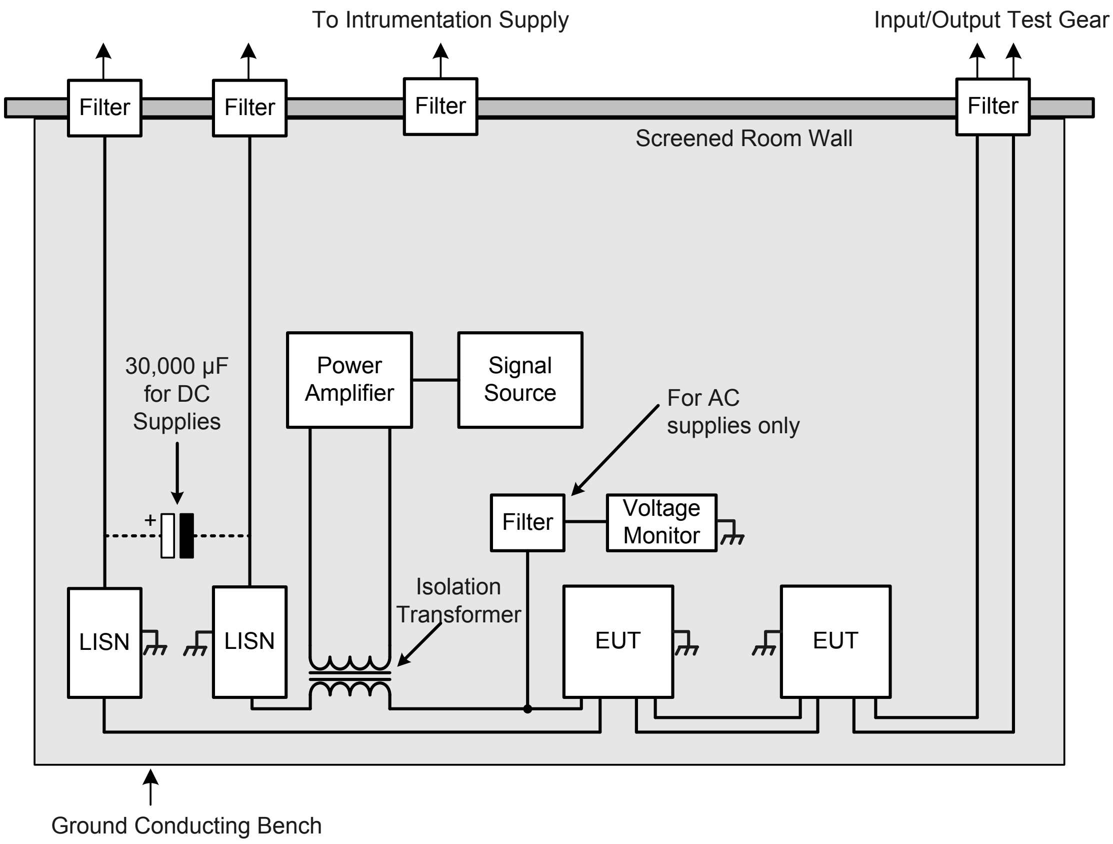


Figure 57 DCS01.B – Typical Test Configuration

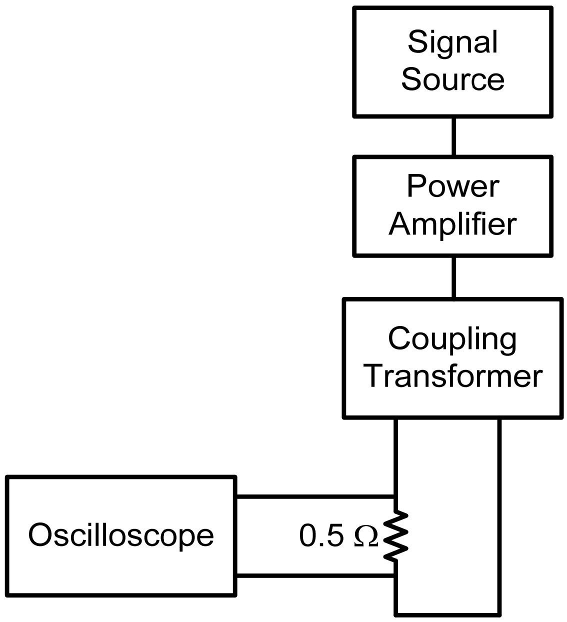


Figure 58 DCS01.B – Calibration

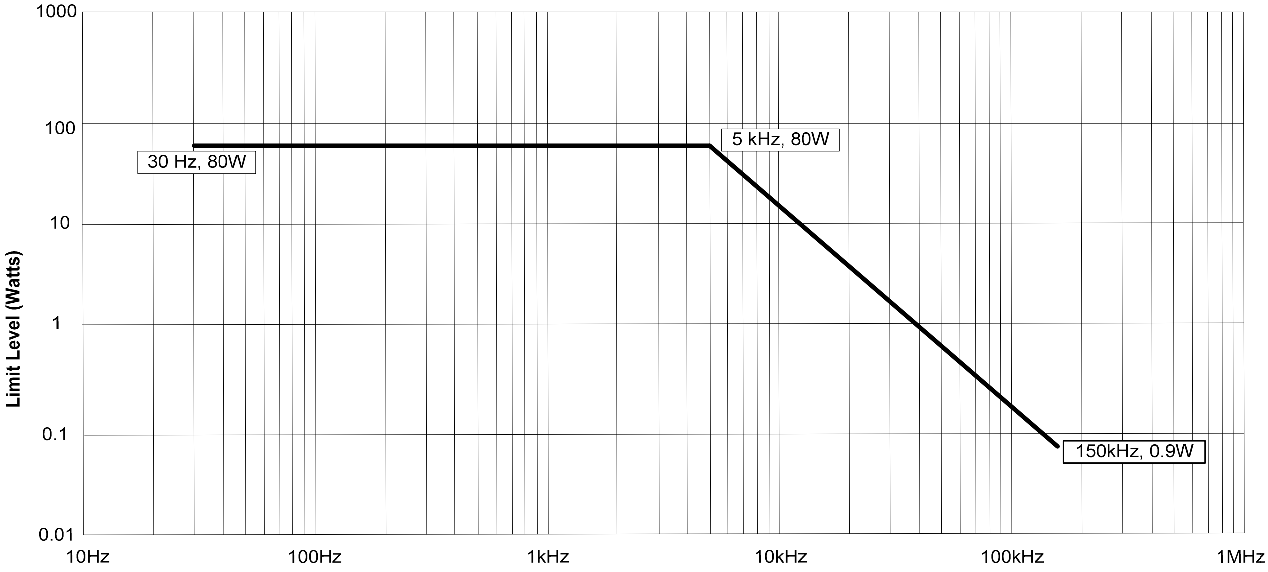


Figure 59 DCS01.B – Power Limit

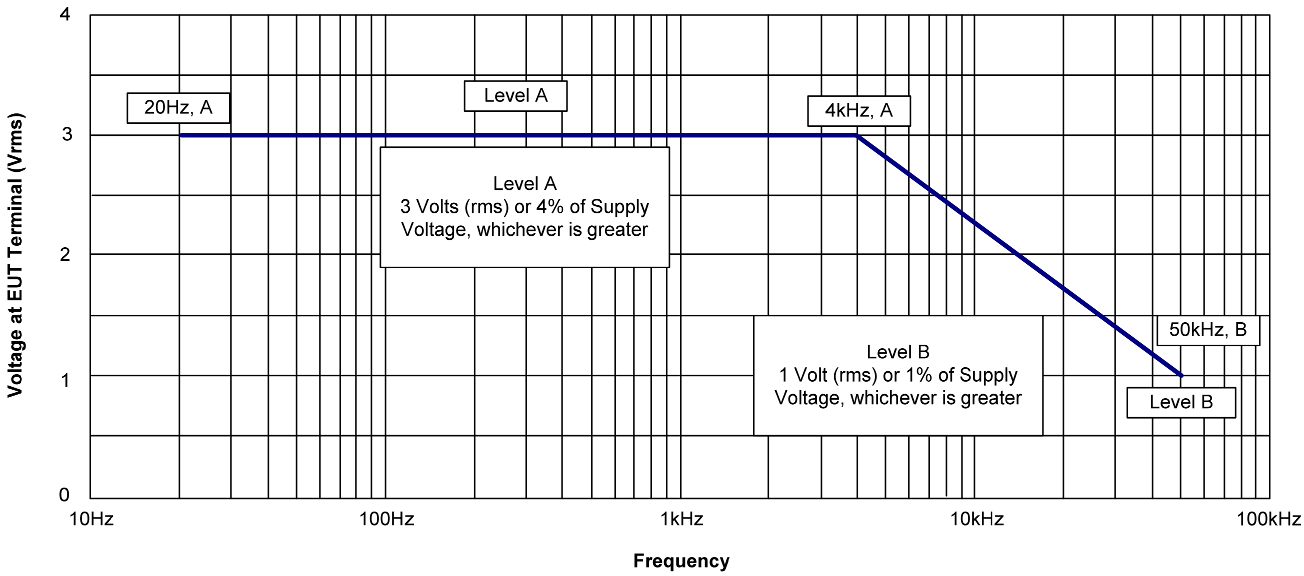


Figure 60 DCS01.B – Limits for Air, Land and Sea Service Use

B.5 DCS02.B Conducted Susceptibility, Control, Signal & Power Lines 50 kHz – 400 MHz

B.5.1 Purpose

The purpose of this test is to confirm that RF signals in the range 50 kHz to 400 MHz, when coupled on to the interconnecting cable looms and power supply lines of an EUT, will not cause degradation of performance. In addition this test will provide an amplitude/frequency malfunction signature for the system which, when compared with the levels of current on the looms (or cables) caused by onboard and external transmitting sources measured during clearance trials, will assist in the establishment of adequate safety margins.

B.5.2 Applicability

Cable looms which connect the EUT to other equipments in the total system (including primary power lines) and those interconnecting units of the EUT are subject to this test.

Reference should also be made to **Clause 9.6**.

Cable looms can be tested as a whole or individual wires can be tested. The looms or individual wires to be tested will be defined in the equipment test plan but some basic ground rules are: -

a) All looms shall be tested as a whole, connector by connector.

b) Primary power lines shall, in addition, be tested individually, injecting and monitoring on each line in turn.

c) On safety critical equipment (including sub-systems responsible for the control and/or initiation of electro-explosive devices) individual wires and/or branch looms may be selected for testing in addition to a. and b. as defined by the Project Manager.

This test shall also be applicable to safety critical and safety related equipment containing circuits which may exhibit a 'window effects' response as identified in the Test Plan. Reference to **Clause 6.19.2** is also required.

NOTE 1 For a system with built in redundancy, e.g. a quadruplex flight control system, simultaneous injections on several looms may be required by the Project Manager.

NOTE 2 Where a cable loom to be tested splits into separate branches and the split occurs at more than 0.5 m from the terminating connector, each branch must be individually tested over the entire frequency range. Where the split occurs at less than 0.5 m then the cable loom should be tested at 50 mm from the back shell of the connector carrying the majority of the cables. Where cable looms carrying conductors used in safety critical operations are to be tested then all branches must be tested irrespective of the point at which the loom splits.

NOTE 3 Window effect testing will normally be conducted following testing performed at the requirement test.

B.5.3 Test Layout

Before commencement of this test **Clauses 6.21.2** and **6.21.3** should be studied. **Figure 61** shows a typical layout for the test.

The probes used for these tests should have the following characteristics when driving current into the 100 Ω calibration jig defined in **Annex C.4**.

a) The insertion loss should be within the limits shown in **Annex C.3 Table 28**. The empirically established performance specifications for bulk current injection probes, driven in the CW mode are presented in **Annex C.3 Table 28**. These specifications are based on normal drive conditions in which probe cores are NOT driven into magnetic saturation. Test engineers are cautioned to ensure that measurements are NOT taken under core saturation conditions, during either calibration or equipment testing using the test set-up shown in **Figure 62**.

b) The probes shall be capable of delivering the jig currents shown in **Figures 63** and **64** for Air and Land services and **Figures 65** and **66**for Sea Services use.

B.5.4 Test Method

The test method has two main elements:

a) Calibration of the current injection probes, which must be done prior to each equipment test or series of consecutive tests. For aircraft equipment consult **Clause B.5.4.2.f**.

b) The equipment test.

NOTE 1 Modulation requirements are specified in **Clause 6.19**.

NOTE 2 The injection probes required for this test are designed to operate in the linear portion of their characteristics for the levels stipulated. If non-linear effects are observed during calibration, i.e. a 1 dB increase in forward power does not produce a corresponding 1 dB increase in the current flowing in the jig then the power amplifier or the injection probe is approaching saturation. If this effect is observed then non-recoverable damage may occur to the probe and investigative action must be taken.

B.5.4.1 Calibration

The following calibration procedure shall be performed prior to the equipment test(s) using the same test equipment layout and probes as will be used for those tests. The injection probe shall be installed in the 100 Ω calibration jig described in **Annex C.4**. The calibration jig shall be terminated in a 50 Ω, 50 W RF coaxial load at one end and by a 50 Ω measuring system (spectrum analyser or RF voltmeter) at the other. A 50 W power attenuator will be required to protect the input of the measuring system. The VSWR of the terminations at both ends of the calibration jig shall be less than 1.2:1 over the frequency range of the test. The injection probe is fed with power from the signal source via the power amplifier. The limits specified for this test method are in terms of current induced in the calibration jig. Two levels are used:

a) An accept/reject level up to which the performance of the EUT shall not be affected.

b) A test level which is higher than the accept/reject level, up to which the equipment is tested to enable a malfunction signature to be obtained for the line or cable loom under test. The EUT must be capable of being tested to this higher level without permanent damage.

The test signal supplied to the injection probe shall be increased until the voltmeter or spectrum analyser indicates that the accept/reject level of current shown in the appropriate limit curve is flowing in the calibration jig. The forward power flow to the probe shall be recorded. The power shall be increased until the test level current is reached, and the forward power flow again recorded. These measurements are to be made over the frequency range 50 kHz to 400 MHz at sufficient intervals to ensure that amplitude variations are less than 1 dB between each measurement point.

The calibration curves shall be shown in the test report. The forward powers to the current injection probes to give the two levels of current shall become the ‘accept/reject level’ and the ‘test level’ respectively, for the equipment test.

B.5.4.2 Equipment Test

a) This test may be applied to whole cable looms or individual conductors, those to be tested being defined in the equipment test plan.

b) As a minimum requirement, the injection probe shall be connected around the complete cable loom and subsequently around any branches of that loom. In all cases the current monitor probe shall be connected around the complete cable loom 50 mm from the connector.

c) The current monitor probe, which is used to measure the current actually induced on the loom or conductor under test, shall be fitted so that the face of the monitor probe nearest the test sample connector is 50 mm from the connector backshell (**Figure 62**). If the overall length of the connector and backshell exceeds 50 mm, the monitor probe shall be placed as close to the connector's backshell as possible and its position noted in the Test Report.

d) The current injection probe shall be fitted around the loom or conductor under test such that the separation of the adjacent faces of the two probes is 50 mm. See **Figure 62**.

e) Radio frequency power applied to the injection probe shall be swept over the test frequency range and the parameters of induced current and forward power recorded. Recordings are required at the test level if no malfunctions occur or at the threshold condition if malfunctions do occur. If malfunctions do occur then the forward power results shall be assessed against the accept/reject limit. Care must be taken not to overheat the cable under test as the injection probe reaches a high temperature with prolonged excitation. To avoid damage to the EUT wiring the induced current shall be limited to the values shown in **Table 13**. The EUT is deemed to have passed the accept/reject criterion if either of the following two conditions are met:

1) The forward power levels recorded during the calibration of the accept/reject levels can be applied without any failure or,

2) The current injected into the EUT during the test, as measured by the monitor probe system, reaches the level specified by the accept / reject current limits **Table 13**.

f) At frequencies where the test sample is susceptible, the signal amplitude shall be reduced until a threshold of susceptibility is determined. Check for hysteresis in signal amplitudes by decreasing and then increasing through the susceptibility threshold. The lower of the two values shall be recorded.

g) For aircraft equipment an extra test is required to assist the clearance agency. This test is to be performed prior to the main test method and consists of measuring the induced current per unit forward power characteristic of the cable under test. This test can be done using the test set-up as shown in **Figure 62** at low power (say 1 mW) and presented in graphical form normalized to 1 watt forward power. This test is helpful generally for indicating cable resonances where malfunctions may occur at lower excitations.

Table 13 Limits for Induced Current on EUT Wiring

Frequency Range (MHz)	Maximum Induced Current Levels (A)			
	Accept / Reject Assessments		Test Level Assessment	
	Equipment feeding ext. aircraft stores	All other Equipment (Inc. Land & Sea)	Equipment feeding ext. aircraft stores	All other Equipment (Inc. Land & Sea)
0.05 – 2.00	0.4	0.1	0.8	0.4
2 - 400	2.0	1.0	4.0	2.0

B.5.5 Limits

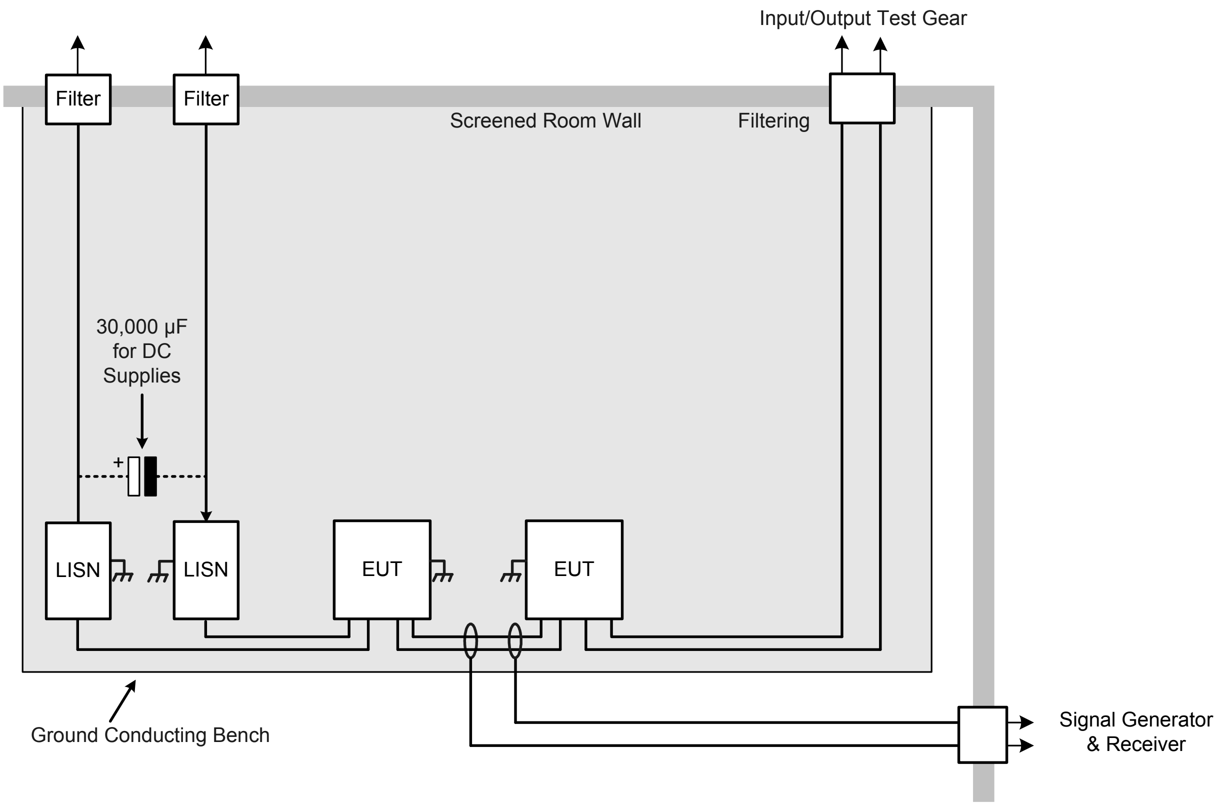
The limits in terms of current in the calibration jig are shown in **Figure 63** for Air Service use, **Figure 64** for Land Service use and **Figure 65** and **Figure 66** for Sea service use.

NOTE 1 The induced current in the EUT cables under test need not be recorded for non-safety critical equipment for Land service use. It is recommended however that the monitor probe is installed and used to ensure that excessive currents are not induced into the circuit under test.

NOTE 2 Enhanced test levels may be specified additionally by the Sea Services sponsoring authority.

NOTE 3 The limits are in peak values and apply to each of the modulation characteristics specified in **Clause 6.19**.

NOTE 4 For Land Based Sea Services the Ship Below Deck Limit should be Used.



NOTE For Directional Coupler/Amplifier/Signal Generator details see **Figure 62**

Figure 61 DCS02.B – Typical Test Configuration Layout

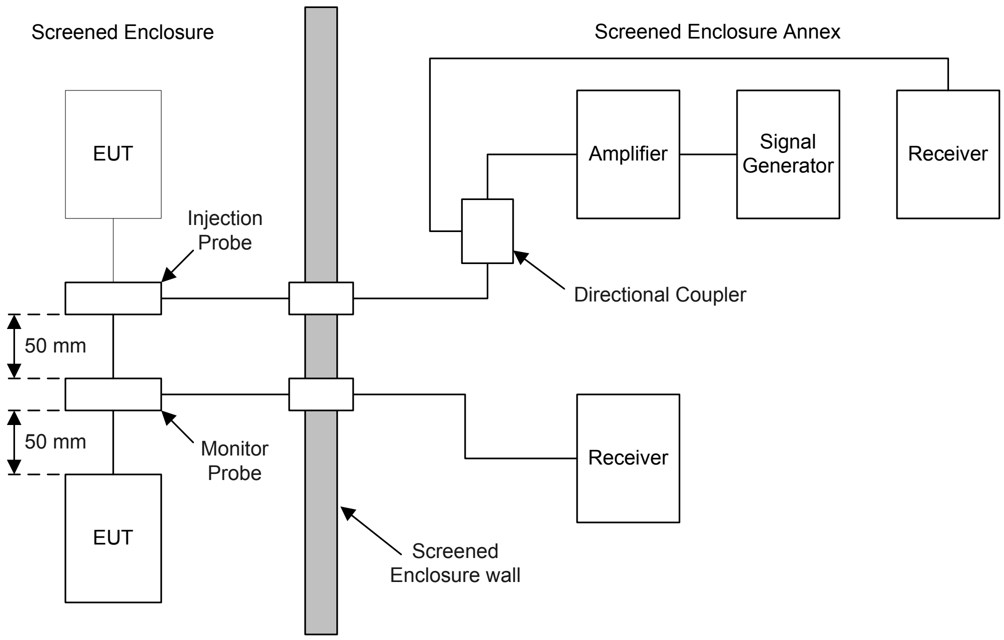
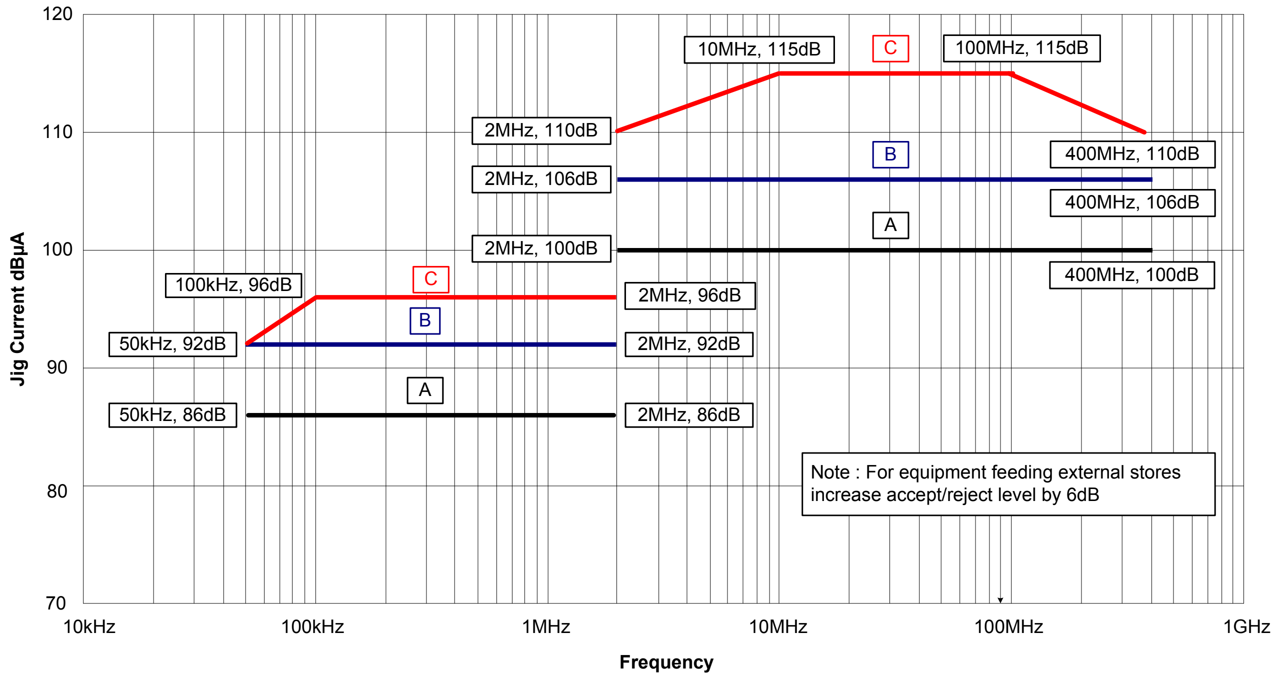


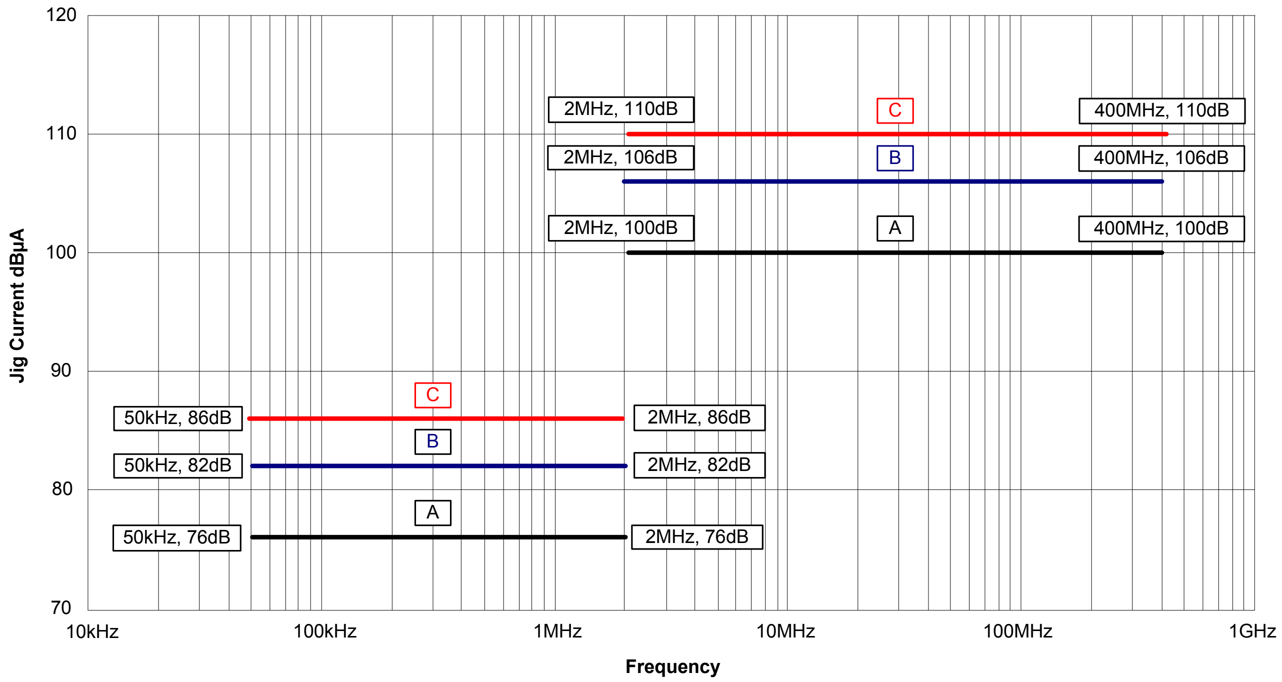
Figure 62 DCS02.B – Typical Test Configuration



A = Accept/Reject test level B = non-safety critical test level C = safety critical test level

NOTE For equipment feeding external stores increase 'accept / reject level' by 6 dB

Figure 63 DCS02.B – Limits for Air Service (in terms of current to be induced into calibration jig)



A = Accept/Reject test level B = non-safety critical test level C = safety critical test level

Figure 64 DCS02.B – Limits for Land Service (in terms of current to be induced into calibration jig)

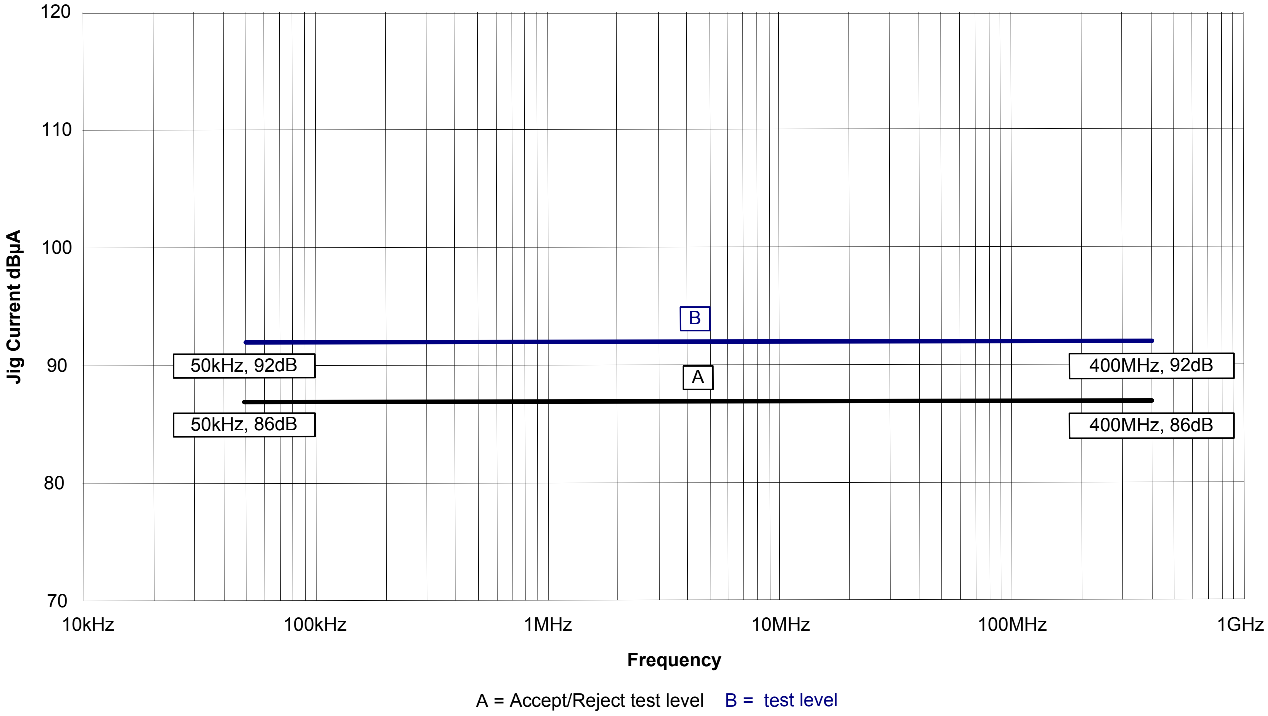


Figure 65 DCS02.B – Limits for Sea Service [Below Decks](in terms of current to be induced into calibration jig)

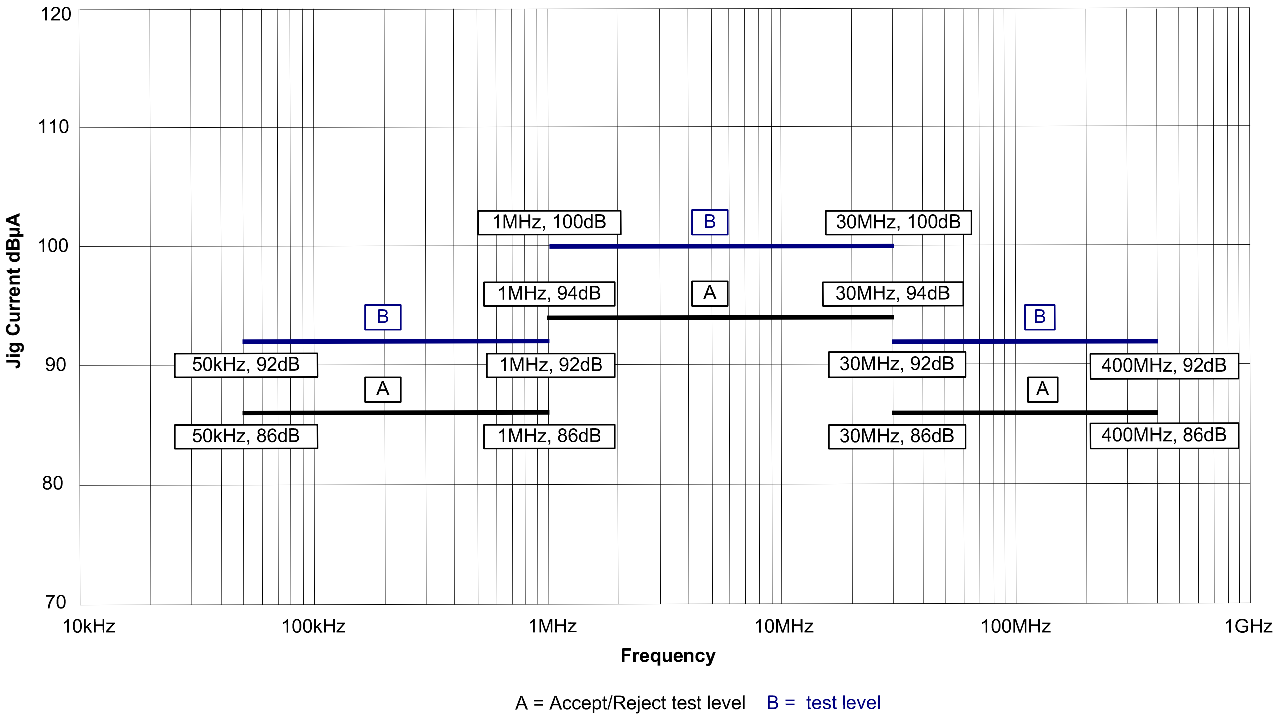


Figure 66 DCS02.B – Limits for Sea Service [Above Decks](in terms of current to be induced into calibration jig)

B.6 DCS03.B Conducted Susceptibility, Control and Signal Lines 20 Hz – 50 kHz

B.6.1 Purpose

The purpose of this test is to confirm that audio frequency currents, which are likely to be flowing in cables adjacent to the EUT control and signal lines, do not cause malfunction of the EUT. Audio systems can be especially sensitive to this test.

B.6.2 Applicability

This test is applicable to all interconnecting or control and signals lines (1m or greater in length) connected to the EUT.

Reference should also be made to **Clause 9.7**.

B.6.3 Test Layout

A typical test layout is shown in **Figure 67**. Reference to **Clauses 6.7**, **6.8**, **6.12** and **Annex C.6** is also required.

B.6.4 Test Method

The test wire shall be closely coupled to each cable form to be tested by wrapping an insulated current carrying wire spiralling at two turns per metre equally spaced and running the whole length of the cable bundle to within 15cms of each end connector. The test wire shall be energized with the specified current over the required frequency range and monitored by means of a suitable method and device (e.g. ammeter/test receiver, voltmeter/resistor, current probe, etc.) capable of measuring up to 50 kHz. Should malfunctions be found during this test the current shall be reduced until the threshold is established and then recorded. Reference to Clause 6 is also required.

B.6.5 Limits

Limits are shown in **Figure 68** for Air Service use and **Figure 69** for both Land and Sea service use respectively.

For the airside, the frequency range of the enhanced limit (146 dBµA), may need to be adjusted depending on the frequency range of the aircraft's ac power system, e.g. if the equipment is installed on aircraft whose primary power is variable over a frequency range of 350 Hz – 800 Hz then the enhanced limit should cover this band.

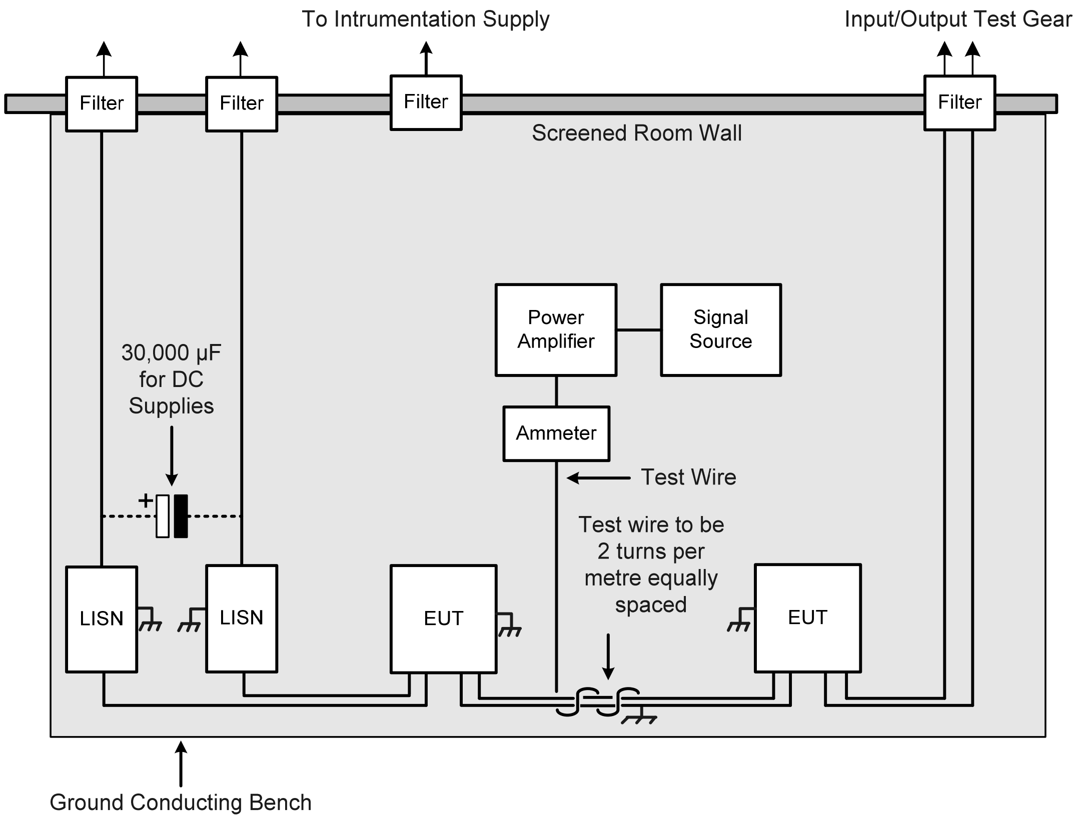


Figure 67 DCS03.B – Typical Test Configuration

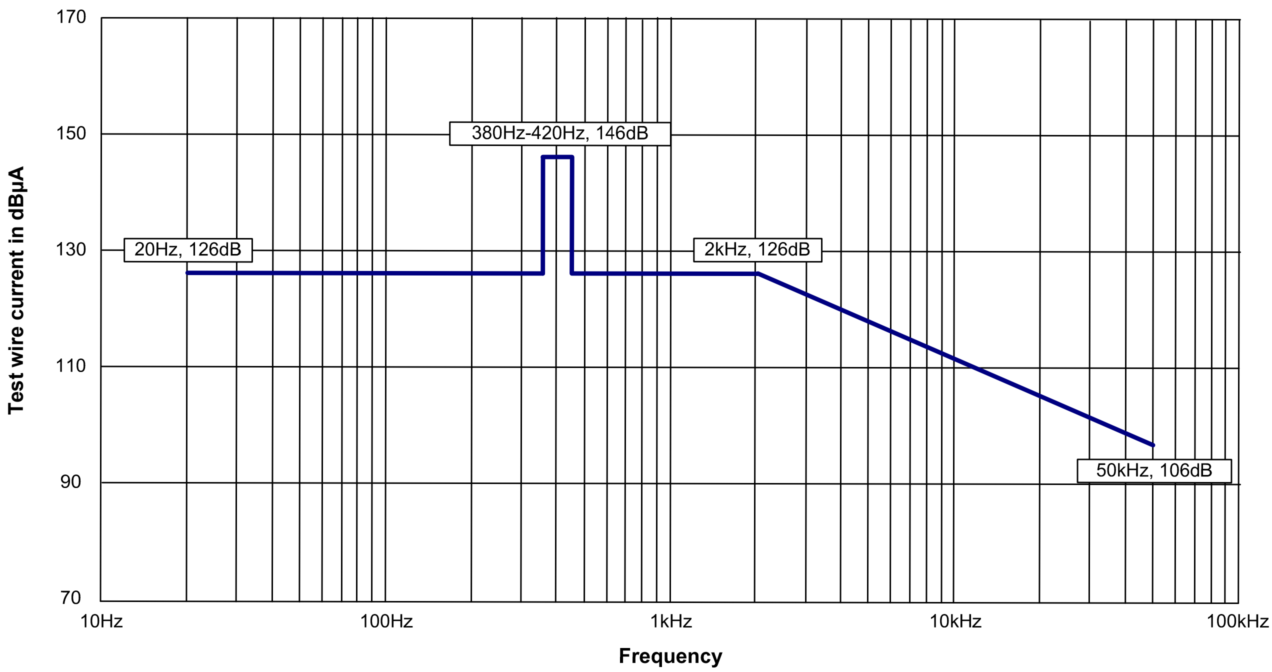


Figure 68 DCS03.B – Limits for Air Service Use

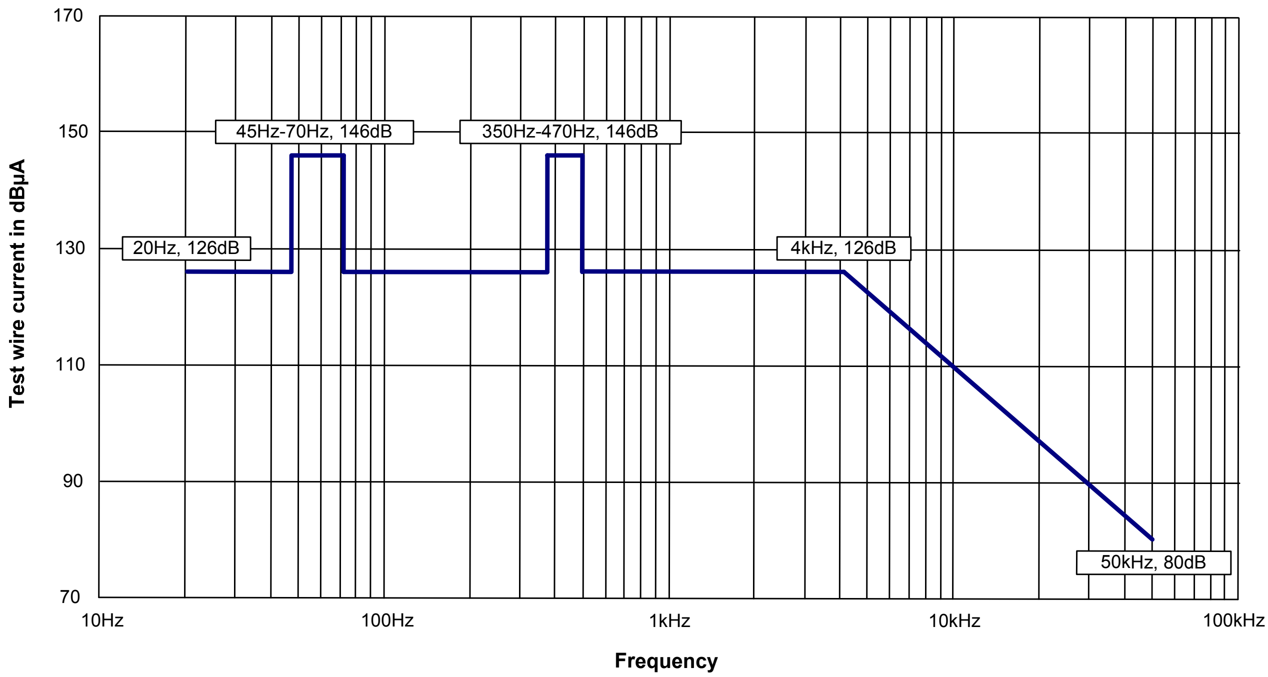


Figure 69 DCS03.B – Limits for Land and Sea Service Use

B.7 DCS04.B Imported Transient Susceptibility (Air Services)

B.7.1 Purpose

The purpose of this test is to ensure that transients of specified characteristics injected on to the power supply and interconnecting cables of EUT will not cause damage, degradation of performance or malfunction. The transients shall be injected in the form of damped sinusoids, at the frequencies to which the EUT is most likely to be susceptible. Two types of transient used are:

a) Type 1 (2 MHz - 30 MHz) representing transients produced by switching, for example by contactor operation.

b) Type 2 (100 kHz) transients simulate voltage spikes which the EUT may experience during group switching of equipment.

B.7.2 Applicability

This test is applicable to EUT AC and DC power cables, which interface with aircraft power supplies and cable looms, which connect the EUT to other equipment in the aircraft system.

Reference should also be made to **Clause 9.8**.

The test should be applied at the EUT ends of each cable and not at the ends connected to simulating test equipment where that is used. As a minimum test requirement the following cable looms and power lines shall be tested for susceptibility as follows: -

a) All looms (including primary power looms) shall be tested as a whole, connector by connector, for susceptibility to both Type 1 and Type 2 transients.

b) Primary power lines shall in addition be tested individually and collectively for susceptibility to Type 2 transients only. Additional tests may be required and will be detailed in the EMC test plan for the EUT.

c) For a cable loom less than 0.5 m in length between back shells the test will not be required

d) For cable looms between 0.5 m and 1 m in length the injection and monitoring probes shall be positioned symmetrically about the cable loom centre

e) All power leads shall be tested as a 1 m loom at the EUT end only

f) Cable looms greater than 1m in length connecting two or more EUT's shall have transients injected at each end in turn.

Where equipment has multi-installation applications, the procurement authority must define the number of configurations to be tested.

B.7.3 Pre-Requisite

Conducted emission test DCE01.B must be performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.7.4 Test Layout

Before commencement of this part of the test **Clause 6.25** should be studied which, defines the performance requirements of the oscilloscope system. **Figure 70** shows a typical test arrangement.

The transient generators required shall provide 2 types of damped sinusoid transient. Type 1 a variable frequency transient tunable over the frequency range 2-30 MHz and Type 2 a fixed frequency transient of 100 kHz. The transients are injected into cable looms using specially designed injection probes. Generator and injection probe performance is specified in **Annex C Clauses C.2.1** and **C.2.3** and **Table 29** using the calibration jigs specified in **Clause Annex C Clause C.4**.

It should be noted that the damping of the transient waveform is verified by injecting into a specified resistive load. When injecting into cables the damping may vary considerably.

The injection probes required for this test are intended for operation in the linear portion of their characteristics, for the levels stipulated. If non-linear effects are observed during calibration, i.e. if a 1 dB increase in forward power does not produce a corresponding 1 dB increase in the current flowing in the jig, then the transient generator or the injection probe is approaching saturation. If this effect is observed then non-recoverable damage may occur to the probe and investigative action must be taken.

B.7.5 Test Method

B.7.5.1 General

The test procedure is based on the bulk current injection technique and uses specially designed injection probes. However, before the transient injection test can be applied it will be necessary to measure the RF impedance of the various cable looms to be tested, over the frequency range 2-30 MHz. These measurements will determine the frequencies where the cables have maximum and minimum impedance (i.e. maximum voltage and current coupling to the cable).

The test has two main sections, (a) selection of the transient injection frequencies from cable impedance measurements and, (b) transient injection testing and monitoring EUT for susceptibility. For both of these tests it will be necessary to measure the induced cable current and the induced cable voltage. A suitable current probe shall measure the current induced in the cables under test. The voltage induced on the cables under test shall be measured using one of two methods depending on the type of cables under test:

a) For injection on individual power lines, the differential voltage induced on the line shall be measured directly, using oscilloscope voltage probes connected to the power line 25 mm from the EUT connector. See **Figures 71** and **72**.

b) For injection on interconnecting cables and groups of power lines, the injection probe shall be fitted with a short, low reactance, single turn monitor loop (around the probe) which is connected to an oscilloscope probe to measure the voltage induced into the cables. See **Figures 73** and **74**.

B.7.5.2 Transient Injection Frequencies

Transients shall be injected at the frequencies listed in the following three sections:

a) Fixed frequencies of 100 kHz, 2 MHz, 3, 5, 7, 10, 15, 20, 25 and 30 MHz.

b) The frequencies at which maximum and minimum cable impedance occur.

c) The most susceptible frequencies in the range 2-30 MHz found from the DCS02.B test (assuming malfunction was detected).

To measure the cable loom impedance, low level swept frequency CW signals are injected into the interconnecting cable forms or power lines under test over the frequency range 2 MHz to 30 MHz. The ratio of the injected cable voltage to the injected cable current is a measure of the cable impedance. The test set-up is shown in **Figure 71** for measurements on individual power lines, and **Figure 73** for measurements on groups of power lines and interconnecting cables. A plot of the cable loom impedance shall be included in the Test Report.

It should be noted that for some types of measuring equipment some rejection filtering at the power line frequency may be necessary to avoid "swamping" the induced low level CW voltage signal.

B.7.5.3 Transient Injection Testing

The transients shall be injected using the test set-up shown in **Figure 72** for individual power lines, and **Figure 74** for groups of power lines and interconnecting cables. At each test frequency the amplitude of the transient induced cable voltage and cable current shall be gradually increased until the test limit is reached (unless malfunction occurs). The frequency of the transient generator shall also be finely tuned for maximum induced voltage and also maximum induced current where the cables are high impedance and low impedance respectively.

At least 10 transients at each frequency shall be applied during a period not exceeding 5 minutes and the EUT monitored for degradation of performance, damage or malfunction. It should be noted that for digital systems it may be necessary to apply the test for longer periods of time in order to determine failure. If required, this should be detailed in the EMC Test Plan. If malfunction occurs, the amplitude of the transient shall be reduced to that for the threshold of malfunction. The transient repetition rate, phase position on the AC waveform (Type 2 transients only) and the transient frequency (Type 1 transients only) shall be varied for maximum susceptibility. The test report shall include details of the levels of transient voltage and current induced on the cables in addition to typical transient waveform oscillograms.

For primary power lines the tests shall be applied at the EUT connector end of the cable. For interconnecting cables, in excess of 1 metre in length, the test shall be applied in turn to each end of the cable. A spacing of 50 mm shall be maintained between the current probes and also between the measuring current probe and the connector of the EUT.

B.7.5.4 Measurement Locations for Type 2 Transient Testing

Table 14 lists the injection probe and voltage measurement locations required for testing various power lines for susceptibility to Type 2 transients:

Table 14 Conductors Injected and Voltage Measurement Locations Type 2 Transients

Power Line Under test	Conductors injected	Voltage Measurement and Location
28 V DC	28 V 0 V 28 V + 0 V[a]	28 V to 0 V 0 V to GND MONITOR LOOP
115 V 400 Hz	115 V Neutral 115 V + Neutral[a]	115 V to Neutral Neutral to GND MONITOR LOOP
3 phase 400 Hz 115 V / 200 V	Phase 1 Phase 2 Phase 3 Neutral Phase 1 + 2 + 3[a] Phase 1 + 2 + 3 + Neutral[a]	Phase 1 to Neutral Phase 2 to Neutral Phase 3 to Neutral Neutral to GND MONITOR LOOP MONITOR LOOP
[a] These power lines are passed thought the injection and monitor probes as a group		

NOTE For power lines having no neutral line the voltage measurements shall be made with respect to the ground conducting bench.

B.7.6 Post-Requisite

As a minimum DCE01.B test is to be performed after all transient susceptibility test have been completed. This is to ensure that no damage to filters or other components has been made which would affect DCE01.B results (See **Clause 6.18**).

B.7.7 Limits

The test limits and waveforms are shown in **Table 15**. The values are in terms of either a maximum induced cable current or a maximum induced cable voltage whichever occurs first, assuming malfunction does not occur. For primary power lines the voltage is measured directly on the power line, but for interconnecting cables the voltage is measured via the monitor turn around the injection probe.

Table 15 Peak Voltage and Current Test limits

Cable Under Test	100 kHz Transients		2 – 30 MHz Transients	
	(V)	(A)	(V)	(A)
Power Lines	700	30	500	20
Control and Signal	100	5	500	20

For Type 2 transients both positive and negative polarities must be applied, this is achieved by reversing the direction of the injection probe.

The limits have been derived from practical measurements performed and also from an examination of the results in existing reports on aircraft transient measurements.

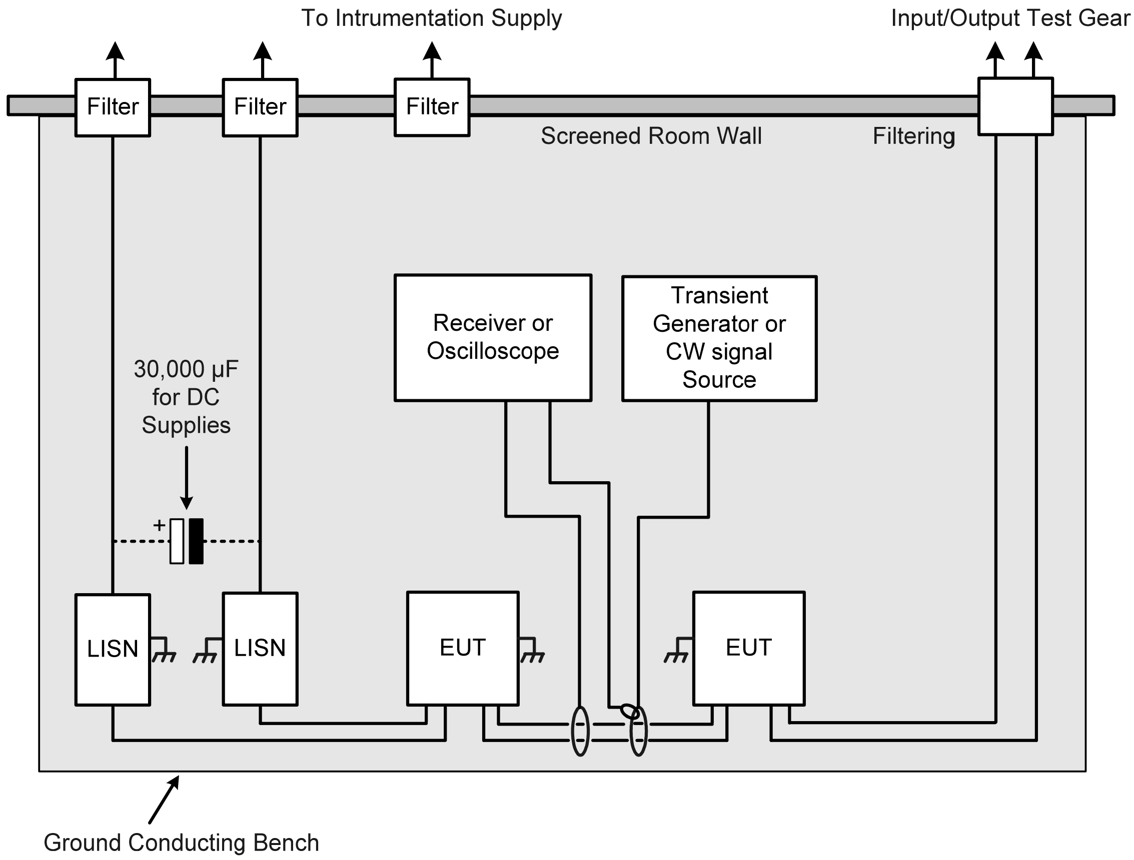


Figure 70 DCS04.B – Typical Test Configuration

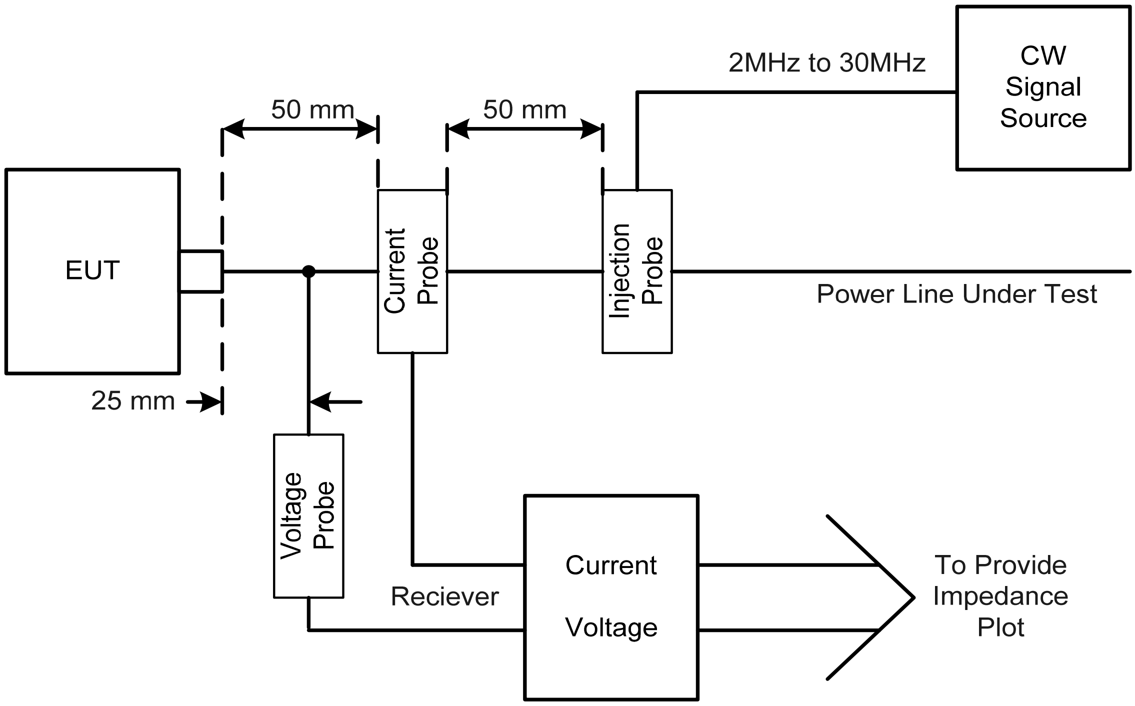


Figure 71 DCS04.B – Typical Test Configuration (for cable impedance measurements - single power lines)

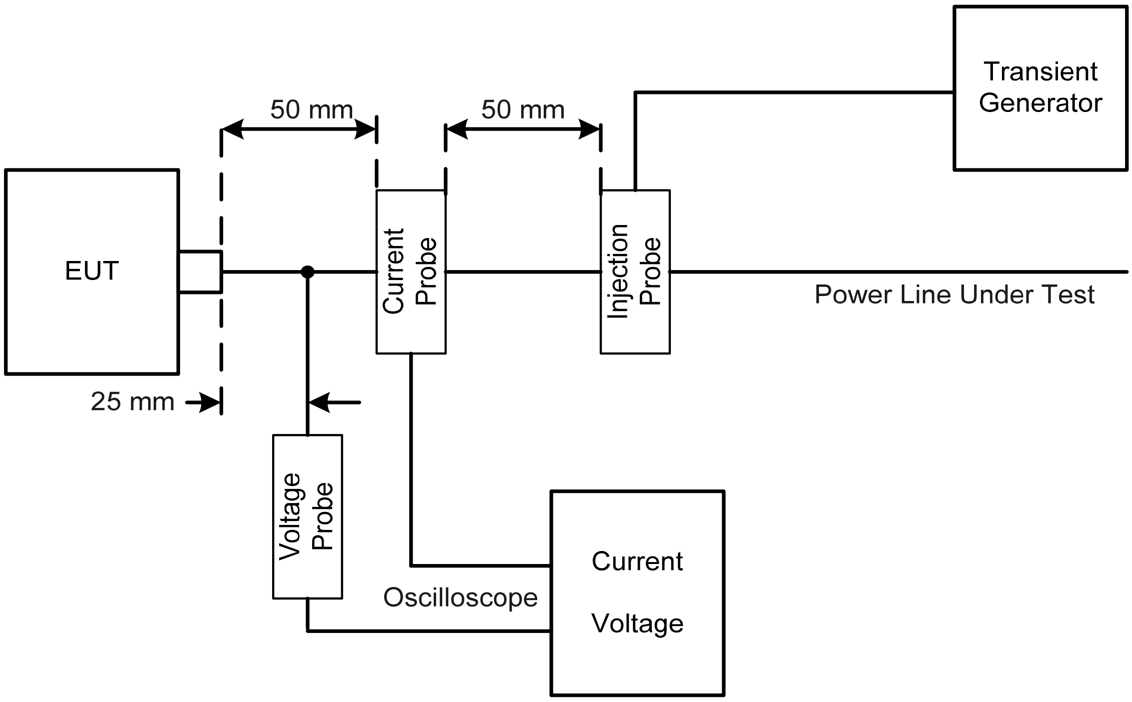


Figure 72 DCS04.B – Typical Test Configuration (for transient injection - single power line)

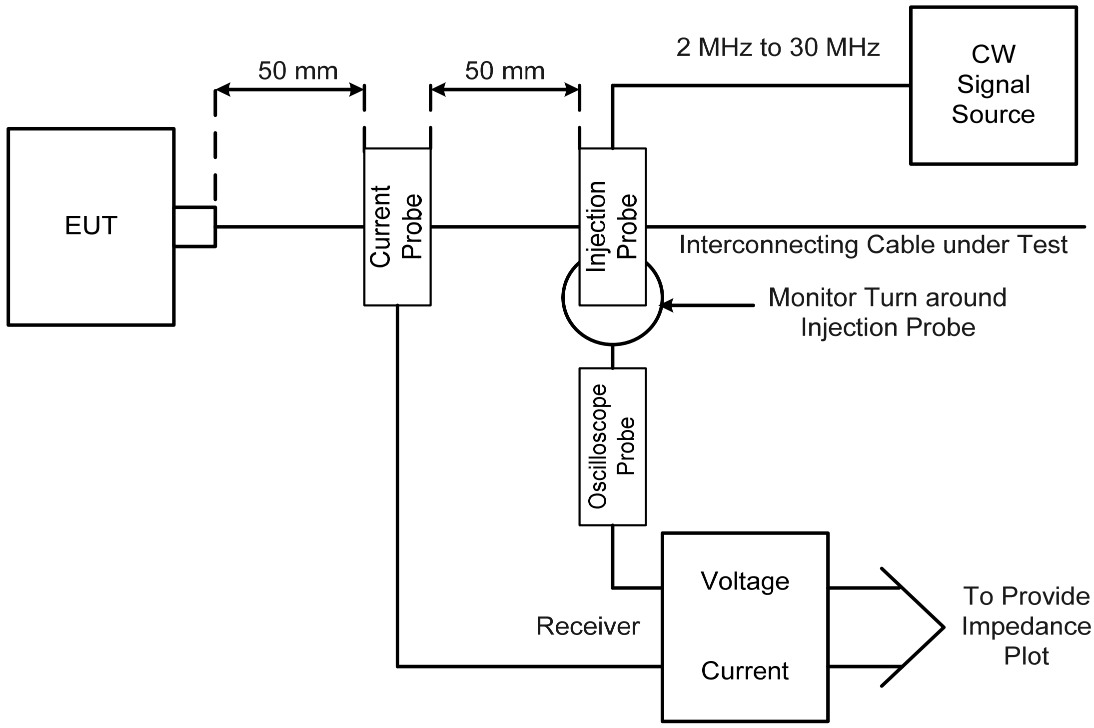


Figure 73 DCS04.B – Typical Test Configuration (for CW impedance measurements - interconnecting cables)

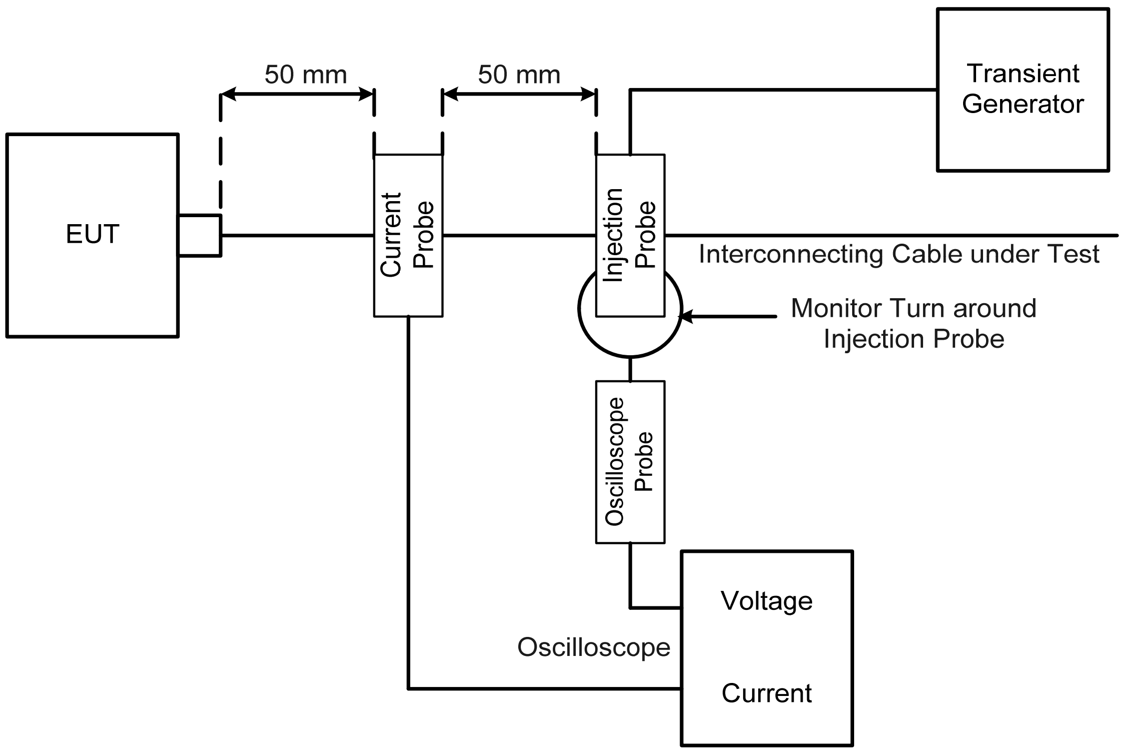


Figure 74 DCS04.B – Typical Test Configuration (for transient injection - interconnecting cables)

B.8 DCS05.B Externally Generated Transients (Land and Sea Services)

B.8.1 Purpose

The purpose of this test is to confirm that the Land and Sea System equipment will withstand externally generated transients imposed on power, signal control cables and ground bonds. This test simulates the high frequency components of transients generated by local switching and defines a minimum test requirement for the purpose of NEMP protection.

B.8.2 Applicability

This test applies to all equipment for use in the Land and Sea Services environments in respect of switching simulation and NEMP hardness.

The test shall be applied to all power lines (common mode), control and signal lines, as well as to ground bonds connected to the EUT. If any cable exceeds 1 metre in length (except primary power lines) then both ends need to be tested.

Equipment connected to antennas, shall additionally be subjected to either radiated free field or direct injection EMP transient testing as defined by the procurement authority. Where the cable loom length between back shells is less than 0.5 m the test will not be required. For cable looms between 0.5 m and 1 m in length the injection and monitoring probes shall be positioned symmetrically about the cable loom centre. .

This test is not applicable to EUT cables, which are terminated directly into antennas. Control and power cables, which interface to an antenna, are subject to this test.

Reference should also be made to **Clause 9.9**.

B.8.3 Pre-Requisite

Conducted emission test DCE01.B must be performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.8.4 Test Layout

A typical test layout is shown in **Figure 75**. The transient generator shall provide a Type 1 variable frequency damped sinusoid, switchable to fixed frequencies over the range 0.5-50 MHz. The generator and injection probe performance, specified in **Annex C Clause C.2.2** and **Table 29**, shall be verified prior to EUT testing, using the 10 Ω calibration jig specified in **Annex C Clause C.4.3.1** and **Table 30**.

Typical injection probe locations are shown in **Figure 75**. At each location, the nearest face of the injection probe shall be 100 mm from the EUT with the monitoring probe 50 mm from the connector.

The EUT shall be positioned in the test house to simulate the cable runs and earth bonding arrangements of the intended platform installation, so far as this is practicable. Reference to **Clauses 6.7**, **6.8** and **6.12** is also required.

Unterminated cables should be avoided and a suitable transducer should be used wherever possible, where this is impractical for test purposes the cable shall be terminated with a 1000 pF capacitor in series with a 50 Ω resistor connected between each conductor and screen or between each conductor and earth if the cable is un-screened.

The LISNs used must be rated to withstand the peak currents and voltages used in this test. Reference to **Annex C Clause C.6** is required.

If the EUT requires special test or auxiliary equipment, very careful consideration must be given to these secondary items since they will also be subjected to pulses when the main unit is under test. Thus test equipment which is rugged and able to withstand test pulses is essential to avoid termination of the test as a result of its malfunction or damage.

B.8.5 Test Method

Each injection probe location shall be subjected to a minimum of 10 applications of the transient at each test frequency. The interval between each application shall be long enough to avoid the cumulative addition of energy from the previous applications. Intervals of between 2s and 10s are normally adequate.

The generator output shall be set at the EUT test levels to achieve the current in the 10 Ω test jig and frequencies shown in **Table 16** and the output applied at each test location. Should malfunctions occur then the generator output level shall be reduced to establish the threshold level.

The tests shall be repeated with the EUT in each of its major operating modes (See **Clause 6.13**).

Where there is a NEMP requirement the switching simulation shall always be conducted first. This will demonstrate the implied compliance at a lower level should the EUT fail any one of the NEMP simulation limits.

NOTE Induced currents flowing in the EUT cabling during this test may be in excess of the values shown in **Table 16** if the cable loop impedance is less than 10 Ω at the frequency of test. The peak induced current amplitude should be recorded.

After all the transients have been applied, conducted emissions test DCE01.B shall be repeated on each power line tested to confirm that any power line filter has not been damaged. This resultant emission profile shall be assessed against the DCE01.B result obtained prior to the transient application. This shall determine whether any damage to the EUT occurred during application of the transients, i.e. Filtering or other component damage. Should any significant changes in emission profile be evident then a FAIL result shall be recorded for this test even if the emission profile has been reduced due to the application of the transient.

NOTE The conducted emission assessment is not intended to show compliance against the DCE01.B limits but is used solely to compare the ‘before’ and ‘after’ emission profiles.

B.8.6 Post-Requisite

As a minimum DCE01.B test is to be performed after all transient susceptibility test have been completed. This is to ensure that no damage to filters or other components has been made which would affect DCE01.B results (See **Clause 6.18**).

B.8.7 Limits

The test levels under which the equipment shall operate correctly are shown in **Table 16**.

NEMP test requirements for Land and Sea Systems define two generic default levels of severity which depend on the predominant location of the equipment cabling. The more severe limits apply where the cables are afforded little protection by the platforms' structure or where the equipment and wiring is in the open (electromagnetically). The test level shall be specified in the test plan based upon the System Requirement document.

The default severe NEMP limits for Land and Sea Systems may be modified for the given installation by analysis of predicted or measured coupling from the free field environment at the resonant length of installation cabling.

Table 16 DCS05.B Limits

Frequency (MHz)	Output Level (Apk) into 10 Ω				
	Switching Simulation	NEMP Simulation			
	All Land and Sea Services Equipment	Sea Services		Land Services	
		Below Decks	Above Decks	Equipment mounted within an armoured vehicle	Equipment in an unprotected location
0.5	10	25	100	10	20
1	10	25	100	14	28
2	10	25	100	20	40
3	10	25	100	20	40
5	10	25	100	20	40
10	10	25	100	20	40
15	7.0	16.75	67	20	40
35	3.4	7.25	29	20	40
50	2.5	5	20	20	40

NOTE 1 For Land Based Sea Services see **Table 6**.

NOTE 2 At the present time the Land service Limits for equipment in an unprotected environment at 35 and 50 MHz are not achievable with the prescribe generator and the test method is under review. Further advice should be sought from DE&S DE3A.

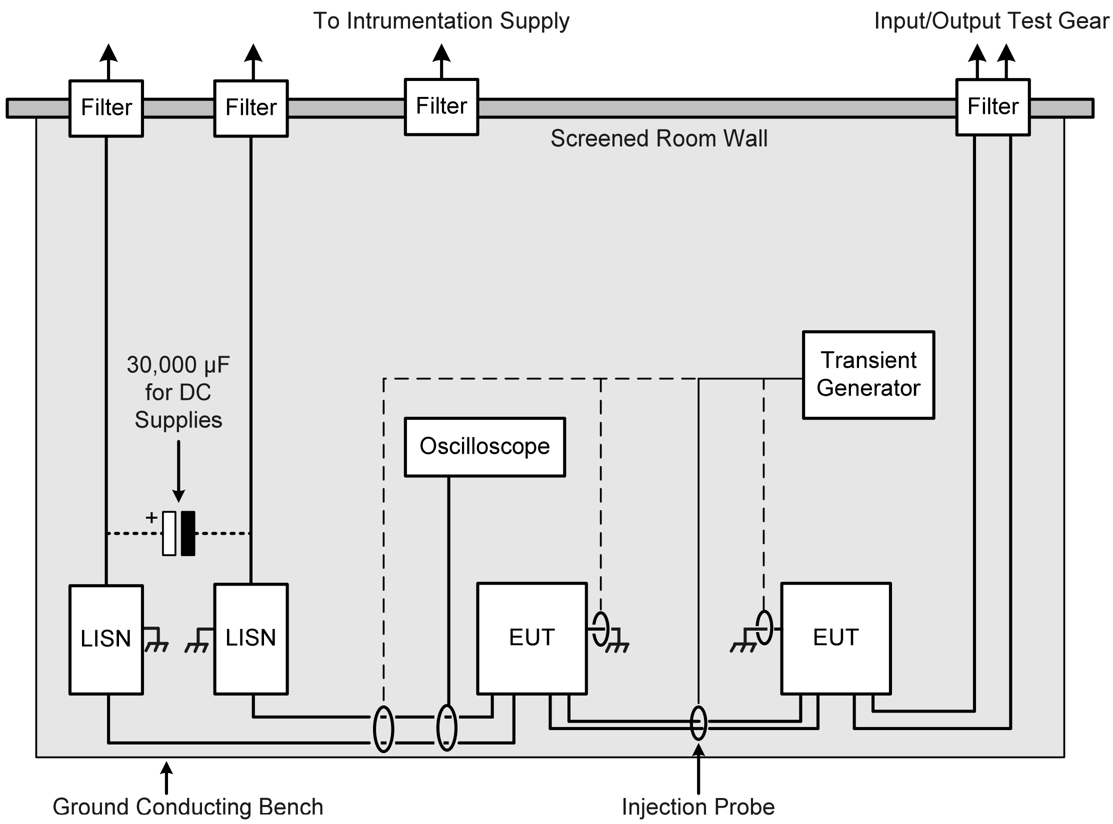


Figure 75 DCS05.B – Typical Test Configuration

B.9 DCS06.B Imported Long Transient Susceptibility AC and DC Systems (Land and Sea Services)

B.9.1 Purpose

The purpose of this test is to ensure that transients typical of those produced by Group Switching of equipment on the power supply lines will not damage the EUT.

B.9.2 Applicability

The test is applicable to all types of EUT and the transients are applied to their power supply inputs. The transient shall be applied to each power lead, which is connected directly to the power supply distribution i.e. both positive and negative lines for DC supplies and live and neutral lines for AC supplies.

Where the cable loom length between back shells is less than 0.5 m the test will not be required. For cable looms between 0.5 m and 1 m in length the injection and monitoring probes shall be positioned symmetrically about the cable loom centre. All power leads shall be tested as a 1 m loom at the EUT end only. Cable looms greater than 1m in length connecting two or more EUTs shall have transients injected at each end in turn. Where equipment has multi-installation applications, the procurement authority must define the number of configurations to be tested.

Reference should also be made to **Clause 9.10**.

B.9.3 Pre-Requisite

Conducted emission test DCE01.B must be performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.9.4 Test Layout

A typical test layout is shown in **Figure 76**. A Type 2 transient generator, with the performance characteristics specified in **Annex C Clause C.2.3** is used with the injection probe as specified in **Annex C Clause C.3** and **Table 29**. Their performance is verified, prior to EUT testing, using the 5 Ω test jig specified in **Annex C Clause C.4**. Reference is also required to **Clauses 6.7**, **6.8**, **6.12** and **Annex C Clause C.6**.

B.9.5 Test Method

Prior to application of the transients to the EUT a calibration shall be performed. This verifies the integrity of the generator output wave shapes and also determines the maximum generator output level to be used during the test.

The calibration is set-up as shown in **Figure 77**. The transient generator output magnitude is adjusted until the required Injection voltage test limit is measured on the oscilloscope. The transient generator output level is then recorded, and this level must not be exceeded during application of transients to the EUT. The wave shape shall meet the requirements of **Annex C Clause C.2.3**.

The EUT shall be installed as shown in **Figure 76**. Ten positive and ten negative polarity transients shall be applied to each power line at the test level, with a gap of approximately 1 second between transients. Positive and negative polarity transients are applied by reversing the direction of the injection probe.

The induced transients shall be monitored as shown in **Figures 78** and **79** so that over stressing the EUT is avoided. The transients are injected at a low level, gradually increasing the generator output until either the injected voltage or current limit is reached, but ensuring that the generator output does not exceed the maximum level recorded during the calibration procedure. The test limit is achieved when any of the aforementioned conditions are met.

During application of the transients the EUT is to be monitored for malfunctions and degradation in performance or damage. Should any occur the transient generator output level is to be reduced until the threshold of susceptibility is reached. This reduced level is then applied into the calibration jig to establish the reduced voltage level for comparison to the test limit.

NOTE 1 The required test limit is measured on the oscilloscope using either a single turn monitor winding wound around the injection probe or the probe's voltage monitor output with a pre-determined correction factor applied.

NOTE 2 In order to measure the required limit on the oscilloscope for 440 V, 415 V and 240 V supplies a 4-turn voltage monitor winding may be added around the probe core. During application of the transients to the EUT an equivalent 4 turn winding shall be connected in series with the power line under test. This winding must be adequately rated for insulation, line current handling capacity and acceptable voltage drop.

NOTE 3 The conducted emission assessment is not intended to show compliance against the DCE01.3 limits but is used solely to compare the 'before' and 'after' emission profiles.

B.9.6 Post-Requisite

After all the transients have been applied, conducted emissions test DCE01.B shall be repeated on each power line tested to confirm that any power line filter has not been damaged. This resultant emission profile shall be assessed against the DCE01.B result obtained prior to the transient application. This shall determine whether any damage to the EUT occurred during application of the transients, i.e. Filtering or other component damage. Should any significant changes in emission profile be evident then a FAIL result shall be recorded for this test even if the emission profile has been reduced due to the application of the transient results (See **Clause 6.18**).

B.9.7 Limits

Ten transients of each polarity are to be applied to each power line at the levels specified in **Table 17** and **Table 18**, subject to the over-riding requirement expressed in the 2nd paragraph of Clause B.9.5.

NOTE For Land Based Sea Services see **Table 6**.

Table 17 Maximum Injected Transient Amplitude Limits (Land Services)

Supply Voltage	Injected Voltage (V peak)	Injected Current (A peak)
415 3∅ 50Hz	2350	100 A (160 dBµA)
240 1∅ 50Hz	1040	58 A (155.3 dBµA)
28V DC	600	30 A (149.5 dBµA)

Table 18 Maximum Injected Transient Amplitude Limits (Sea Services)

Supply Voltage	Injected Voltage (V peak)	Injected Current (A peak)
440V 60Hz 170 to 720V DC	2000	100A (160 dBµA)
115V 60/400Hz	750	40A (152 dBµA)
28V DC	600	30A (149.5 dBµA)

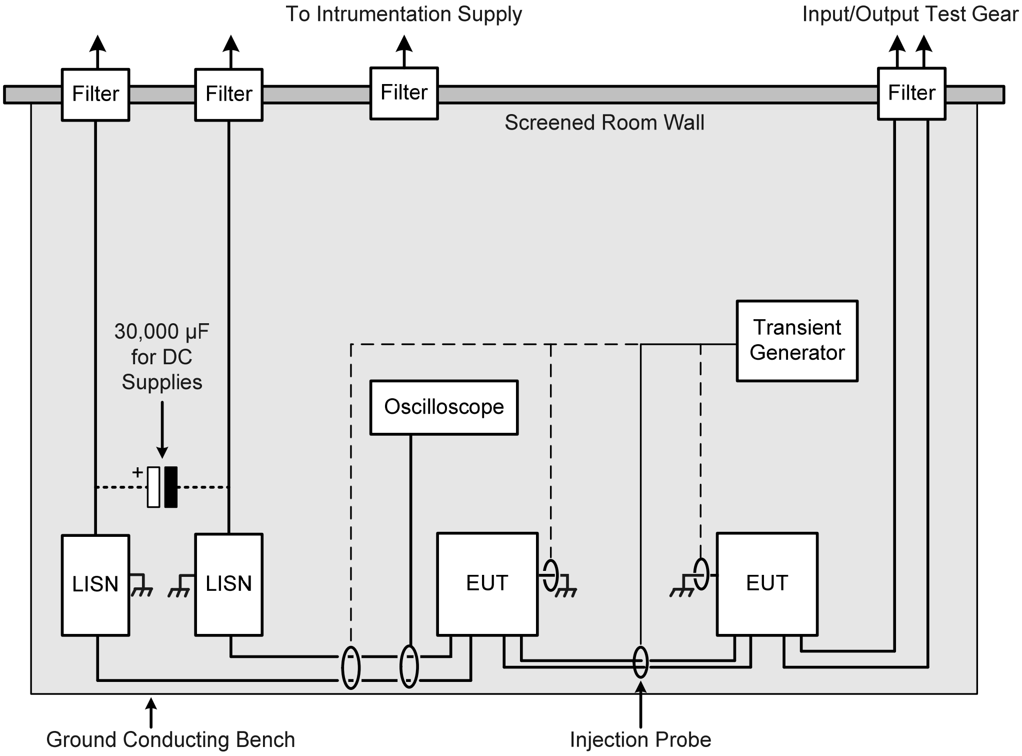
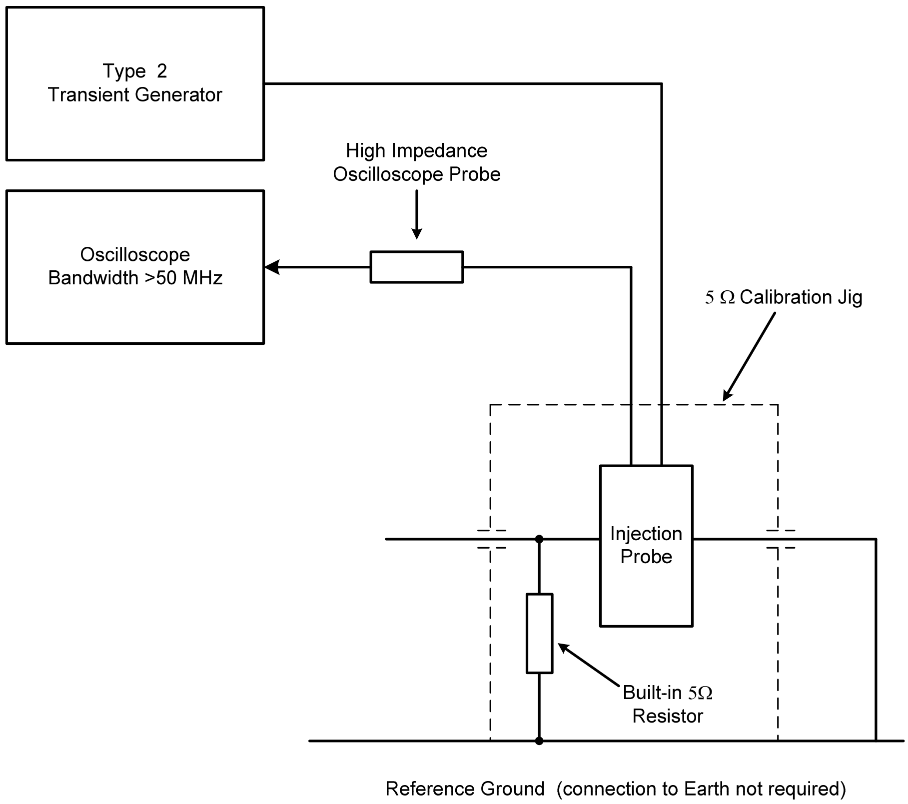


Figure 76 DCS06.B – Typical Test Configuration



NOTE The Oscilloscope probe is connected to a single turn of wire loop wrapped around the injection probe. 4 turns are required for 440 V, 415 V and 240 V limits.

Figure 77 DCS06.B – Calibration Set-Up

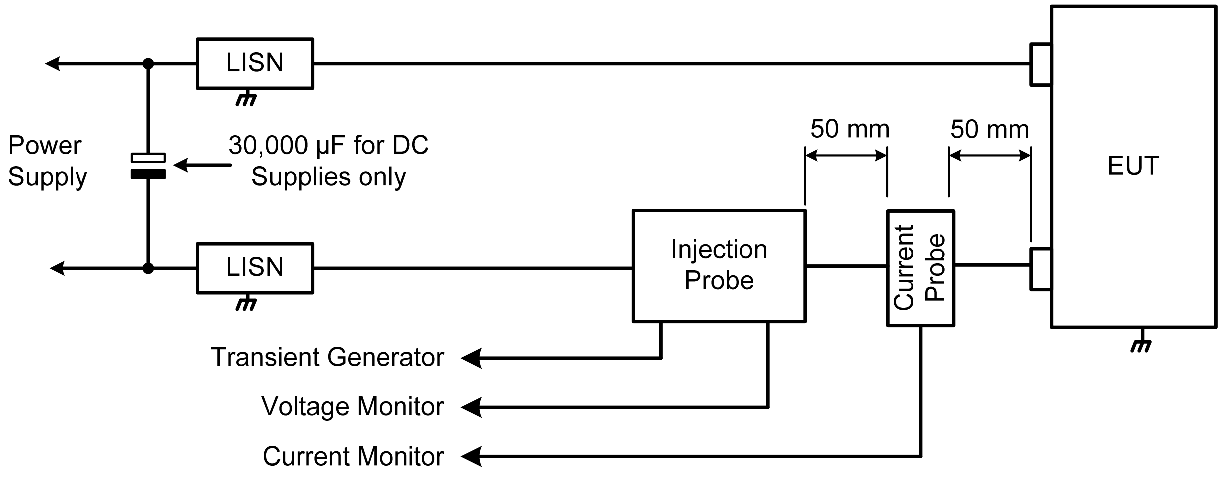


Figure 78 DCS06.B – Injection and Monitoring Details for DC Supplies

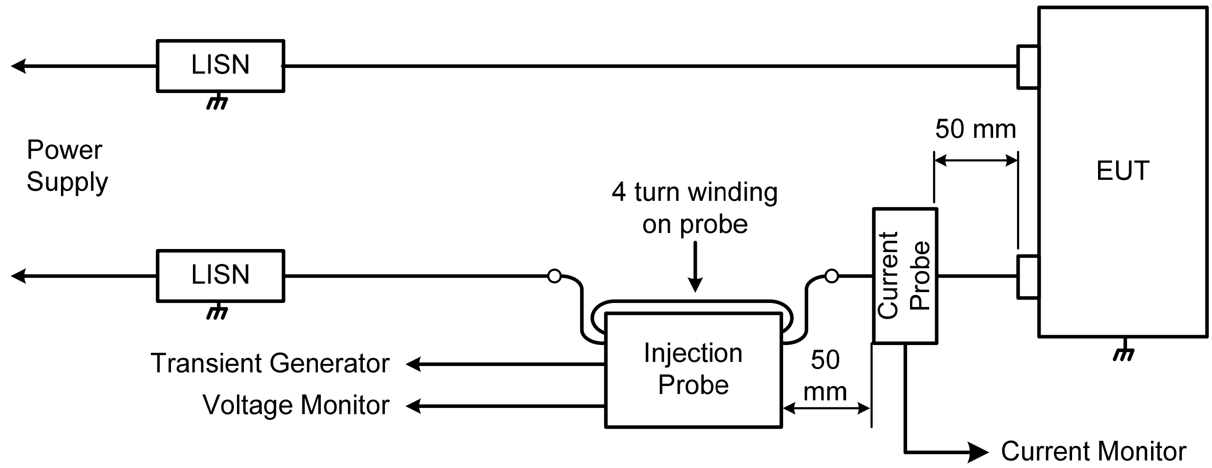


Figure 79 DCS06.B – Injection and Monitoring Details for AC Supplies

B.10 DCS08.B Externally Generated Transients (Air Services)

B.10.1 Purpose

The purpose of this test is to confirm that the EUT will withstand transients induced upon its power and signal cables without damage or malfunction as defined in the Test Plan. Transient characteristics are based on the expected induced current levels due to the coupling of both the Nuclear Electromagnetic Pulse (NEMP) and the high frequency components of the Lightning Electromagnetic Pulse (LEMP).

B.10.2 Applicability

The test applies to all Type 1 equipment, for use in aircraft or air force procured land or ship based equipment, which may be considered critical for aircraft operation. Type 2 and 3 equipment shall be considered with regard to their function and vulnerability. Reference should also be made to **Clause 7.2**.

The test is applicable to all power, control and signal cable looms.

Cable looms shall be representative of the installation and each cable loom sub-group tested separately (i.e. the power loom and each signal and control loom which is routed separately from the connector).

Primary power lines shall, in addition, be tested individually, injecting and monitoring each line in turn.

If the cable loom diameter will not fit within the injection probe window, the loom shall be subdivided and the configurations defined in the Test Plan.

Where the cable loom length between back shells is less than 0.5 m the test will not be required. For cable looms between 0.5 m and 1 m in length the injection and monitoring probes shall be positioned symmetrically about the cable loom centre. All power leads shall be tested as a 1 m loom at the EUT end only. Cable looms greater than 1m in length connecting two or more EUTs shall have transients injected at each end in turn. Where equipment has multi-installation applications, the procurement authority must define the number of configurations to be tested.

Reference should also be made to **Clause 9.11**.

NOTE Where a cable loom to be tested splits into separate branches and the split occurs at more than 0.5 m from the terminating connector, each branch must be individually tested over the entire frequency range. Where the split occurs at less than 0.5 m then the cable loom should be tested at 50 mm from the back shell of the connector carrying the majority of the cables. Where cable looms carrying conductors used in safety critical operations are to be tested then all branches must be tested irrespective of the point at which the loom splits.

B.10.3 Pre-Requisite

Conducted emission test DCE01.B must be performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.10.4 Test Layout

Annex C Clause C.2.4 and **Table 29** specify the Type 1A/M and 1B variable frequency transient generators and performance characteristics and the Injection Probes which shall be used. Their performance shall be verified before EUT testing, using the 100 Ω calibration jig specified in **Annex C Clause C.4**, **Figures 80**, **81** and **82** show typical test arrangements.

B.10.5 Test Method

B.10.5.1 General

This test defines the injection of damped sinewave transients on to the cable looms of the EUT with the EUT interface cabling and bonding representative of the defined installation configurations.

Where test DCS02.B is also applicable, it must be carried out prior to test DCS08.B, in order to find resonance/malfunction frequencies.

Table 19 defines the frequencies at which the damped sinewave transients are to be injected. However, additional testing will be necessary at the following frequencies:

Susceptible frequencies found during test DCS02.B i.e. those frequencies where malfunctions occur below the over test limit.

Resonances found during the DCS08.B cable loom impedance measurements or during the DCS02.B cable resonance test.

Injection on power lines is to be made at the EUT connector end of the line. For cable looms between the EUT units or loads representative of other equipment, **Clause B.10.2** defines the requirement.

B.10.5.2 Equipment

The open circuit transient voltage of the generator and the appropriate injection probe is measured by placing a small low inductance loop around the injection probe. The output of the loop is monitored using an oscilloscope. It should be noted that voltages up to 4 kV will be induced in this loop. A suitable monitor loop is described in **Annex C.5**.

Current monitoring probes must be capable of accurately recording the transient without saturation either by the primary current flow in the cable loom under test or when combined with the level of the injected transient. The transfer impedance characteristic should preferably be flat over the required frequency range.

For voltage measurements, a suitable high voltage probe or a high impedance, high voltage divider will be required providing a combined measurement system bandwidth response of 100 MHz. The high voltage probe capacitance shall not exceed 20 pF and the input resistance shall not be less than 4 kΩ.

The oscilloscope shall be DC coupled with a minimum bandwidth of 100 MHz, have an external time base trigger, and provide a 50 Ω input impedance for the monitoring current probe. A means of recording the oscilloscope trace must be provided. Fast digitising oscilloscopes are recommended.

B.10.5.3 Cable Loom Impedance

Figure 80 shows the test arrangement and probe positions for measuring the impedance of each of the cable looms. Low level CW is injected via the injection current probe and swept between 2-50 MHz. The voltage and current are detected by the analyser and the impedance for each cable loom impedance plotted for inclusion in the Test Report. This impedance measurement is only necessary if the DCS02.B cable resonance test has not been carried out or the configuration or current probe positions are different.

B.10.5.4 Transient Injection

Transient injection shall be carried out at the frequencies identified and defined in Clause B.10.5.1 using the test arrangement shown in **Figure 82**, where the CW signal source has been replaced by the transient generator.

At each frequency defined by the cable loom impedance measurement, the transient generator shall be adjusted to align with the exact cable loom resonance. Since cable loom resonances may have a significant coupling effect on the generator it is recommended that the generator frequency be checked by averaging the zero crossings of the waveform.

A minimum of 5 transients shall be injected at each frequency and at the limit amplitude at either the current, voltage or the volt-amp limit on each cable loom defined in the Test Plan. See **Part 1 Clause 10** of this Standard. The time interval between transients shall be between 2 and 4 seconds, if a malfunction occurs, the transient amplitude shall be reduced to obtain the threshold. The Test Report shall state the peak induced transient current, the peak probe loop voltage and the volt-amp product at each test frequency. The Test Report shall also record the frequencies at which failures occurred together with the threshold levels of any effects.

Table 19 Primary Test Injection Frequencies

Test Number	Frequency (MHz)	Test Number	Frequency (MHz)	Test Number	Frequency (MHz)
1	2.00	18	6.10	35	18.7
2	2.14	19	6.52	36	19.9
3	2.28	20	6.96	37	21.3
4	2.44	21	7.44	38	22.7
5	2.60	22	7.94	39	24.3
6	2.78	23	8.48	40	25.9
7	2.97	24	9.06	41	27.7
8	3.17	25	9.68	42	29.6
9	3.38	26	10.3	43	31.6
10	3.61	27	11.0	44	33.7
11	3.86	28	11.8	45	36.0
12	4.12	29	12.6	46	38.4
13	4.40	30	13.4	47	41.0
14	4.70	31	14.4	48	43.8
15	5.02	32	15.3	49	46.8
16	5.36	33	16.5	50	50.0
17	5.72	34	17.5		

B.10.6 Post-Requisite

As a minimum DCE01.B test is to be performed after all transient susceptibility test have been completed. This is to ensure that no damage to filters or other components has been made which would affect DCE01.B results (See **Clause 6.18**).

B.10.7 Limits

For internally mounted equipment, the levels of the maximum peak induced current, the maximum probe loop voltage and the maximum volt-amp product of the current and voltage are shown in **Table 20**.

Table 20 Limits for Maximum Peak Induced Current, Probe Loop Voltage and Volt-Amp Product

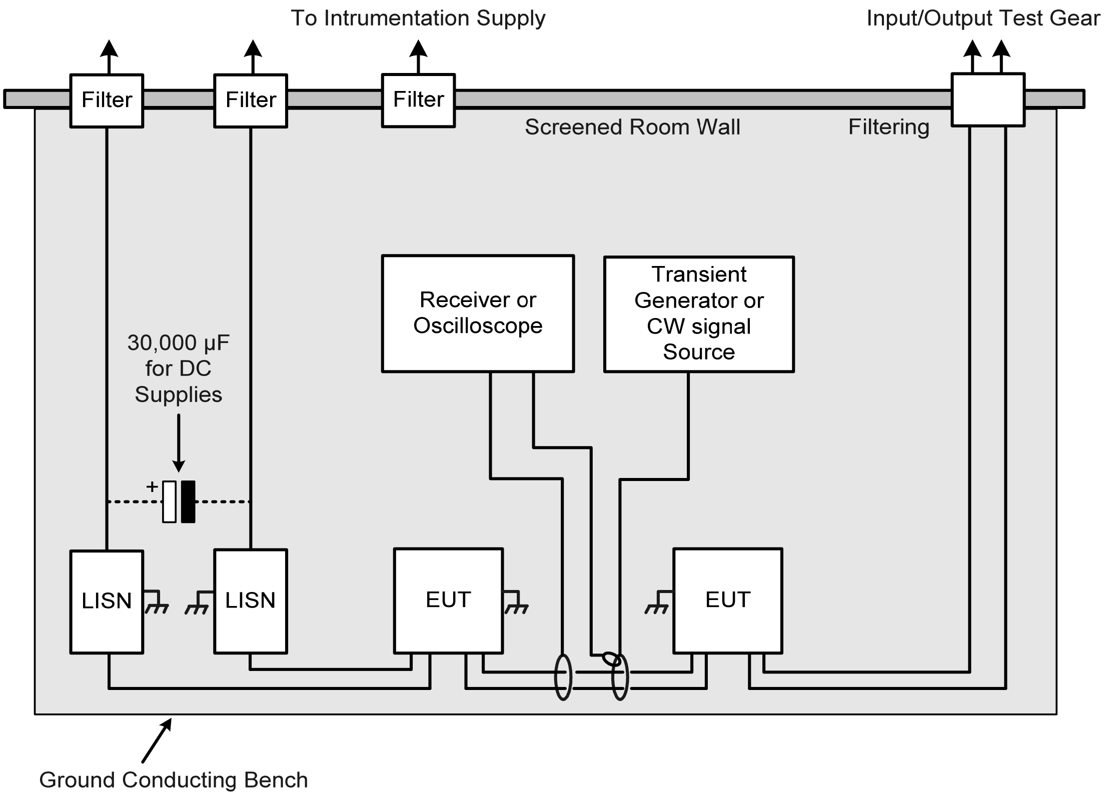
Frequency Range (MHz)	Maximum Peak Induced		
	Current (A)	**Loop voltage (kV)**	**Volt-Amp (kV-A)**
2 – 30	30.0	3.00	30.0
30	30.0	3.00	30.0
35	25.5	2.55	23.2
40	21.6	2.16	17.3
45	18.1	1.81	12.1
50	15.0	1.50	7.5

NOTE 1 Between 30-50 MHz the amplitude reduces linearly with the logarithm of the frequency.

NOTE 2 For external or unprotected equipment, the values of each of the three maximum peak induced parameters shall be doubled at each test frequency

NOTE 3 Where NEMP only is of concern, then the above limits may be re-defined

NOTE 4 The test limit will be achieved when any one of the above three criteria is satisfied. The volt-amp product is that obtained by taking the product of the maximum voltage and current taking no account of the sign or the relative time of the two signals



NOTE See **Figures 81** and **82** for Probe spacing.

Figure 80 DCS08.B – Typical Test Configuration

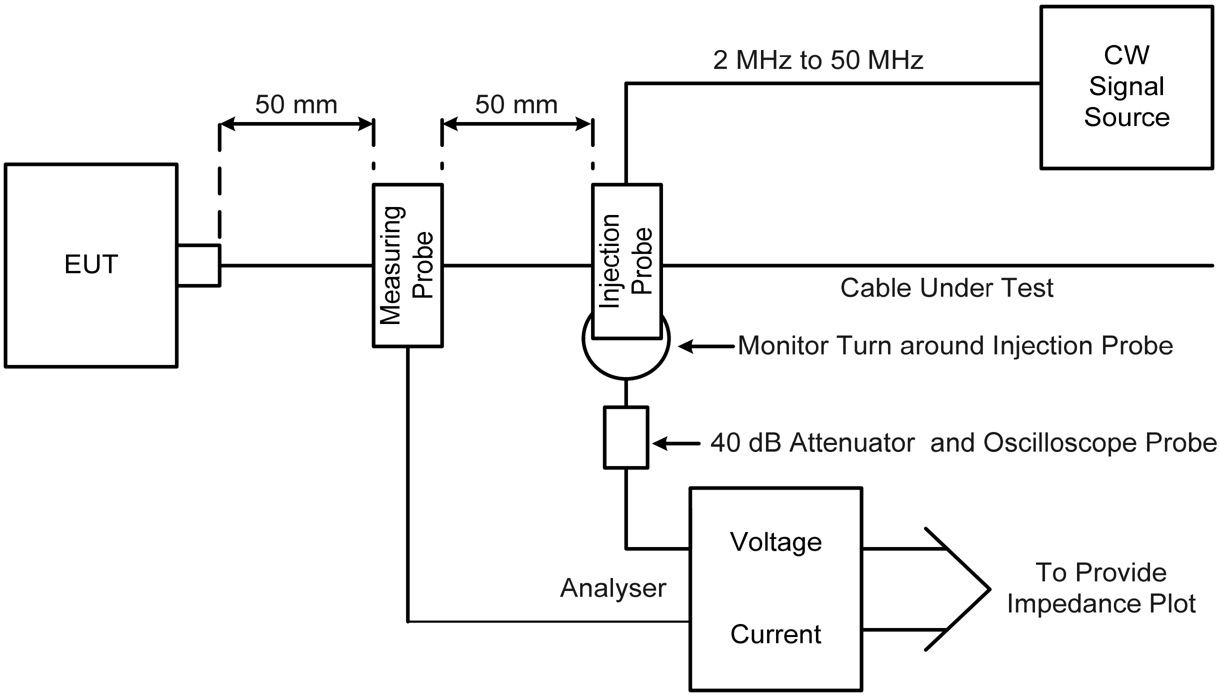


Figure 81 DCS08.B – Typical Test Configuration for CW Impedance Measurement

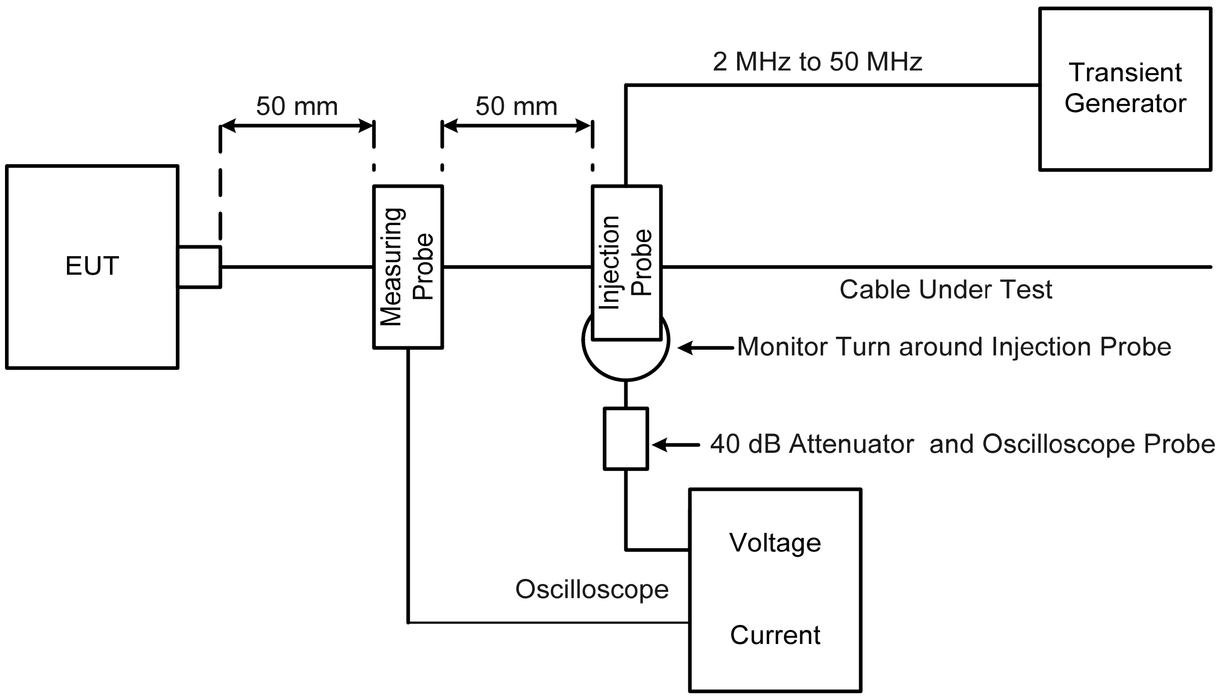


Figure 82 DCS08.B – Typical Test Configuration for Transient Injection

B.11 DCS09.B Imported Lightning Transient Susceptibility (Air Services)

B.11.1 Purpose

A direct lightning strike to an aircraft will result in the coupling of electrical transients to equipment wiring, including the EUT ground bonding arrangements. The purpose of this test is to ensure that these transients will not cause damage, malfunction or unacceptable performance degradation of the equipment. These performance criteria will be defined in the Test Plan.

B.11.2 Safety Considerations

The pulse generators used in these tests produce lethal voltages and suitable safety precautions must be taken. Operators, trials engineers and observers must be made aware of the potential hazards and instructed to follow the approved safety procedures of the Test House responsible for the conduct of the tests.

When testing with the Long Pulse Waveform, in particular, it is advisable for personnel in the vicinity of the EUT to wear eye protection. Some components have been known to explode and project debris over distances of several metres.

Some types of pulse generators can produce a high intensity burst of noise when they are fired. Operators, trials engineers and observers should be made aware of this and advised to wear ear protection.

B.11.3 Applicability

The test applies to all Type 1 equipment for use in aircraft or any air force procured land or ship based equipment, which may be considered critical for aircraft operation. Type 2 and 3 equipment shall be considered with regard to their function and vulnerability. Reference to **Clause 7.2** is required.

The test is applicable to all units comprising an EUT. Interface load boxes and exercising equipment shall, in respect of earthing and bonding, be representative of the installation including the mounting trays.

If any two units of an EUT are mounted less than 0.5 m apart and their ground bonding points are to the same part of the aircraft structure, then this test is not applicable to the two units separately. In this case the two units will be regarded as a single unit with their ground bonding leads joined together and tested with respect to other units comprising the EUT.

If any two units of an EUT are mounted less than 0.5 m apart and have any of their ground bonding points connected to different parts of the aircraft structure, then the units shall be tested separately.

Some of the more complex EUT may require clarification of the test method and approval of test plans and procedures by the MOD Project Manager (Should the Project Manager find difficulty in this then specialist advice should be sought).

Reference should also be made to **Clause 9.12**.

B.11.4 Pre-Requisite

Conducted emission test DCE01.B must have been performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.11.5 Test Layout

A typical test layout is shown in **Figure 83**. The EUT should be laid out in accordance with the general requirements of **Clause 7**. It should be functioning and configured in a manner representative of the actual aircraft installation. Care must be taken to ensure that the LISNs used are rated to withstand the currents and voltages used in this test. Reference to **Annex C.6** is also required.

The EUT must be isolated from the ground conducting bench using 50 mm thick insulating material capable of withstanding the maximum test voltage.

If special-to-type test, exercising equipment or other units which do not form part of the operational EUT fit are present, it must be confirmed that the grounding and bonding philosophy is fully representative of the aircraft installation. This is to ensure that the injected currents and voltages will be distributed around the EUT in a representative manner. It must also be ensured that equipment that does not form part of the EUT are not themselves upset by the testing and cannot give rise to erroneous fault conditions.

Interconnecting layout cable bundles must be laid out in such a manner as to minimise any non-representative inductive interactions, i.e. only bunch together those cable bundles that would be run together in the aircraft installation.

B.11.6 Pulse Generators

The generator(s) used for this test should be capable of producing the Short, Intermediate and Long duration waveforms specified in **Annex C Clause C.2.5**. The performance of these generators shall be verified using the same output leads, which will be used, subsequently, to connect each generator to the EUT.

B.11.7 Test Method

a) Identify the main grounding point for each unit of the EUT.

b) Disconnect all local EUT grounding straps from the test facility ground conducting bench, i.e. those grounding straps, safety earths and signal earths etc. which are intended to be grounded to the same part of the aircraft structure within 0.5 m of the EUT. Connect the disconnected ends together to form an isolated grounding point for the EUT.

c) Connect the pulse generator between the facility ground conducting bench and the isolated EUT grounding point using the same test leads that were used for the calibration procedure.

d) Switch the EUT on and ensure that it is operating in accordance with the EMC Test Plan.

e) Operate the pulse generator and increase the output from zero up to the test limit in steps not exceeding 10% of the required test limit. Apply at least 3 transients at each step, with a delay of at least 8 seconds between each.

f) If a malfunction occurs, record the applied peak current and voltage levels.

g) If no malfunction occurs, increase the generator output until the peak current or peak voltage test limit is reached and then apply 10 transients, separated by at least 8 seconds, over a period of not more than 2 minutes. Record a typical set of the current and voltage waveforms that appear between the equipment case and earth.

h) Repeat the above procedure for both positive and negative polarity pulses.

B.11.8 Application of Test Waveforms

The Short Pulse waveform shall be applied to all EUTs. If it is known that a particular equipment is intended to be installed in an aircraft with a well bonded, low impedance, largely metallic structure then the Intermediate Pulse waveform shall be applied in addition to the Short Pulse.

For equipment that is intended to be installed in largely Carbon Fibre Composite (CFC) airframes or equipment whose interconnecting wiring is run in areas covered by CFC panels then the Long Pulse waveform shall be applied in place of the Intermediate Pulse.

If it is not known where the equipment is to be installed then guidance should be sought from the relevant project office.

The four test categories are defined in **Clause B.11.10** and the test levels are shown in **Table 21**.

B.11.9 Post-Requisite

As a minimum DCE01.B test is to be performed after all transient susceptibility test have been completed. This is to ensure that no damage to filters or other components has been made which would affect DCE01.B results (See **Clause 6.18**).

B.11.10 Limits

Equipment Categories

The limits on induced current and voltage depend on the category of equipment to be tested. The four test categories are defined as follows:

a) CAT A Equipment and cabling installed in a protected EM environment such as a completely enclosed compartment in a metallic materiel.

b) CAT B Equipment and cabling installed in a partially exposed EM environment such as below a dielectric cover in a largely metallic structure.

c) CAT C Equipment and cabling bonded to the same part of the materiel structure and installed in an exposed EM environment where large portions of the structure are constructed from poorly conducting materials or CFC.

d) CAT D Equipment and cabling bonded on different parts of the materiel structure and installed in an exposed EM environment where large portions of the structure are constructed from poorly conducting materials or CFC.

Where equipment and cables can be defined in more than one of the above categories then the test levels associated with the more severe environment shall be applied.

The limits for Equipment Categories are shown in **Table 21**.

Table 21 Peak Waveform Amplitude Limits

Category	Peak waveform amplitude, current and voltage					
	Short		Intermediate		Long	
	(V)	(A)	(V)	(A)	(V)	(A)
A	125	250	125	250	N/A	N/A
B	300	600	300	600	2000	1000
C	750	1500	750	1500	2000	3000
D	1600	3200	1600	3200	2000	10000

NOTE Some branches of the EUT harness will be very low impedance (screened cables) and some high impedance (unscreened cables). The low impedance cables will have high current flow (up to 10,000 A) and the high impedance cables will have high voltages induced at the maximum generator outputs. It is important to note that the applicable limit is met when either the peak current or voltage reaches the required level.

When testing equipment using the Long waveform if the voltage limit is reached before the current limit, testing should be stopped and then recommenced using the Intermediate waveform at CAT D levels.

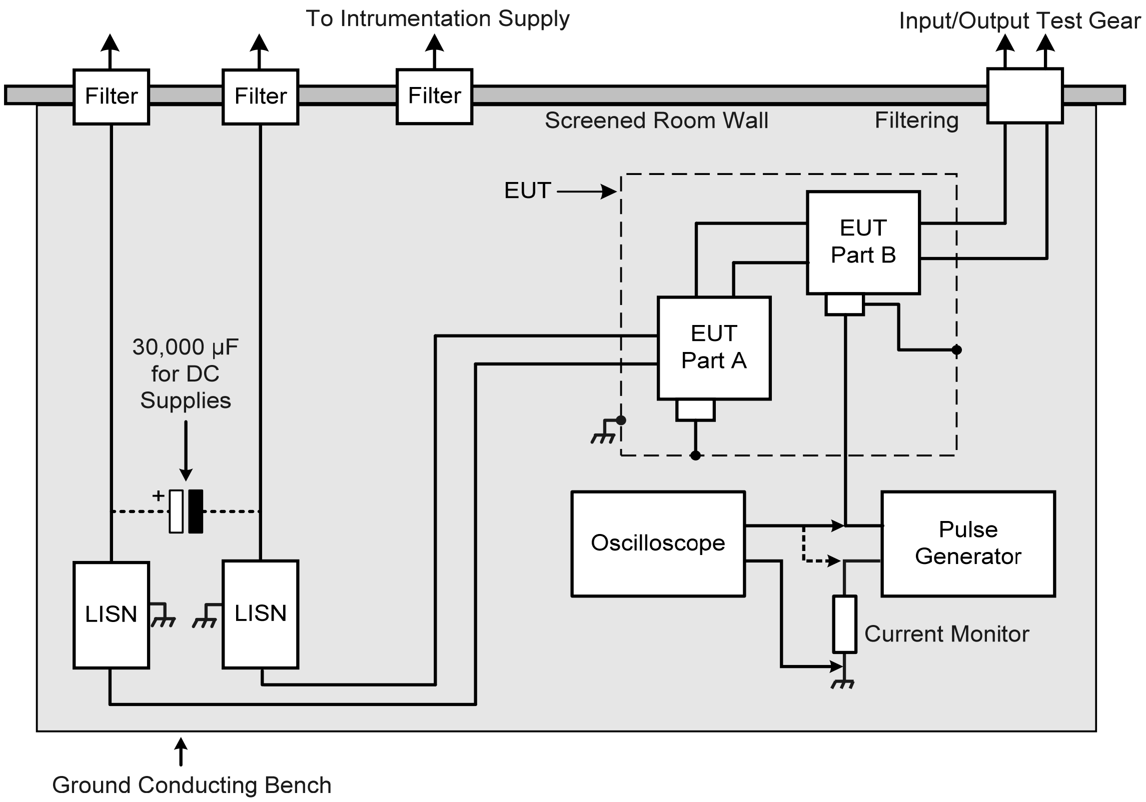


Figure 83 DCS09.B – Typical Test Configuration

B.12 DCS10.B Electro Static Discharge (ESD)

B.12.1 Purpose

See **Clause 9.13** for all details relating to this test.

B.13 DCS12.B Imported Low Frequency Transient Susceptibility Power Lines (Sea Services)

B.13.1 Purpose

The purpose of this test is to confirm that the EUT will withstand imported low frequency transients imposed upon its power supply lines. This test simulates the effect of voltage transients observed due to switching of machines and other loads on ship and submarine power supply systems.

B.13.2 Applicability

This test applies to all equipment in use in the Sea Services environment connected to ship and submarine power supplies. Positive-going and negative-going, damped sinewave transients between 10 and 16 kHz, are to be applied to individual supply lines of an EUT, for both AC and DC incoming supplies. Battery operated equipment which may be connected to a platform supply, for example, during battery charging, shall also be subjected to this test.

Reference should also be made to **Clause 9.14**.

B.13.3 Pre-Requisite

Conducted emission test DCE01.B must have been performed prior to performing any transient test.

NOTE If the test has been performed as part of the trial then this is acceptable.

B.13.4 Test Layout

A typical test layout is shown in **Figure 84**. The characteristics of the injected transient and performance criteria of the generator are specified in **Clause B.13.5**.

The equipment under test shall be installed in the test house in such a way as to accurately simulate the intended platform installation. The secondary of the injection transformer shall be wired into each line under test at the LISN end.

B.13.5 Generator Characteristics

The generator is intended to simulate imported low frequency damped sinusoid transients, imposed on power lines. The generator shall incorporate an output transformer having a secondary winding to be connected in series with the power line under test. The generator shall be capable of providing three alternative fixed output voltages. The specific performance characteristics of the generator output, when the secondary winding is terminated with a 10 Ω ± 5% low inductance resistor, are shown in **Table 22** with typical waveforms shown in **Figures 85** and **86**.

B.13.6 Pre-Test Generator Check

Prior to the in-line connection of the transient generator secondary winding, the output of the generator, when terminated with a 10 Ω ± 5% low inductance resistor, shall be checked to be compliant with the test levels shown in **Table 23**.

B.13.7 Test Method

With the transient generator connected in series with the supply line under test, the EUT is to be checked for correct function and operation prior to the application of the transients.

Each supply line in turn shall then be subjected to twelve positive-going applications of the transient using the generator output settings appropriate to the EUT supply voltage as shown in **Table 22** followed by twelve negative-going transients. These transients shall be applied at a rate of one every 2-5 seconds.

The generator output voltage shall be monitored to record in the test report the voltage induced into the cable under test, together with examples of the actual induced transient waveforms.

During each transient application, the EUT shall be monitored for degradation of performance, damage or malfunction as defined in the EMC test plan. When testing digital systems it may be necessary to apply a greater number of transients to ensure detection of any malfunction. In this case, the EMC test plan should include some guidance to ensure capture of a malfunction during test.

Any malfunction, failure or damage of the equipment shall be investigated and recorded in the Test Report.

Table 22 DCS12.B Generator Performance Characteristics

Output voltage (Vpk) ± 10%[a]	600	750	2500
Frequency (kHz) ± 10%[b]	15.9	15.9	10.9
Relative amplitude of 3rd ½ cycle[c]	0.6 – 0.8	0.6 – 0.8	0.2 – 0.3
Output impedance (Ω) ± 10%[d]	0.15	0.4	2.5

[a] Specified as the amplitude of the first half cycle e.g. Vpk.

[b] Calculated from the combined duration of the first three half cycles

[c] e.g. V/Vpk

[d] Specified as the value of resistance which, when connected across the secondary winding, reduces the winding voltage (amplitude of first half cycle) to half the open circuit voltage.

B.13.8 Post -Requisite

As a minimum DCE01.B test is to be performed after all transient susceptibility test have been completed. This is to ensure that no damage to filters or other components has been made which would affect DCE01.B results (See **Clause 6.18**).

B.13.9 Limits

The EUT shall continue to function properly, during and after the application of the transients whose levels are specified in **Table 23**.

NOTE The peak voltage recorded on the oscilloscope may be different from that seen during the calibration procedure if the input impedance of the EUT and LISN in series is different from 10 Ω ± 5% at the frequency of the transient.

Table 23 Level of Applied Transients

EUT Supply Voltage (V)	Peak Voltage Across 10 Ω Resistor (V)
440 V – 60 Hz 170 – 720 V DC	2500 ± 15%
115 V – 60/400 Hz	750 ± 10%
24 V DC	600 ± 10%

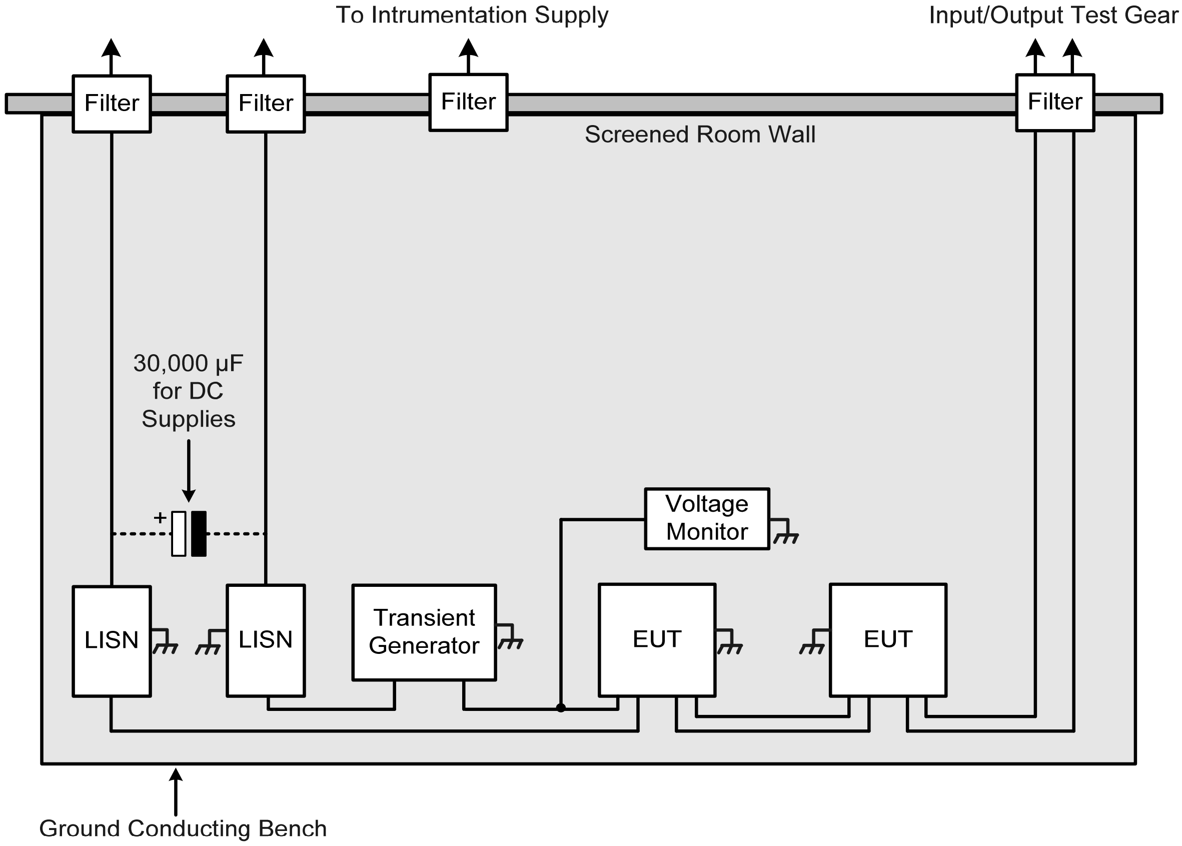


Figure 84 DCS12.B – Typical Test Configuration

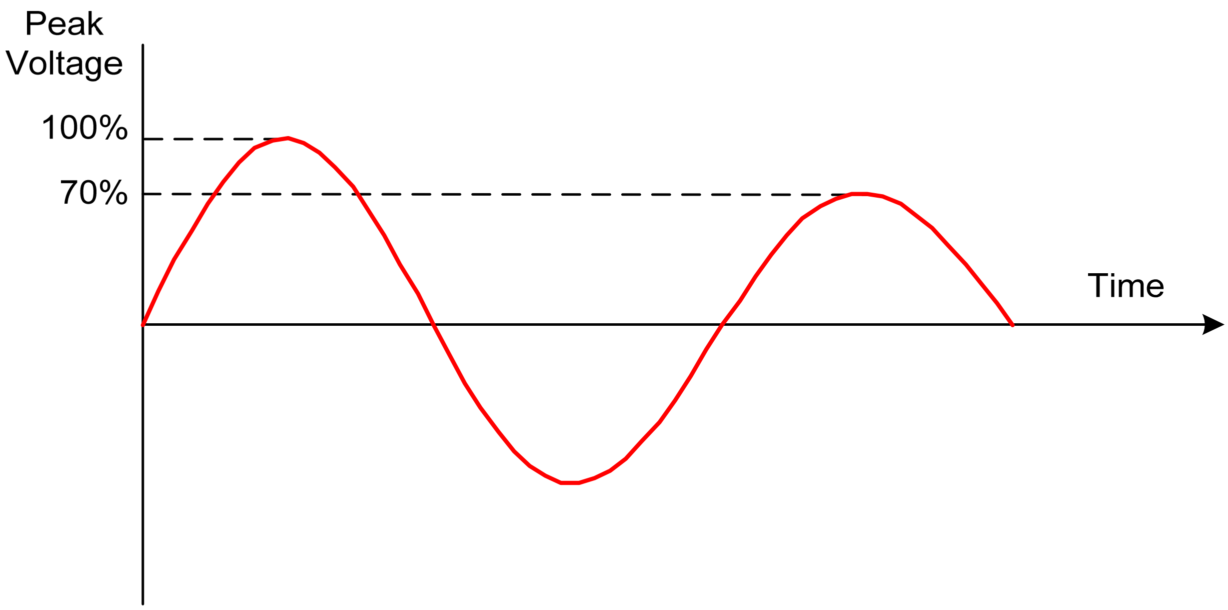


Figure 85 DCS12.B – Typical Transient Waveform (600 V and 750 V)

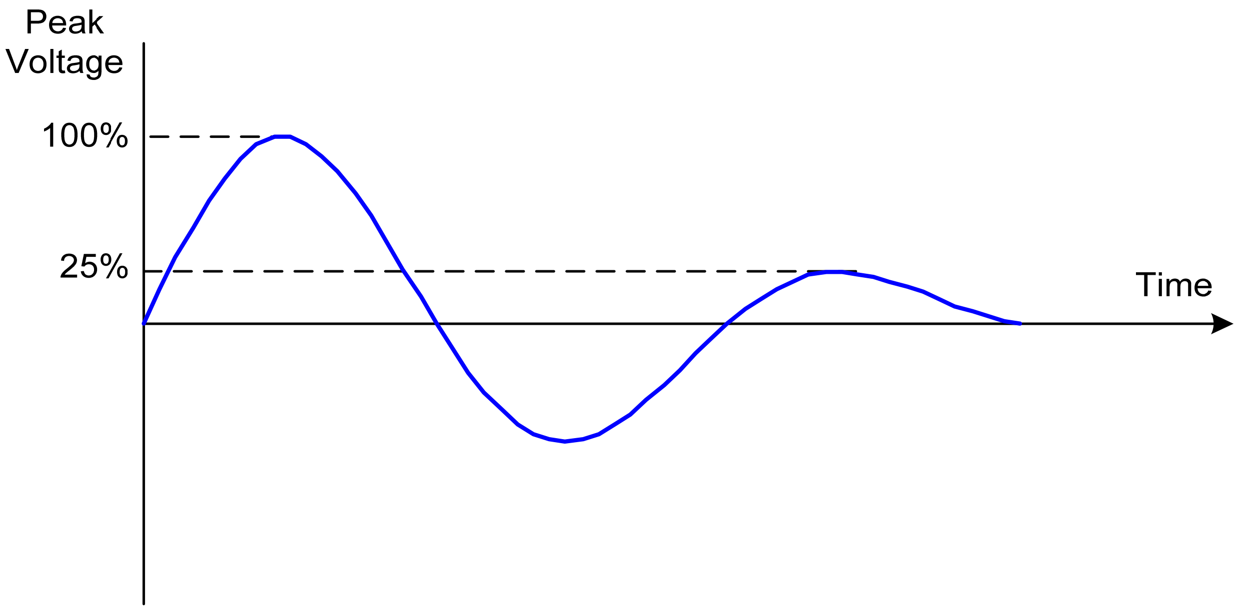


Figure 86 DCS12.B – Typical Transient Waveform (2500 V)

B.14 DRE01.B Radiated Emissions Electric (E) Field 10 kHz – 18 GHz

B.14.1 Purpose

The purpose of this test is to confirm that the E Field emissions have been controlled to the required limits so that the performance of the most sensitive equipment (communications receivers etc.) is not impaired.

B.14.2 Applicability

This test is applied to the EUT, and its connecting harness.

Transmissions from antennas are not subject to the limit of this test but are subject to the performance specification requirements. Equipment for test which is normally connected to antennas shall for this test be fitted with a screened dummy antenna where possible and be subject to the limits of this test. The limit of the fundamental frequency of transmission may be relaxed at the discretion of the Project Manager.

Reference should also be made to **Clause 9.15**.

NOTE For Class A and B land based equipment, in the frequency range 1.6 MHz to 30 MHz, Test Method DRE03.B shall be used.

B.14.3 Test Layout

A typical EUT, interconnecting harness and test equipment layout is shown in **Figure 87** with typical antenna arrangements in **Figures 88**, **89**, **90** and **91**. Reference is also required to **Clause 6** is required especially sub **Clauses 6.7**, **6.8** and **6.12**.

B.14.4 Test Method

The radiated emissions are monitored using the specified antennas for each mode defined in the Test Plan (see **Part 1 Clause 10** of this Standard). For small test samples the monitoring antennas shall be positioned opposite the test sample. For larger layouts with several units, tests at extra positions will be required so that the maximum radiated emissions can be recorded. Reference to **Clause 6**, especially sub **Clauses 6.10**, **6.15**, **6.16** and **6.22** and **Annex C Clause C.6** is also required.

NOTE See **Clause 6.30.2** re overload precautions if using an active rod.

B.14.5 Limits

Recommended limits and frequency ranges are shown in **Figures 92**, **93**, **94**, **95** and **96**. Reference to **Clauses 7.4**, **7.5** and **7.6** is also required.

NOTE For Land Based Sea Services see **Table 6**.

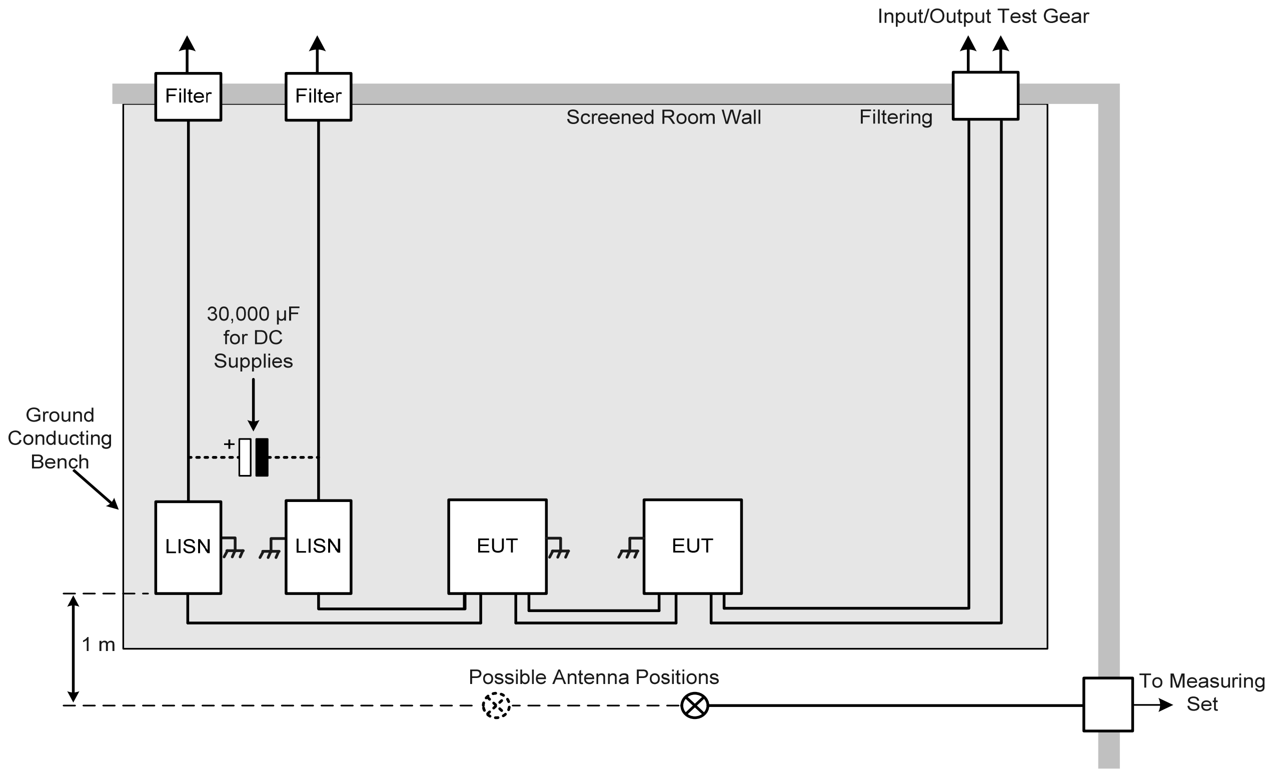
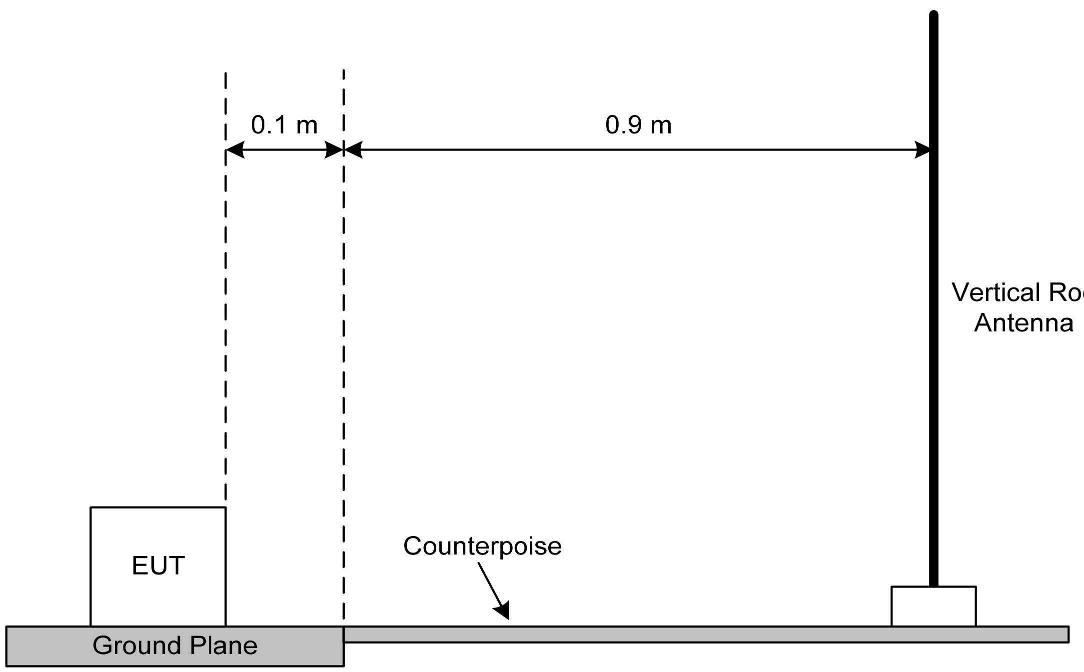
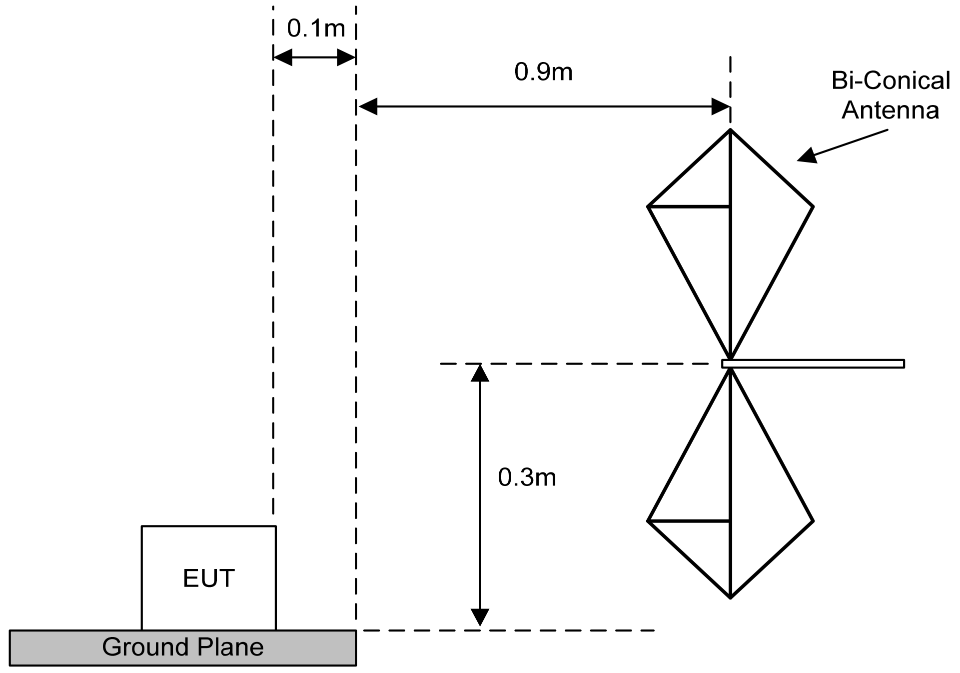


Figure 87 DRE01.B – Typical Test Configuration



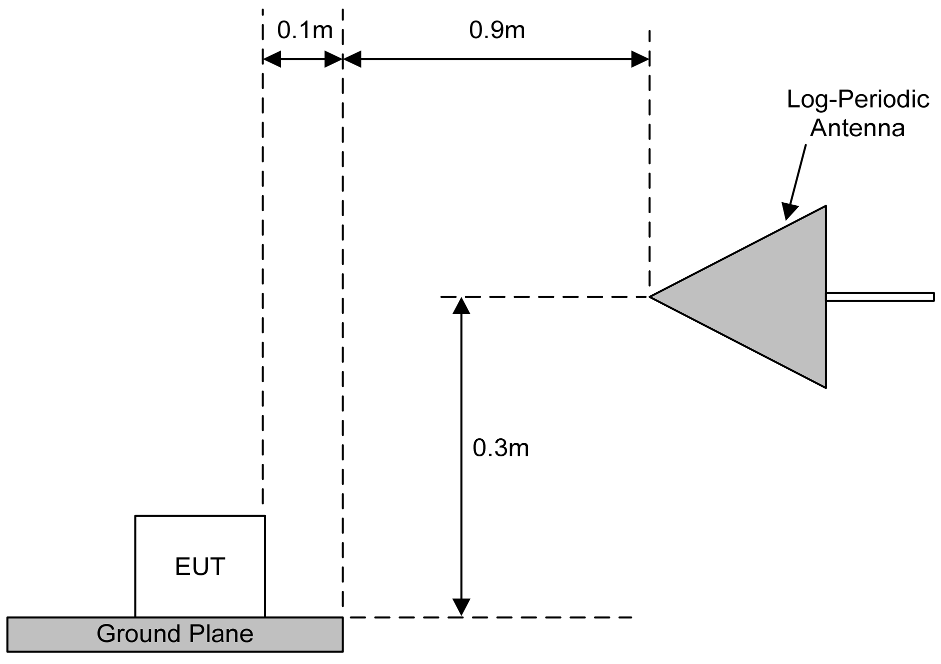
Using a Vertical Rod Antenna over the Frequency Range 14 kHz to 30 MHz

Figure 88 DRE01.B – Typical Arrangement for Rod Antenna Position



Using a Bi-Conical Antenna over the nominal Frequency Range 25 MHz to 300 MHz

Figure 89 DRE01.B – Typical Arrangement for Bi-Connical Antenna Position



Using a Log-Periodic Antenna over the nominal Frequency Range 200 MHz to 1 GHz

NOTE A Double Ridge Wave Guide antenna may also be used

Figure 90 DRE01.B – Typical Arrangement for Log Periodic Antenna Position

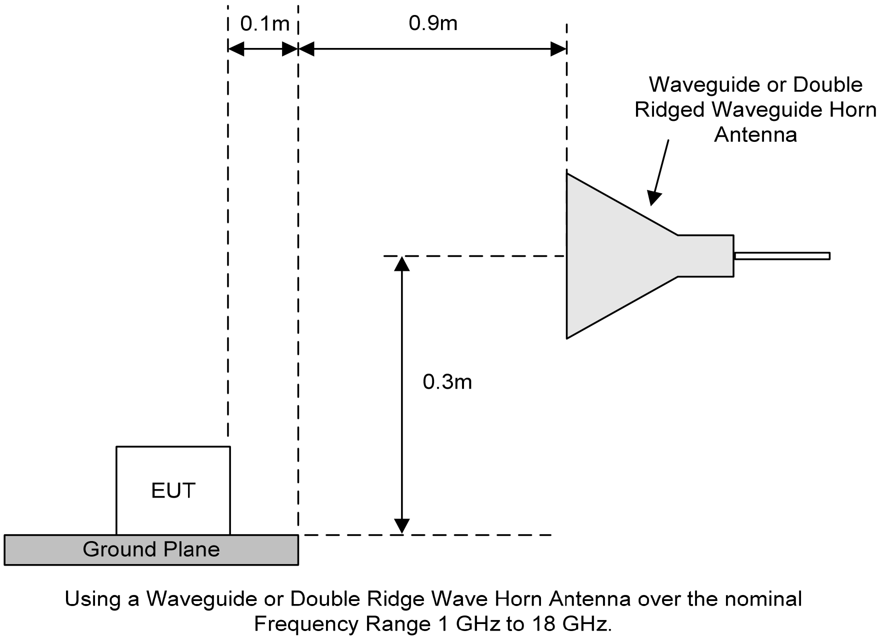
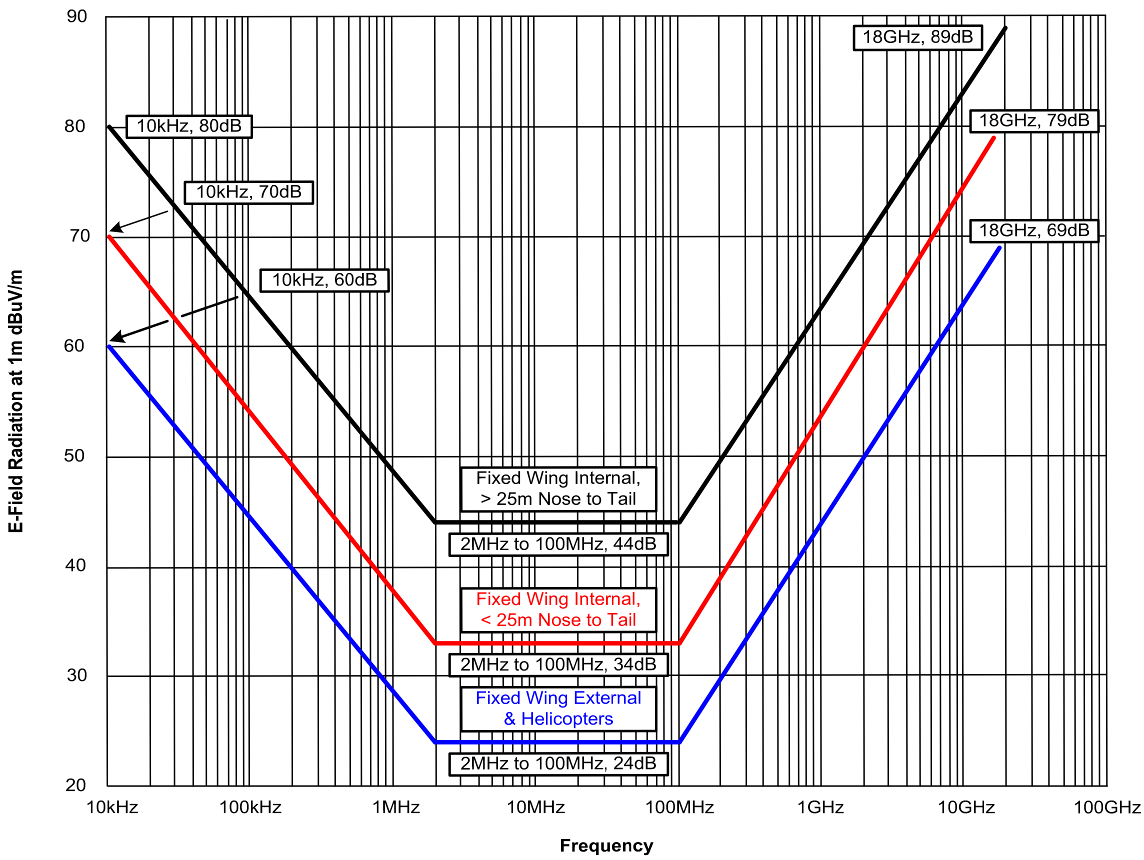
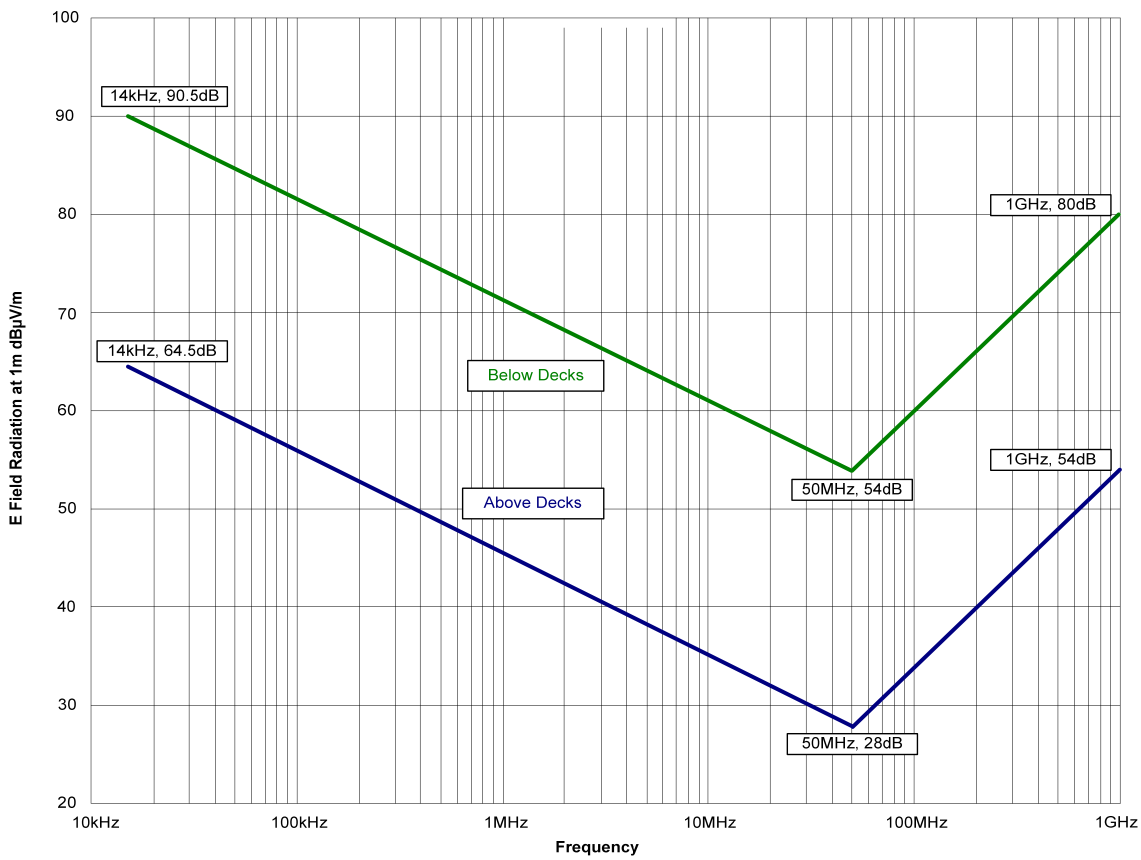


Figure 91 DRE01.B – Typical Arrangement for Waveguide or Double Ridge Horn Antenna Position



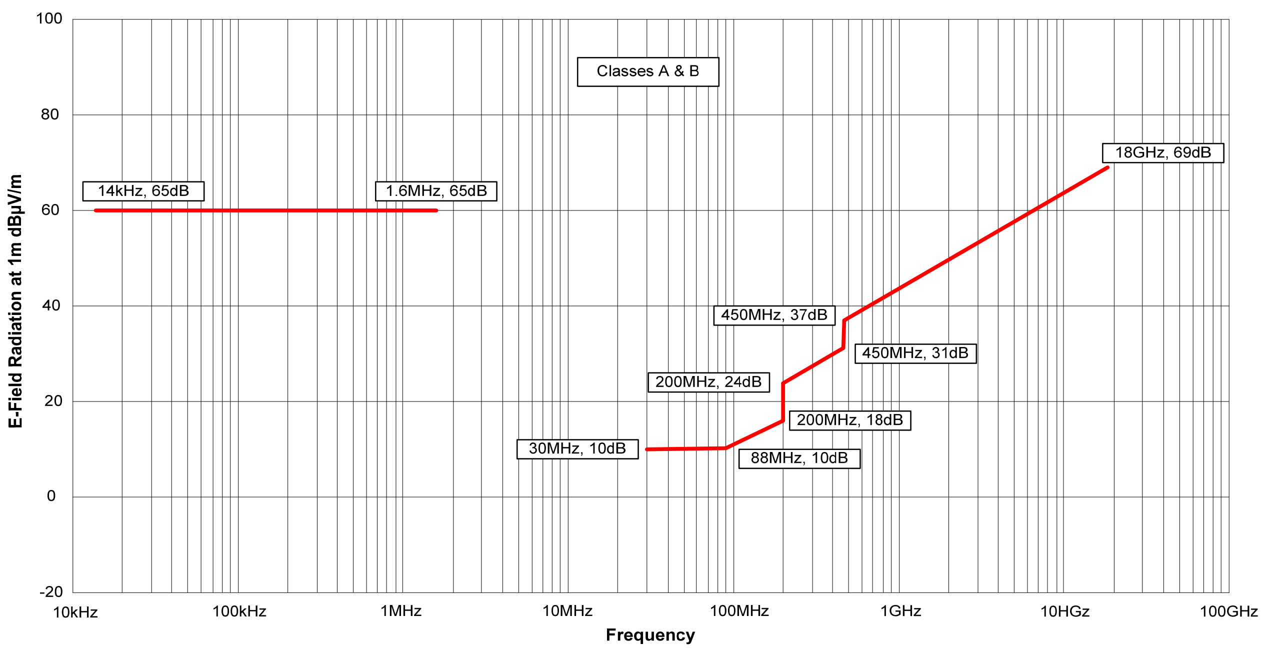
NOTE Limits above 1 GHz only apply to equipment which includes intentionally generated signals at a frequency greater than 100 MHz

Figure 92 DRE01.B – Limits for Air Service Use



NOTE For Limits above 1 GHz the Project Manager shall be consulted

Figure 93 DRE01.B – Limits for Sea Service Use



NOTE For ECM applications reference should be made to the tailored limits in the following DSTL documents: DSTL/PL15013 and DSTL/TR/249848.

Figure 94 DRE01.B – Limits for Land Service Use Classes A and B (30 MHz - 18 GHz)

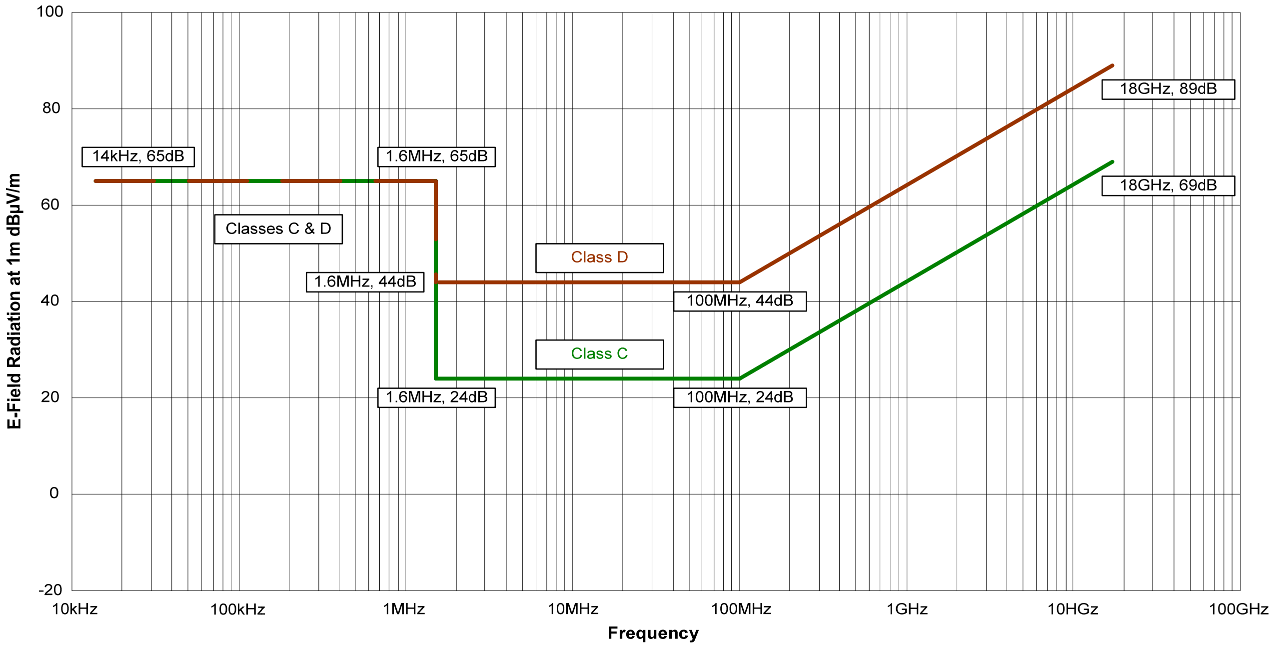


Figure 95 DRE01.B – Limits for Land Service Use Classes C and D (30 MHz - 18 GHz)

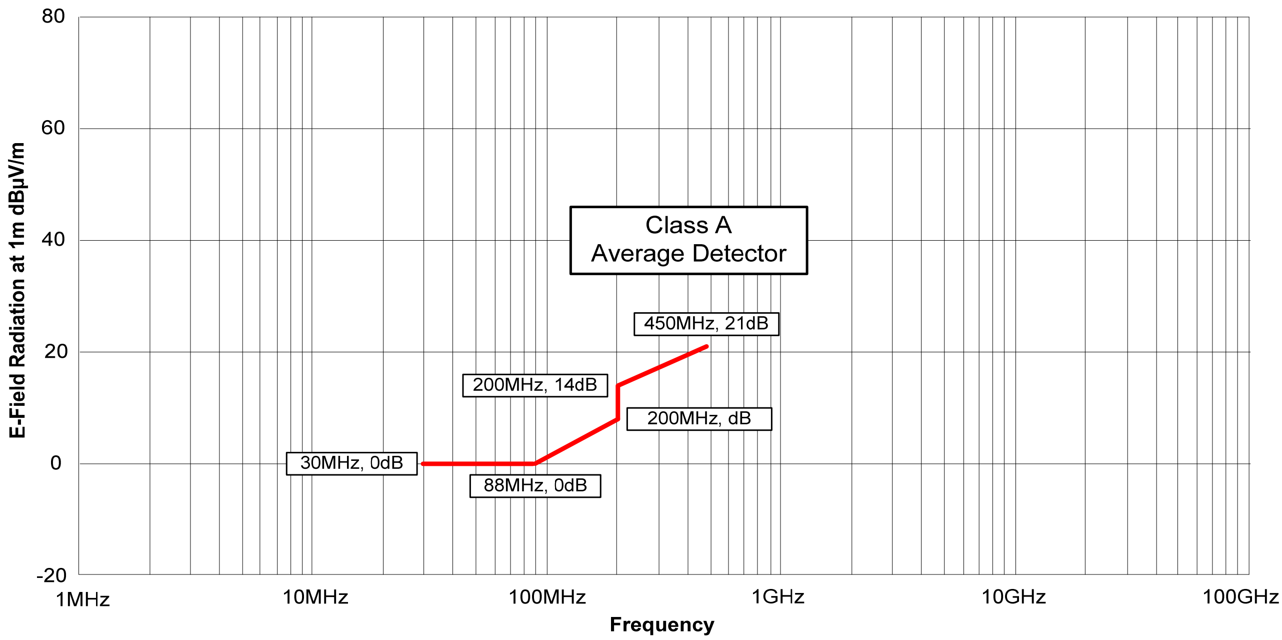


Figure 96 DRE01.B – Limits for Land Use Class A 30 MHz - 450 MHz - Average Detector (10 kHz Bandwidth)

B.15 DRE02.B Radiated Emissions Magnetic (H) Field 20 Hz – 100 kHz

B.15.1 Purpose

In order to achieve compatibility between modern equipment operating together, limitations on emissions and control of susceptibility must be clearly defined. The levels of H field related to both emissions and susceptibility have been formulated from composite measurements taken within the confines of military platforms and an average level of emissions established.

Since these levels are realistic, equipment should be designed to operate satisfactorily in this environment. It may be found impracticable to meet the emission limits for some equipment in which case if the distance is established at which the amplitude limit level is met for the equipment under test, segregation by that distance from other equipment or cabling may offer a realistic alternative.

B.15.2 Applicability

All EUT units and associated cables are subject to this test.

Reference should also be made to **Clause 9.16**.

B.15.3 Test Equipment

See **Clause 6.22.2** for details of the coil. The location and orientation of the coil with respect to the EUT is shown in **Figure 6**.

B.15.4 Test Layout

A test layout is shown in **Figure 97** but reference to **Clause 6** especially sub **Clauses 6.7**, **6.8**, **6.12** and **Annex C Clause C.6** is also required.

B.15.5 Test Method

A field-measuring device in the form of a multi-turn loop shall be placed 70 mm from each face of the EUT and its associated cables with connection to a suitable frequency selective voltage measuring equipment. The plane of the loop shall be parallel to the face of the test sample and a search made for the maximum emission level over the frequency range of test.

Measurements are made with the plane of the loop both parallel and at right angles to each face of the test sample and along the associated cable harnesses maintaining a 70 mm separation between the centre of the actual coil windings and the EUT. Particular attention should be given to the critical frequencies of the test sample.

In the event of the unit under test exceeding the specified limit at 70 mm, the distance and position at which compliance is achieved shall be declared. Reference to **Clause 6**, especially sub **Clauses 6.10**, **6.15**, **6.16** and **6.22** is also required.

B.15.6 Limits

Limits for Air Service, Ship and Land service use are shown in **Figure 98**.

NOTE For Land Based Sea Services see **Table 6**.

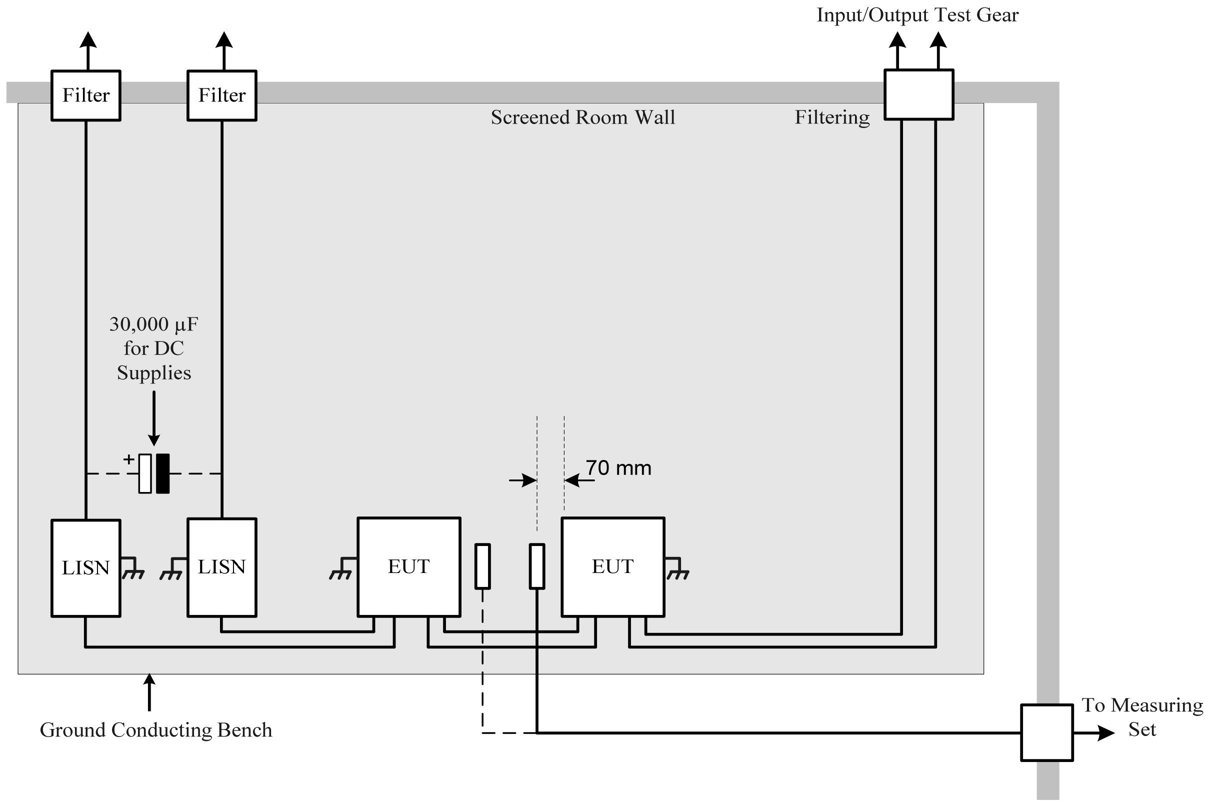
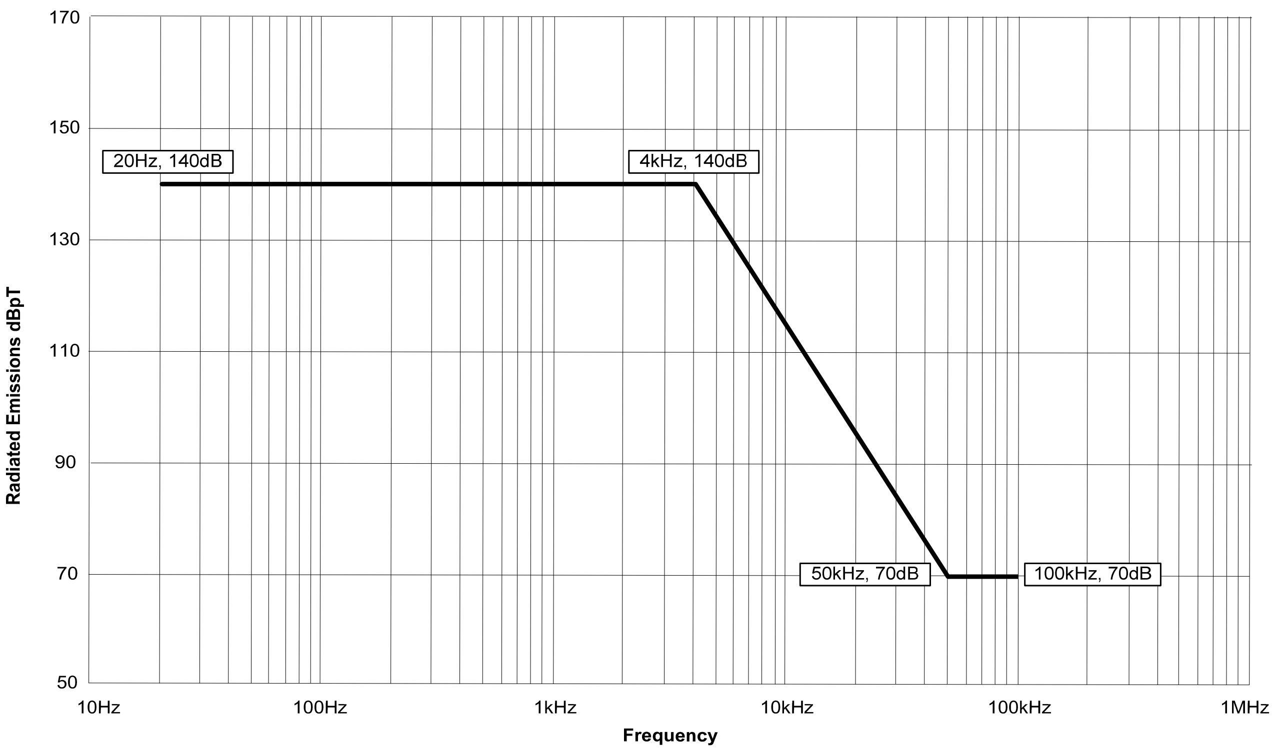


Figure 97 DRE02.B – Typical Test Configuration



NOTE For ECM applications reference should be made to the tailored limits in the following DSTL documents: DSTL/PL15013 and DSTL/TR/249848.

Figure 98 DRE02.B – Limits for Air, Land and Sea Service Use

B.16 DRE03.B Radiated Emissions E Field (Land Service) Tuned Antenna 1.6 MHz – 30 MHz

B.16.1 Purpose

The purpose of this test is to confirm that the E field emissions have been controlled to the required limit, so that the receive performance of radio communications equipment in the nearby operational environment is not impaired. This test method employs tuned antenna systems which are significantly more sensitive than the broadband antennas used in Test Method DRE01.B. This test method is primarily to meet Land Service Class A and B requirements.

B.16.2 Applicability

This test is applied to an EUT and its connecting harness when it is to be incorporated either in a land vehicle, or any Army equipment, with a receiving antenna operating in the frequency band 1.6 MHz to 30 MHz.

This method is used when the EUT, is deployed at Class A or B distances from a receiving antenna, operating over the frequency range 1.6 MHz to 30 MHz.

Transmissions from antennas are not subject to the limits of this test but are subject to the specific performance specification requirements for that transmitter. An EUT, which is normally connected to an antenna, shall be fitted with a screened dummy antenna for this test. The limit at the fundamental frequency of transmission may be relaxed at the discretion of the Project Manager.

Reference should also be made to **Clause 9.17**.

B.16.3 Test Equipment

The antenna system to be used for measuring emissions in this test shall have similar sensitivities to that deployed operationally near the EUT. It will therefore incorporate automatic tuning to each operational frequency. More than one antenna system may be needed to cover the required frequency range. It is the contractor's responsibility to ensure the availability of these antenna systems when required for testing purposes.

The output voltage from the test antenna system shall be measured across a nominal impedance, equivalent to that presented by the operational receiver normally connected to that system.

To achieve the required sensitivity, receiver bandwidth of 1 kHz shall be used.

B.16.4 Test Layout

A typical layout of the EUT and test antenna is shown in **Figure 99** (elevation) and **Figure 100** (plan).

Reference to **Clause 6**, especially sub **Clauses 6.7**, **6.8**, and **6.12** is also required.

B.16.5 Test Method

Where a CNR HF tuning unit is part of the operational fit, an AAMTU (Automatic Antenna Matching and Tuning Unit) can be fitted in its place, with appropriate test equipment, the limitations of manually tuning a Clansman Turf (tuning unit RF) are avoided and swept measurements are possible over the HF band.

Manual measurement techniques can be used only for indication purposes and are deemed non-compliant with the requirements of this specification. Measurements will be made across the 6dB bandpass of the tuner unit.

Before testing commences a check shall be made for correct tuning of the measuring system. This is performed at the extremities and centre of the tuneable frequency range. A signal generator is connected to a calibrated antenna at a distance of 1m from the antenna and a small signal applied, the signal propagated should be within 2 dB of the specified limit.

If the automated measuring system fails to tune at any frequency then the test engineer must either perform another automatic sweep over that part of the frequency range or check using a manual technique that no emissions are present.

Wherever possible the rod antenna used for testing shall be the standard vehicle antenna used with a Clansman HF radio installation. The length of the antenna to be used, with an AAMTU shall be a 2.4 m rod.

B.16.6 Limits

Limits are shown in **Figure 101**.

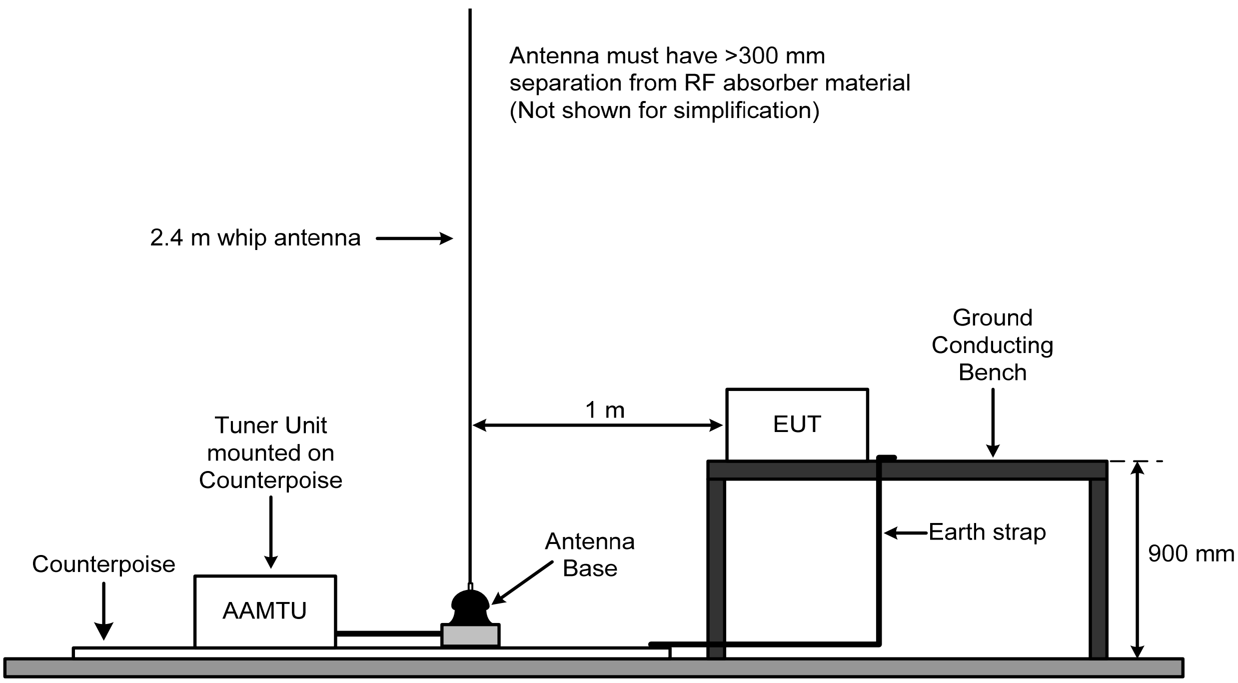


Figure 99 DRE03.B – Typical Test Configuration (Elevation)

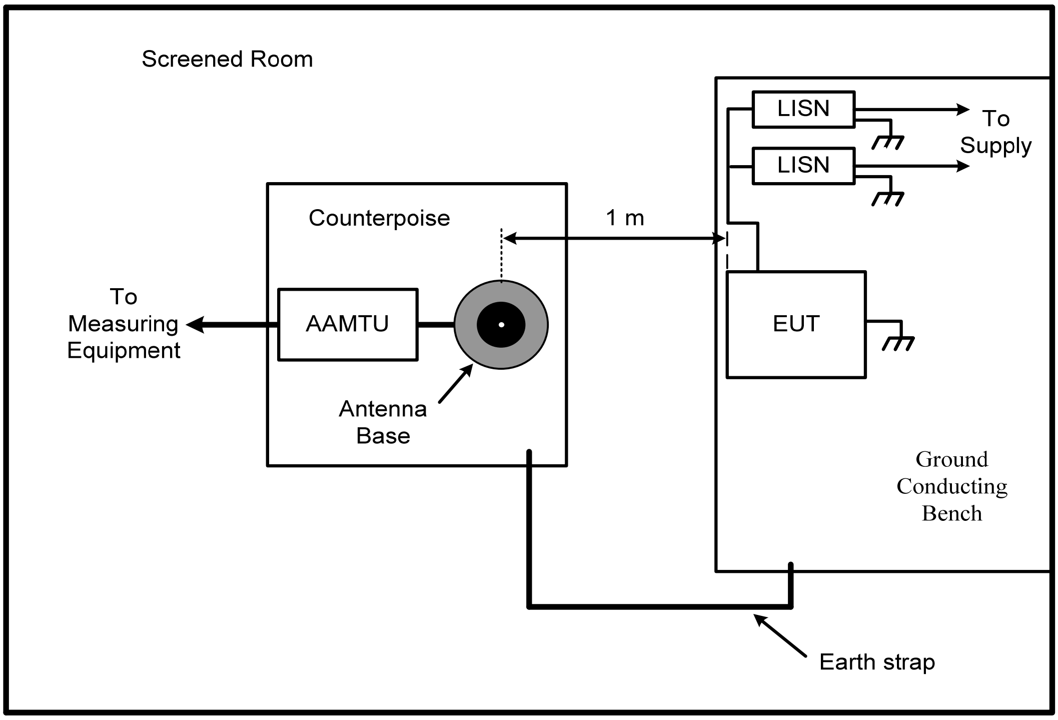
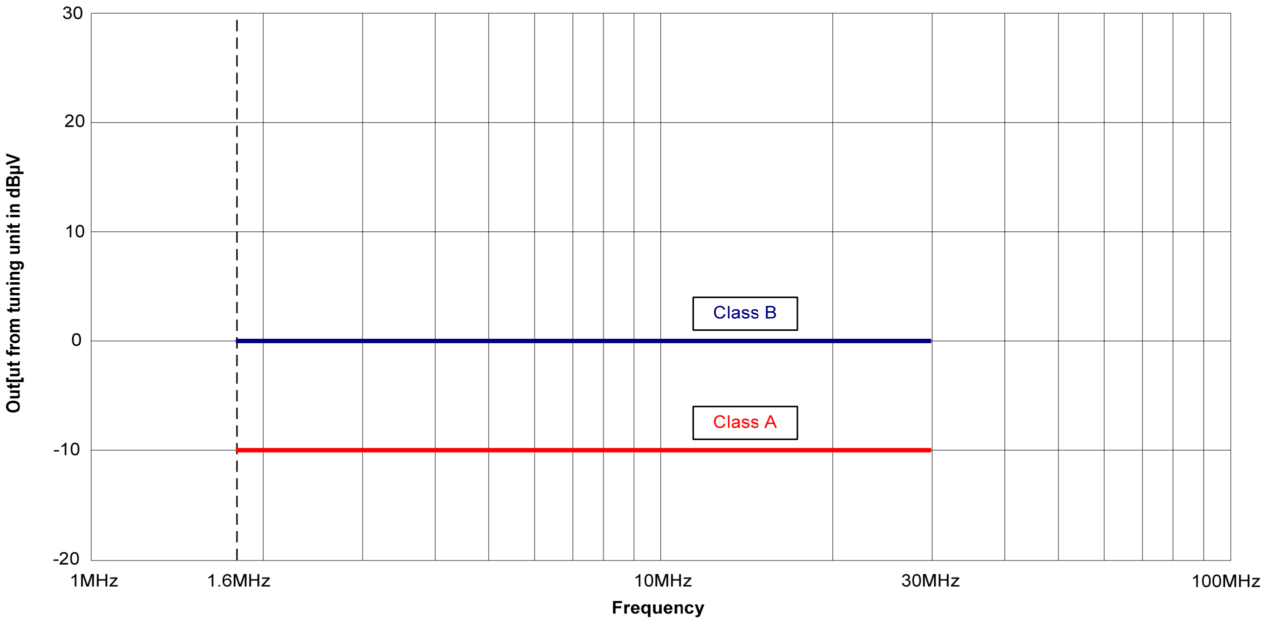


Figure 100 DRE03.B – Typical Test Configuration (Plan)



NOTE See **Clause 7.4** and **7.5** for Grading and Classification of Limits.

Figure 101 DRE03.B – Limits for Land Service Use Classes A and B 1.6 MHz - 30 MHz - Peak Detector (1 kHz Bandwidth)

B.17 DRS01.B Radiated Susceptibility Magnetic (H) Field 20 Hz – 100 kHz

B.17.1 Purpose

In order to achieve compatibility between modern equipment operating together limitations on emissions and susceptibility must be clearly defined. The levels of H Field related to both emissions and susceptibility have been derived from extensive measurements taken within the confines of ships, aircraft and land service vehicles.

Since these levels are realistic, equipment should be designed to operate satisfactorily in this environment. It may be found impracticable to meet the susceptibility requirements for some equipment, in which case if the distance is established at which the amplitude limit level is met for the equipment under test, segregation by that distance from other equipment may offer a realistic alternative.

B.17.2 Applicability

All EUT units, i.e. boxes, cases or cabinets are subject to this test.

Reference should also be made to **Clause 9.18**.

B.17.3 Test Layout

A test layout is shown in **Figure 102**. Reference to **Clause** 6, especially sub **Clauses 6.7**, **6.8**, and **6.12** is also required.

B.17.4 Test Method

A circular radiating loop as defined in **Clause 6.22.9** shall be used. The energized loop shall be moved over each face of the equipment under test at a constant spacing of 50 mm between the plane of the loop and the equipment face while the equipment is being continuously monitored for malfunction. Particular attention should be given to the potentially critical frequencies of the EUT. In the event of the unit under test failing to meet the specified limits at a loop spacing of 50 mm, the distance at which compliance is achieved shall be recorded. The coil current should be as near sinusoidal as possible to avoid harmonic problems, and adjusted to the prescribed level monitored by a current probe. The field produced by the radiating loop is defined as that recorded by the loop specified in test method DRE02.B when the spacing between the planes of the loops is 50 mm. Reference to **Clause 6**, especially sub **Clauses 6.10**, **6.15**, **6.16** and **6.22** is also required.

B.17.5 Limits

Limits for Air Service use are shown in **Figure 103** while limits for Sea Services and Land service use are shown in **Figure 104**.

NOTE For Land Based Sea Services see **Table 6**.

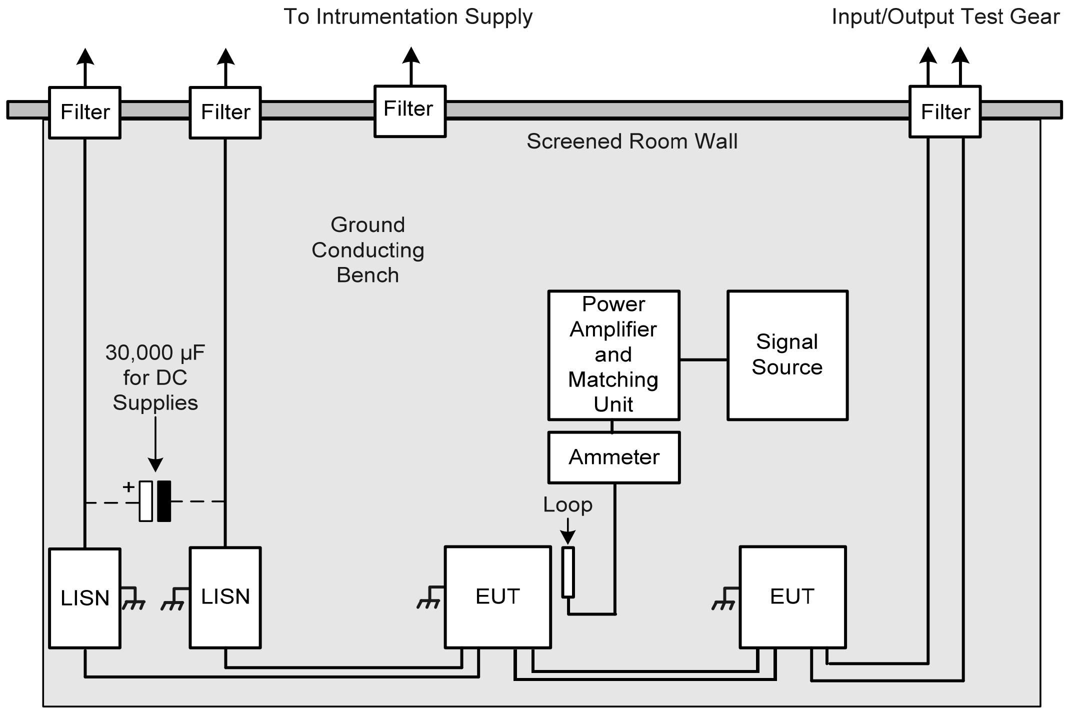


Figure 102 DRS01.B – Typical Test Configuration

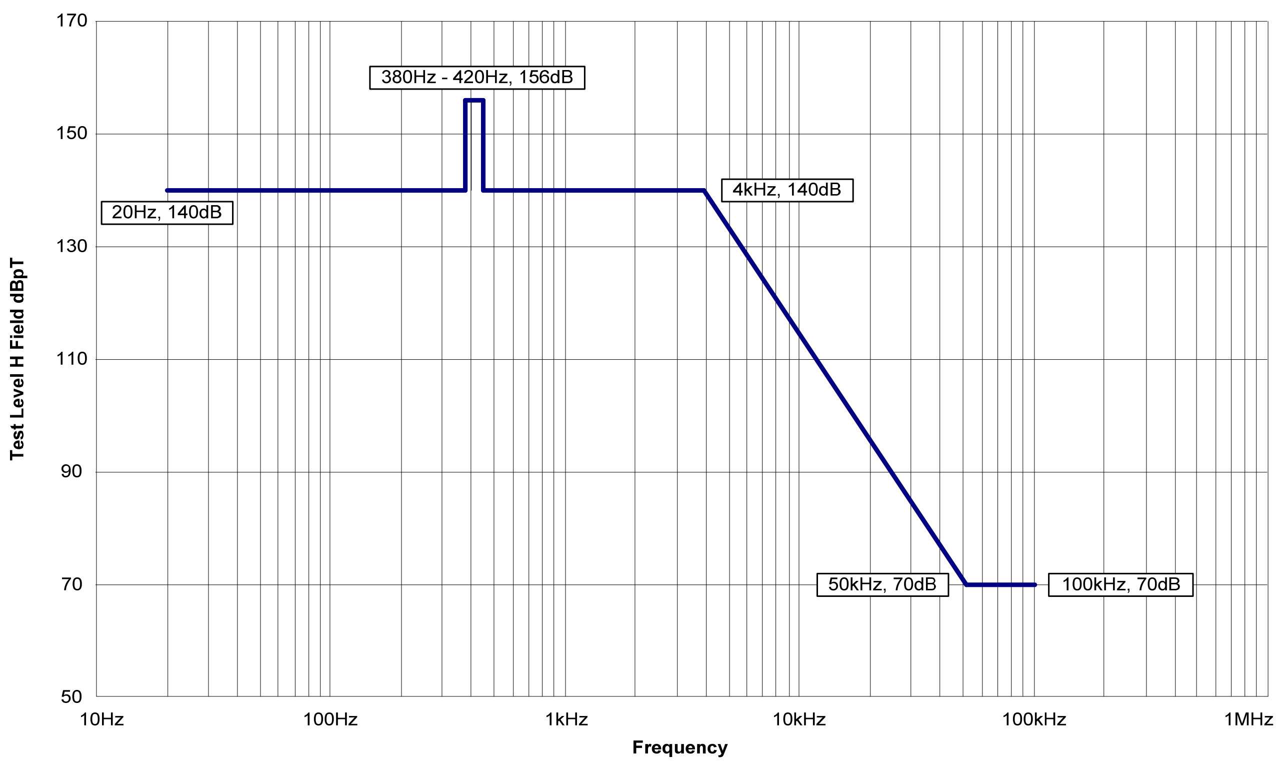


Figure 103 DRS01.B – Limit for Air Service Use

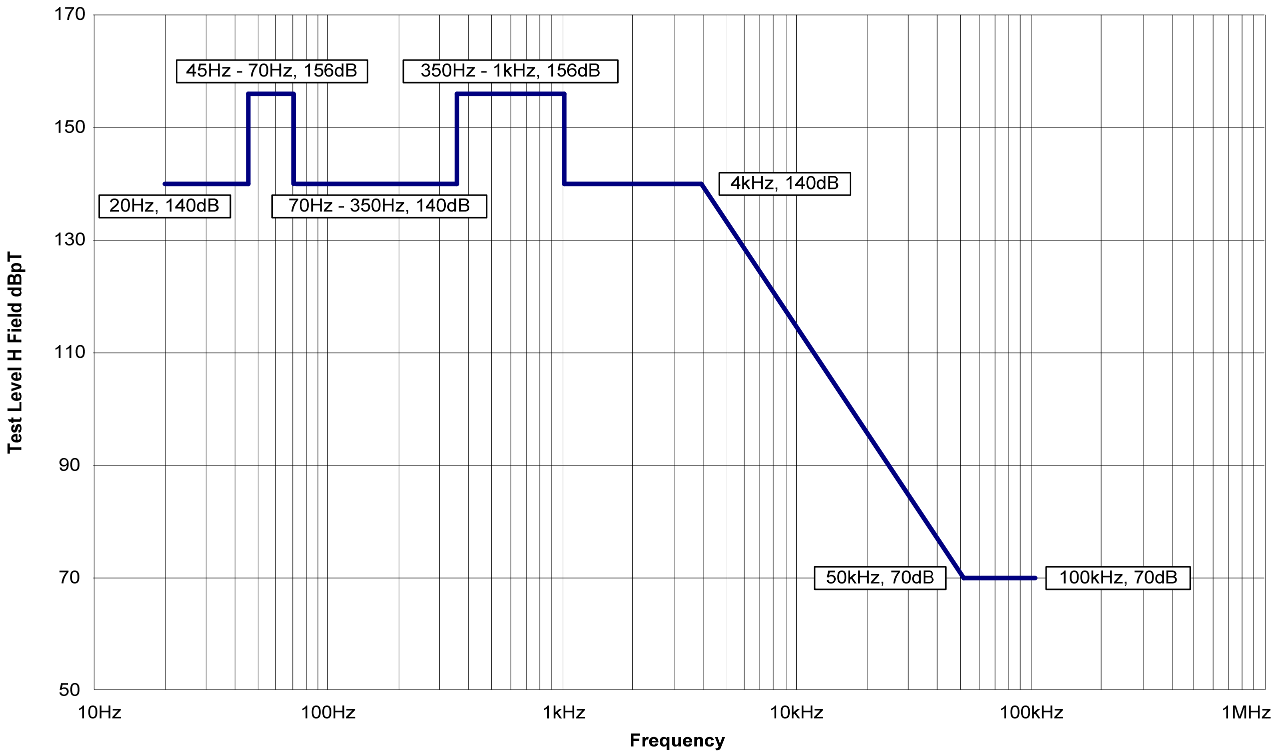


Figure 104 DRS01.B – Limit for Land and Sea Service Use

B.18 DRS02.B Radiated Susceptibility Electric (E) Field 10 kHz – 18 GHz

B.18.1 Purpose

The purpose of this test is to confirm that the EUT will perform without malfunction when subject to high level RF fields from transmitting sources.

B.18.2 Applicability

The EUT together with its wiring harness.

Reference should also be made to **Clause 9.19**.

This test shall also apply to safety critical and safety related equipment containing circuits which may exhibit a 'window effects' response as identified in the Test Plan. Reference to **Clause 6.19.2** is also required.

NOTE Window effect testing will normally be conducted following testing performed at the requirement test level.

B.18.3 Test Layout

A typical layout for a screened room test is shown in **Figure 105**. Reference to **Clause 6**, especially sub **Clauses 6.7**, **6.8**, and **6.12** is also required.

B.18.4 Test Method

The specified transmitting antenna shall be energized so that field strengths in excess of the test limit are produced. If a malfunction occurs when sweeping through the frequency range the signal strength shall be reduced to establish the threshold level.

At frequencies above 1 GHz discontinuities in the screening of the EUT shall be presented to the transmitting antenna directly, i.e. turn the EUT so that numerical displays, CRT screens, LRU connectors etc. are normal to the main beam of energy from the transmitter antenna.

For aircraft use, in special cases, it may be necessary to record the RF current levels induced into selected wiring looms at 50 mm from the connector of the EUT up to 1 GHz. This is a special requirement to be called for by the Project Manager in cases where the data obtained is specifically required for subsequent aircraft trials.

The RF field produced shall be monitored adjacent to the EUT. Reference to **Clause 6**, especially sub **Clauses 6.19**, **6.22** and **6.26** is also required.

B.18.5 Limits

Limits are shown in **Figures 106** for Air, **Figure 107** for Sea Services and **Figures 108** and **109** for Land Service use.

NOTE 1 See **Clause 7.5** for classification of limits.

NOTE 2 The limits are shown in peak values and apply to each of the modulation characteristics specified in **Clause 6.19**.

NOTE 3 For Land Based Sea Services see **Table 6**.

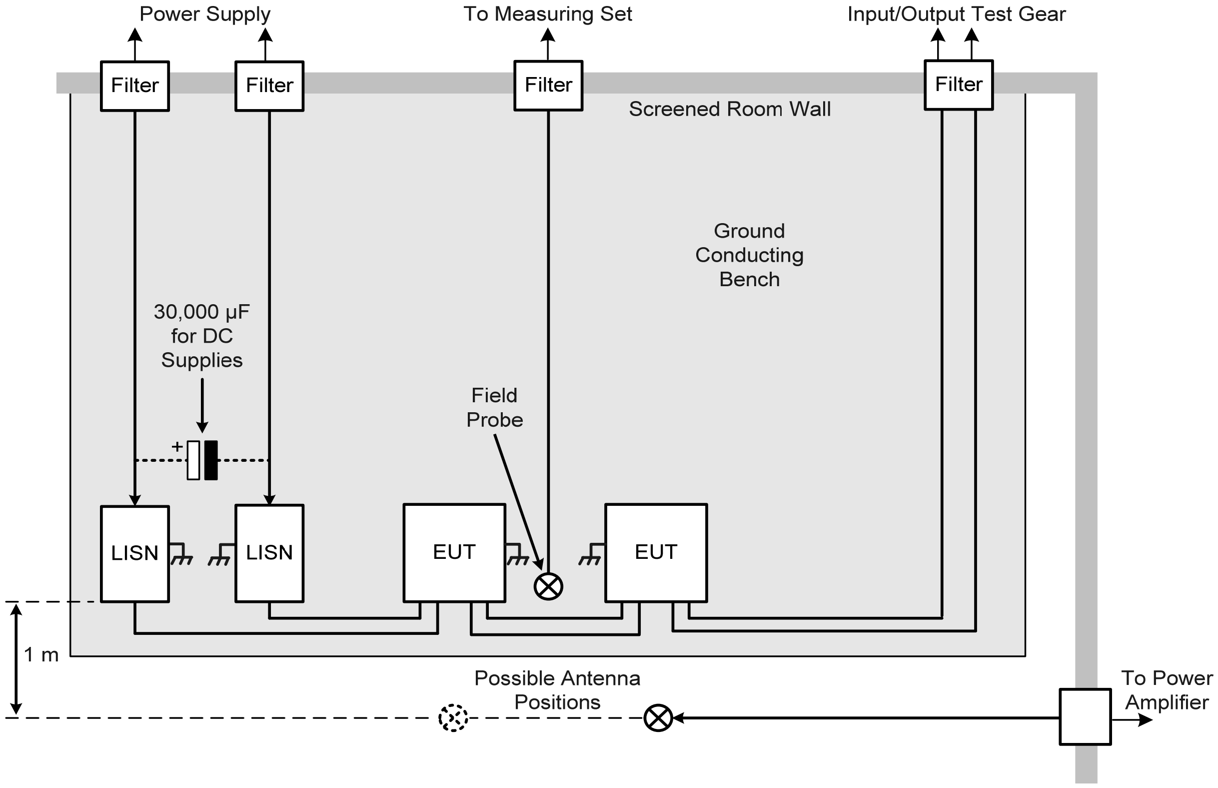
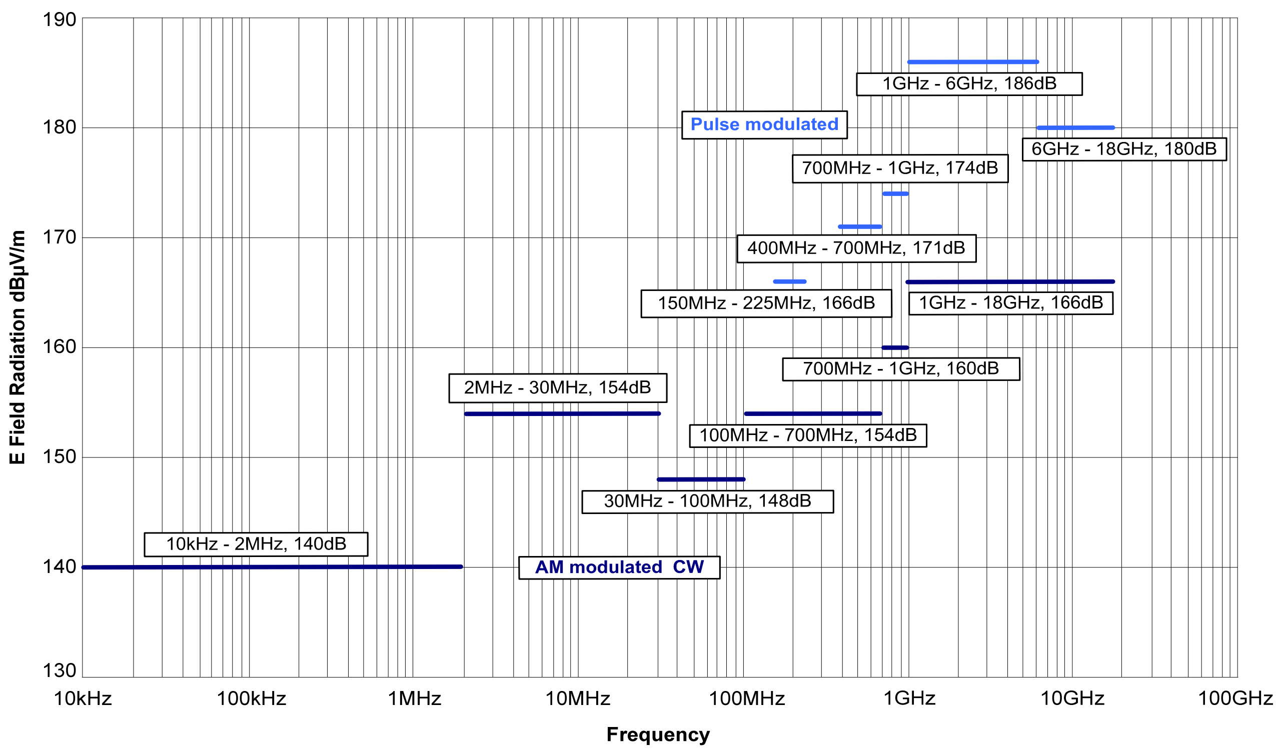
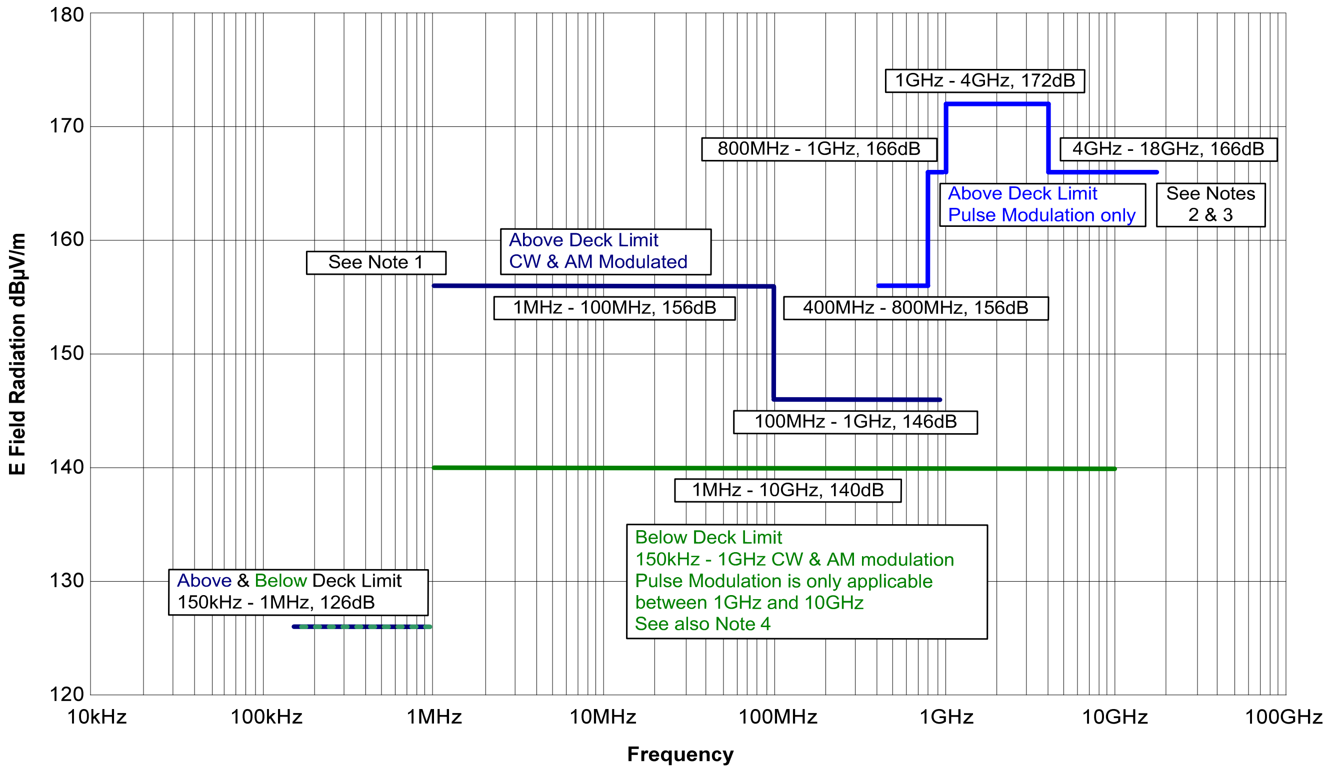


Figure 105 DRS02.B – Typical Test Configuration



NOTE The above limits should be tailored for specific applications, since most air platforms have there own specification
Externally mounted equipment or equipment mounted in unprotected areas should be tested to the aircrafts full external environment

Figure 106 DRS02.B – Limits for Air Service Use



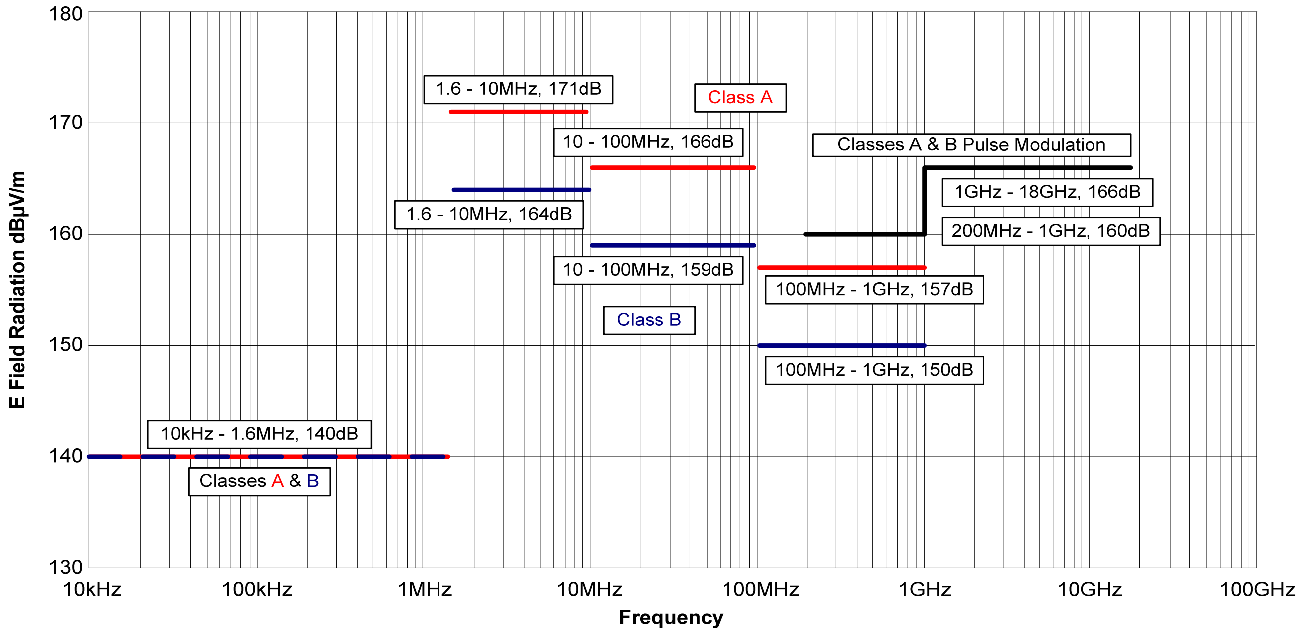
NOTE 1: The “Above Decks” limit from 1 MHz to 10 MHz should be raised to 166 dBμV/m if the equipment is located within 15 m of an HF antenna and also from 10 MHz to 32 MHz if the equipment is within 10 m of an HF antenna. If within 4 m of an antenna an in-situ test will be also be required see BR 4050.

NOTE 2: If equipment is installed on a mast where main beam illumination from own ship transmitters is possible the limit should be increased to the level expected to be seen. Table 16 in Part 2 of this Standard provides some guidance.

NOTE 3: Microwave receivers directly connected to antennas should be protected from damage to the levels shown in Table 15 columns 5 & 6 in Part 2 of this Standard.

NOTE 4: In Vehicle Decks or Hangers where troops and vehicles may be carried the Below Deck Limit shall be raised to 154dBμV/m from 1.6 MHz to 450 MHz.

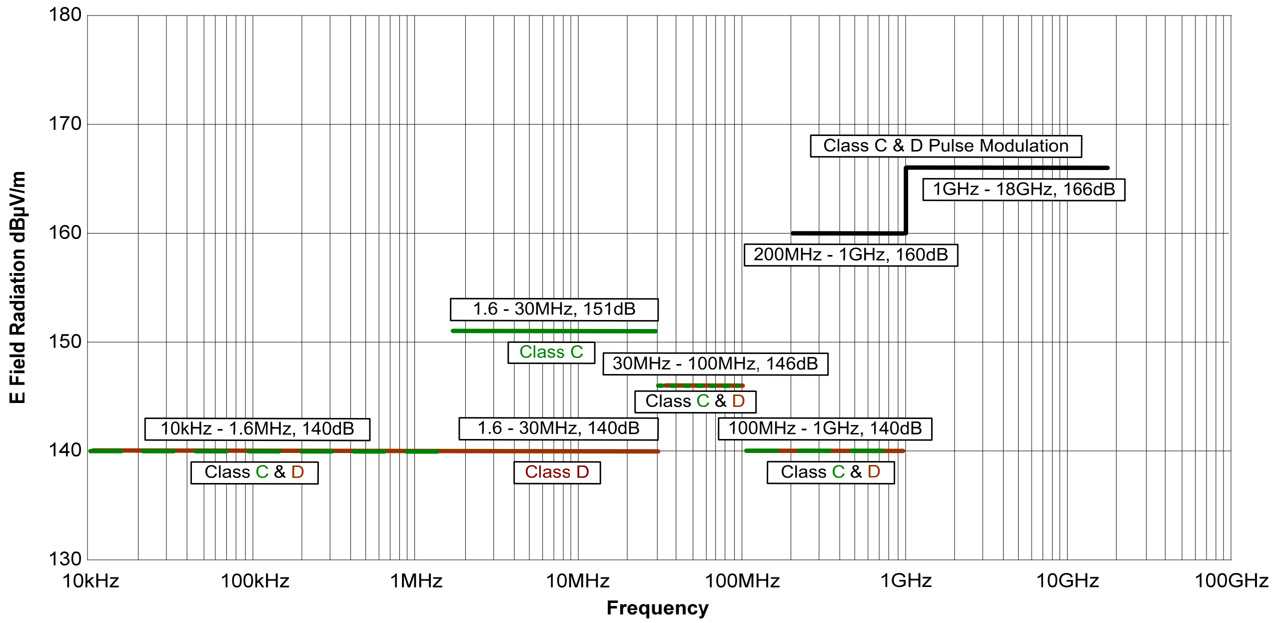
Figure 107 DRS02.B – Limits for Sea Service Use



NOTE 1: The Pulse Modulation Limit from 4 to 6 GHz should be increased to 180 dBµV/m if the equipment is sited in the main beam and within 100 m of a microwave transmitter

NOTE For ECM applications reference should be made to the tailored limits in the following DSTL documents: DSTL/PL15013 and DSTL/TR/249848.

Figure 108 DRS02.B – Limits for Land Service Use Classes A and B



NOTE 1: The Pulse Modulation Limit from 4 to 6 GHz should be increased to 180 dBµV/m if the equipment is sited in the main beam and within 100 m of a microwave transmitter

Figure 109 DRS02.B – Limits for Land Service Use Classes C and D

B.19 DRS02.B Radiated Susceptibility, Electric (E) Field Alternative Method (Air Services)

B.19.1 General

Reverberation chamber tests provide an alternative to the standard radiated susceptibility test described in **Clause B.18** for susceptibility testing at frequencies greater than 100 MHz (Note: the chamber size will determine the lowest useable frequency for a particular facility). An aircraft compartment is a heavily loaded resonant cavity while a reverberation chamber is a lightly loaded resonant cavity. A reverberation chamber test generates a complex electromagnetic environment similar to that in an aircraft compartment whereas an anechoic chamber or open field site test generates far-field, plane waves.

The advantages of a reverberation chamber are:

a) It illuminates the entire volume inside the chamber rather than "spot" illumination of a limited volume;

b) Multiple configurations are not necessary since the mechanical stirrer moves the fields through all angles and polarizations throughout the chamber;

c) Less RF input power is required to generate a given test field due to the high Q of the reverberation chamber than is required in an absorber-loaded chamber or at an open site.

B.19.2 Reverberation Chamber Requirements

The reverberation chamber consists of a shielded room with a metal paddle wheel fitted off centre. RF is transmitted into the room via an antenna, beamed at the paddle wheel or into a corner. Design details of the reverberation chamber can be found in the National Institute of Standards and Technology report 1092.

As the paddle wheel rotates, the maximum field obtained during one rotation of the paddle wheel is the same at any point (greater than 0.5 wavelength from the rooms bounding walls, floor and ceiling) in the room.

The chamber is normally used at frequencies above that which supports 60 modes. Equation 1 below defines the frequencies for the various modes that exist in a chamber of dimensions a*b*d.

$$f_{mnp} = 150\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{p}{d}\right)^2}\ \text{MHz}$$

Equation 1 Calculation of Modal frequencies

(Frequencies at which particular modes can exist in the Mode Stir Chamber)

Where- m, n and p are integers

Certain design guidelines apply to a reverberation chamber suitable for this test:

a) The paddle wheel or tuner should have a diameter of at least half a wavelength at its lowest frequency of operation. The larger the paddle wheel, the better the performance of the reverberation chamber, particularly at lower frequencies. If the enclosure configuration permits, a paddle wheel with a minimum dimension of one wavelength (at the lowest useable frequency) should be a design goal. The paddle wheel should have one dimension a significant fraction of one dimension of the room. The recommendation in the draft IEC reverberation chamber test technique is ¾. The paddle wheel should be asymmetrically shaped. It is usually most convenient to support it from the ceiling with the driver motor outside the chamber. A computer controlled stepping motor is desirable. A variable speed, continuous motor is acceptable, but the time response of EUTs must be fast relative to stirrer speed for this option to be viable.

b) The stirring ratio should be at least 20dB when the chamber is loaded with the test object. The stirring ratio is the ratio of the maximum to minimum field at a fixed location in the room during one rotation of the paddle wheel. This figure will reduce, the greater the loading in the chamber by the test object. Although this guideline when taken on its own it does not mean the room is operating satisfactorily.

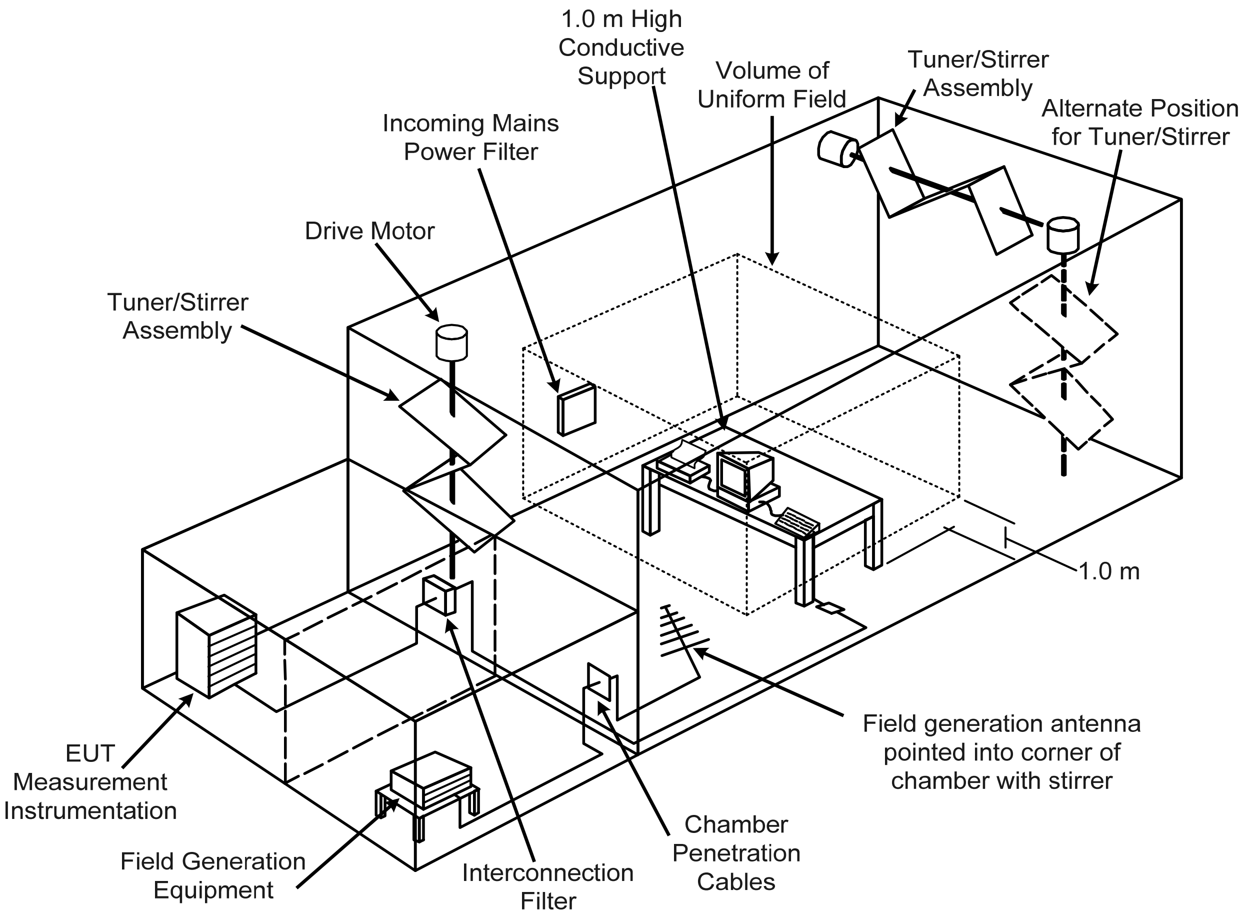
c) At least 60 modes should exist at the lowest frequency of use.

d) The chamber should be free of any materials which exhibit absorptive properties. Examples of articles which should be removed include tables, chairs, floors, etc made of wood or other absorbing materials.

e) The chamber time constant, as described in **Clause B.19.5.3**, shall be less than 0.4 of any modulation test waveform pulse width. This will assure that the field will rise to at least 92% of the pulse maximum.

The acceptability of the chamber must be validated by proving the field uniformity meets the requirements defined in **Clause B.19.4**.

An example of a Reverberation Chamber test Facility is shown in **Figure 110**.



NOTE 1 Working volume must be at least 1.0 metre (or $\lambda/4$) from any chamber surface, field generating antenna or tuner assembly.

NOTE 2 The chamber should remain free of any unnecessary absorbing materials. Items such as wooden tables, carpeting, floor covering, wall covering or ceiling tiles should not be used. Exposed light fixtures are also a source of potential loading. For new chambers, it is recommended that an evaluation of the chamber be conducted prior to installation of any support equipment other than doors, vents and access panels.

Figure 110 DRS02.B – Alternative Method - Example of suitable Reverberation Chamber test facility

B.19.3 Procedure Overview

This clause defines an alternative radiated susceptibility test using a Reverberation Chamber and consists of the following basic steps:

Prior to the fitting of the test bench and/or EUT:

a) A performance based field uniformity calibration technique shall be performed to demonstrate adequate reverberation chamber performance following initial construction or after major modification to the reverberation chamber. The chamber calibration technique is carried out to demonstrate the chamber meets the field uniformity requirements as defined in this procedure. In addition, it is important to determine the lowest useable frequency (LUF) of the reverberation chamber employed. The described chamber field uniformity calibration is to be carried out over a test/working volume, which includes the location of the conductive test bench within the reverberation chamber. The chamber calibration addresses only mode tuned (stepped tuner rotation) operation of the reverberation chamber: mode stirred (continuous tuner rotation) operation is not allowed. The field uniformity measurement should be carried out with the conductive test bench removed from the reverberation chamber. The test is to be carried out at 9 locations for 3 individual axes (x,y,z) at each test location, i.e. 27 measurement points in total (B.19.4.1). The field within the chamber is considered uniform if the standard deviation is within 3dB above 400 MHz, and sloping linearly (on a semi-log plot) from 4 to 3 dB from 100 MHz to 400 MHz see **Figure 111**.

b) A calibration technique for linear/passive field monitoring antennas used during EUT testing. The linear/passive field monitoring antennas are to be calibrated against a three axis E-field sensor (calibrated in free space). The purpose of this aspect of the test is to allow continuous monitoring of the field during the test with an antenna and associated monitoring equipment with a fast response time. Again this test is performed with the test bench removed and conducted at the same time as the field uniformity test described above in section a) (**Clause B.19.4.2**).

c) A method of checking the impact of field uniformity and chamber loading following initial construction or after major modification to the reverberation chamber. This test is performed to determine the maximum acceptable loading of the chamber for future testing (**Clause B.19.4.3**).

Prior to the start of the test with the test bench and EUT installed in the chamber:

d) A “quick check” chamber performance measurement made when the equipment to be tested and test bench are installed in the chamber. The purpose of this test is to confirm the loading of the chamber is less than that simulated during the initial chamber calibration c. (**Clause B.19.5.2**).

e) A method to measure the minimum pulse width that can be sustained in the room for pulse modulation testing (**Clause B.19.5.3**). If the chamber time constant is greater than 0.4 times the required pulse width for more than 10% of the test frequencies, absorber must be added or the pulse width increased (not to exceed 100µs).

The test procedure itself utilizes mode tuned procedures see **Clause B.19.5.4**.

B.19.4 Calibration: Chamber Field Uniformity and Loading Validation

As an initial guide to chamber performance and input power requirements, perform a “one-time” empty chamber calibration (no EUT) using the procedures of **Clause B.19.4.1**. It is suggested the empty chamber calibration be carried out on an annual basis or after major modification to the reverberation chamber.

For normal operation the lowest test frequency (fs) is 100 MHz, and field uniformity is demonstrated over the first decade of operation. If a start frequency other than 100 MHz is chosen, for example a small chamber used to generate high field strengths, the chamber field uniformity must still be verified over the first decade of operation. The frequency at which a chamber can be used to conduct measurements is the frequency at which the chamber meets the field uniformity requirements in **Figure 111**.

B.19.4.1 Field Uniformity Validation

a) Clear the working volume (i.e. remove test bench) and place the receive antenna at a location within the working volume of the chamber as outlined in the notes of **Figure 112**. Set the amplitude measurement instrument to monitor the receive antenna on the correct frequency.

b) Place the E-field probe at a location on the perimeter of the chamber working volume as shown in **Figure 112**.

c) Beginning at the lowest test frequency (fs), adjust the RF source to inject an appropriate input power, PInput, into the transmit antenna. The transmit antenna shall not directly illuminate the working volume or the receive antennas and probes. Directing the source antenna into one corner of the chamber is an optimum configuration. The frequency shall be in band for both transmit and receive antennas which shall be linearly polarized antennas. Care must be taken to ensure that the harmonics of the RF input to the chamber are at least 20 dB below the fundamental.

d) Step the tuner through 360° in discrete steps (m ode-tuned operation) so that the amplitude measurement instrument and E-field probe captures the minimum number of samples as outlined in **Table 24** over one complete tuner rotation. Care must be taken to ensure that the dwell time is sufficiently long enough that the amplitude measurement instrumentation and E-field probes have time to respond properly.

e) Record the maximum amplitude and average amplitude (linear average: i.e. watts, not dBm) of the receive signal (P_{MaxRec}, P_{AveRec}), the maximum field strength ($E_{Max\ x,y,z}$) for each axis of the E field probe, the maximum total vectorial field strength (ETotal), and the average value of the input power (P_{Input}) over the tuner rotation.

NOTE The value for input power, P_{Input}, is the forward power averaged over the tuner rotation and the maximum total E-field is the root sum squared (RSS) of the magnitude of the rectangular components at one position of the tuner. The number of samples used to determine the average should be at least the same as the number of samples used for chamber calibration. Large variations in input power (i.e. 3 dB or more) are an indication of poor source/amplifier performance. All calibrations are antenna specific. Changing antennas may void calibrations. All power measurements are relative to the antenna terminals. This procedure provides generic values of antenna efficiency for log periodic and horn antennas. Other types of antennas may be used, provided their efficiency is known.

f) Repeat the above procedure in log spaced frequency steps as outlined in **Table 24** until frequency is at least 10fs.

g) Repeat for each of the nine probe locations shown in **Figure 112** and for nine receive antenna locations (one of which must be at the centre of the working volume) until 10fs.

h) Above 10fs only three probe and receive antenna locations need to be evaluated. The probe and antenna shall maintain the required clearance from each other and from chamber fixtures. One location for the probe and antenna shall be the centre of the working volume. Repeat steps d. and e. for the remainder of the calibration frequencies as outlined in **Table 24**.

NOTE 1 The receive antenna should be moved to a new location within the working volume of the chamber for each change in probe location. The antenna should also be placed in a new orientation relative to the chamber axis at each location (at least 20° in each axis). For reference purposes x = chamber length (longest dimension), y = chamber width, and z = chamber height. The probe does not necessarily need to be oriented along the chamber axes during calibration.

NOTE 2 Care should be taken to ensure that the proper separation distance between the antenna and probe are maintained. Each location should be at least 0.75 metre (or l/4 at the lowest test frequency) from any previous location. If the receive antenna is to be mounted in a fixed position during routine testing, it is suggested that one of the locations should be the intended permanent location of the receive antenna.

i) Using the data from step e above, normalize each of the maximum E-field probe measurements to the square root of the average input power:

$$\ddot{E}_{x,y,z} = \frac{E_{Maxx,y,z}}{\sqrt{P_{Input}}}$$

Where:

$E_{Max,y.z}$ = maximum measurement from each probe axis (i.e. 27 measurements below 10fs, and 9 above 10fs),

$\overset{\leftrightarrow}{E}_{x,y,z}$ = normalized maximum measurement from each probe axis, and

P_{Input} = average input power to the chamber during the tuner rotation at which was recorded.

and

$$\overset{\leftrightarrow}{E}_{Total} = \frac{E_{MaxTotal}}{\sqrt{P_{Input}}}$$

Where:

$E_{MaxTotal}$ = maximum measurement of the total E-field from the probe at each location (i.e. 9 measurements below 10fs, and 3 above 10fs)

$\overset{\leftrightarrow}{E}_{Total}$ = normalized maximum total measurement from each probe location

P_{Input} = average input power to the chamber during the tuner rotation at which was recorded.

j) For each calibration frequency, calculate the average of the normalized maximum for each axis of the E-field probe measurements, $\left\langle \overset{\leftrightarrow}{E}_{x,y,z} \right\rangle$

i) For each frequency below 10fs:

$$\left\langle \overset{\leftrightarrow}{E}_x \right\rangle_9 = \left(\sum \overset{\leftrightarrow}{E}_x \right) \Big/ 9$$

$$\left\langle \overset{\leftrightarrow}{E}_y \right\rangle_9 = \left(\sum \overset{\leftrightarrow}{E}_y \right) \Big/ 9$$

$$\left\langle \overset{\leftrightarrow}{E}_z \right\rangle_9 = \left(\sum \overset{\leftrightarrow}{E}_z \right) \Big/ 9$$

Also calculate the average of the normalized maximum of all the E-field probe measurements giving equal weight to each axis (i.e. each rectangular component), $\left\langle \overset{\leftrightarrow}{E} \right\rangle_{27}$

NOTE $\langle \; \rangle$ denotes arithmetic mean, i.e.

$$\left\langle \overset{\leftrightarrow}{E} \right\rangle_{27} = \left(\sum \overset{\leftrightarrow}{E}_{x,y,z} \right) \Big/ 27$$

represents the sum of the 27 rectangular E-field maximums (normalized) divided by the number of measurements.

ii) Repeat i. for each frequency above 10fs, replacing 9 with 3 and 27 with 9

k) For each frequency below 10fs determine if the chamber meets the field uniformity requirements as follows:

i) The field uniformity is specified as a standard deviation from the mean value of the maximum values obtained at each of the nine locations during one rotation of the tuner. The standard deviation is calculated using data from each probe axis independently (e.g. σ_x) and the total data set (e.g. σ_{27}). (Caution – DO NOT confuse "total data set" with the total E-field).

The standard deviation is given by:

$$\sigma = \alpha * \sqrt{\frac{\sum (\ddot{E}_i - \langle \ddot{E} \rangle)^2}{n-1}}$$

Where:

N	=	number of measurements,
$\ddot{E}_i$	=	individual normalized E-field measurement,
$\langle \ddot{E} \rangle$	=	arithmetic mean of the normalized E-field measurements
α	=	1.06 for $n \leq 20$ and 1 for $n > 20$.

For example, for the x vector:

$$\sigma_x = 1.06 * \sqrt{\frac{\sum (\ddot{E}_{ix} - \langle \ddot{E}_x \rangle_9)^2}{9-1}}$$

Where:

$\ddot{E}_{ix}$	=	individual measurement of x vector, and
$\langle \ddot{E}_x \rangle$	=	arithmetic mean of normalized $E_{Max\ x}$ vectors from all 9 measurement locations.

and for all vectors:

$$\sigma_{27} = \sqrt{\frac{\sum (\ddot{E}_{ix,y,z} - \langle \ddot{E} \rangle_{27})^2}{27-1}}$$

Where:

$\ddot{E}_{ix,y,z}$	=	individual measurements of all vectors (x, y and z),
$\langle \ddot{E} \rangle_{27}$	=	arithmetic mean of normalized EMax x,y,z vectors from all 27 measurements, and
σ_{27}	=	standard deviation of all vectors (x, y, and z).

The standard deviation is expressed in terms of dB relative to the mean:

$$\sigma(\mathrm{dB}) = 20 * \log\left(\frac{\sigma + \langle \ddot{E} \rangle}{\langle \ddot{E} \rangle}\right)$$

ii) The chamber passes the field uniformity requirements if the standard deviation of the individual field components (e.g. $\sigma_{x,y,z}$) does not exceed the standard deviation specified in **Figure 111** for more than two frequencies per octave, and the standard deviation for all vectors (i.e. σ27) does not exceed the specified standard deviation. If the chamber fails to meet the uniformity requirement it may not be possible for the chamber to operate at the desired lower frequency. If the margin by which the chamber fails to meet the uniformity requirement is small, it may be possible to obtain the desired uniformity by:

I) Increasing the number of samples (i.e. tuner steps) by 10% to 50%,

II) Normalizing the data to the net chamber input power ($P_{Net} = P_{Input} – P_{Reflected}$), or

III) Reducing the size of the working volume.

If the chamber exceeds the required field uniformity, the number of samples required may be reduced, but not below a minimum of twelve tuner steps. This offers the ability to optimize each chamber for the minimum number of samples and therefore minimize test time.

NOTE If the tuner fails to provide the required uniformity then the uniformity may be improved by increasing the number of tuners, making the tuner(s) larger, or lowering the Q by adding absorber. The chamber characteristics (size, construction method, wall materials) should also be evaluated to determine if the chamber is likely to pass the requirement. Chambers with no more than 60 to 100 modes at the lowest test frequency or very high Qs (such as those encountered in all welded aluminium chambers) are likely to encounter difficulty in meeting the required uniformity.

IMPORTANT Once a chamber has been modified (e.g. absorber added, etc.) or the calibration procedure modified (e.g. changed number of tuner steps, etc.) to obtain a desired characteristic, that configuration and/or procedure must remain the same for the duration of the test for that calibration to remain valid.

B.19.4.2 Receive Antenna Calibration

The receive antenna calibration factor (ACF) for an empty chamber is determined to provide a baseline for comparison with a loaded chamber (see **Clause B.19.5.2**).

Calculate the receive Antenna Calibration Factor (ACF) for each frequency using the following equation:

$$ACF = \left\langle \frac{P_{AveRec}}{P_{Input}} \right\rangle_{9@\le 10f_s \quad \text{or} \quad 3@\ge 10f_s}$$

where P_{Input} is the average input power from e. above for the corresponding location at which the average received power (P_{AveRec}) from e. above was measured. The calibration factor is necessary to correct the antenna measurements for several effects including antenna efficiency.

NOTE < > denotes arithmetic mean, i.e. $\langle P_{AveRec} \rangle_9 = (\Sigma P_{AveRec})/9$

The normalized E field $\left\langle \ddot{E} \right\rangle_{27}$ outlined in **Clause B.19.4.1 j**. (i. and ii.) is based on measurements from E field probes. The average of the E field components can also be estimated using the maximum received power from an antenna. As a cross check to probe performance, calculate the normalized E field for each frequency above $4f_s$ using the following equation:

$$\ddot{E} = \left\langle \frac{\frac{8\pi}{\lambda}\sqrt{5 * \frac{P_{MaxRec}}{\eta_{rx}}}}{\sqrt{P_{Input}}} \right\rangle_{9@\le 10f_s \quad \text{or} \quad 3@\ge 10f_s}$$

Where

P_{MaxRec} = the maximum received power over one tuner rotation at an antenna location from Clause B.19.4.3.5,

P_{Input} = the average chamber input power from **Clause B.19.4.3.5** for the corresponding location at which P_{MaxRec} was measured, and

η_{rx} = the antenna efficiency factor for the receive antenna which can be assumed to be 0.75 for a log periodic antenna and 0.9 for a horn antenna.

Any discrepancies greater than ± 3 dB between the probe and antenna based measurements must be resolved.

B.19.4.3 Maximum Chamber Loading Verification

In order to determine if the chamber is adversely affected by an EUT which “loads” the chamber, perform a one-time check of the chamber field uniformity under simulated loading conditions. It is suggested the “loaded” chamber calibration be carried out only once in the life of the chamber or after major modification to the chamber. Prior to each test a calibration shall be conducted using the procedures of **Clauses B.19.5.2** and **B.19.5.3**.

a) In the working volume of the chamber, install a sufficient amount of absorber to load the chamber to at least the level expected during normal testing (a factor of sixteen change in ACF (12 dB) should be considered as a nominal amount of loading).

b) Repeat the calibration outlined in **Clause B.19.4.1** using the eight outer locations of the E-field probe. Care should be taken to ensure that the E-field probe and receiving antenna maintain a distance of greater than l/4 from any absorber.

c) Determine the chamber loading by comparing the Antenna Calibration Factor (ACF) from the empty chamber to that obtained from the “loaded” chamber (See **Clause B.19.4.2**)

$$\text{Loading} = \frac{ACF_{\text{Empty Chamber}}}{ACF_{\text{Loaded Chamber}}}$$

d) Repeat the calculation of the field uniformity using the data from only eight locations.

If the chamber loading results in:

1) The rectangular component of the fields exceeding the allowed standard deviation for more than two frequencies per octave, or

2) If the standard deviation for all vectors (i.e. σ_{27}) exceeds the allowed standard deviation then the chamber has been loaded to the point where field uniformity is affected.

In such case the chamber amount of loading must be reduced and the loading effects evaluation must be repeated.

No loading verification is required above $10f_s$.

B.19.5 Equipment Test

B.19.5.1 Test Setup

Except as specifically noted in this section, the requirements of **Clause 6** apply to the reverberation chamber tests.

The typical test setup should be as shown in **Figure 110**. The equipment layout should be representative of the actual installation as specified in **Clause 6**. The EUT shall be located inside the working volume as defined in **Clause B.19.4.1**. Moreover, the EUT volume shall not take up more than 8% of the chamber volume.

The transmit and receive antennas shall be the same antennas used in **Clause B.19.4.1**.

The transmit antenna should be in the same location as used for calibration. Establish software installation, modes of operation and stability of the EUT, test equipment, and all monitoring circuits and loads.

B.19.5.2 Calibration

Prior to each test, with the EUT and supporting equipment in the chamber, perform a chamber calibration according to the following procedure.

a) Place the receive antenna at a location within the working volume of the chamber and maintain 0.75 metre (or $\lambda/4$ at the lowest test frequency) separation from the EUT, supporting equipment, etc., as outlined in **Figure 112**. Set the amplitude measurement instrumentation to monitor the receive antenna on the correct frequency.

b) Beginning at the lowest test frequency (f_s), adjust the RF source to inject an appropriate input power, (P_{Input}), into the transmit antenna. Care must be taken to ensure that the harmonics of the RF input to the chamber are at least 20 dB below the fundamental.

c) Operate the chamber and the tuner taking into account the possible additional features defined in **Clause B.19.4.1 k.(ii.)** that have been required to meet the homogeneity criterion. Care must be taken to ensure that the dwell time is sufficiently long enough to ensure that the amplitude measurement has time to respond properly.

d) Record the maximum amplitude and average amplitude of the receive signal (P_{MaxRec}, P_{AveRec}), and the average value of the input power, P_{Input}. The measurement instruments should have a noise floor at least 20 dB below the maximum received power (P_{MaxRec}) in order to collect accurate average data.

e) Repeat the above procedure for each test frequency.

f) Calculate the chamber calibration factor (CCF) for each frequency using the following equation:

$$CCF = \left\langle \frac{P_{AveRec}}{P_{Input}} \right\rangle_n$$

Where:

CCF = the normalized average received power over one tuner r rotation with the EUT and supporting equipment present

P_{AveRec} = the average received power over one tuner rotation from step d.

P_{Input} = the forward power averaged over one tuner rotation from step d.

n = the number of antenna locations the CCF is evaluated for. Only one location is required; however, multiple locations may be evaluated and the data averaged over the number of locations, n.

g) Calculate the chamber loading factor (CLF) for each frequency using the following equation:

$$CLF = \frac{CCF}{ACF}$$

Where

CCF = the ratio of the average received power to input power obtained in step f. above

ACF = the ratio of the average received power to input power obtained in the antenna calibration in **Clause B.19.4.2**.

If the magnitude of the chamber loading factor is in excess of that measured in **Clause B.19.4.3 c**, for more than 10% of the test frequencies, there is a possibility that the chamber may be loaded to the point where field uniformity is affected. In such case the chamber uniformity measurements outlined in **Clause B.19.4.1** must be repeated with the EUT in place or with a simulated loading equivalent to the EUT.

NOTE If the value of P_{AveRec} measured in d above is within (i.e. not greater than or less than) the values recorded for all nine locations in **Clause B.19.4.1**., calculation of the CLF is not necessary and the value of the CLF can be assumed to be one (1).

B.19.5.3 Q and Time Constant Calibration

In order to assure that the time response of the chamber is fast enough to accommodate pulsed waveform testing, determination of the chamber time constant shall be accomplished using the following procedure:

a) Using the CCF from the chamber calibration (**Clause B.19.5.2.f**.), calculate the quality factor, Q, for every test frequency above 400 MHz using:

$$Q = \left(\frac{16\pi^2 V}{\eta_{Tx}\eta_{Rx}\lambda^3} \right)(CCF)$$

Where:

η_{Tx}, η_{Rx} = Antenna efficiency factors for the transmit and receive antenna respectively and can conservatively be assumed to be 0.75 for a log periodic and 0.9 for a horn antenna,

V = the chamber volume (m^3),

λ = the free space wavelength (m) at the specific frequency, and

CCF = the chamber calibration factor.

b) Calculate the chamber time constant, τ, for every test frequency above 400 MHz using:

$$\tau = \frac{Q}{2\pi f}$$

Where

Q = the value calculated in step (a.) above

F = the test frequency (Hz).

c) If the chamber time constant is greater than 0.4 of any modulation test waveform pulse width for more than 10% of the test frequencies, absorber must be added to the chamber or the pulse width increased. If absorber is added, repeat the Q measurement and the calculation until the time constant requirement is satisfied with the least possible absorber. A new CLF must be defined if absorber material is required.

B.19.5.4 Mode Tuned RS Test Procedures

CAUTION — RF fields can be hazardous. Observe appropriate RF exposure limits.

Determine the chamber input power for each test frequency for the electric field test limits (**Figure 111**) using the equation:

$$P_{Input} = \left[\frac{E_{Test}}{\left\langle \overleftrightarrow{E}_{Total} \right\rangle_n * \sqrt{CLF}} \right]^2$$

Where:

E_{Test} = the required field strength (V/m) from **Figure 111**.

CLF = the chamber loading factor from **Clause B.19.5.2.g**.

$\left\langle \ddot{E}_{Total} \right\rangle_n$ = the mean of the normalized maximum total E field as defined in **Clause B.19.4.1 i.**

It will be necessary to interpolate between the calibration frequency points to obtain the normalized E field calibration ($\ddot{E}$) for the test frequencies.

Use the number of tuner steps as listed in **Table 24**. The tuner should be rotated in evenly spaced steps so that one complete revolution is obtained per frequency.

The applied field strength is derived from P_{Input} computed above in this section. Set the input power to P_{Input} and record its value. The receive antenna is used as verification that the transmit path is functioning correctly.

Step through the frequency range to the upper frequency limit using the appropriate modulations. Modulate the carrier as specified in **Clause B.19.7**. When modulation is applied, ensure that the peak amplitude complies with the definitions of **Figure 111**. The dwell time for this procedure should be consistent with EUT cycle time and equipment reporting time. Dwell at internal modulation, data and clock frequencies, as required.

While dwelling at each frequency, evaluate EUT operation and determine compliance with applicable equipment performance standards.

B.19.6 Limits

Limits are shown in **Figure 106** for Air service use. These limits should be tailored as required to meet individual project requirements.

NOTE 1 The limits are shown in peak values and apply to each of the modulation characteristics specified in **Clause B.19.7**.

NOTE 2 For Air Systems with wiring feeding to or from external stores the limit should be a minimum of 6 dB above that shown. The actual level will be chosen by the Project Manager and defined in the EMC Test Plan and should reflect the actual external environment.

B.19.7 Modulation

Consider applying modulations associated with the EUT, such as clock, data, IF, internal processing or modulation frequencies. Consider any possible low frequency response characteristic of the EUT, for example a flight control equipment's response to 1 to 3 Hz modulation in the 2 to 30 MHz HF range. When using 1 Hz to 3 Hz modulation, ensure that sweeping and/or frequency stepping is suspended during the «off» period of the modulation.

The following modulation types are an attempt to define generic modulation types which should simulate the effects of modulations found in practice with as small a number as possible to prevent excessive test times:

B.19.7.1 50 kHz to 400 MHz

a) CW

b) AM, >90% square wave at 1kHz prf

c) 300 Hz - 3 kHz square wave amplitude modulation of depth >90 % with a superimposed 1 Hz square wave modulation of at least 90 % depth. The frequency is linearly swept from 300 Hz to 3 kHz during the on period of the 1 Hz square wave and reset in the off period. Ensure that sweeping and/or frequency stepping is suspended during the «off» period of the 1Hz modulation.

For the radiated test: in all cases the test signal must meet the peak requirement with the exception of the band 150 MHz to 225 MHz where the above modulations only apply to the average requirement. The peak requirement for this band being covered in **Clause B.19.7.2.a**.

B.19.7.2 400 MHz to 18 GHz

a) 1 kHz pulse modulation of at least 90 % depth. The pulse width shall be 20 µS. This signal should in addition be switched on and off at a rate of 1 Hz to simulate the effect of rotational radars. The test signal must meet the peak requirement.

b) 1 kHz square wave amplitude modulation of at least 90 % depth. The test signal must meet the average requirement.

c) CW, the test signal must meet the average requirement.

If a system is considered to be more sensitive to a modulation type not covered by the above but which may be expected to occur in practice, this modulation type should be tried during testing.

The test time can be minimized by determining the modulations to which the system under evaluation is most sensitive. If the system under test is most sensitive to only one type of modulation over the complete frequency band, use only this modulation for the test rather than running the tests with all the modulations listed above.

Table 24 Reverberation Chamber Test Criterion

Frequency Range[a]	Number of samples[b] recommended for calibration and test[c d]	Number of frequencies[e] required for calibration
f_s to 4 f_s	60	50 / decade
4 f_s to 8 f_s	36	50 / decade
Above 8 f_s	18	20 / decade

[a] fs is the start frequency

[b] independent tuner positions or intervals

[c] the minimum number of samples is twelve (12)

[d] the number of samples used to meet the calibration requirement must remain fixed for each frequency range

[e] log spaced

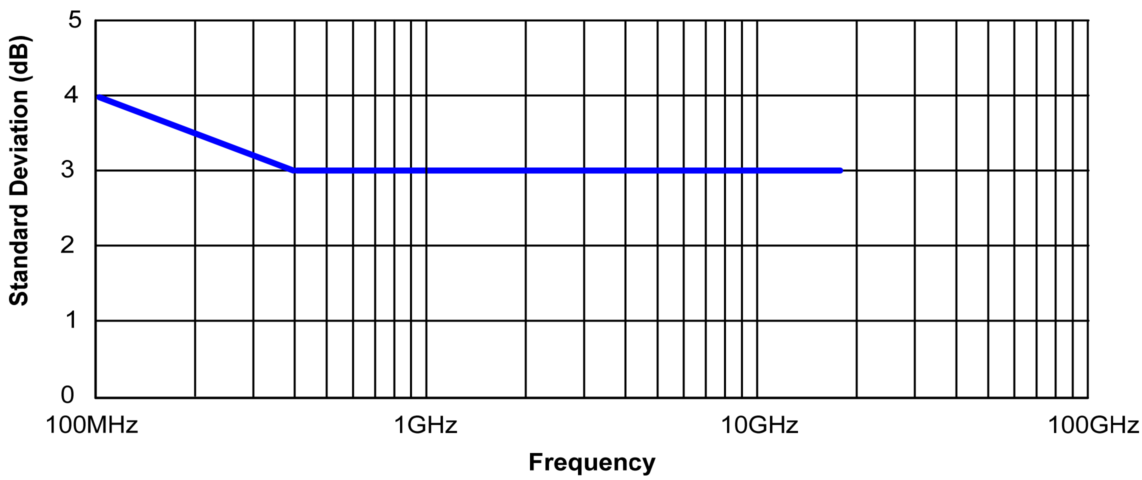


Figure 111 DRS02.B – Alternative Method -Allowable Standard deviation for Field Uniformity Test

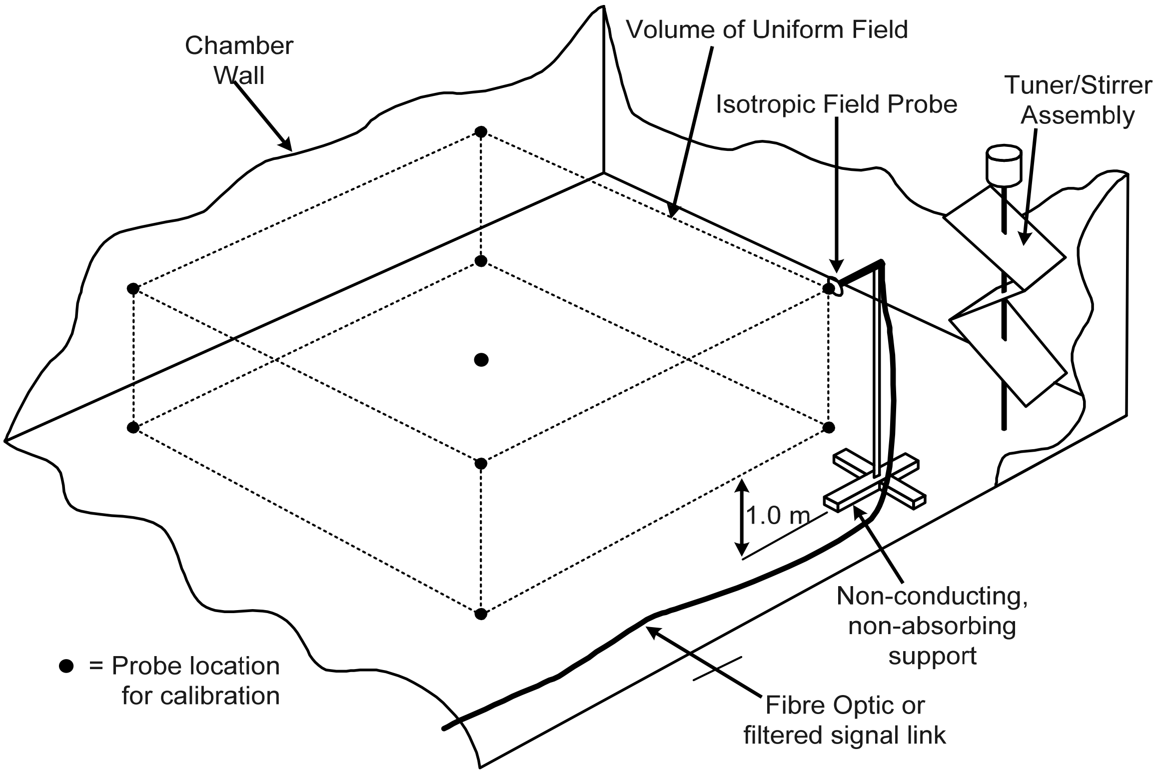


Figure 112 DRS02.B – Alternative Method - Probe locations for Reverberation Chamber Calibration

NOTE 1 Calibration of the fields inside the reverberation chamber shall consist of nine probe locations.

NOTE 2 The locations shall enclose a volume as shown above. This volume is the “working volume” of the chamber. The surfaces bounding the working volume should not be located closer than 0.75 metre (or λ/4 at the lowest test frequency) from any chamber surface, field generating antenna or tuner assembly. For calibration and monitoring purposes the receive antenna may be located at any location within the working volume. The transmit antenna should be directed into a corner of the chamber if possible. Directing the antenna into the tuner is also acceptable. The location of the transmit antenna shall remain fixed during calibration and testing. The location of the transmit antenna shall be the same for both calibration and testing.

NOTE 3 The working volume may be sized to suit the maximum working volume of the chamber or sized to suit the items to be tested. It is recommended that the working volume be sized to suit the maximum working volume since a second calibration will be required if larger items are to be tested.

NOTE 4 An isotropic probe that provides access to each of the three axes shall be used to conduct calibrations. A calibrated electrically short dipole antenna (i.e. less than 0.1 m) may be substituted provided that the dipole antenna is positioned at three mutually perpendicular orientations for each measurement location. Care should be taken to ensure that its connecting cable does not influence the dipole. An optically isolated measurement system (isotropic probe or dipole) is recommended.

NOTE 5 The minimum separation distance may be reduced to less than 0.75 metre provided that the separation is greater than λ/4 for the lowest test frequency. Separation distances of less than 1/4 metre are not recommended in any case.

B.20 DRS03.B Magnetic Field (DC) Susceptibility (Land and Sea Services)

B.20.1 Purpose

The purpose of this test is to confirm that the magnetic field produced by degaussing coils, the effect of deperming and by high level currents flowing in cables or electromagnets, does not cause malfunction of the EUT.

B.20.2 Applicability

This test is applicable to all equipment containing components potentially sensitive to magnetic fields, e.g. cathode ray tubes, photo multipliers, sensitive Hall effect devices and moving coil meters. For an EUT comprising a number of units, each unit with potentially sensitive components shall be tested individually. The interconnecting cables do not have to be subjected to this test.

For EUT (or units of a system) greater than $1m^3$ or weighing more than 100kg it is considered generally impractical to apply the standard test method. For these equipment types a localised test method shall be applied to all the areas of the equipment considered most likely to be susceptible.

Reference should also be made to **Clause 9.20**.

NOTE 1 Wherever possible the standard test method shall be applied.

NOTE 2 All assessable faces to be tested.

B.20.3 Helmholtz Coil Specifications

B.20.3.1 Helmholtz coil specification for the standard method

The Helmholtz coil assembly shall consist of two identical closely wound circular coils on the same axis, with the planes of the coils parallel and spaced by a distance equal to the radius of the coils. An energising DC current shall be passed through both coils in series, so that the magnetic field due to each coil is in the same direction.

$$\text{Number of turns on each coil} = \frac{\text{Required field strength (A/m) x coil radius (m)}}{\text{0.716 x Current (Amps)}}$$

The recommended size of coil to be used shall be such that the longest dimension of the EUT does not exceed 1.1 times the radius of the coils.

NOTE The coil assembly shall be constructed on a non-magnetic former.

B.20.3.2 Helmholtz coil specification for the Localised test method

The Helmholtz coil assembly shall consist of a single closely wound circular coil.

$$\text{Number of turns on each coil} = \frac{\text{2 x Required field strength (A/m) x coil radius (m)}}{\text{0.716 x Current (Amps)}}$$

To ensure adequate magnetic coverage of the potentially susceptible areas of the EUT, the coil radius shall be at least 1.5 times the largest dimension of the area being assessed, but having a minimum radius of 0.5m.

B.20.4 Test Layout

The Helmholtz coil shall be positioned with its coils no closer than 1m from any ferrous materials. This may include. e.g.. Screen enclosure walls, test equipment, filing cabinets, light fittings, conduit etc.

For the standard test method the EUT shall be positioned centrally within the coil with all cable forms to the unit under test being taken out of the sides of the Helmholtz coil assembly via the shortest possible route.

A typical arrangement of the EUT within the Helmholtz coil assembly is shown in **Figure 113**.

For the localised test method the area of the EUT to be assessed shall be located centrally with respect to the coil at a separation distance of 0.5 times the coil radius as shown in **Figure 114**.

It is not mandatory for Line Impedance Stabilising Network's (LISN's) to be used for this test, however the earth to the EUT must be an RF type and under no circumstances a domestic mains earth.

B.20.5 Standard Test Method (For units up to 1m^3)

Prior to application of the test field to the EUT, the DC current supplied to the Helmholtz coil assembly to generate the required test level must be calculated. This is achieved using the following formula:

$$\text{Current (Amps)} = \frac{\text{Required field strength (A/m) x coil radius (m)}}{\text{Number of turns on each indivadual coil x 0.716}}$$

NOTE The formula for calculating the test level is derived from established magnetic field theory in free space. It is not required to physically measure the field generated either in free space or upon application to the EUT.

The area of the EUT (or unit of the EUT system) to be assessed shall be immersed in the magnetic test field produced by the double multi-turn circular coil. The test shall be applied to each test position in turn with the coils energised first with a positive polarity and subsequently with a negative polarity. This reverses the direction of the magnetic field produced.

B.20.6 Localised Test Method

The separation distance between the EUT and the coil is dependant upon the mechanical dimensions of the coil being used. Care must be taken when placing the coil that it is no closer than 0.5 of its radius as this may start to affect the field being produced. Similarly the separation distance should not exceed this as this will mean a substantial reduction in field applied to the EUT. The dimension of the coil used and its placement relative to the EUT shall be recorded in the test report.

The test field shall be applied for a duration long enough to comprehensively establish whether any malfunction, degradation in performance or damage has occurred to any part of the EUT. Additionally the EUT shall be checked for permanent magnetising effects after application of the test field.

Should malfunctions occur at the test levels, the field is to be reduced and increased such that any hysteresis effect is determined. The upper and lower thresholds of susceptibility shall be recorded together with the orientation and polarity details.

The ripple content (peak to peak) of the direct current used to energise the Helmholtz coil assembly shall be kept to a minimum and shall not exceed 10% of the DC level.

B.20.6 Limits

For Land Service a static magnetic test level of 350A/m shall be applied.

For Sea Services a test level of 800A/m or higher (up to 4800 A/m) shall be applied to simulate DC magnetic field effects. Reference to DEF STAN 08-123 data sheet 38 should be made to determine appropriate test levels and pass/fail criteria.

For all Sea Services testing the test field shall be ramped linearly at a rate of 1600A/m/s up to the required test level.

B.20.7 Useful Information

A field strength of 1 Amp/metre is equivalent to:

A field strength of	0.0126 Oersted
A flux density of	0.0126 lines/cm2
	0.0126 Gauss
	1.26 Micro weber/m^2
	1.26 Micro Tesla
	1260 Gamma

A test level of 800A/m is therefore approximately 1 milli Tesla.

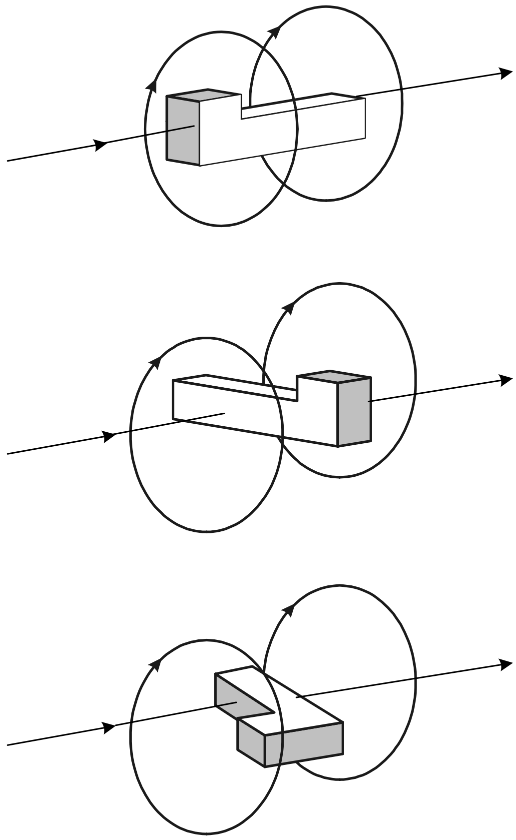


Figure 113 DRS03.B – b Arrangement of EUT within Helmholtz Coil Assembly

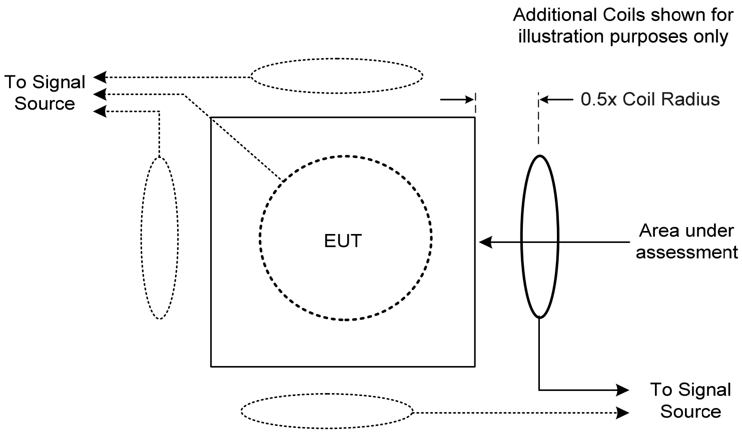


Figure 114 DRS03.B – Localised Test Method

Annex C
Performance Specification for Specialised Test Equipment

C.1 Generators and Calibration Jigs

Table 25 shows the generator type and associated calibration jig to be used for a particular test, together with the number of the Clause where more detailed information may be found.

Table 25 Generator and Calibration Jig Combination by Test Title

Test Title and Frequency Band	Generator Output (Clause)	Calibration Jig Title
DCS02.B 50 KHz – 400 MHz	Modulated CW	100 Ω
DCS04.B – 100 kHz	Long Switching Transient (C.2.3)	5 Ω
DCS04.B 2 MHz – 30 MHz	Switching Transient (**Clause C.2.1**)	100 Ω
DCS05.B 0.5 MHz – 50 MHz	EMP and Switching Transient (**Clause C.2.2**)	10 Ω
DCS06.B 100 kHz	Long Switching Transient **Clause C.2.3**)	5 Ω
DCS08.B 2 MHz – 50 MHz	NEMP / LEMP (**Clause C.2.4**)	100 Ω
DCS09.B	Imported LEMP (**Clause C.2.5**)	None
DCS10	ESD pulse (**Clause 9.13**)	2 Ω
DCS12.B	Imported Low Frequency Transient (**Clause B.13.5**)	10 Ω
NOTE Injection probes are specified in **Clause C.3** and **Table 28** and **Table 29**. Calibration Jigs are specified in **Clause C.4** and **Table 30**		

C.1.1 Safety Considerations when using Pulse Generators

The pulse generators referred to in **Clause C.2** can produce lethal voltages. Operators, trials engineers and observers should be made aware of the potential hazards and instructed to follow the approved safety procedures of the Test House responsible for the conduct of the tests. When testing with the Long Waveform, in particular, it is advisable for personnel in the vicinity of the EUT to wear eye protection. Some components have been known to explode during the test and project debris over distances of several metres.

Some types of pulse generators can produce a high intensity burst of noise when they are fired. Operators, trials engineers and observers should be made aware of this and advised to wear ear defenders.

C.2 Transient Generator Performance Specifications

This clause specifies the performance of the various transient generators called up in **Annexes A** and **B** of this part of the standard. In all cases, the output waveform characteristics are required to be those achieved using the generator and injection probe combinations given in **Table 25** in conjunction with the specified test jig. Note that the coupling cables and their length are an integral part of the output shaping circuit. It is mandatory, therefore, that the same coupling cables used for the waveform and output amplitude verification shall be used when conducting equipment tests.

C.2.1 Type 1 – DCS04.B Variable Frequency Transient Generator

The generator, in association with its complementary injection probe, shall generate a damped sinusoid waveform as in **Figure 115**, when observed at and loaded with the 100 Ω calibration jig. The specific performance characteristics of the generator and probe, when loaded by the calibration jig unless otherwise stated, are as follows:

a) Output Frequency: Continuously tuneable to any frequency between 2 MHz and 30 MHz.

b) Frequency Accuracy: The measured frequency of the transient shall lie within ±10% of the indicated frequency setting of the generator. The frequency of the transient shall be determined from the average time interval between the zero crossings over the first eight half cycles during injection using the type of probe described in **Table 29** with the 100 Ω calibration jig.

c) Waveform Decay: The amplitude of the eighth half cycle shall be at least 25% but less than 75% of the peak half cycle when measured in the 100 Ω calibration jig. The nominal Q value of this waveform lies in the range 6.8 to 32.8.

d) Output Voltage: This is defined as the peak voltage of the highest amplitude half cycle when the injection probe is open circuit i.e. out of the calibration jig, not clamped around a cable but otherwise closed. An output voltage of up to 500 Vpk is required when measured using a single turn monitor loop as described in **Clause C.5.1** and **Figure 120**.

e) Output Current: An output current of up to 20 Apk for the highest amplitude half cycle is required, when measured in the 100 Ω calibration jig.

f) Amplitude Control: The output should be capable of adjustment so that a reduction of at least 30:1 from the defined maximum level is possible, while preserving the required waveform.

C.2.2 Type 1N: DCS05.B Fixed Frequency Transient Generator

The generator, in association with its complementary injection probe, shall generate a damped sinusoid waveform as in **Figure 115**, at fixed frequencies, when observed at and loaded with the 10 Ω calibration jig. The specific performance characteristics of the generator and probe, when loaded by the calibration jig unless otherwise stated, are as follows:

a) Output Frequency: Damped sinusoidal transients shall be provided at the following frequencies: 0.5, 1.0, 2.0, 3.0, 5.0, 10.0, 15.0, 35.0 and 50.0 MHz.

b) Frequency Accuracy: The measured frequency of the transient shall lie within ±10% of the indicated frequency setting of the generator. The frequency of the transient shall be determined from the average time interval between zero crossings over the first eight half cycles, during injection using the type of probe described in **Table 29** into the 10 Ω calibration jig.

c) Waveform Decay: The amplitude of the eighth half cycle shall be at least 25% but less than 75% of the peak half cycle when measured in the 10 Ω calibration jig. The nominal Q value of this waveform lies in the range 6.8 to 32.8.

d) Output Current: The maximum required peak current, of the highest amplitude half cycle measured in the calibration jig, is 100 Apk at all frequencies up to 10 MHz. From 10 MHz up to 50 MHz, log (peak current) reduces linearly with log (frequency), to 20 Apk at 50 MHz as shown in **Table 26**. For some tests, the maximum currents must be controlled down to less than 2.5 Apk while preserving the required waveform, so a suitable pulse attenuator will be required.

The attenuator is used in conjunction with the injection probe to increase the range of output control of the transient generator when required. This provides a reduction of output to enable the lower transient level tests, simulating contractor switching transients, to be performed.

Table 26 Output Current against Frequency for Type 1N Generator

Frequency (MHz)	Output (Apk) into 10 Ω
0.5	100
1.0	100
2.0	100
3.0	100
5.0	100
10	100
15	67
35	29
50	20

C.2.3 Type 2: DCS04.B & DCS06.B Fixed Frequency Generator

The generator, in association with its complementary injection probe, shall generate at 100 kHz a damped sinusoid waveform as in **Figure 116**, when observed at and loaded with the 5 Ω calibration jig. The specific performance characteristics of the generator and probe, when loaded by the calibration jig unless otherwise stated, are as follows:

a) Frequency Accuracy: The measured frequency of the transient shall lie within ±10% of the indicated frequency setting of the generator. The frequency of the transient shall be determined from the average time interval between zero crossings over the first three half cycles, during injection using the type of injection probe described in **Table 29**, with the 5 Ω calibration jig.

b) Waveform Decay: The amplitude of the third half cycle using the type of injection probe described in **Table 29**, shall be at least 25% but less than 50% of the amplitude of the peak half cycle when measured in the 5 Ω calibration jig. The nominal Q value of this waveform lies in the range 2.3 to 4.5.

c) Output Voltage: An output voltage of up to 700 Vpk is required when measured at the injection probe monitor output via an oscilloscope having a high impedance input. The required output voltage level is that of the peak half cycle measured with the injection probe open circuit, i.e. out of the calibration jig, not clamped around the cable but otherwise closed.

d) Output Current: An output current of up to 30 Apk is required when measured in the 5 Ω calibration jig. The required level of output current is that of the peak half cycle.

e) Amplitude Control: The amplitude of the output shall be capable of adjustment so that a reduction of at least 10:1 from the defined maximum level is possible while preserving the required waveform.

f) Injection Phase: Control (AC power lines): Control of the point of application of the transients on ac power lines, with respect to the phase of the ac waveform, shall be available; external trigger and variable transient repetition rate facilities are also required.

C.2.4 Type 1A/M and 1B DCS08.B Variable Frequency Transient Generators

These generators together cover the required frequency range. Each generator, in association with its complementary injection probe, shall generate a damped sinusoid waveform as in **Figure 115**, when observed at and loaded with the 100 Ω calibration jig. The specific performance characteristics of the generator and probe, when loaded by the calibration jig unless otherwise stated, are as follows:

a) Output Frequency: The required output shall be provided at any frequency in the range 2 MHz and 50 MHz. Non-mandatory design guidance is available for the construction of the two generators to cover the frequency range. The Type 1A/M generator provides the required output between 2 MHz and 30 MHz while the 1B generator provides the required output between 30 MHz and 50 MHz.

b) Frequency Accuracy: Measured frequency of the transient shall lie within ±10% of the indicated frequency setting of the generator. The frequency of the transient shall be determined from the average time interval between zero crossings over the first eight half cycles, during injection using the type of injection probe described in **Table 29** with the 100 Ω calibration jig.

c) Waveform Decay: The amplitude of the eighth half cycle, using the type of injection probe described in **Table 29,** shall be at least 25% but less than 75% of the amplitude of the peak half cycle when measured in the 100 Ω calibration jig. The nominal Q value of this waveform lies in the range 6.8 to 32.8. See **Figure 112** for an example of a simulated waveform.

d) Output Voltage: This is defined as the peak voltage of the highest amplitude half cycle when the injection probe is open circuit (out of the calibration jig and not clamped around a cable). An output voltage of 4 kVpk is required from 2 MHz to 30 MHz, reducing linearly with frequency to 2 kVpk at 50 MHz. This output is required when measured using a single turn monitor loop as described in **Clause C.5**.

e) Output Current: An output current of up to 40 Apk for the highest amplitude half cycle is required from 2 MHz to 30 MHz, when measured in the 100 Ω calibration jig. The required level then reduces linearly with frequency to 20 Apk at 50 MHz.

f) Amplitude Control: The amplitude of the output shall be capable of adjustment so that a reduction of at least 10:1 from the defined maximum level is possible, while preserving the required waveform.

C.2.5 Type 3 DCS09.B Pulse Generators

These generators provide a single uni-directional current pulse which is injected into an equipment ground bonding lead to simulate the current induced by a direct lightning strike on an aircraft. Three different pulse waveforms are specified as 'short', 'intermediate' and 'long,' in terms of pulse rise-time and duration; they are illustrated in **Figure 117**. The specific performance characteristics of the generator are as follows:

a) Pulse Characteristics: **Table 27** specifies the output waveform required of each type of pulse generator and shows the maximum peak short circuit current and maximum peak open circuit voltage to be provided.

b) Amplitude Control: Equipment intended for operation in an exposed electromagnetic environment require testing with the high current and voltage levels shown in **Table 27**. For equipment to be operated in a protected electromagnetic environment, the current and voltage test levels are reduced by a factor of about 13 for the short pulse and 40 for the intermediate pulse. The current for the long pulse is reduced by a factor of 10 but no reduction is made in the open circuit voltage. Control of amplitude to meet the different test levels is essential while preserving the required waveform.

   The generator output requirements as specified in **Table 27** shall be verified. The source impedance shall be verified at the output terminals and all other parameters verified using the output leads which will be used subsequently to connect the pulse generator to the EUT. Verification of both positive and negative polarity output waveforms is required. The output leads should be of solid copper, preferably not exceeding 75 mm in length with a cross-section of 25 mm x 2 mm.

c) Generator Design: A separate generator is likely to be required for each of the three waveforms.

Table 27 Pulse Waveform and Output Characteristics

Pulse Duration	Short	Intermediate	Long
Rise time to pk (µs)	0.1 (see Note 1)	6.4	50
Fall time to zero from start (µs)	6.4 (see Note 2)	-	-
Fall time to 50 % pk from start (µs)	-	70	500
Max short circuit current (kA)	0.32	1.0	10
Max open circuit voltage (kV)	1.6	5.0	2.0
Generator Source Impedance (Ω)	5.0	5.0	0.2

NOTE 1 This is the maximum time allowed to reach peak amplitude. All other times have a tolerance of ± 20%.

NOTE 2 After the zero crossing the pulse amplitude is permitted to undershoot but by no more than 20% of peak amplitude.

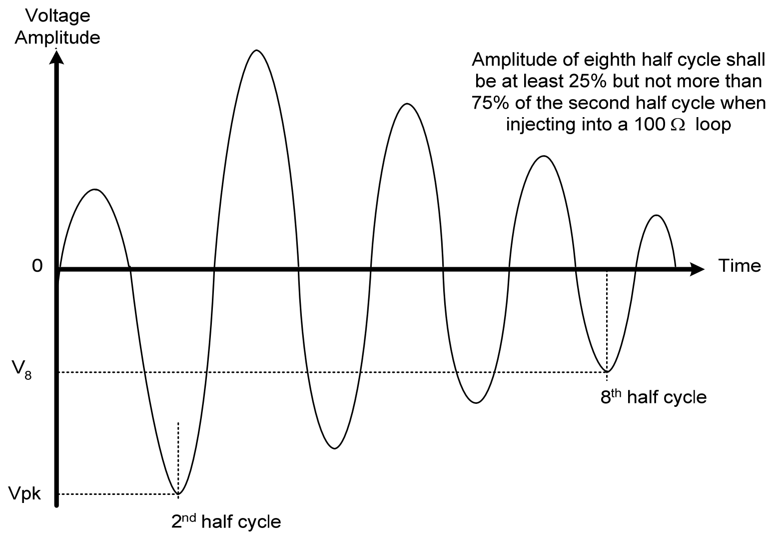


Figure 115 Typical Type 1 Transient Wave Form

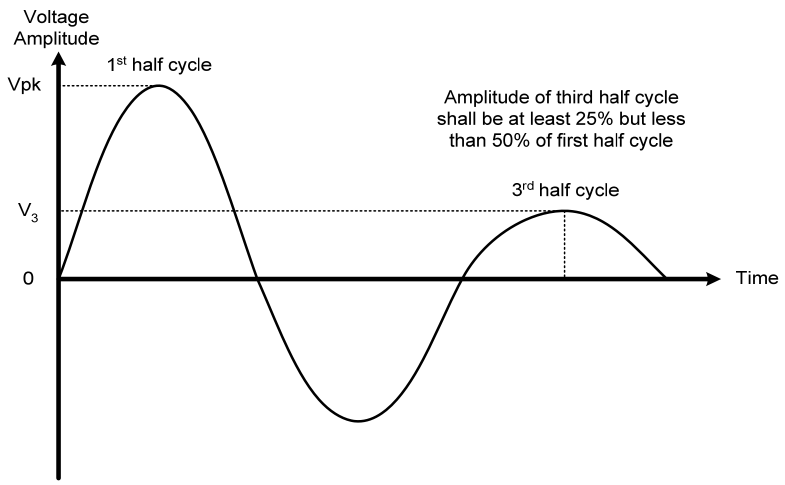
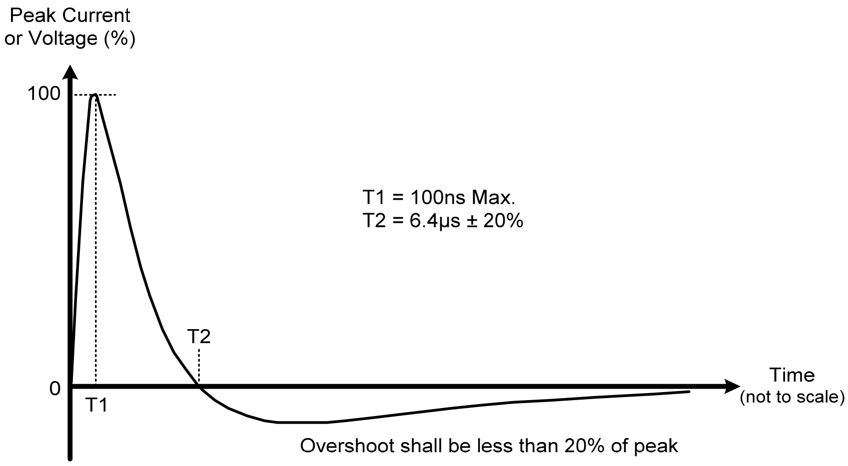
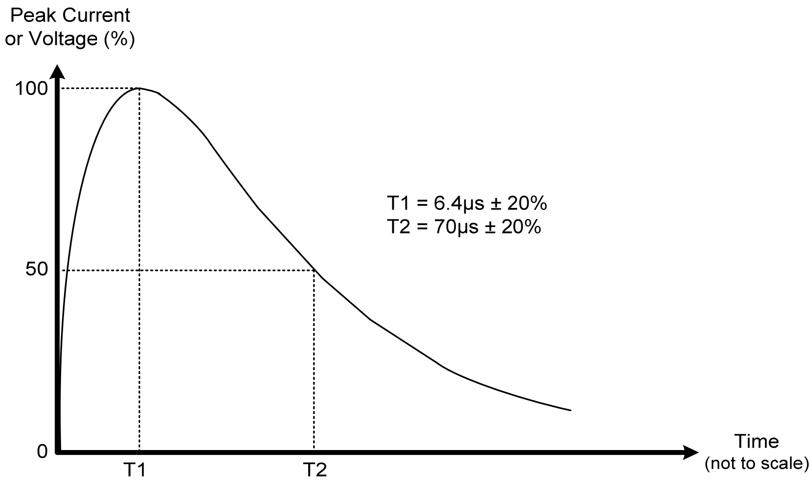


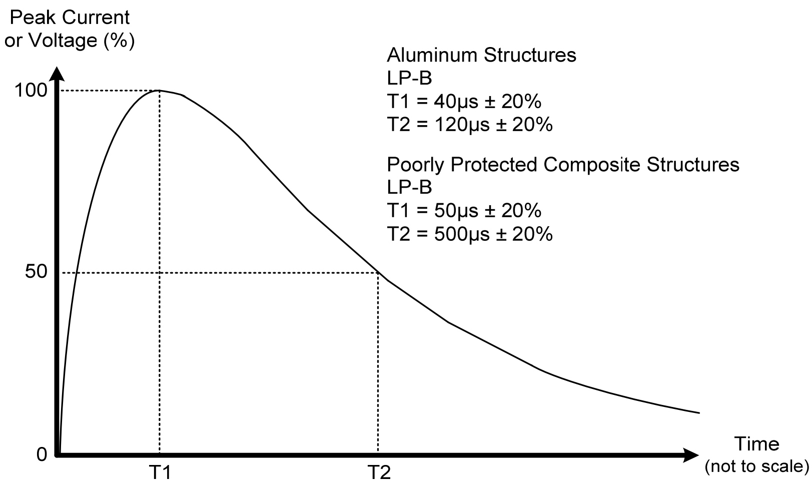
Figure 116 Typical Type 2 Transient Wave Form



(a) Short Pulse (SP) Waveform Simulating Aperture Coupling



(b) Intermediate Pulse (IP) Waveform Simulating Resistive Coupling



(c) Long Pulse (LP) Waveform Simulating Diffusion / Redistribution Coupling

Figure 117 Typical Type 3 Waveform (DCS09.B)

C.3 Injection Probe Performance

The empirically established performance specifications for bulk current injection probes, driven in both the CW and transient modes are presented in **Table 28** and **Table 29** respectively. These specifications are based on normal drive conditions in which probe cores are NOT driven into magnetic saturation. Test engineers are cautioned to ensure that measurements are NOT taken under core saturation conditions, during either calibration or equipment testing.

Probes of alternative specifications are acceptable only if compliance with the Standard can be demonstrated, when they are employed in the combinations presented in **Table 25**.

Table 28 Performance Specifications for CW Injection Probes

Test Title	**DCS02.B**		
Frequency range (MHz)	0.05 – 4.0	4 – 200	200 – 400
Self inductance (mH) ± 20%	29.2	0.7	0.35
Self resonant frequency (MHz) ± 25%	1.25	53.5	70.0
Resonant impedance (Ω) ± 25%	394	233	165
Insertion loss (dB) ± 3 dB at Frequency (MHz)			
0.05	21.0		
0.10	15.0		
0.20	12.0		
0.30	10.7		
0.40	10.1		
0.50	9.9		
1.0	10.0		
4.0	11.0	11.0	
5.0			
10.0		6.0	
20.0			
30.0		4.9	
50.0			
100.0		5.0	
200.0		5.5	5.5
400.0			6.0
Max CW input drive : (W)	100	100	100
NOTE In an ambient temperature of 20℃, the probe must withstand repeated applications of 100 W CW, lasting 30 minutes per application without damage to itself or the cable being tested. A cool-down period, not exceeding 30 minutes, is acceptable between successive power applications.			

Table 29 Performance Specifications for Transient Injection Probes

Test Title	DCS04.B DCS06.B	DCS05.B DCS08.B	DCS04.B DCS08.B	DCS04.B DCS08.B
Frequency range (MHz)	0.1±10%	0.5 – 50	2 – 400	2 – 100
Self inductance (mH) ± 20%	4.0	0.70	0.30	0.35
Self resonant frequency (MHz) ± 25%	8.0	40	77	70
Resonant impedance (Ω) ± 25%	179	328	180	165
Insertion loss (dB) ± 3 dB at Frequency (MHz)				
0.10	31			
0.50		29.0		
1.0		20.0	20.0	
2.0		17.0	17.0	22.0
4.0				
5.0		10.0	10.0	14.0
10.0		6.0	4.5	8.5
20.0				6.0
30.0				6.0
50.0		4.5		6.0
Max input drive (kVpk)	1.0	4.0	4.0	4.0

C.4 Calibration Jigs

C.4.1 Bulk Current Jig

C.4.1.1 Purpose

The 5, 10 and 100 Ω jigs listed in **Table 25** are each intended to be used in the demonstration of acceptable output current waveform from a particular combination of bulk current generator and injection probe.

Each calibration jig must present a specified essentially resistive, impedance to the injection probe and, since the output current is calculated from the voltage measured across a terminating impedance, the value of that terminating impedance must be known.

For details of a 100 Ω jig see **Clause C.4.3.2** for details.

C.4.1.2 Design

The calibration jig comprises a short, low-loss transmission line around the central conductor of which the injection probe may be clamped. The line is terminated at one end by a known resistive impedance. The other end, the calibration port, is fitted with an RF connector so that the line may be driven for jig calibration purposes. During jig calibration, no injection probe is fitted.

C.4.1.3 Use with Injection Probe

When the calibration jig is used to validate a bulk generator/injection probe combination, the connector on the calibration port is used to terminate the line by a short circuit (in the case of the 5 Ωand 10 Ω jigs) or by a 50 Ω resistive load for the 100 Ω jig.

C.4.1.4 Voltage measurement

For the 5 Ω and 10 Ω jigs the voltage developed across the terminating resistor, set up by the current flowing through it, must be measured close to the resistor terminals with a high impedance measuring system such as an oscilloscope fitted with a x10 input probe. For the 100 Ω jig, which requires a 50 Ω termination at each end of the transmission line, one 50 Ω terminating resistor can be implemented by a 50 Ω measuring system.

C.4.2 ESD 2 Ω Calibration Resistance

The ESD generator shall be designed and calibrated in accordance with BS EN 61000-4-2:1995. The generator shall be in calibration and have been calibrated by an approved calibration laboratory with the required parameters traceable to National/International standards.

C.4.3 Specification of Calibration Jigs

C.4.3.1 Bulk Current Jigs

The input impedance of the jig shall be measured at the calibration port, with the opposite end of the transmission line terminated in the specified resistance. The measurement shall be made at dc and at intervals over the frequency range which encompasses most of the pulse energy. This measurement is to ensure that the impedance of the jig transmission line, terminated by the specified resistance, is controlled within acceptable limits.

The transfer impedance of the terminating resistance shall be measured by injecting a known RF current into the calibration port and observing the resultant voltage developed across the terminating resistor with a high impedance RF voltmeter or oscilloscope. Refer to **Clause 6.25**. The ratio of the voltage to the current gives the value of the transfer impedance. Current may be injected from an external generator connected to the calibration port and its value measured directly with a current probe around the transmission line or by calculating it from the generator voltage and the measured input impedance. See **Table 30**.

When a generator output is being checked, the current in the jig may be calculated by dividing the observed voltage across the terminating resistor by its transfer impedance.

Table 30 Jig Input and Transfer Impedance Requirements

Calibration Jig	Input impedance (Ω)		Transfer Impedance (Ω)
	DC	RF	
5 Ω	5 ± 5%	5 ± 10%	5 ± 10%
10 Ω	10 ± 5%	10 ± 10%	10 ± 5%

C.4.3.2 DCS02 100Ω Calibration Fixture

A commonly used calibration fixture is shown in **Figure 118**. Other designs are available. The top is removable to permit the lower frequency probes to physically fit. The calibration fixture can be scaled to accommodate larger injection probes. **Figure 119** displays the maximum VSWR that this calibration fixture should exhibit when measured without a current probe installed in the fixture. The presence of a probe will usually improve the VSWR of the fixture.

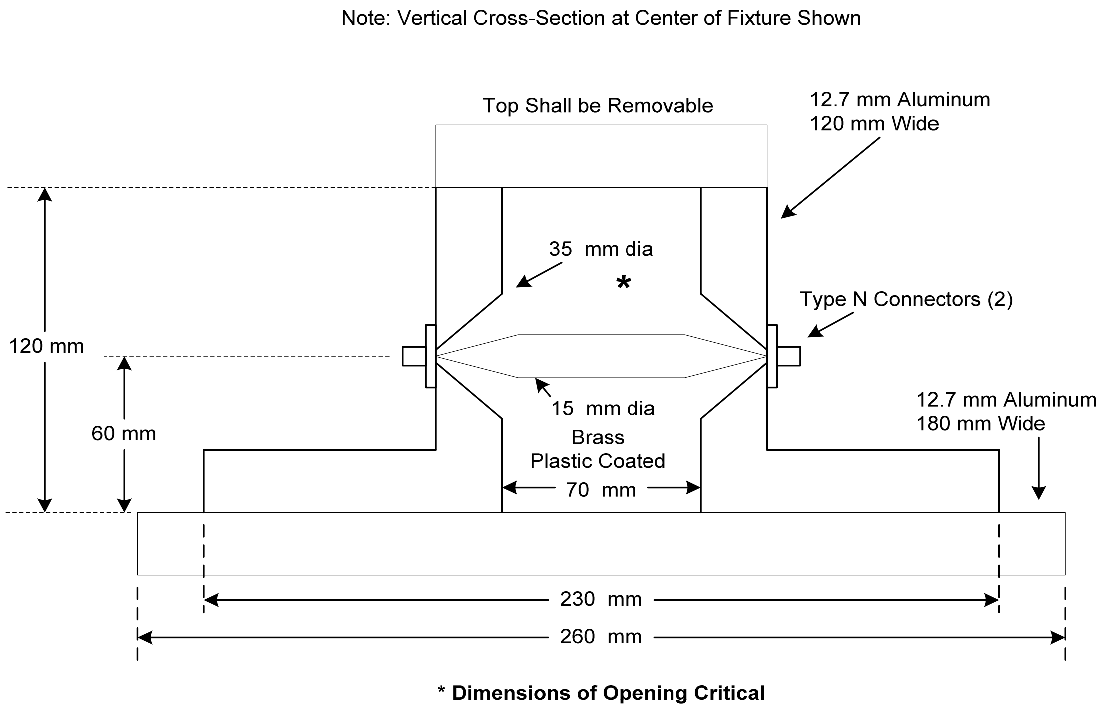


Figure 118   Typical DCS02 Calibration Fixture

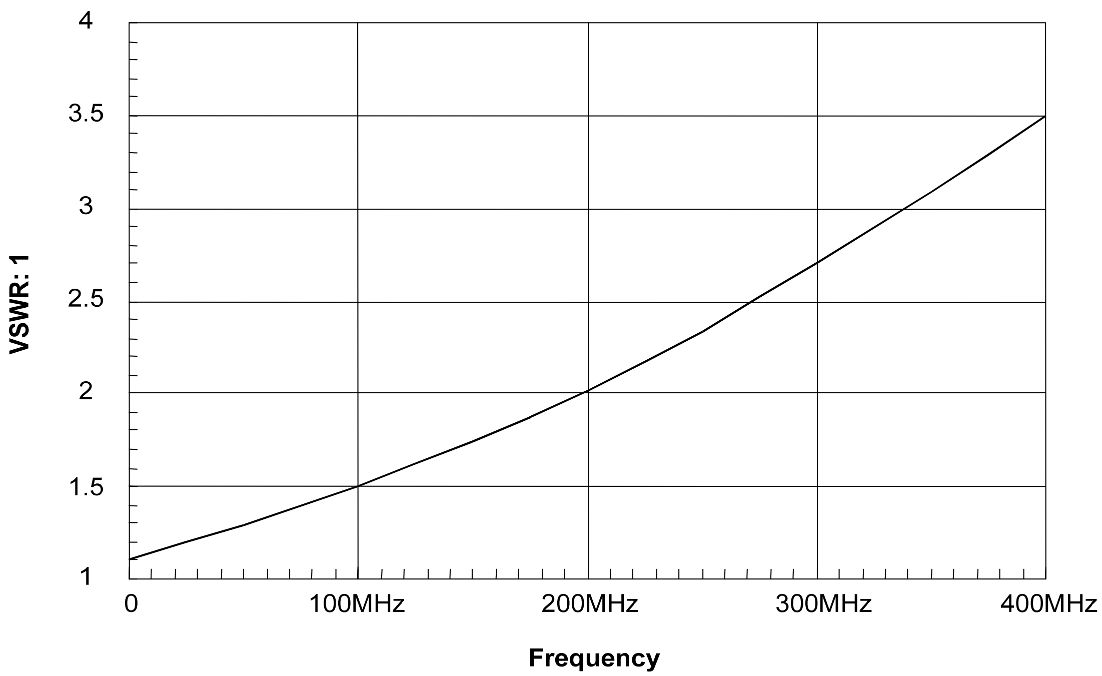


Figure 119   Maximum VSWR of Calibration Fixture

C.5 Monitor Loops and Voltage Probes

C.5.1 Monitor loop – Test Methods DCS04.B and DSC08.B

The monitor loop is required to measure the injection probe open circuit conditions. The loop must present a low inductance and hence should be manufactured from a solid copper conductor having a cross section of not less than 10 mm^2; the loop should be insulated to withstand kilovolt levels and fit closely around a cross-section of the injection probe. In some circumstances the loop can generate several kilovolts across its ends, so the loop must be insulated appropriately and the complete probe handled with care when in use. The loop shall be terminated by a screened potential divider with a nominal division ratio of 100:1. The resistance of the lower limb of the divider is 50 Ω and a resistance of this value should be installed in the probe. The output of the probe should be terminated by a 50 Ω 'through load' (or a 50 Ω attenuator) whose output can be measured remotely via a 50 Ω coaxial cable. This cable is connected and matched at the input of the waveform viewing oscilloscope to avoid standing waves on the cable. If a 50 Ω oscilloscope input port is available the cable should be connected to that port. If only a high impedance oscilloscope input is available, it should be terminated with a 50 Ω 'through load' and the cable connected to that load. A suitable probe design is shown in **Figure 120**.

The division ratio of the potential divider must be calibrated with the waveform viewing oscilloscope connected so that an accurate calculation of the loop output voltage may be made from the oscilloscope reading. The nominal division ratio of the probe as illustrated in **Figure 120** (measured using a high impedance probe on its output) will be about 100:1. When terminated by a 50 Ω 'through termination' and connected to a 50 Ω oscilloscope the division ratio is 300:1.

C.5.2 Voltage Probes – Test Method DCE01 (Part 4)

Figure 121 shows the design of voltage probes that may be used over the frequency range 20 Hz to 10 MHz for conducted emissions test DCE01 in Part 4 of this Standard, where the power line current exceeds the rating of current probes or the physical size of the cable precludes the use of a current probe.

Probes shall be calibrated by measuring the voltage division ratio over the test frequency range, when terminated by the measuring equipment impedance, so that the conducted emission level can be calculated accurately from the measuring set voltage.

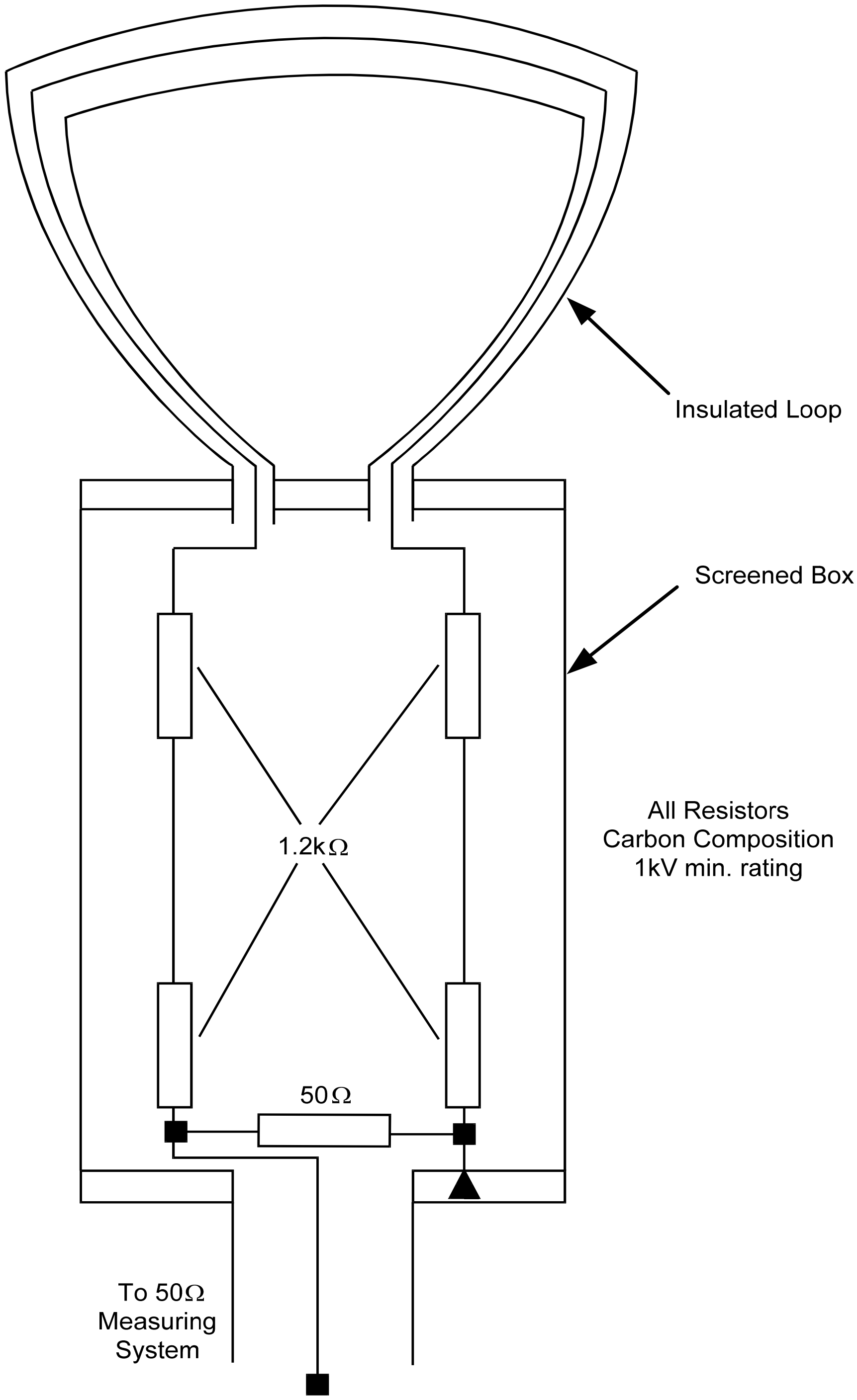
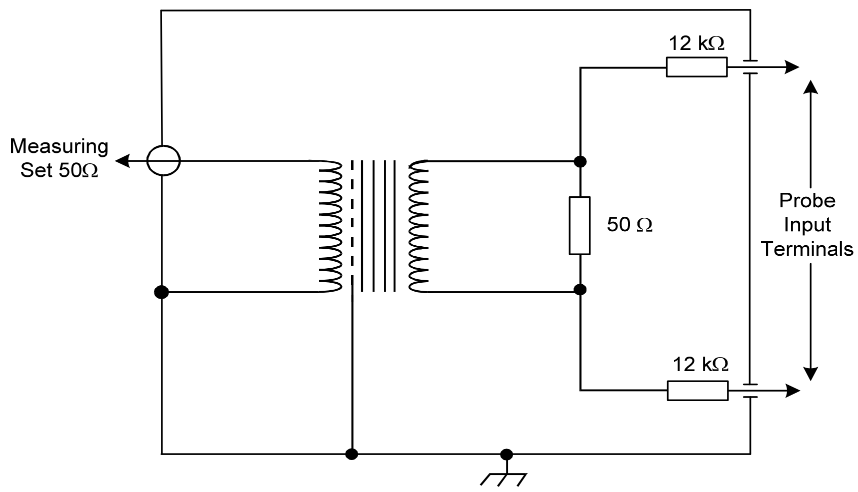
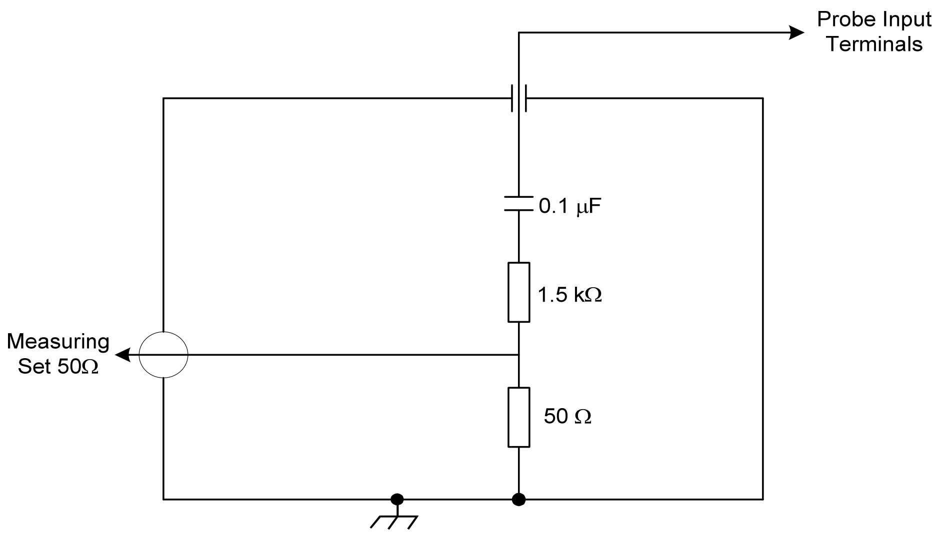


Figure 120 Monitor Loop Probe for Tests DCS04 and DCS08



(a) Voltage Probe 20 Hz – 100 kHz



(b) Voltage Probe 100 kHz – 10 MHz

Figure 121 Voltage Probes 20 Hz - 10 MHZ for Test DCE01 (Part 4)

C.6 Line Impedance Stabilizing Network (LISN)

C.6.1 Impedance / Frequency Characteristic

In order to provide a defined power source impedance the supply to the EUT shall be made via a line impedance stabilizing network. This is a three terminal device, with one terminal earthed, to be connected in series with each power supply conductor between the power source and the primary power input of the EUT. The power source is connected to the supply terminal of the LISN while the LISN EUT terminal is connected to the power input terminal of the EUT. The measuring set terminal of the LISN shall be terminated to the LISN case by a 50 Ω non-reactive resistor. This resistor may be provided by an externally connected 50 Ω measuring system or by a discrete resistor, of adequate power rating, at the LISN. The case of the LISN shall be bonded to the ground conducting bench.

The LISN shall provide the impedance / frequency characteristics shown in **Figures 122** and **123**. The impedance is that measured between the EUT terminal and case with the LISN supply terminal left unconnected.

C.6.2 Constructional Details (not mandatory)

Figure 124 and **Table 31** give constructional details for a typical LISN. The 10 µF bushing capacitor should be integral with the LISN and suitable for safety protection measures taken.

For DC supplies an additional 30,000 µF ± 50% capacitor shall be connected between positive and negative on the power supply side of the two LISNs to improve the low frequency performance. **Figure 125** shows protection circuitry which may be required to reduce switch-on surges.

The LISNs shall be permanently connected to the power supplies and used in all tests detailed in this specification.

C.6.3 Calibration

This procedure defines the activities that shall be undertaken in the calibration of LISN transfer impedance over the frequency range of 1 kHz to 400 MHz. At the time of writing most Network Analysers (NWA) and Impedance Analysers do not have the capability to encompass the whole of the above frequency range, therefore a combination of ATE Impedance Analysers may be required. LISN units are often designed with connectors for high current mains power applications that complicate impedance metrology techniques in the UHF frequency band. The measurement technique requires calibrated specialist adapters to interface LISN terminal connectors with standard impedance connectors up to 400 MHz. Adapters should be rigid and short in length as possible. Adapters will require calibration for loss and electrical length, to enable correction of transfer impedance measurements, which are significantly at UHF test frequencies. The calibration of adapters should be verified using an impedance standard such as a calibrated mismatch. This will improve confidence and assist to determine the adapter measurement uncertainty contribution to the LISN transfer impedance total measurement uncertainty.

To calibrate a LISN the following steps should be carried out:

a) Connect the measurement terminal adapter to Equipment Under Test (EUT) end of LISN.

b) Leave the supply terminal end of the LISN open circuit.

c) Fit a calibrated 50 Ω termination on to the measurement port.

d) Connect the calibrated and verified ATE Impedance Analyser to the measurement terminal via a specialist adapter.

e) Perform measurement as instructed by the ATE Impedance Analyser procedure and record open circuit characteristic.

f) Adapter Correction: Correct for transfer impedance from the ATE Impedance Analyser reference plane to the LISN EUT terminal plane. (If not already performed in the ATE Impedance Analyser Calibration).

C.6.4 Limits

Figure 122 and **123** show the limit lines for the LISN transfer impedance characteristic. Consideration must be given to the total measurement uncertainty of the measurement technique across the whole of the frequency range. No lower limit applies between 5 kHz and 100 kHz in **Figure 122**.

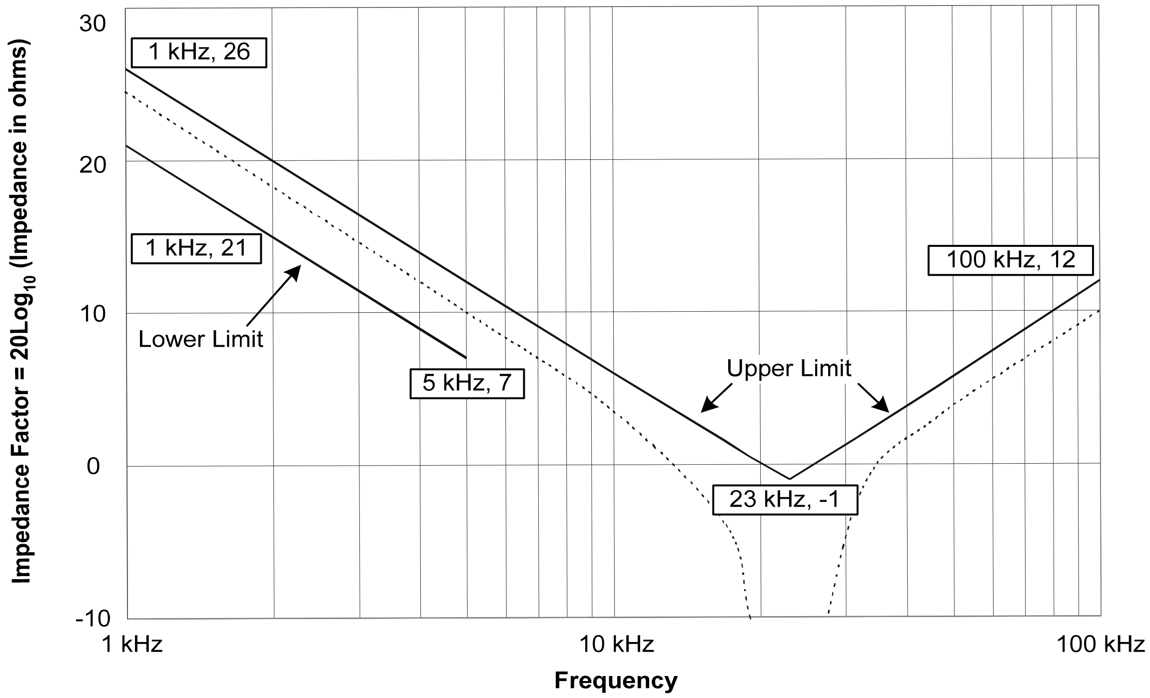


Figure 122 Limits for Low Frequency Impedance/Frequency Characteristics of LISN

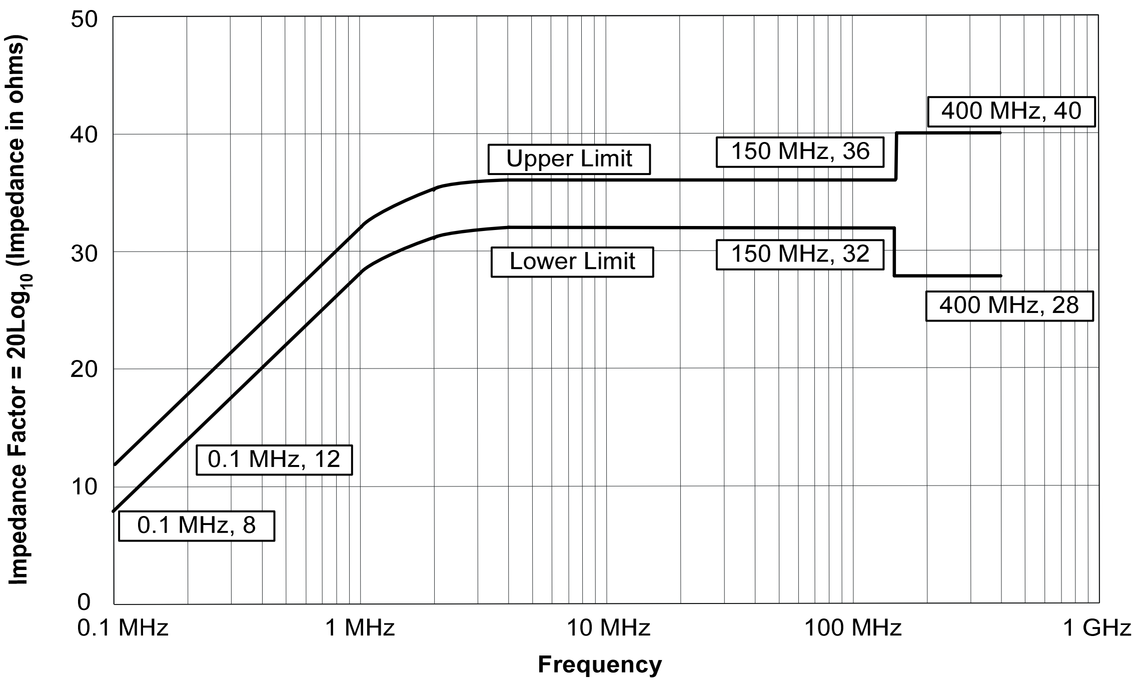


Figure 123 Limits for High Frequency Impedance/Frequency Characteristics of LISN

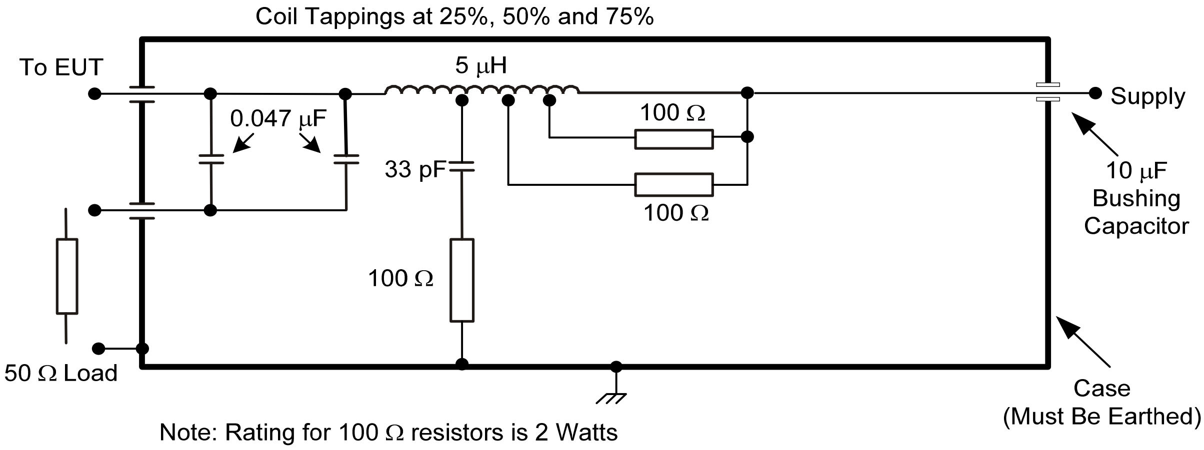


Figure 124 Circuit Diagram of Typical LISN

Table 31 Details of Inductor

Current Rating (A)	Inductance μH	Inside Diameter (mm)	Length (mm)	Number of Turns	Conductor Cross Section (mm)
10	5	25.4	32	20	1.6 Diameter
100	5	50	115	18	6 Diameter
500	5	90	178	11	12.5 x 12.5 (Square)

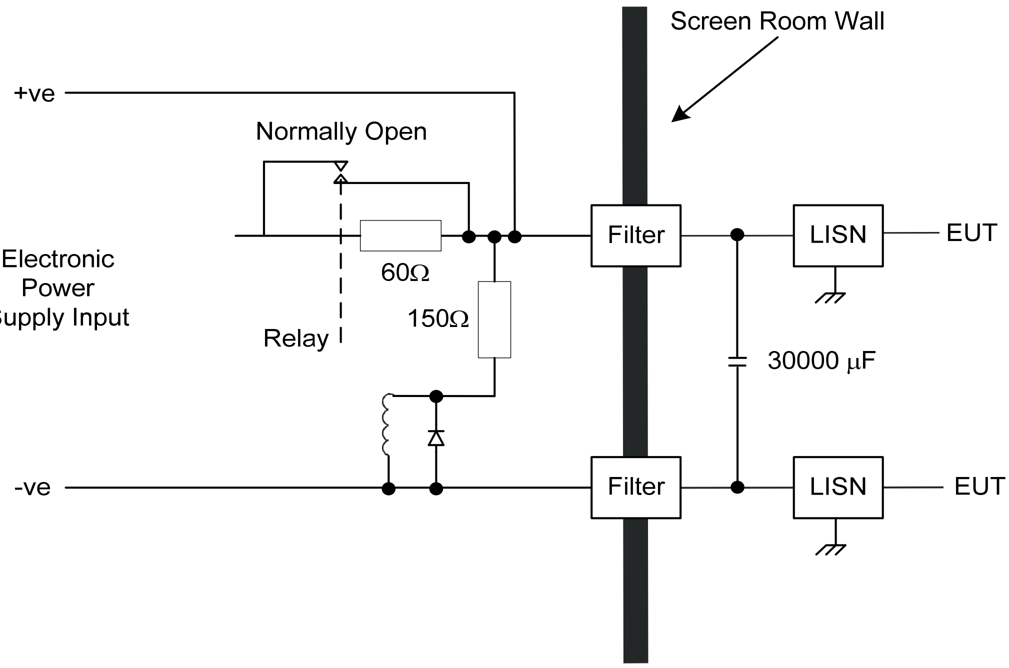


Figure 125 Modification of DC Supplies to Limit Surge Currents

C.7 Method For Damping Screened Rooms

C.7.1 Aim

To provide some general guidance on the selective use of Radio Frequency Absorbing Material [RAM] within a screened room to limit effects of resonant modes and reflections on the accuracy of EUT measurements.

C.7.2 Objective

The objective is the economical lining of a screened room such that EUT emission measurements can be made whose results are within ± 10 dB of the values which would be obtained in free space conditions, over the frequency range 30 MHz to 250 MHz. The tolerance is reduced to ± 6 dB over the frequency range 250 MHz to 1 GHz. This method is a means of reducing the amount of anechoic material necessary to create a quite zone within the screened room and is an alternative to a fully lined room.

C.7.3 Damping Material

There are two basic types of RAM available, carbon loaded foam and ferrite tiles.

Carbon loaded foam in the form of cones are more effective at higher frequencies where the cone length exceeds a quarter wavelength; they can be bulky and not particularly robust. Ferrite material in the form of solid or honeycomb tiles are more effective at lower frequencies. The tiles are conveniently thin and work down to at least 30 MHz, although not so well above 1 GHz. They are also very heavy when compared with cones of carbon loaded foam and their use may require structural reinforcement of the screened room.

Optimum results require the use of both these materials. Ferrite tiles absorb energy at the lower frequencies while carbon loaded foam reduces reflections at higher frequencies.

The use of carbon loaded foam on ferrite tiles, however, has not been found to provide any enhanced performance.

Manufactures' performance data for carbon loaded foam and ferrite tiles is usually determined under far-field conditions. When these materials are used in most screened rooms below 200 MHz they are usually exposed to near-field conditions and hence this data should be used with care when selecting absorbing material.

C.7.4 Room Dimensions and Resonant Frequencies

The resonant frequencies depend on the dimensions of the room and it is required of this Standard that the fundamental (lowest) resonant frequency is not less than 30 MHz. The resonant frequencies for a rectangular screened room are given by the formula:

$$f_{mnq} = \frac{c}{2}\sqrt{\left(\frac{m}{w}\right)^2 + \left(\frac{n}{l}\right)^2 + \left(\frac{q}{h}\right)^2}$$

Where: f_{mnq} = resonant frequency (Hz) for particular positive integer values of m, n and q. Only one of these integers may be set to zero for a mode to exist.

c = velocity of light ($3*10^8$m/s)

w = width of room (m)

l = length of room (m)

h = height of room (m)

From this formula a maximum sized screened room with the fundamental resonance not less than 30 MHz could have the following dimensions:

Length = 9 m

Width = 6 m

Height = 4 m.

Here q has been set to zero, while m and n have each been set to their lowest possible values of unity.

NOTE These damping requirements are not applicable where large EUT (greater than 1 m^3) testing requires the use of screened rooms that exceed these maximum dimensions. In this case see **Part 4** of this Standard However, it is suggested that RAM is strategically placed to reduce reflections from screened room walls which might give rise to measurement anomalies. Positioning of RAM must be considered on an individual EUT basis but likely areas are behind the measurement antenna and EUT where reflections would have the most effect.

The dimensions of the smallest screened room permitted are governed by the physical constraints set by the following.

a) Maximum EUT size allowed 1 m^3

b) EUT to Measuring Antenna separation distance of 1 m and the need to maintain a clearance of 0.3 m between the damping material and the EUT/measurement antenna.

c) Requirements would be satisfied by a room for which

i) Length = 4.9 m

ii) Width = 2.8 m

iii) Height = 2.4 m

iv) The fundamental resonant frequency would be 62 MHz.

NOTE The smallest size screened room cannot be used for **Annex A** DRE03.A measurements due to the length of the whip antenna required.

For further guidance on the damping of a screen room reference should be made to the DStan report: “Report on the Stage III Research into the Damping and Characterization of Screened Rooms for Radiated Emission Testing in Def Stan 59-41 which can be found at www.dstan.co.uk.

C.8 Screened Room Damping Performance Verification Procedure

C.8.1 Aim

To define a standard measurement procedure for assessing the damping performance of partially and fully lined screened rooms with and without a ground conducting bench.

C.8.2 Introduction

Radiated emission measurements made within un-damped screened rooms can be subject to errors exceeding 20 dB due to resonant conditions and reflections. This depends on factors such as whether the electric or magnetic component is being measured, the measurement frequency and detection bandwidth.

A cost effective solution to minimise the effects, suitable for EUT sizes up to 1 m^3, has been developed and validated both experimentally and by modelling. The solution is based on the use of a partially or fully damped screened room and is a requirement for all EMC radiated emission measurements carried out in **Annexes A**, and **B** of this Part of the Standard.

The damping performance criteria for the screened room shall be measured using one of the following methods and checked annually under the quality control procedures detailed in ISO 17025. Measurement shall be repeated whenever the room damping material or its configuration is changed, or when a different EMC measuring antenna type or model is used.

C.8.3 Objectives

C.8.3.1 Screen Room WITHOUT a Ground Conducting Bench – Man Worn, Man Portable Equipment

To verify that the antenna coupling between a calibrated dipole antenna and a calibrated broadband EMC measuring antenna set 2 m from it, is within a certain tolerance of the coupling which would be obtained if the antenna set-up was situated in free space.

The maximum permitted tolerances are:

a) ±10 dB over the frequency range 30 MHz to 250 MHz

b) ±6 dB from 250 MHz to 1 GHz

Measurements are to be made with both vertical and horizontal polarisations. Example test equipment is given in **Clause C.8.4** and procedures in **Clause C.8.5**. Alternative site verification procedures are permitted if agreed with the MOD Project Manager (e.g. ANSI 63.4, CISPR 22 and ETSI TR 102 273-2).

C.8.3.2 Screen Room WITH a Ground Conducting Bench – Line Replacement Units & Sub Systems

To verify that in a screened room with a ground conducting bench as specified in **Clause 6.4**, the coupling between a Comparison Noise Emitter and a calibrated broadband EMC measuring antenna set 1 m from it, is within certain tolerance as stated below of the coupling which would be obtained if the same set-up was situated on a ground conducting bench mounted on an Open Area Test Site (OATS).

The maximum permitted tolerances are:

a) ±10 dB over the frequency range 30 MHz to 250 MHz

b) ±6 dB from 250 MHz to 1 GHz

Measurements are to be made with the CNE and the receive antennas vertically and horizontally polarized. For these measurements an antenna calibrated in accordance with **Clause 6.22** shall be used. Example test equipment is given in **Clause C.8.4** and procedures in **Clause C.8.6**.

NOTE A conducting bench has a large effect on the room characteristics, particularly at low frequencies where the room dimension is less than half a wavelength. Whether or not the bench is terminated at the ends by connection to the sidewalls has an impact on the field levels. In particular the bench strongly attenuates horizontally polarised signals between an EUT and the antenna. This can be up to 20dB of attenuation

C.8.4 Test Equipment

The following equipment is required:

a) Network analyser with S-parameter test set and calibration kit (N type, 50 Ω) or Spectrum analyser with tracking generator (or signal generator) and two 10 dB, 50 Ω attenuators or Receiving system with signal generator and two 10 dB, 50 Ω attenuators.

b) Two non-metallic antenna stands.

c) Applicable to screened rooms WITHOUT a ground conducting bench.

An 86 cm (tip to tip) and a 16 cm (tip to tip) dipole as transmit antennas; Bi-conical and Log periodic (or a Bi-log antenna) as appropriate for the receive antenna use

d) Applicable to screened rooms WITH a ground conducting bench.

A Comparison Noise Emitter (CNE having a top loaded monopole antenna element calibrated in accordance with procedure specified in **Clause C.8.7**.

e) Bi-conical and Log periodic or Double-Ridge Waveguide (DRWG) antennas as appropriate for the receive antenna.

f) Cables with double braided outer screens shall be used. It is recommended that ferrite sleeves be placed at 150 mm spacing starting close to the antenna input, along the length of each cable. As an alternative a Fibre Optic link can be used.

C.8.5 Method of Measuring Damping Performance of a Screened Room WITHOUT a Ground Conducting Bench

The first step is to calculate the free space coupling.

The free space coupling is derived from a theoretical calculation and expressed as a Theoretical Normalised Site Insertion Loss (TNSIL). The attenuation between the ports of the two antennas imagined at the same separation distance in free space, is calculated and normalised by subtracting the sum of the two antenna factors (known from their prior calibration). The TNSIL, in dB units at measurement frequency f, is calculated from the following general formula:

$$TNSIL = 20Log_{10}\left(\frac{c * Z_a * d}{\eta_o}\right) - 20Log_{10}(f)$$

Where:

TNSIL units are in dB.

f = frequency, Hz

c = velocity of light, $3*10^8$ m/s

Z_a = antenna terminal characteristic impedance, 50 Ω

d = antenna separation distance in metres, 2 m

ηo = free space impedance, 120πΩ

For convenience in calculation over each frequency band and expressing the frequency in MHz, the formula reduces to:

$$TNSIL = 38.0 - 20\log_{10}(f\ MHz)$$

The graph of this function is shown in **Figure 126**.

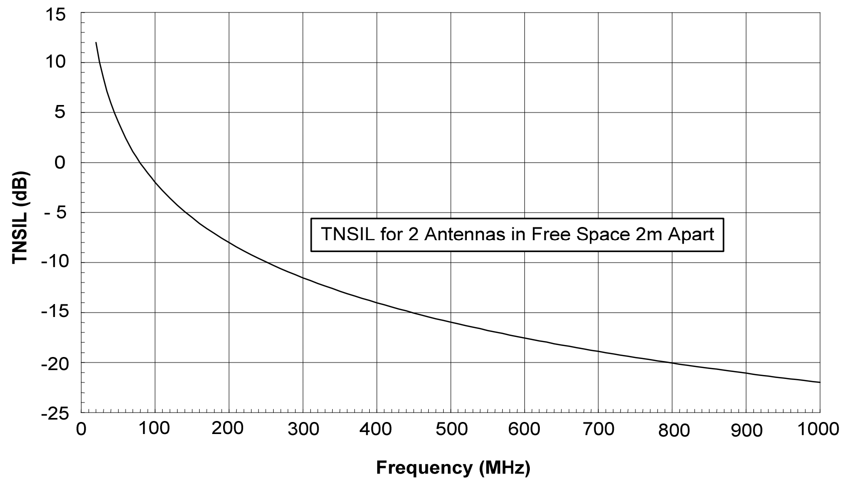


Figure 126 Theoretical Normalised Site Insertion Loss

C.8.5.1 Frequency Bands

Measurements shall be performed with both transmit and receive antennas similarly polarised, first vertically, then horizontally, over the frequency bands shown in **Table 32**.

Table 32 Antenna Requirements for each Frequency Band

Band	Frequency Range	Antenna	
		Transmitting	Receiving
1	30 MHz to 220 MHz	86 cm dipole	Bi conical or Bi log
2	200 MHz to 300 MHz	16 cm dipole	Bi conical or Bi log
3	200 MHz to 1 GHz	16 cm dipole	Log periodic or Bi log

C.8.5.2 Equipment Set-Up

Place the centre of the elements (calibration reference point) of the transmitting dipole, 1.3 m ±10 mm from the back wall (front of the intended EUT location) of the room, 1 m ±10 mm from the floor and with its balun extending towards the back wall. The dipole is deployed first with vertical and then with horizontal polarisation. Position the calibration reference point on the receiving antenna 2 m ±10 mm from the transmitting antenna, 1 m ±10 mm from the floor, with the antenna in the same polarisation. The receiving antenna balun must extend away from the transmitting antenna. See **Figures 127**, **128**, **129**, and **130**.

A 10 dB 50 Ω attenuator shall be connected directly to each antenna port unless a network analyser is to be used. Care must be taken to ensure that the antenna feed cables do not affect the measurement. This is best avoided by extending the cables out horizontally from the antennas to the end walls of the room, drop to the floor and route round the perimeter of the room until they reach the penetration panel. From thence, further cables then complete connection to transmit and receive functions of the measuring equipment. See **Figure 131** for a typical cable layout.

NOTE Care should be taken to avoid placing the antennas on the exact centre line of the screened room as this location is most affected by the room's resonances.

C.8.5.3 Measurement Procedure

The measurements shall be carried out, using vertical and then horizontal antenna polarisation, for each frequency band specified in **Table 32**.

a) Measure the total attenuation, A_c (dB), of transmit and receive cables, (and attenuators if fitted) connecting the measuring equipment to the antennas. If a network analyser is used, a full two-port calibration must be performed (A_c = 0) which will also have the advantage of compensating for any mismatch.

b) Reconnect the cables to the antenna and measure the attenuation A_a (dB) which now includes additional attenuation between the two antennas.

NOTE 1 Swept attenuation measurements shall be made over the frequency bands specified in **Table 32**. If stepped measurements are made, sufficiently small bandwidths shall be used to minimise the effects of measurement noise and ensuring capture of all resonances. However, swept measurements are preferred.

NOTE 2 The output of network analysers is usually in terms of gain and hence must be negated to provide attenuation values.

c) Calculate the room NSIL from:

$NSIL = A_a – A_c – AF_t – AF_r$ (units in dB)

Where

AF_t and AF_r are the antenna factors, in dB, for transmit and receive antennas respectively and are provided by the calibration authority for a suitable number of frequencies in the band for which the antennas are designed to be used.

d) Calculate the difference (in dB) between the TNSIL and the NSIL for each measurement frequency. If these differences are equal to or less than the tolerance specified in **Clause C.8.3.1**, the screen room is deemed to have met the damping requirements.

NOTE Bi-conical elements must be fitted with cross bar elements see **Figures 127** and **128** above, to eliminate their resonances.

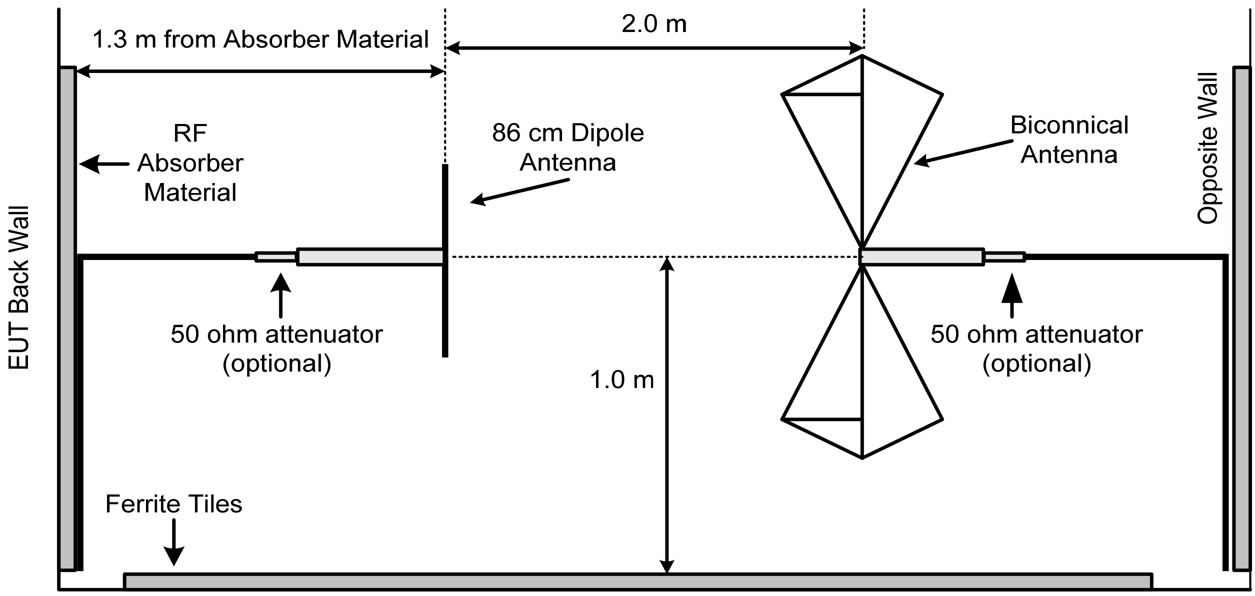


Figure 127 Antenna Positions for Band 1. 86cm Dipole and Bi-Conical

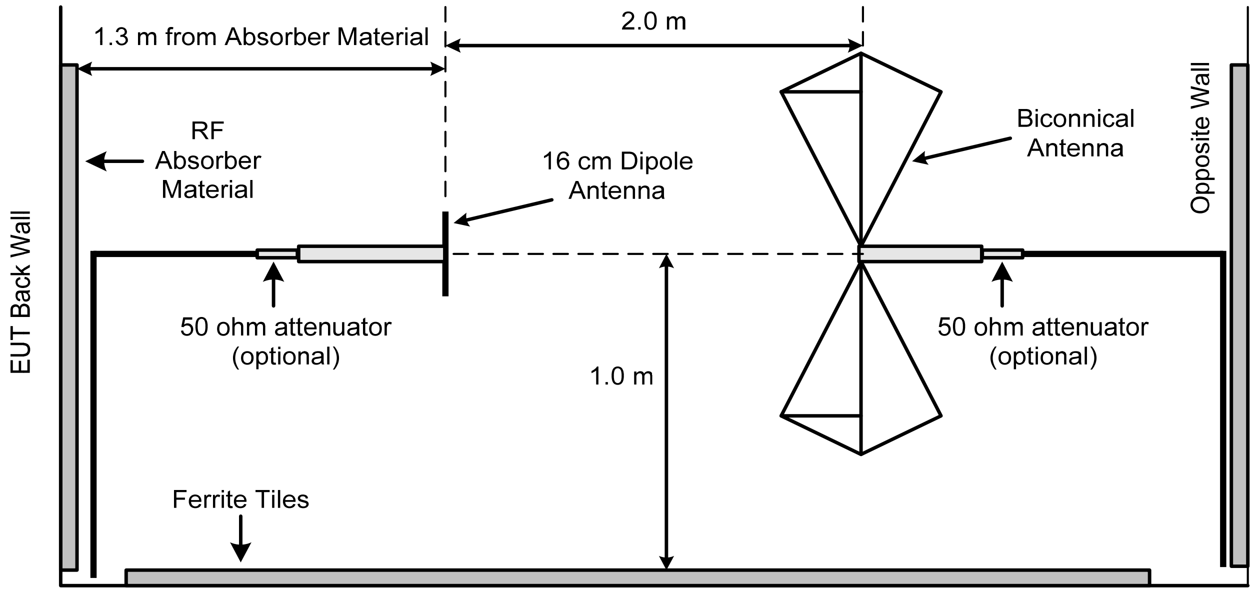


Figure 128 Antenna Position for Band 2. 16cm Dipole and Bi-conical

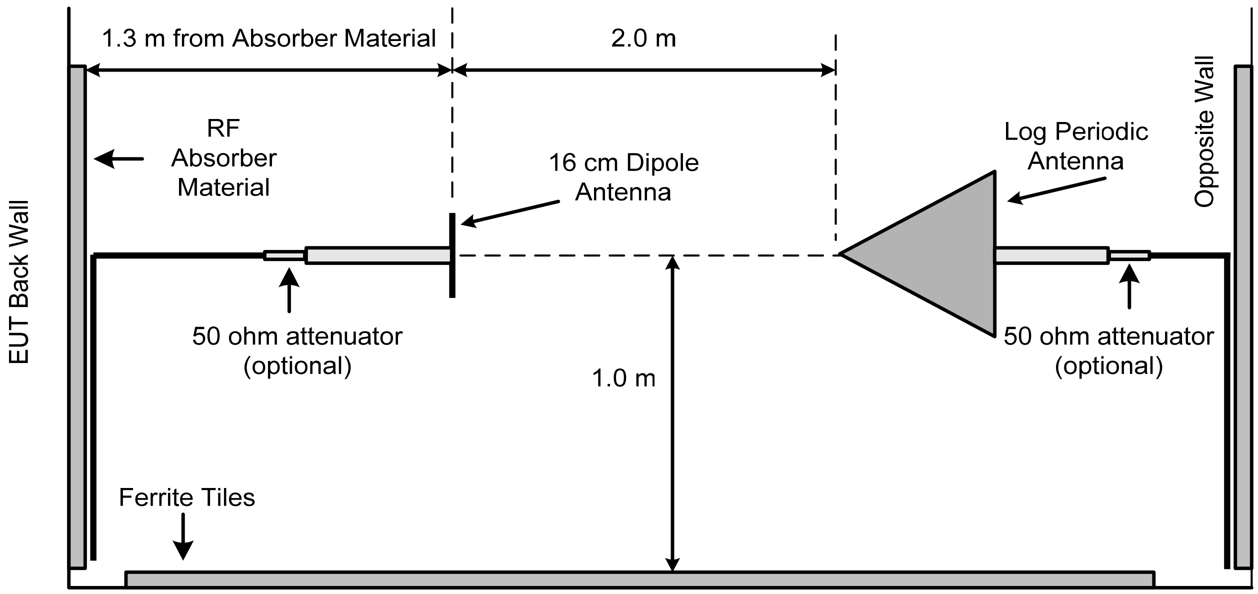


Figure 129 Antenna Positions for Band 3. 16cm Dipole and Log-Periodic

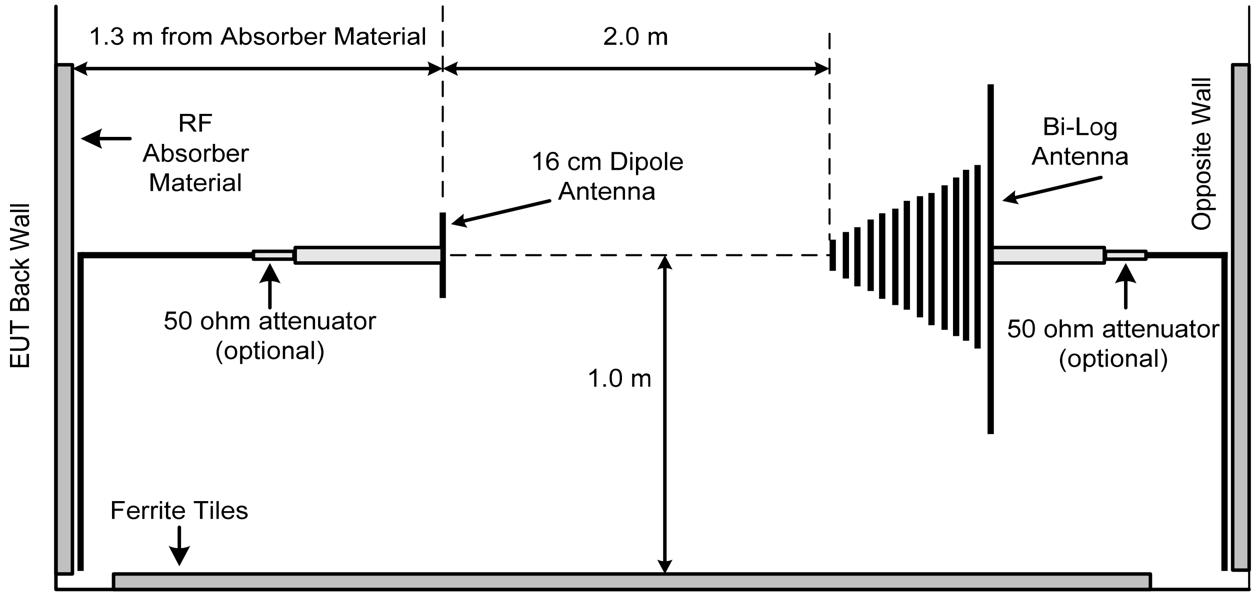


Figure 130 Antenna Positions for Bands 2 and 3. 16cm Dipole and Bi-Log

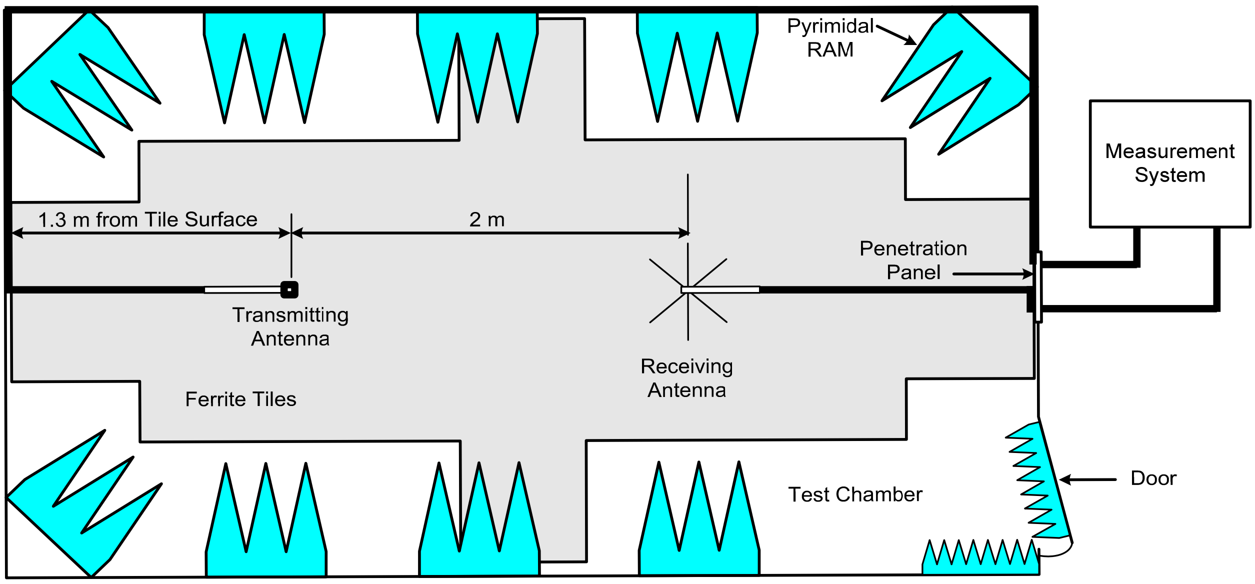


Figure 131 Cable Layout Diagram

C.8.6 Method of Measuring Damping Performance in a Screened Room WITH a Ground Conducting Bench

a) Measurements shall be performed with the receiver directly connected to the CNE output to determine the level of conducted emissions.

b) Measurements shall be performed with both the CNE and receive antennas vertically and horizontally polarised over the frequency bands shown in **Table 33**.

Table 33 Antennas required for each Frequency Band

Band	Frequency Range	Antenna	
		Transmitting	Receiving
1	30 MHz to f_1 MHz	CNE	Bi conical
2	f_1 MHz to 1 GHz	CNE	Log-periodic or Double Ridge Waveguide
NOTE Frequency f_1 is typically between 200 to 300MHz dependent on the test antenna employed.			

C.8.6.1 Equipment Set-Up

Fit the top loaded monopole antenna to the RF output of the CNE.

a) Vertical polarization: Place the CNE on a 50 mm stand-off insulator with the front face of the CNE 100 mm from the front edge of the ground conducting bench in the vertical position see **Figure 132**. Measurements are to be made for the position on the ground conducting bench as shown in **Figure 133**.

The receive antennas shall be mounted as shown in **Figures 134** and **135** which show the receive antenna heights and distances from the base of the CNE, for vertical polarization. The receiving antenna balun must extend away from the transmitting antenna.

b) Horizontal Polarization: Turned the CNE through 90 degrees and placed on a 300mm stand-off insulator with the front face of the CNE 100mm from the electrical front edge of the ground conducting bench see **Figure 136**. Measurements are to be made for the position on the ground conducting bench as shown in **Figure 133**.

The receive antennas shall be mounted as shown in **Figures 137** and **138** which show the receive antenna heights and distances from the front face of the CNE with the antennas mounted in the horizontally polarised position.

c) A 10 dB 50 Ω attenuator shall be connected directly to the receiving antenna. Care must be taken to ensure that the antenna cable does not affect the measurement. This is best avoided by extending the cable out horizontally from the antenna to the end walls of the room, drop to the floor and route round the perimeter of the room until they reach the penetration panel. From thence, further cables then complete connection to transmit and receive functions of the measuring equipment.

NOTE 1 Wood or Tufnul should be avoided when selecting an insulator for use with the CNE as these materials may affect the accuracy of the measurement, thin-walled plastic tube or glass fibre is preferred.

NOTE 2 The centre of the CNE when used for horizontal polarization is the bottom of the monopole.

C.8.6.2 Measurement Procedure

Using swept techniques measure the conducted emissions (in dBμV) from the CNE over the range 30MHz to 1GHz. Then measure the radiated emission levels (in dBμV) over the frequency range 30 MHz to 1 GHz, for the CNE position and for both vertical and horizontal polarizations.

a) Measure the total attenuation, A_c (dB), of receive cables and attenuators connecting the measuring equipment to the antenna.

b) Reconnect the cables to the antenna. Set the CNE to operate (check battery status).

c) Set up the measurement receiver with the following settings:

1) Detector type: Peak

2) Measurement bandwidth: 100 kHz

3) Frequency step size: 1 MHz

4) Minimum detector dwell time 20ms

Calculate the room result in dBμV/m from measured value

$$= V_r + A_c + AF_r \text{ (units in dB)}$$

Where V_r is the received voltage in dBuV

A_c is the magnitude of the total loss due to cables and attenuation in the receive path

AF_r is the free space antenna factor, in dB, for the receive antenna

NOTE Where a log-periodic dipole array (LPDA) antenna is used the varying phase centre positions with frequency introduces uncertainties in the measured field strength intended at a measurement distance of 1 m from the tip of the antenna to the CNE. This uncertainty is due to a discrepancy between the position on the antenna that the field is actually picked up at a given frequency and the intended measurement point 1 m from the tip of the antenna to the EUT. Therefore these corrections are to be added to the free space antenna factor AFr for the LPDA antenna during calibration of the LPDA antenna, see **Clause 6.22**.

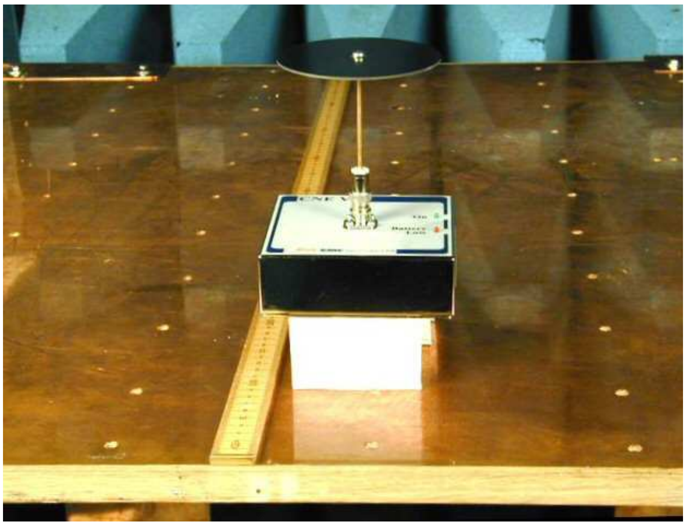


Figure 132 CNE on a 50 mm Stand showing Distance from Front Edge of the Ground Conducting Bench for Vertical Polarisation

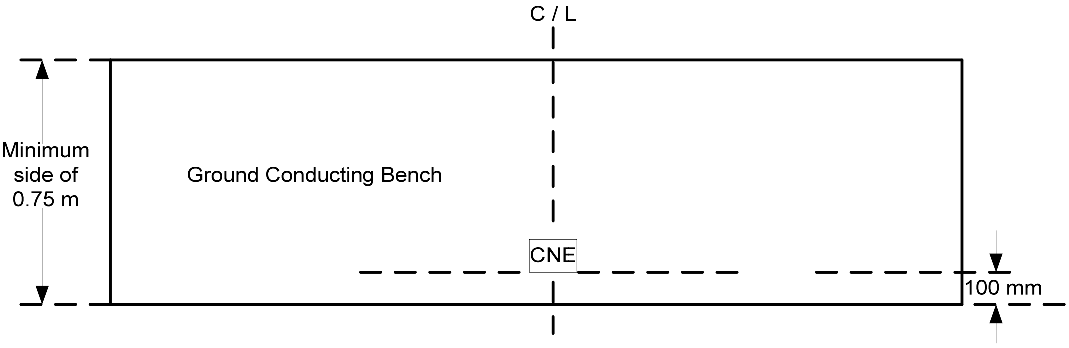


Figure 133 CNE on the Ground Conducting Bench

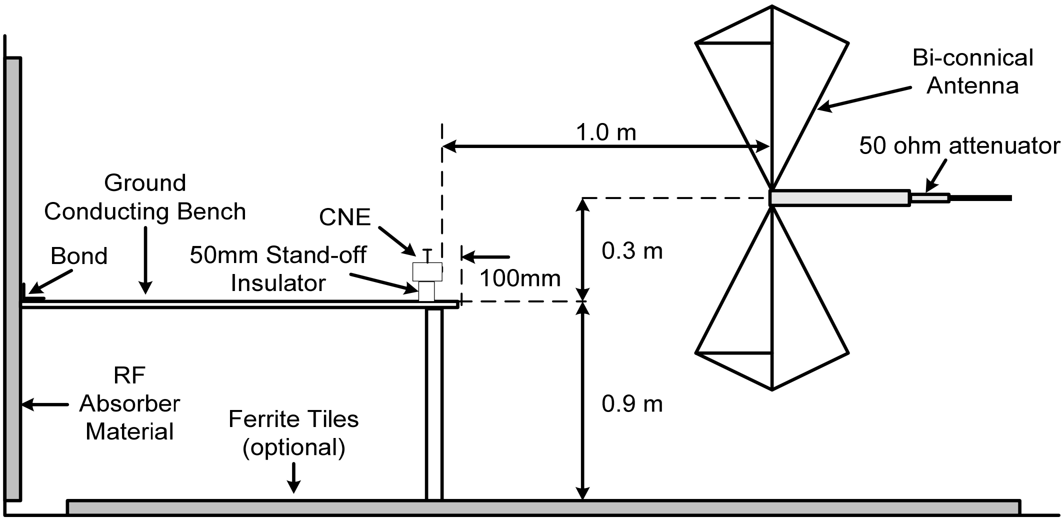


Figure 134 CNE and Bi-conical Antenna Measurements Vertical Polarisation (Nominal Frequency Range 30 – 300 MHz)

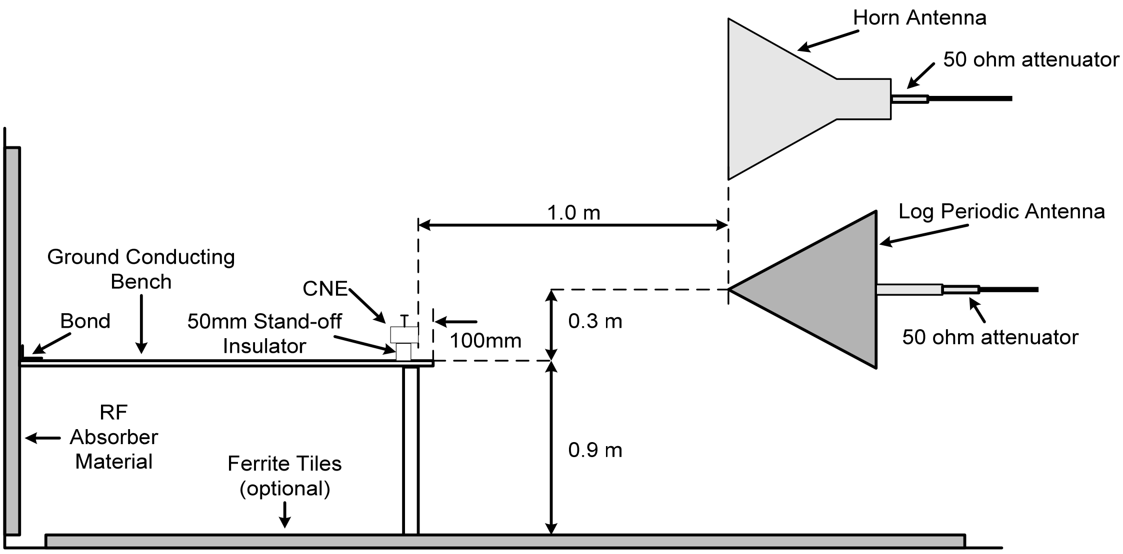


Figure 135 CNE and Log Periodic / Horn Antenna measurements Vertical Polarisation (Nominal Frequency Range 200 MHz to 1 GHz)

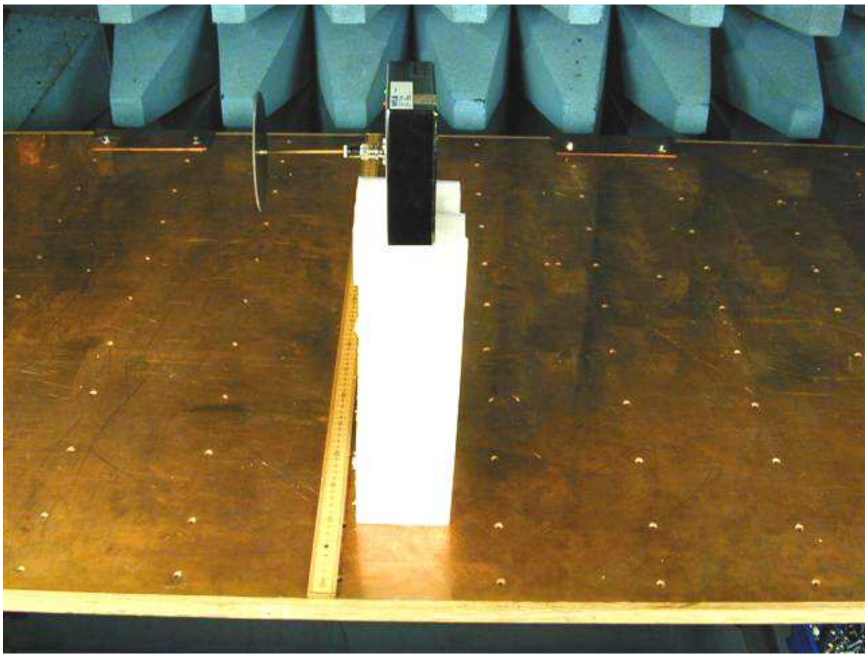


Figure 136 CNE on a 300mm stand showing distance from front edge of the Ground Conducting Bench for Horizontal Polarisation

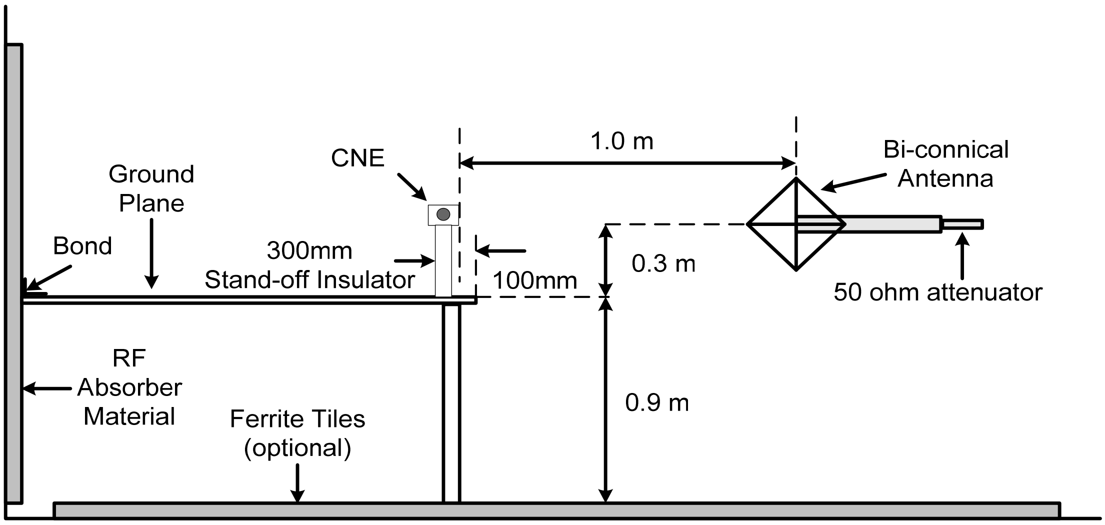


Figure 137 CNE and Bi-conical Antenna Measurements Horizontal Polarisation (Nominal Frequency Range 30 to 300MHz)

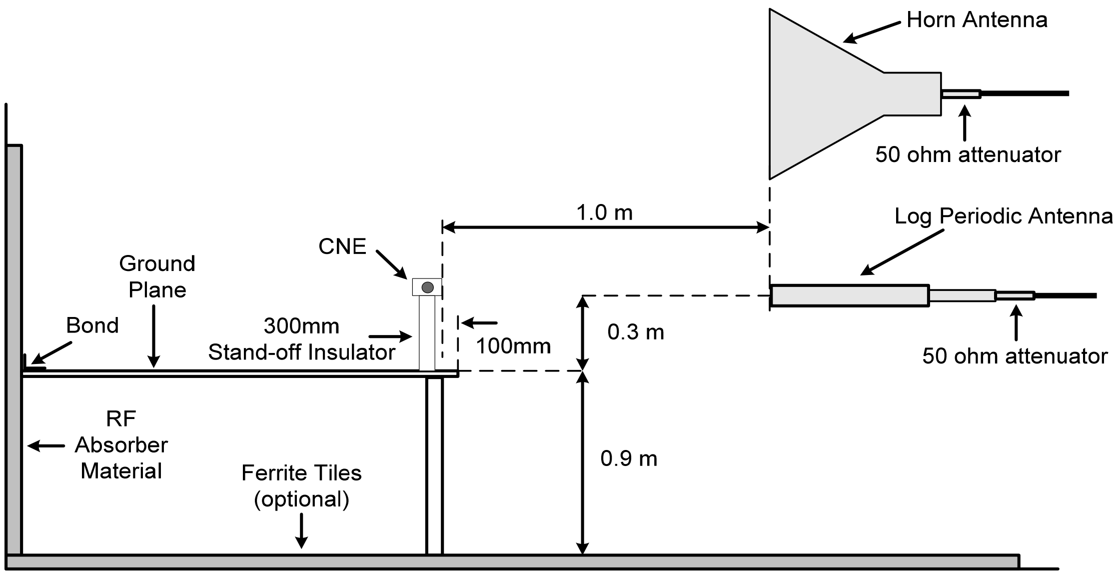


Figure 138 CNE and Log Periodic / Horn Antenna measurements Horizontal Polarisation (Nominal Frequency Range 200 MHz to 1 GHz)

C.8.7 Calibrated Performance of the CNE on an OATS – Applicable to Screened Rooms WITH a Ground Conducting Bench

The CNE radiated emissions shall be measured with the CNE mounted on a ground conducting bench as specified in **Clause C 8.6.2**. The ground conducting bench shall have a minimum area of 2.25 square metres and a minimum depth of 0.75 metres. This shall be placed on a standard ground plane, for example as described in CISPR 16-1-4 and bonded to the ground plane with earth bonding straps as specified in **Clause 6.4**. Conducted and Radiated measurements shall be made as specified in **Clause C.8.6.2**. The measurements shall be traceable to National/International standards, for example the ground plane shall conform to CISPR 16-1-5 and the antenna factors of the antennas shall be measured to traceable standards as specified in **Clause 6.22**.

This calibration need only be undertaken on the CNE once or when it is suspected that the CNE performance may have changed. If the CNE conducted output is measured and compares to within +/- 1dB of the original conducted calibration and a physical inspection of the CNE and antenna reveals no physical change or damaged components then it is likely that the radiated performance has not changed significantly and the original radiated calibration data can be used for the verification of the room. During verification the radiated output can also be checked for consistency with the original levels

The measurements shall be a duplicate of the measurements described in **Clause C.8.6**. Because the ground conducting bench does not have its rear edge bonded to the metal wall of a screened room, the conducting straps to ground shall be connected vertically from the rear edge to the ground plane (see **Clause 6.4**) of the OATS see **Figure 139**. Care shall be taken, particularly with vertically polarised biconical antennas, to extend the cable horizontally behind the antenna for a few metres before dropping vertically down to the ground plane. This reduces the level of reflections from the cable.

The ground plane shall be free from any obstructions over a radius of 20m or more from the antennas, so there will be a long cable to the receiver. The attenuation of the cable can be counted as part of the 10 dB attenuation added to the antenna, (see Clause **C.8.6.1 c**), so where the measured signal is too close to the noise floor of the receiver, a lower value of attenuation on the antenna can be used. The attenuation of the cable shall be measured to determine the amount of fixed attenuation to be used. Ideally the received signal should be at least 10 dB above the receiver noise floor.

NOTE 1 Open field sites in most locations have ambient radio interference. The intrusion of this interference is solely dependent on the level of field radiated from the CNE. It is unlikely that the output of the CNE will be sufficient to overcome the interference, particularly at the lower frequencies and this could limit the usefulness of the data in evaluating the screened room. However, by knowing the radiated characteristic of the CNE in an ideal environment, and by measuring the signature of the ambient separately on the same day as this Clause is carried out, it is possible to interpolate and alter the CNE open site radiated data to effectively remove the ambient.

NOTE 2 A 10 dB pad is specified because the return loss of biconical antennas can be as low as 1 dB at 30 MHz. Generally the return loss of LPDA antennas is greater than 10 dB, in which case it is not essential to use a 10 dB pad. A criterion to aim for is that the mismatch uncertainty shall be less than ± 0.5 dB, and this will dictate what pads need to be used.

NOTE 3 Measurements on an OATS can be affected by adverse weather conditions and large variations in temperature of the cables. Measurements should not be made when there is precipitation. Effects of temperature variation can be minimised by taking a measurement of the cable attenuation close in time to the measurement of the CNE emission. Temperature variation can minimised by using white sheathed cables. It is recommended that photographs of the set-up are taken to show conformance to the measurement criteria.

Record the model and serial numbers of the CNE and antennas, and the model of the receiver. With the antennas set up and the CNE switched off, record the levels of ambient RF signals with both horizontal and vertical antenna polarisations. Ambient signals can be removed from the CNE data measured on the OATS by interpolation between the frequency points for comparison of this data with the corresponding screened room data.

Figure 139 Ground Conducting Bench on an OATS showing the Conducting Straps to Ground

C.8.8 Performance Requirements

Using the corrected results calculate the difference (in dB) between the CNE measured result on the OATS (dBµV/m) and measured value in the screened room for each measurement frequency. If these differences are equal to or less than the tolerance specified in **Clause C.8.3.2**, the screen room is deemed to have met the damping requirements.

C.8.9 Recording Of Results

Produce a graph of the conducted results from the CNE in dB vs frequency. Produce a graph showing the difference in dB vs frequency of the corrected results and the CNE calibration results and damping pass/fail tolerances specified in **Clause C 8.3.2**.

The graphs shall incorporate as a minimum:

a) Frequency graduations (logarithmic scale over two decades) from 10MHz to 1GHz

b) Amplitude graduations (at least every 2dB)

c) CNE mode of operation (i.e. Vertical Polarization)

d) Receive antenna polarization and position

e) Test conditions.

f) Date of test

g) Title of test

h) Test method used

C.9 Voltage Probes

C.9.1 Voltage Probes – Test Methods DCE03.B & DCS01.B

The requirements of **Clause 6.25** can be conveniently met by proprietary high impedance voltage probes supplied as accessories for use with proprietary oscilloscopes. However, the accurate measurement of transient amplitude in conducting test DCE03.B may sometimes be prejudiced by the high amplitude response at the power supply frequency. This clause describes the design of a twin-T filter, tuned to the supply frequency, which is connected at the oscilloscope input, in tandem with a voltage probe, which attenuates the power supply frequency response by at least 30 dB.

Figure 140 shows a typical x10 voltage probe connected via a twin-T filter to an oscilloscope. For simplicity, the additional components necessary to ensure broad-band performance are not shown. Typical component values for the probe and oscilloscope are $Z_1 = 9\ \mathrm{M}\Omega$ and $Z_0 = 1\mathrm{M}\Omega$, giving a x10 attenuation. For probes with both series and shunt resistances Z_1 should be calculated as the output impedance of the probe.

Given the impedance's of the probe and oscilloscope combination to be used, the component values of the twin-T network may now be calculated for the chosen power frequency f_0. To ensure symmetry of the twin-T response at frequencies well above and below f_0.

$$\text{Let } R = \sqrt{(2Z_1Z_0)}$$

$$\text{and } 2R = 2\sqrt{(2\,Z_1Z_0)}$$

To locate the notch frequency at f_0 let $\omega_0 = 2\pi f_0$

$$\text{then } C = 1/R\omega_0$$

$$\text{and } 2C = 2/R\omega_0$$

The use of 1% tolerance components, in series and parallel combinations to achieve the calculated values, is usually satisfactory. The filter components should be installed in a screened box with short connections between them. Note that the overall attenuation from probe input to oscilloscope input, at frequencies well above the notch frequency is:

$$A = Z_0/(Z_1+2R+Z_0) \text{ rather than } Z_0/(Z_1+ Z_0) \text{ without the filter.}$$

For a x10 probe and a notch frequency of 50 Hz the probe attenuation without the filter is 20 dB while with the filter it is 25.3 dB at all frequencies except in the vicinity of the notch frequency. The attenuation exceeds 35 dB between 30 Hz and 82 Hz and exceeds 55 dB within ± 5% of the notch frequency.

It will be necessary to calibrate the attenuation of the probe/filter/oscilloscope combination over the required frequency range to check that the notch frequency has been sufficiently centred on the power frequency and the attenuation away from the notch frequency is constant near the design value. This attenuation value will be used to determine the true transient amplitude. At this stage it may be necessary to optimise the broad-band performance of the probe using the adjustments provided in the probe and then re-calibrate.

The probes may also be used to assist in accurate measurement of the imposed ripple on the power lines, when performing test DCS01.B.

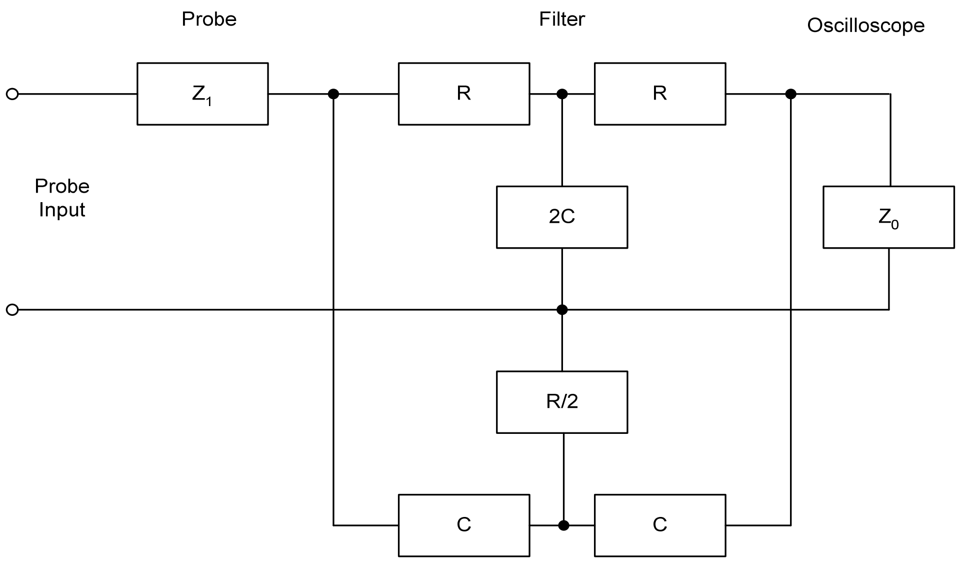


Figure 140 Basic Circuit for Probe/ Filter / Oscilloscope Combination

C.10 Antenna Calibration

Free-space antenna factor (AFfs) simply means that the antenna is calibrated in a plane wave (i.e. far field) and the mutual coupling effects of the surroundings to the antenna are negligible (< ± 0.3 dB, included in the AF uncertainty). This method is preferred to calibrations undertaken at 1 metre separation where mutual coupling between the antennas and with their images in the ground plane causes higher measurement uncertainties. Also the free-space antenna factor can be used to calculate the antenna factors to be used for 1 m, 3 m and 10 metre measurement distances so only one calibration is necessary. The different antenna factors with associated uncertainties should be provided by the calibration laboratory at the time of calibration.

The marked position in the centre of the antenna is that normally used at a range of 3 m or 10 m and must not be used for measurements at 1 m (on a 10 m range the error in the AF at the extremities of the antenna is up to ± 0.3 dB and therefore corrections are not normally deemed necessary).

At a given frequency the LPDA antenna measures the field at a specific position along its length, called its phase centre. If the tip of the LPDA antenna is 1 m from the EUT, the field strength will be measured at the phase centre corresponding to the frequency of measurement, therefore the distance to the EUT will be greater than 1 m so the field measured will be less than if the phase centre had been positioned at the 1 m position. For example if the dipole element on the LPDA antenna that picks up the field at 200 MHz is 1.6 m from the EUT, the field at 1 m from the tip will be underestimated by 4.1 dB, and so a correction is to be made to take account of phase centre variations with frequency.

The method of deriving corrections is described in the DTI publication by NPL: A National Measurement Good Practice Guide No. 73 - Calibration and Use of Antennas, Focusing on EMC Applications, which is obtainable from www.npl.co.uk.

Appendix 4 of the Guide No. 73 deals with uncertainties in using LPDA antennas and describes how the free space antenna factor can be corrected to provide an antenna factor for use at separations from a defined reference point on the antenna, in the case of this standard, 1 m from the tip of the antenna. The correction requires knowledge of the phase centre positionsof the LPDA in use. To simplify this process for this standard, a generic “dimensional template” for LPDA has been derived based on the dimensions of 20 LPDA antenna designs. The template specifies that the elements that are active in the frequency range 200 MHz to 1000 MHz on an LPDA antenna lie within a triangle of base 0.712 m and height 0.625 m ± 0.062 m. If the dimensions of the LPDA antenna to be used lie outside this template, the following approach cannot be used and reference must be made to the Guide No.73, Appendix 4. If the antenna has been designed for a lowest frequency of 300 MHz, the formula will apply if the antenna has an apex angle similar to the apex angle of the template.

The antenna correction factor AFcorr is to be added to the free-space antenna factor, which relates to the phase centre position of the LPDA antenna at each frequency. The effect of this is to extrapolate the field strength from the position at which the antenna picks up the field, to the position of the tip on the antenna assuming this coincides with the apex of the triangle of the dimensional template. This assumption can be checked as described below. The accuracy of the extrapolation of the field strength, from the position of the active dipole element to the tip of the antenna, depends on the magnitude (and phase) of reflections from the environment; if the field is not uniform over the extent of the LPDA antenna there will be uncertainty in the magnitude of the corrected field.

The formula given in the Guide No.73 Clause A4.2.1 simplifies to the following, for the template dimensions given above and for 1 m separation and a reference point at the tip (therefore d = 0), see **Figure 141**.

$$AF_{corr} = 20\log_{10}(1+P) \text{ dB}$$

Where:

P = $125/f_{MHz}$ (m) and is the distance (m) of the phase centre from the LPDA tip.

f_{MHz} Frequency in MHz

Table 34 shows the correction factors that apply for LPDA antennas whose dimensions conform with the template described above.

Table 34 Correction Factors

Frequency MHz	AFcorr dB
200	4.2
250	3.5
300	3.0
350	2.7
400	2.4
450	2.1
500	1.9
550	1.8
600	1.6
650	1.5
700	1.4
750	1.3
800	1.3
850	1.2
900	1.1
950	1.1
1000	1.0

By using the above approach to correct the free space antenna factor for use at 1m separation from the EUT, the uncertainty (additional to the AF uncertainty) in extrapolated field strength is within ± 0.3 dB.

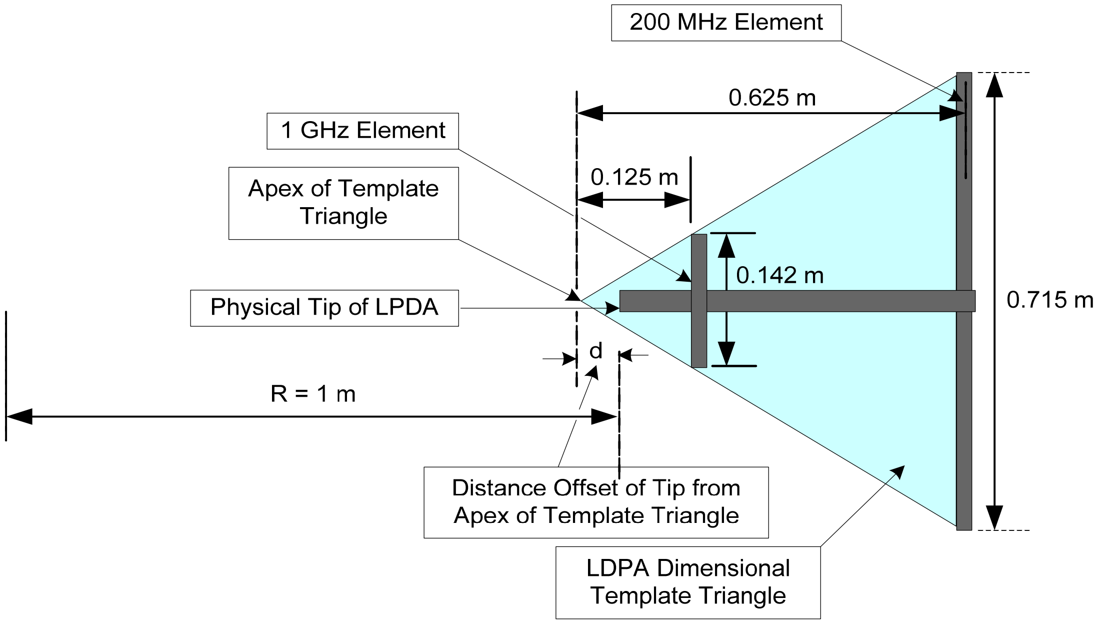


Figure 141 LPDA Dimensional Template Parameters

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Contract Requirements

When Defence Standards are incorporated into contracts users are responsible for their correct application and for complying with contractual and statutory requirements. Compliance with a Defence Standard does not in itself confer immunity from legal obligations.

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