Specification for

Limits and methods of measurement of the immunity of marine electrical and electronic equipment to conducted and radiated electromagnetic interference

Limites et méthodes de measure de la susceptibilité des matériels électriques et électroniques embarqués au brouillage électromagnétique conduit et rayonné - Spécifications

Grenzwerte und Verfahren sur Messung der Empfindlichkeit von elektrischen und elektronischen Geräten auf Schiffen gegenüber geleiteten und abgestrahlten elektromagnetischen Störungen

BSI STANDARDS

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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Marine Equipment Council
British Shipbuilders
Department of Transport (Marine Directorate)
Electronic Components Industry Federation
General Council of British Shipping
Institution of Electrical Engineers
Marine Engine and Equipment Manufacturers' Association
National Union of Marine Aviation and Shipping Transport Officers (NUMAST)
North East Coast Institution of Engineers and Shipbuilders

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Contents

Foreword

This British Standard has been prepared under the direction of the General Electrotechnical Standards Policy Committee, on the basis of a proposal from the Department of Transport.

In preparing this British Standard, several existing standards were studied to determine the suitability of incorporating all or part of them within it. In studying the specifications it was apparent that the two most relevant were IEC 533 and BS 3G 100 : Part 4 : Section 2. However, the former does not specify tests for immunity to radiated interference and the latter requires the limits and frequency ranges covered to be suitably modified to reflect conditions applicable to merchant ships.

It has been assumed in specifying the limits for the various conditions that the equipment incorporates adequate power line filters with correct radio frequency bonding; that the equipment enclosures and associated cabling are correctly installed and bonded, and that the requirements for spatial separation of the various cable groups as specified in the relevant British Standards have been observed.

Equipment which complies with this specification may still be susceptible to conducted and radiated interference if incorrectly installed and it is important to observe the manufacturer's recommendations in this respect. Attention is also drawn to the guidance given in BS 1597, BS 5260 and 'Recommendations for electromagnetic compatability aboard ships'[1)].

Compliance with a British Standard does not of itself confer immunity from legal obligations

[1)] Appendix 7 of the 'Regulations for the Electrical and Electronic Equipment of Ships', available from the Institution of Electrical Engineers, 2 Savoy Hill, London WC2R OBS.

Specification

0 Introduction

The increasing use of electronic equipment on board merchant ships in differing complexity to perform a variety of functions increases the possibility of electromagnetic interference between systems and from external sources causing degradation in system performance and malfunctions. The incorrect operation of certain types of equipment as a result of electromagnetic interference could affect the safety of the vessel or endanger personnel.

The growing acceptance of the use of techniques such as cable multiplexing will inevitably lead to the installation of electronic equipment on deck where it is subject to greater interference from the main transmitters, passing ships or shore-based radar transmissions. In addition, radiation can induce currents in above deck cabling thereby conducting interference into below deck equipment or coupling into adjacent cabling.

In addition the feeder cables of transmitting navigational aids (navaids) may radiate to adjacent equipment or associated cabling with the possibility of degradation in performance or malfunction of the equipment.

The proliferation of microcomputer-based surveillance and control and the increasing use of digital computers in general which are particularly susceptible to impulsive interference highlights the need to achieve a satisfactory immunity standard for electronic equipment installed in the marine environment.

1 Scope

This British Standard specifies limits and describes methods of measurement of the immunity of marine electrical and electronic equipment to conducted and radiated interference which may be produced by electrical, electronic or radio and radar equipment intended for marine installations. Such interference may be either narrowband or broadband in nature; narrowband interference is produced at discrete frequencies whereas broadband interference is produced over a spectrum of frequencies, emanates from switching devices and is of an impulsive nature. The limits and methods of measurement of the immunity of equipment to transient phenomena are also specified.

This standard specifies tests for determining the compliance of the equipment or systems to the relevant specification, with the equipment being tested in a laboratory or similar facility under defined conditions. This standard does not include tests for immunity of equipment to the effects of electrostatic discharges or tests performed in situ.

Equipment is classified in two categories, as follows:

(a) that which is installed above deck or in areas of high electromagnetic interference;

(b) that which is installed in metallic compartments or within the vessel which affords natural screening.

Differing limits are specified in each case where relevant.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the definitions relating to electromagnetic interference given in BS 4727 : Part 1 : Group 09 apply.

3 Measurements

3.1 Screened room

Determination of equipment immunity to conducted and radiated interference shall be carried out within a screened room to eliminate the effects of extraneous interference. The dimensions of the room shall be not less than 2.5 m high × 3 m wide × 5 m long. Power supplies to the screened room shall be adequately filtered.

3.2 Ground plane

A ground plane having an area of not less than 1.5 m^2 shall be provided within the screened room and bonded to the walls at points not more than 1 m apart.

3.3 Artificial mains network

In order to ensure reproducibility of results an artificial mains network complying with clause **9** of BS 727 : 1983 shall be inserted in each line of the power supply to the equipment under test or test sample (EUT). When not in use each network shall be terminated with a 50 Ω co-axial non-reactive resistor. The network shall be mounted on the ground plane or on the enclosure and bonded to it.

3.4 Disposition of the equipment

3.4.1 *General*

The EUT shall be installed on the ground plane and bonded to it in accordance with figure 1. The test equipment shall be installed outside the screened room and preferably in an additional screened room. The equipment complete with its power supply leads and interconnecting leads shall be arranged in a manner similar to that for normal operation. Power supply leads shall be arranged at 50 mm above the ground plane on insulating supports with lead lengths preferably not exceeding 600 mm. The leads shall be either screened or unscreened as in the practical installation. The equipment shall operate into its full electrical load or with the value of load which will result in the most susceptible condition.

3.4.2 *Multiple units, including above and below deck*

Where the EUT consists of sub-units, some of which are above and some below deck, the connecting cables shall be bonded to the point of entry and exit of the screened room. The sub-unit under test shall have approximately 10 m of connecting cable to the point of exit from the screened room.

4 Immunity to conducted audio frequencies

4.1 Limits

The EUT shall not malfunction or otherwise deviate from the relevant performance when a signal of 3 V r.m.s. sine-wave over the frequency range 50 Hz to 10 kHz is applied to the lines supplying a.c. or d.c. power to the EUT. The signal source shall, as far as practicable, suppress any voltages at harmonic frequencies.

4.2 Method of measurement

Arrange the EUT as shown in figure 2.

The audio signal source shall have an output impedance not exceeding 1 Ω at the secondary terminals of the isolating transformer. The isolating transformer shall be capable of carrying a secondary current of up to 100 A without saturation.

Monitor the applied signal with a high impedance voltmeter, with the EUT disconnected.

Reconnect the EUT and sweep the signal source through the frequency range at a rate slow enough to permit the detection of any malfunction or deviation of the performance of the EUT.

NOTE. When the EUT incorporates power line conditioning units utilizing automatic transformer tap changing, the applied signal level at the lower frequency limit may cause continuous operation of the tap changing circuitry possibly resulting in malfunction. In these cases the lower frequency limit should be relaxed and limited to that value which does not cause continuous operation of the tap changing circuitry. The relaxed lower frequency limit should not normally be higher than 400 Hz.

5 Immunity to earth lead coupling

5.1 Limits

The EUT shall not malfunction or otherwise deviate from the relevant performance specification when a sine-wave signal of 1 V r.m.s. over the frequency range 10 kHz to 50 kHz is injected via the earth lead. The signal source shall, as far as practicable, suppress any voltages at harmonic frequencies.

5.2 Method of measurement

Arrange the EUT shown in figure 3.

The EUT shall be isolated from the ground plane and its earth connection taken to the ground plane through the secondary winding of the isolating transformer.

The signal source shall have an output impedance not exceeding 1 Ω and the isolating transformer shall be capable of carrying a secondary current of up to a 100 A without saturation.

Monitor the applied signal with a high impedance voltmeter, with the EUT disconnected.

Reconnect the EUT and sweep the signal source through the frequency range at a rate slow enough to permit the detection of any malfunction or deviation of the performance of the EUT.

NOTE. When the EUT incorporates power line conditioning units utilizing automatic transformer tap changing, the applied signal level at the lower frequency limit may cause continuous operation of the tap changing circuitry possibly resulting in malfunction. In these cases the lower frequency limit should be relaxed and limited to that value which does not cause continuous operation of the tap changing circuitry. The relaxed lower frequency limit should not normally be higher than 400 Hz.

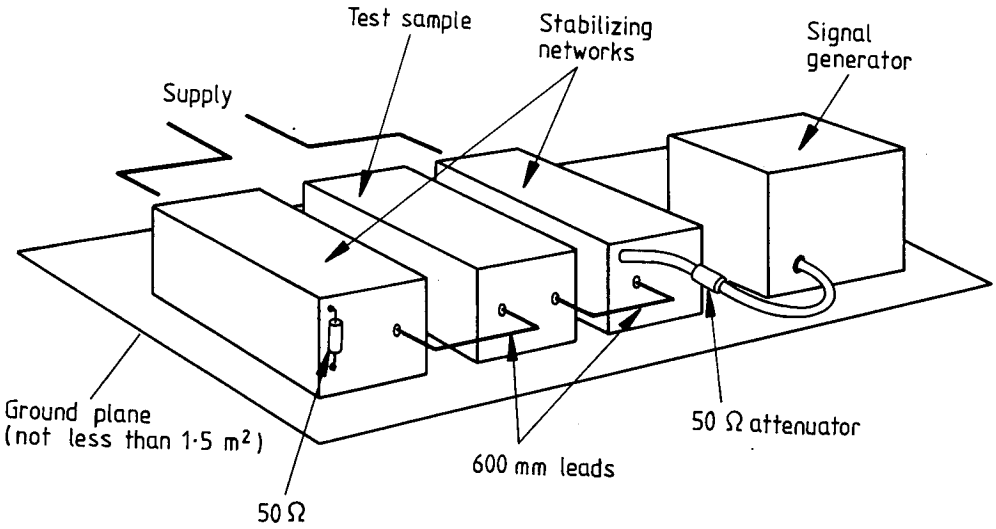


Figure 1. Typical arrangement for test for conducted interference at radio frequencies

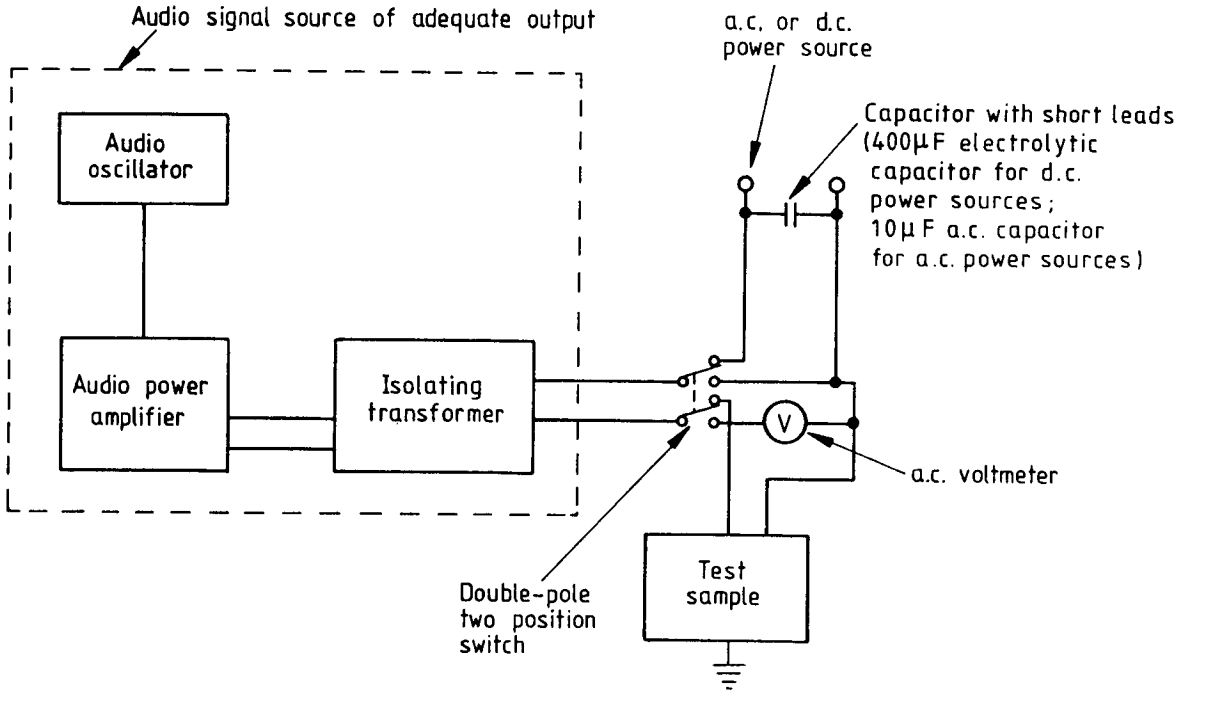


Figure 2. Typical arrangement for test for conducted interference at audio frequencies

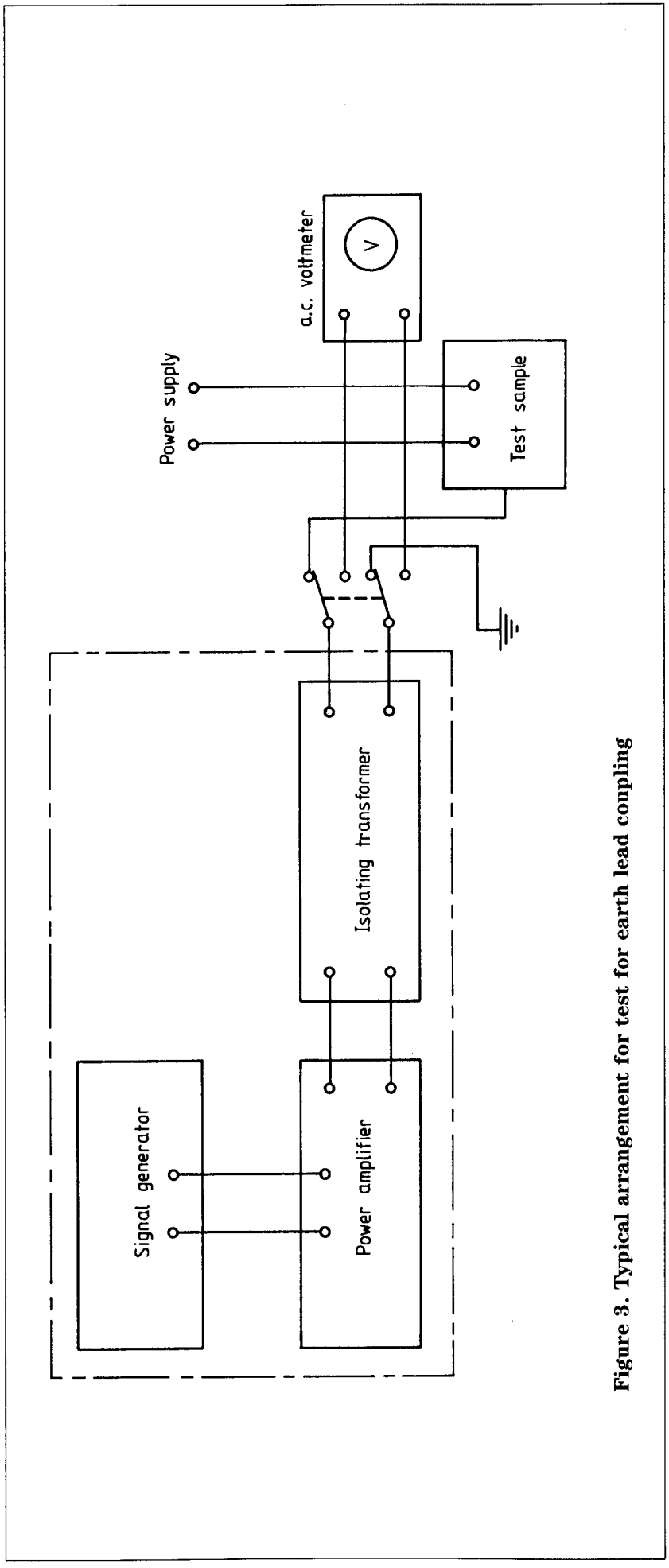


Figure 3. Typical arrangement for test for earth lead coupling

6 Immunity to conducted radio frequencies

6.1 Limits

The EUT shall not malfunction or otherwise deviate from the relevant performance specification when a modulated sine-wave signal of 1 V r.m.s. over the frequency range 10 kHz to 50 MHz is applied to the power lines. The signal source shall, as far as practicable, suppress any voltages at harmonic frequencies.

6.2 Method of measurement

Arrange the EUT as shown in figure 1 (see **3.4.1** concerning screened/unscreened leads). Apply the signal to the radio frequency terminal of the artificial mains network through a 50 Ω attenuator of not less than 10 dB to provide a matched resistive load.

The EUT, the artificial mains network and the test equipment shall be bonded to the ground plane.

Modulate the applied signal to a depth of at least 80 % at 1 kHz and sweep through the frequency range at a rate slow enough to permit the detection of any malfunction or deviation of performance of the EUT. Adjust the carrier level of the applied signal to 1 V r.m.s. at the input of the artificial mains network.

7 Immunity to radiated interference

7.1 Limits

The EUT shall not malfunction or otherwise deviate from the relevant performance specification when subjected to the radiated field strengths specified in **7.2** or **7.3** over the frequency range 0.03 MHz to 300 MHz.

Limits for the frequency range between 0.3 GHz and 10 GHz are under consideration.

7.2 Equipment within hull or screened areas

For equipment installed below deck or within the ship superstructure where screening is naturally obtained the field strength over the frequency range shall be 1 V/m.

7.3 Equipment above deck

For equipment installed above deck or in areas of high interference the field strength shall be 30 V/m between 1.5 MHz and 30 MHz and 10 V/m above and below that band.

7.4 Method of measurement

Install the EUT as shown in figure 4 or figure 5. Determine the field strength in a range of frequencies across the relevant bands by substituting a suitable measuring receiver and antenna in place of or alongside the EUT. The

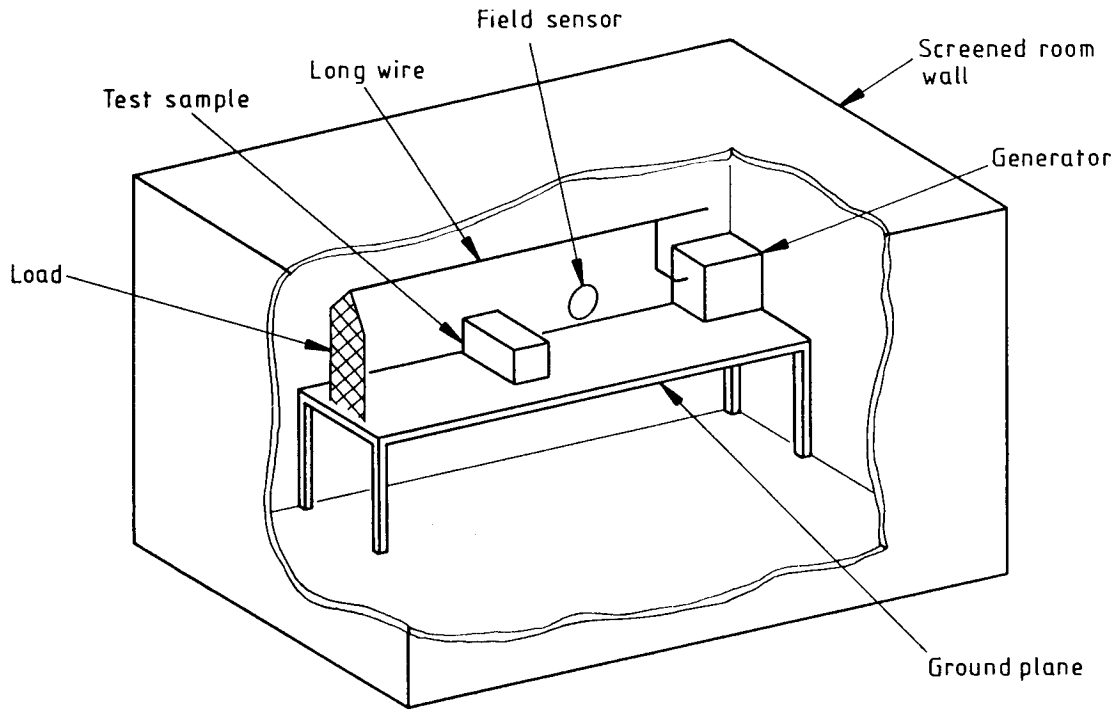


Figure 4. Typical arrangement for test for radiated interference using a long wire antenna

measuring receiver shall comply with either clause **4** or **5** of BS 727 : 1983. Generate the field using a suitable range of signal sources and associated antennas as shown in figures 4 and 5. The advantages of using broad band antennas, e.g. biconical, cavitenna, log periodic, are emphasized, in that the need for retuning is avoided.

8 Immunity to transients on power lines

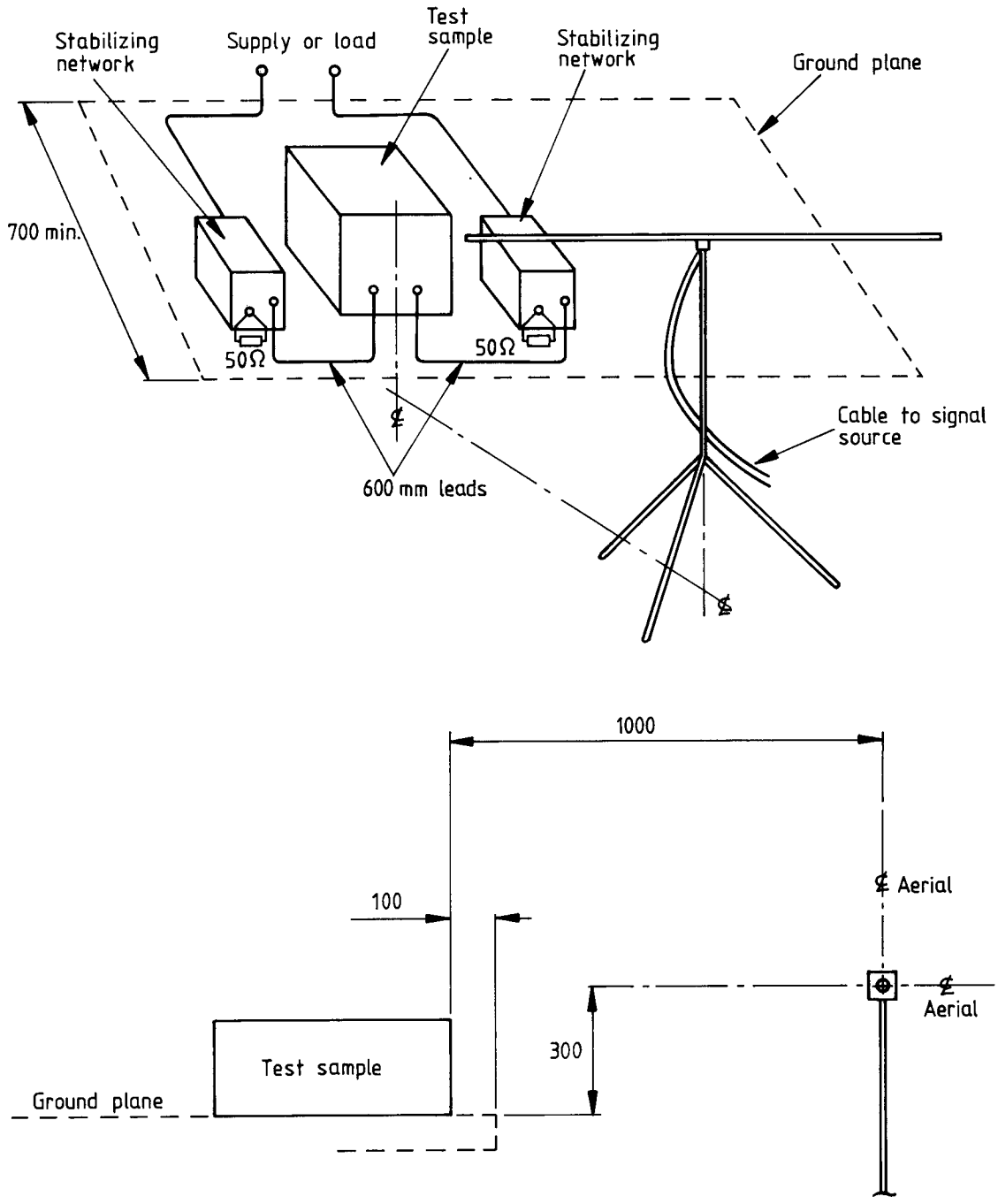
8.1 Limits

The EUT, using an a.c. power supply, shall not malfunction or otherwise deviate from the relevant performance specification when subject to the transient phenomena generated by the method described in **8.2**.

8.2 Method of measurement

Equipment capable of generating pulses producing rise times of 100 ns and durations of 10 μs shall be used. The pulse repetition frequency (p.r.f.) shall be 50 Hz or 60 Hz. The tolerance on the rise time and duration shall be $\pm$ 10 %. The rise time is defined as the time between 10 % and 90 % of maximum amplitude and the duration is that at 50 % maximum amplitude. Arrange the EUT as shown in either figure 6(a) or 6(b), as appropriate. Apply alternative positive and negative pulses of twice the line peak voltage, e.g. for 250 V a.c. 50 Hz this would be 707 V, to the power supply lines of the EUT. The pulses shall be synchronized with the supply waveform and positioned throughout it at intervals of 45°. Apply the pulses of each polarity for a duration of 1 min at each position.

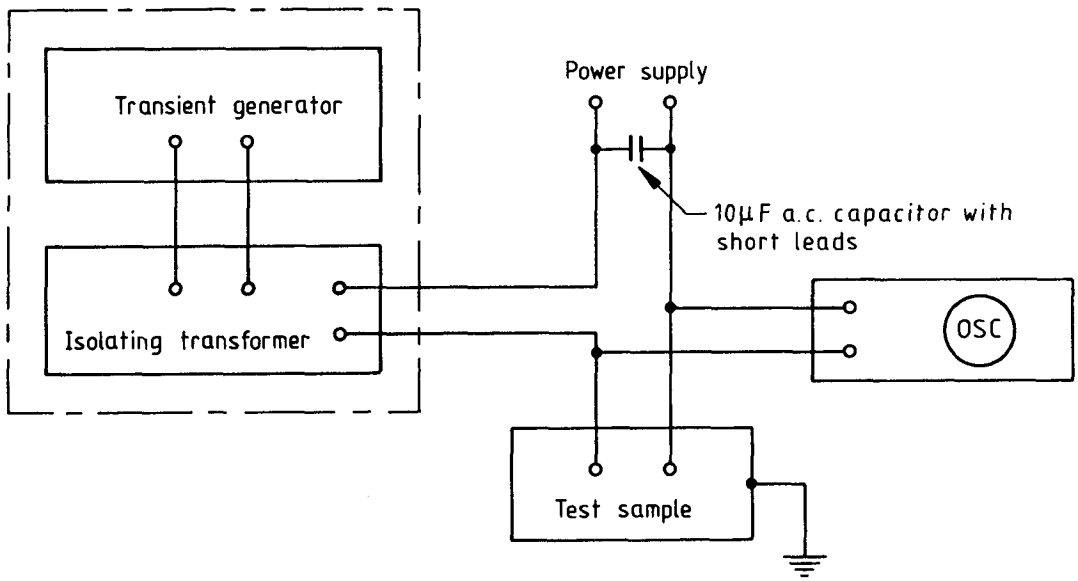
NOTE. In figure 6(b) it is recommended that the isolating transformer should be coupled to the EUT via a low impedance coupling capacitor. The oscilloscope in parallel to the power supply should be electrically insulated and warning given of high voltage. It is further recommended that an inductor of 250 μH should be inserted in series with the power supply to ensure that the transient voltage appears across the EUT.



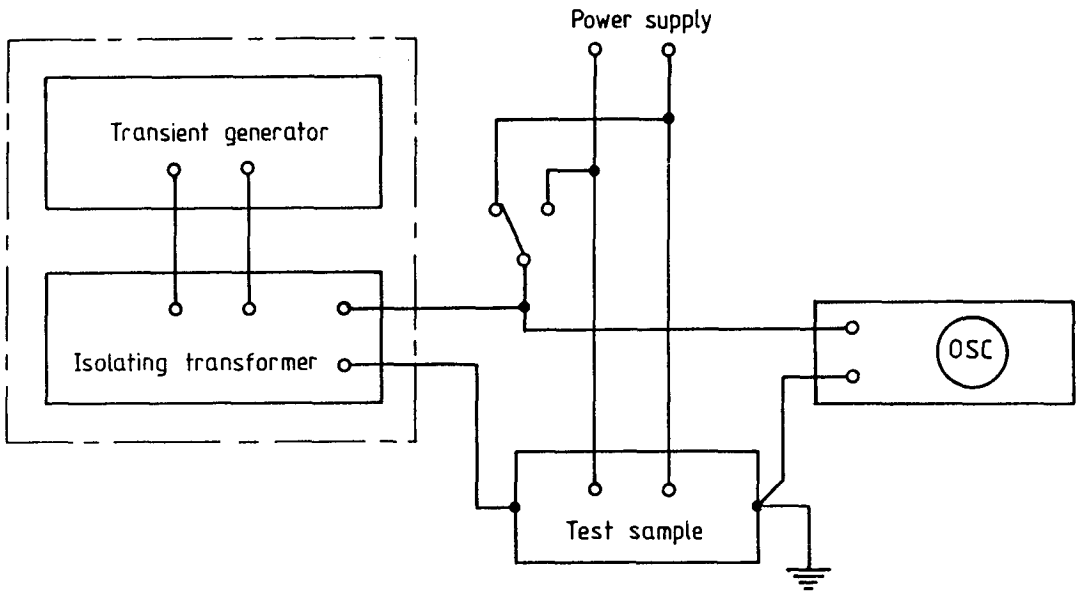
All dimensions are in millimetres.

Note. Stabilizing network to be bonded to the ground plane or to the enclosure as appropriate.

Figure 5. Typical arrangement for test for radiated interference using a horizontal dipole or an appropriate broadband antenna



(a) symmetrical type



(b) asymmetrical type

Figure 6. Typical arrangements for test for injected transients

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Publications referred to

BS 727 Specification for radio-interference measuring apparatus

BS 1597 Specification for limits and methods of measurement of electromagnetic interference generated by marine equipment and installations

BS 4727 Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms
Part 1 Terms common to power, telecommunications and electronics
Group 09 Radio interference terminology

BS 5260 Code of practice for radio interference suppression on marine installations

BS 3G 100[1)] Specification for general requirements for equipment for use in aircraft
Part 4 Electrical equipment
Section 2 Electromagnetic interference at radio and audio frequencies

IEC 533[1)] Electromagnetic compatability of electrical and electronic installations on ships

Institution of Electrical Engineers. *Regulations for the electrical and electronic equipment of ships*

[1)] Referred to in foreword only.

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