FCC METHODS OF MEASUREMENTS OF OUTPUT SIGNAL LEVEL, OUTPUT TERMINAL CONDUCTED SPURIOUS EMISSIONS, TRANSFER SWITCH CHARACTERISTICS, AND RADIO NOISE EMISSIONS FROM TV INTERFACE DEVICES

Office of Science and Technology

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Certain edits have been made to this document since it was first published as Appendix B to the Report and Order in General Docket 79-244, 48 FR 13209 (March 29, 1983) in order to reflect the changes in the Erratum in this proceeding released July 6, 1983, the latest developments in measurement techniques, and to be more consistent with FCC/OST MP-4, FCC Methods of Measurements of Radio Noise Emissions from Computing Devices (December 1983). Additional information dealing with accessories, cables, and antennas has been included in this edition.

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1.0 SCOPE

This standard sets forth uniform methods of measurement of radiated and powerline conducted radio noise emitted from a TV interface device defined in Section 15.4 of FCC Rules. Methods of measurements of output signal level, output terminal conducted spurious emissions, and transfer switch characteristics are also covered herein. These methods of measurements will be used by the FCC in testing a TV interface device, whether it is stand-alone or built in combination with a video source or a TV receiver. Applicants for certification of a TV interface device are advised to employ these methods. The technical standards for the TV interface device are set forth in Subpart H of Part 15 of FCC Rules (47 C.F.R. § 15.601 et seq.).

2.0 REFERENCE STANDARD

The following shall form a part of this standard to the extent applicable: American National Standard Specifications for Electromagnetic Interference and Field Strength Instrumentation. 10 kHz to 10 GHz. ANSI C63.2 (1980).

3.0 DEFINITIONS

The definitions in Parts 2 and 15 of the FCC Rules and the following shall apply to use of this standard.

3.1 Equipment under test (EUT)

A representative TV interface device or system, video source, accessories, etc. being tested or evaluated.

3.2 Ambient level

The magnitude of radiated or conducted signals and noise existing at a specific test location and time.

3.3 Emission

Electromagnetic energy produced by a device that is radiated into space or conducted along wires and is capable of being measured.

3.4 Ground plane

A conducting surface used to provide uniform reflection of an impinging electromagnetic wave. Also, the common reference point for electrical potentials.

3.5 Line Impedance Stabilization Network (LISN)

A network (sometimes called mains network) inserted in the supply mains lead of the EUT that provides a specified measuring impedance for radio noise voltage measurement and isolates the EUT and the measuring equipment from the supply mains at radio frequencies.

3.6 Radio noise

Electromagnetic emissions in radio frequency range that may be superimposed upon a desired signal:

(a) Radiated radio noise. Such radio noise is transmitted into space and may include both the radiation and induction components of a field.

(b) Conducted radio noise. Such radio noise is propagated from the device into the public electrical power network via the supply cord.

3.7 Random noise

Electromagnetic disturbance (noise) originating in a large number of discrete disturbances with random occurences in time and amplitude. The term is most frequently applied to the limiting case where the number of transient disturbances per unit time is large, so that the spectral characteristics are the same as those of thermal noise (thermal noise and the shot noise are specified cases of random noise).

3.8 Narrowband radio noise

Radio noise having a spectrum exhibiting one or more sharp peaks, narrow in width compared to the nominal bandwidth of the measuring instrument, and far enough a part in frequency to be resolvable by the instrument.

3.9 Active picture field

The time during which a frame of a television picture is produced, exclusive of the horizontal and vertical blanking and synchronizing intervals.

4.0 GENERAL TEST CONDITIONS

All tests shall be performed with a video source connected and operating. If the TV interface device is constructed in combination with an associated video source (i.e. both devices located in the same cabinet), that source shall be used for the

tests. If the TV interface device does not have a built-in source of video signal, or has a provision for an external video source, it shall use a Vertical Interval Test Signal (VITS) shown in Figure 4 of this test procedure, applied continuously throughout the active picture field. However, a TV interface device that provides for input from a specific accessory, such as the video camera on a video cassette recorder, need not be tested with the VITS signal, provided it is tested with the accessory. If the TV interface device can operate from either internal or external VITS source, tests shall be run with the interval video source and then the external VITS source.

All tests shall be performed with the level of the VITS at 1 volt and then at 5 volts.

NOTE: A TV interface device designed for specific accessories need not be tested with the 1 to 5 volt VITS signal. It is sufficient to test the TV interface device with the specified accessory attached.

All unused RF terminals shall be terminated in their proper impedance during all measurements.

If the TV interface device is capable of operating on more than one video carrier frequency, then separate measurements shall be made on each video carrier frequency.

4.1 Test sites

The test site environment must be one that assures valid, repeatable measurement results. A measurement is valid to the extent that it is a true representation of the characteristics being measured, and the same measurement procedure yields repeatable results. For radiated measurements on representative samples of an equipment type, testing is normally conducted in an open field (see 4.1.1) although other alternatives are permitted (see 4.1.1.1 and 4.1.1.2). A description of the test facility used for testing computing devices subject to certification shall be filed with the Commission, pursuant to Section 15.38 of the FCC Rules (47 C.F.R. § 15.38).

4.1.1 Open field tests

Measurements of radiated radio noise should be made in an open, flat area characteristic of cleared, level terrain. For details on how to set up a suitable site, see FCC OST Bulletin 55, "Characteristics of Open Field Test Sites", available from the FCC Consumers Assistance Office, Washington, D.C. 20054. Measurements made by the Commission will be performed on an open field test site.

4.1.1.1 Tests at laboratory, factory, or other facilities

Compliance with the FCC limits for the TV interface device shall be based on tests made in open field test site or equivalent. Where it can be shown that the results of tests made in an anechoic room, dedicated factory site or other facility are correlatable to those made in an open field site, such tests results will be considered acceptable. Sufficient tests over the entire frequency range of 30 to 1000 MHz shall be made to demonstrate that the alternate site produces results that correlate with the results of tests made in open field. In the event that the Commission tests a sample device, measurements will be made in an open field and the result so obtained will determine compliance.

4.1.1.2 Testing in a shielded enclosure

Radiation measurements made in a shielded enclosure are suitable only for determining the frequency profile of an EUT; they are not suitable for determining the actual levels of the emissions unless it can be shown that the results of tests made in the enclosure are correlatable to those made in an open field. Conducted radio noise measurements made in a shielded enclosure are acceptable and, in fact, preferable.

4.2 Measurement instrumentation

Measurement of output signal level, output terminal conducted spurious emissions, and transfer switch isolation should be made with an instrument capable of measuring the level of the video modulated signal during maximum amplitude peaks (Calibration will be in terms of the RMS value of an equivalent sinusoid). The VSWR at the measuring instrument when connected to the device shall be less than 1.5. The bandwidth of the measuring instrument shall be at least 100 kHz. No post-detector filtering shall be employed for any of these measurements.

Measurement of radiated and conducted radio noise shall be made with a radio noise meter conforming to the American National Standard Specifications for Electromagnetic Interference and Field Strength Instrumentation 10 kHz to 10 GHz, C63.2 (1980). Alternatively, a spectrum analyzer may be used as the measuring instrument, provided that it is used, when necessary, with appropriate accessories to provide sufficient sensitivity and overload protection to insure accurate, repeatable measurements of all emission over the specified frequency range.

NOTE: Accessories needed would depend on the measurement situation and could include preamplifiers for sensitivity improvement, filters and/or attenuators for overload protection, and additional quasi-peak detection circuitry. Overload is defined as harmo-

nic distortion, intermodulation, or gain compression of spectrum analyzer input signals. Precautions may have to be taken to insure that the spectrum analyzer operates linearly before taking final measurements. Consult user's manual for instructions and guidance. Application notes on the use of spectrum analyzers and other instruments are also available from several manufacturers.

4.2.1 Measuring instrument calibration

The calibration of the measuring instrument, including any accessories that may affect such calibration, shall be checked frequently enough to assure its accuracy. Adjustments shall be made and correction factors applied in accordance with instructions contained in the manual for the measuring instrument.

4.2.2 Detector function selection and bandwidth

During radiated radio noise testing, radio noise meters or spectrum analyzers that include weighting circuits shall have the detector function set to the CISPR quasi-peak function. The 6 dB bandwidth of the measuring instrument shall not be less than 100 kHz for radiated radio noise measurements over the frequency range of 30 to 1000 MHz. During conducted radio noise testing, radio noise measuring instruments shall have the detector function set to the CISPR quasi-peak function. The 6 dB bandwidth of the necessary measuring instrument shall not be less than 9 kHz over the frequency range 450 kHz to 30 MHz. Post detector video filters, if used, shall be wide enough not to affect the quasi-peak detector reading. Alternatively, field strength meters and spectrum analyzers without CISPR weighting circuits may be employed, provided measurements are made on the peak basis, and recorded as observed (without any resumed correction for the difference between CISPR quasi-peak and peak detector function).

NOTES: 1. The above specified bandwidths have tolerance prescribed in ANSI standard C63.2-1980.

2. If bandwidths greater than those expressed in 4.2.2. are used, higher readings may result for an EUT with broadband emanations.

3. Data taken with measuring instrumentation employing logarithmic amplifiers when using the average function will represent the average of the logarithm of the voltage level. If the emanation observed is pulsed, broadband observed values will be materially lower than the true average of voltage. Instrument overload is likely to occur with linear IF systems if the emission pulse duty cycle is less than that for which the measuring instrumentation is rated. Data correction for

spectrum analyzer observations should include corrections for the pulse desensitization factor. The average values of emanations can be calculated using this correction applied to peak indications, if the duty cycle is known or can be measured.

4. For isolation switch measurements only, a bandwidth narrower than 100 kHz may be used at the option of the test engineer, provided he or she ensures a calibrated reading at the narrower bandwidth and includes this information in the measurement report.

4.2.3 Units of measurement

Measurements of radiated radio noise shall be reported in terms of microvolts per meter (uV/m), or dB above 1uV per meter (dB(uV/m)) at a specified distance. The indicated readings on the radio noise meter or spectrum analyzer shall be converted to microvolts per meter (uV/m) or dB above 1uV per meter (dB(uV/m)) by use of appropriate conversion factors. Measurements of conducted radio noise shall be reported in terms of microvolts (uV) or dB above 1 uV (dB(uV)).

Measurements of output signal level shall be reported in microvolts (uV) or in dB above 1 uV (dB(uV)). The impedance at the output terminals at which this measurement is made shall also be specified. If a balun is used, the loss of the balun must be reported and accounted for.

Measurements of output terminal conducted spurious emissions shall be reported im microvolts (uV) or in dB above 1 uV (dB(uV)). The frequency and level of each emission shall be specified. If a balun is used, the loss of the balun must be reported and accounted for.

The isolation of the transfer switch is to be reported in microvolts (uV) or in dB above 1 uV (dB(uV)), measured over the frequencies of the output signal, in most cases TV channels 3 and 4. The impedance at the antenna input terminals at which this measurement is made shall be specified (see Section 4.0).

4.2.4 Antennas

A calibrated, tuned half-wave dipole antenna is preferred for measuring the level of radiated emissions. Other linearly polarized antennas are acceptable, provided the results obtained with such antennas are correlatable to levels obtained with a tuned dipole. The antenna shall be capable of measuring both horizontal and vertical polarizations. Over the frequency range of 30 to 1000 MHz, the Commission will use tuned half-wave dipole antennas for compliance testing.

4.2.4.1 Antenna-to-test unit distance

The horizontal distance between the measuring set antenna and the EUT shall be measured from the closest point of the EUT, as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the EUT. All intra-system cables and connecting devices shall be included within this boundary. Radiation measurements may be made at any distance between 3 to 10 meters, provided the results are extrapolated to 3 meters using the inverse distance linear relationship.

4.2.4.2 Antenna height variation

The measurement antenna must be varied in height above ground to obtain the maximum signal strength. For measurement distances up to and including 10 meters, the antenna height shall be varied from 1 to 4 meters. Beyond 10 meters, the height shall be varied from 2 to 6 meters. These height scans apply for both horizontal and vertical polarizations, except that for vertical polarization the minimum height should be increased so that the lowest point of the bottom end of the dipole (or other antenna), at any frequency, clears the site ground surface by approximately 25 cm.

At sites other than open field, alternative scanning heights and procedures may be used, provided it can be shown that equivalent results are obtained.

4.2.5 Preliminary testing and monitoring

It is often valuable to perform preliminary radiated measurements at a closer distance than specified for compliance to determine the emission characteristics of the EUT. At close-in distances, it is easier to determine the spectrum signature of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions as discussed in 4.5.1. A site other than open field may be used for this purpose, but the test engineer should be aware that the alternate site may not produce precisely correlatable results. Where a radio noise meter is used for this spectrum search, it is recommended that either a handset or loudspeaker be connected as an aid in detecting ambient signals and finding frequencies of significant emission from the EUT.

Preliminary testing is optional. However, if preliminary tests are not performed, the steps outlined above (spectrum signature, EUT arrangement) must be accounted for when making tests at the distance used on the open field site.

4.3 Frequency range to be scanned

For radiation measurements, the frequency range from 30 to 1000 MHz shall be searched. For conducted measurements, the frequen-

cy range from 450 kHz to 30 MHz shall be searched. The six highest emission relative to the appropriate limit shall be measured and reported. To facilitate testing with a radio noise meter, the frequency range covered in the particular test should be scanned while monitoring with headset or loudspeaker. If any indicated peaks appear while scanning, readings shall be taken at the frequencies where they occur. The scan rate shall be such that noise signals above the radio noise meter sensitivity threshold are not omitted from detection.

NOTE: Automatic scan techniques are acceptable but the maximum scan speed is limited by the response time of the measuring system and (where applicable) the repetition rate of the radio noise to be measured.

4.4 Data reporting format

The measurement results expressed in accordance with 4.2.3 and specific limits where applicable, shall be presented in tabular or graphical form or alternatively as recorder charts or photographs of a spectrum analyzer display, showing the level vs. frequency. Since alternate test methods are provided, test data must identify the methods used. Statements as to the instrumentation employed, instrument attenuator and bandwidth settings, detector function, EUT arrangements, a sample calculation with all conversion factors, and all other pertinent details shall be included along with the measurement results.

The justification for selecting a particular EUT configuration as tending to produce maximized emissions must be documented in the test report. The test report should also show precisely how the interface cables were finally arranged when the measurements were made.

NOTE: In the case of devices required to be certificated, refer also to Part 2 (Sections 2.909, 2.925, 2.926, and 2.1033) and Part 15 (Sections 15.38, 15.44 15.45, 15.46, and 15.79) for general provisions applicable to all applications for certification.

5.0 OUTPUT SIGNAL MEASUREMENTS

The measuring instrument shall have the characteristics described in 4.2.

5.1 Output signal level measurements

When the RF output of the TV interface device is to be fed to the TV receiver via coaxial cable, the signal level shall be measured by direct connection to the measuring instrument with proper matching between the measuring instrument and the TV interface device.

If the RF output is fed to the TV receiver via "twin lead", the output shall be connected to a balanced RF voltmeter or to a balun, which in turn is connected to the measuring instrument. Connecting cables shall be kept as short as possible.

The RF output signal level is construed to mean the highest RF level present at the output terminals during normal use of the TV interface device. Measurements shall be made of the levels of both the aural and visual carriers of each TV channel on which the TV interface device operates.

5.2 Output terminal conducted spurious emission measurement

When the RF output signal is intended to be fed to the TV receiver via coaxial cable, measurements shall be made by direct connection to the test instrument with proper matching between the measuring instrument and the TV interface device. If the output is fed via "twin lead", measurements are to be made through an appropriate balun with connecting cable kept as short as practical.

The frequency range 30 to 1000 MHz shall be investigated to locate significant emission.

5.3 Transfer switch isolation measurement

Measurements shall be made of the maximum voltage at the antenna input terminals of the switch for all positions of the transfer switch. The maximum voltage shall correspond to the peak envelope power of the video modulated signal during maximum amplitude peaks.

If the antenna input terminal is to be connected to the antenna via coaxial cable, the signal level shall be measured by direct connection to the measuring instrument with proper matching between the measuring instrument and the TV interface device.

5.3.1 Balanced line tests

The following shall apply to the measurement of the signal level at the antenna input of the transfer switch if the signal is fed via "twin lead".

The TV interface device shall be supported so that the non-coaxial terminals are at a height between 75 and 150 centimeters above ground.

A section of balanced transmission line of the intended type, 3/4 of a wavelength long at the TV interface device output signal frequency, shall be connected to the antenna input terminals of the switch and supported in a straight horizontal line from the TV interface device to the measuring equipment. There shall be a lateral clearance of at least 75 centimeters from any part of the line to any other object.

The transmission line shall be connected to a balanced RF voltmeter or to a balun which in turn is connected to the measuring instrument.

Measurements of the signal level shall be made with 3/4 wavelength transmission line and with transmission lines of decreasing line length, in at least ten equal decrements (total of 11 measurements), to a length of 1/4 wavelength. For isolation switch measurements, the video carrier of the device is the only signal which needs to be measured.

The signal level at the non-coaxial antenna input terminal of the transfer switch is taken to be the median of the values obtained in these measurements.

5.3.2 Alternative balanced line tests

All 11 measurements of 5.3.1 need not be performed if it can be shown that one of the following conditions is satisfied.

(a) If and when maximum signal level has been reached, measurements should be performed following the procedure in 5.3.1. The maximum level is reached when at least two (2) points before and two (2) points after the determined maximum are reached and are of a lower value.

(b) Alternatively, the previous test need not be performed if a preliminary measurement is made of any length of the balanced transmission line less than 5 meters and measured signal level does not exceed $0.173\sqrt{R}$ microvolts.

6.0 TEST CONDITIONS FOR RADIATED AND POWERLINE CONDUCTED MEASUREMENTS

All modes of operation of the TV interface device (EUT) shall be investigated to find the maximum emanations.

6.1 Test conditions for EUT

The equipment under test (EUT) shall be configured and operated in a manner that tends to maximize its emission characteristics in a typical application. Power and signal distribution, grounding, interconnecting cabling and physical placement of equipment of a test system shall simulate the typical application and usage as nearly as practicable. The EUT shall be furnished with rated (nominal) voltage as specified in the individual equipment power requirements. The power supplied to the EUT may need to be filtered to meet the requirements of 6.2.1.

6.1.1 Conditioning of the EUT

The EUT shall be operated for a sufficient period of time to approximate normal operating conditions.

6.1.2. Accessories

The EUT should be connected to at least one of each type of accessory provided by the manufacturer.

It is recommended that interconnecting cables should be of the type and length specified in the individual equipment requirements. If the length may vary, the test engineer should select the length that in his or her judgement will most likely produce maximum emissions. In general, this decision should be based on trial and error tests. If the cables will be purchased separately by the consumer, and shielded or special cables are used during FCC tests to achieve compliance, then it is suggested that a note be included in the instruction manual advising of the need to use such shielded cables.

Excess length of cables shall be bundled at the approximate center of each cable by folding back and forth so as to form a bundle not exceeding 30 to 40 centimeters in length. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at a user installation, disposition of the excess cable is left to the test engineer.

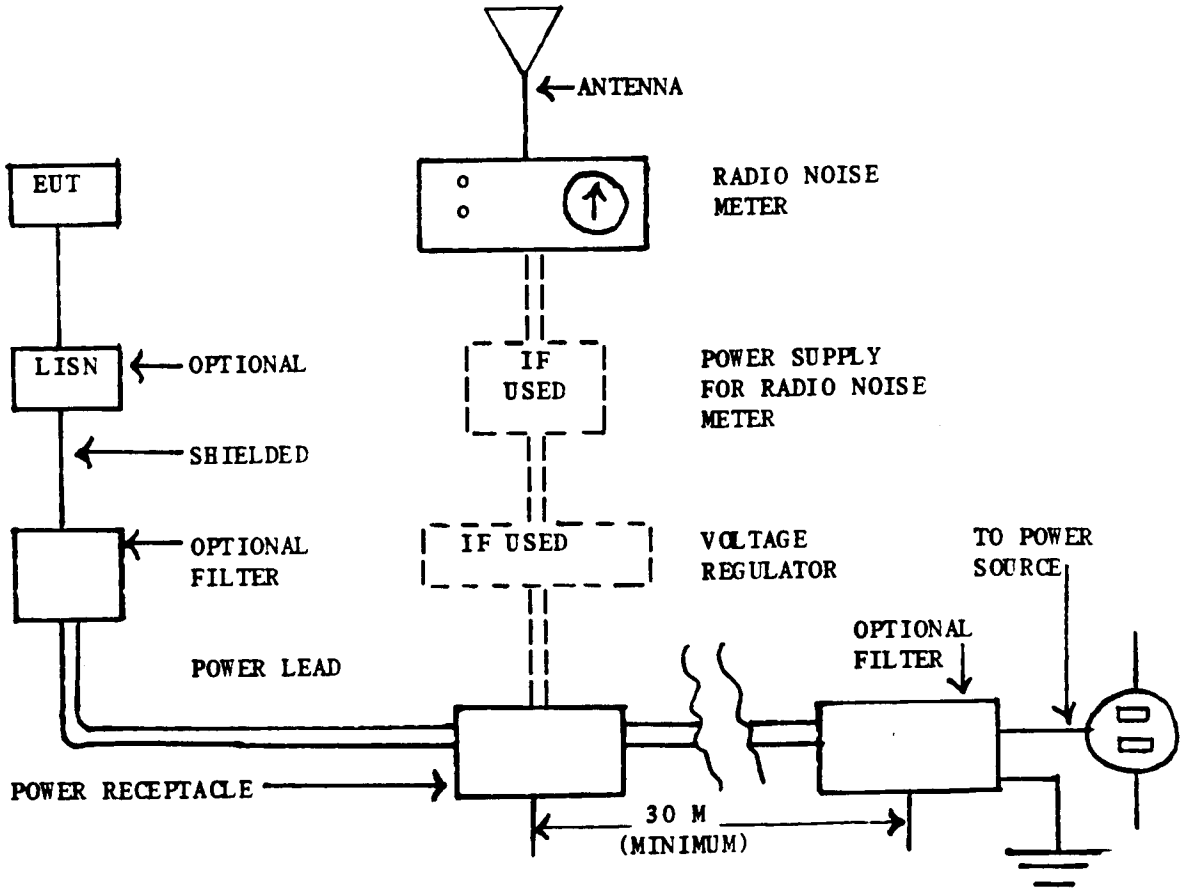
Products that provide a unique interface port for peripherals that are not yet available, may be tested by attaching a cable, extended one meter vertically above the device and left unterminated.

6.1.3 EUT grounding

The EUT shall be grounded in accordance with the manufacturer's requirements and conditions of intended use. If the EUT is operated without a ground connection, it shall be tested ungrounded. When the EUT is furnished with a grounded terminal or internally-grounded lead, and when this terminal or lead is used for actual installation conditions, the ground lead or connection shall be connected to a ground plane (or facility for earth ground) simulating actual installation conditions. Any internally-grounded lead included in the plug end of the line cord of the EUT shall be connected to ground through the utility power service (see also 7.1 and 7.3).

6.2 Test environment

The environment at the test site should satisfy the following conditions:



* ALL LEADS MUST BE RESTING ON THE GROUND OR UNDER GROUND

FIGURE 1 - SUGGESTED LAYOUT FOR OPEN FIELD TESTS

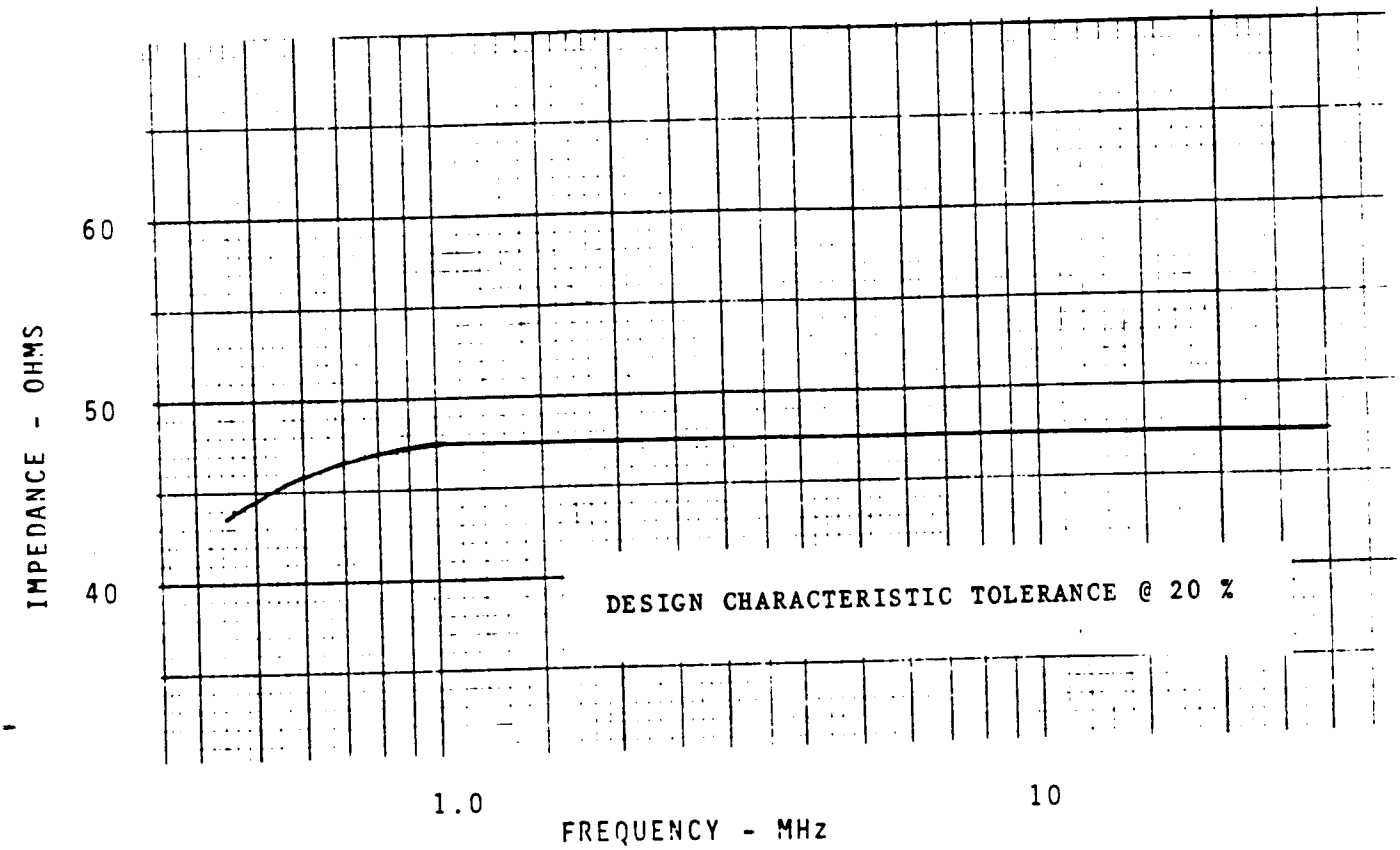


FIGURE 2 - IMPEDANCE FREQUENCY CHARACTERISTICS OF LINE IMPEDANCE STABILIZATION NETWORK (450 kHz to 30 MHz)

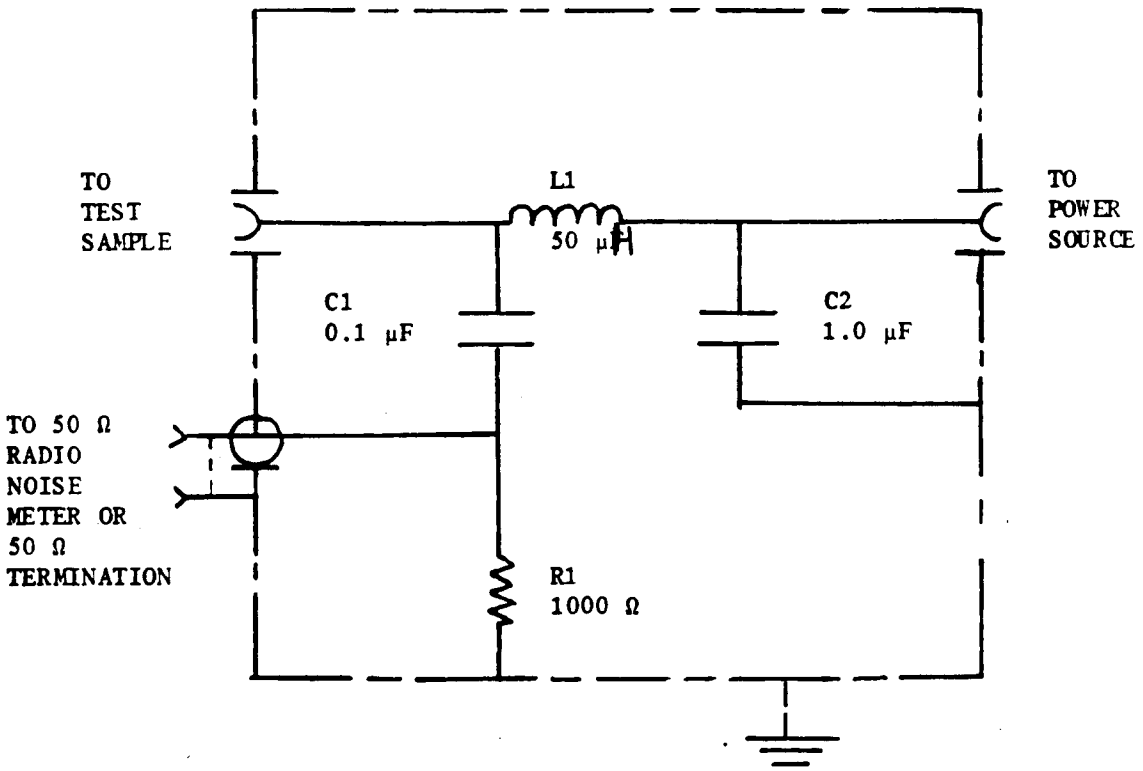
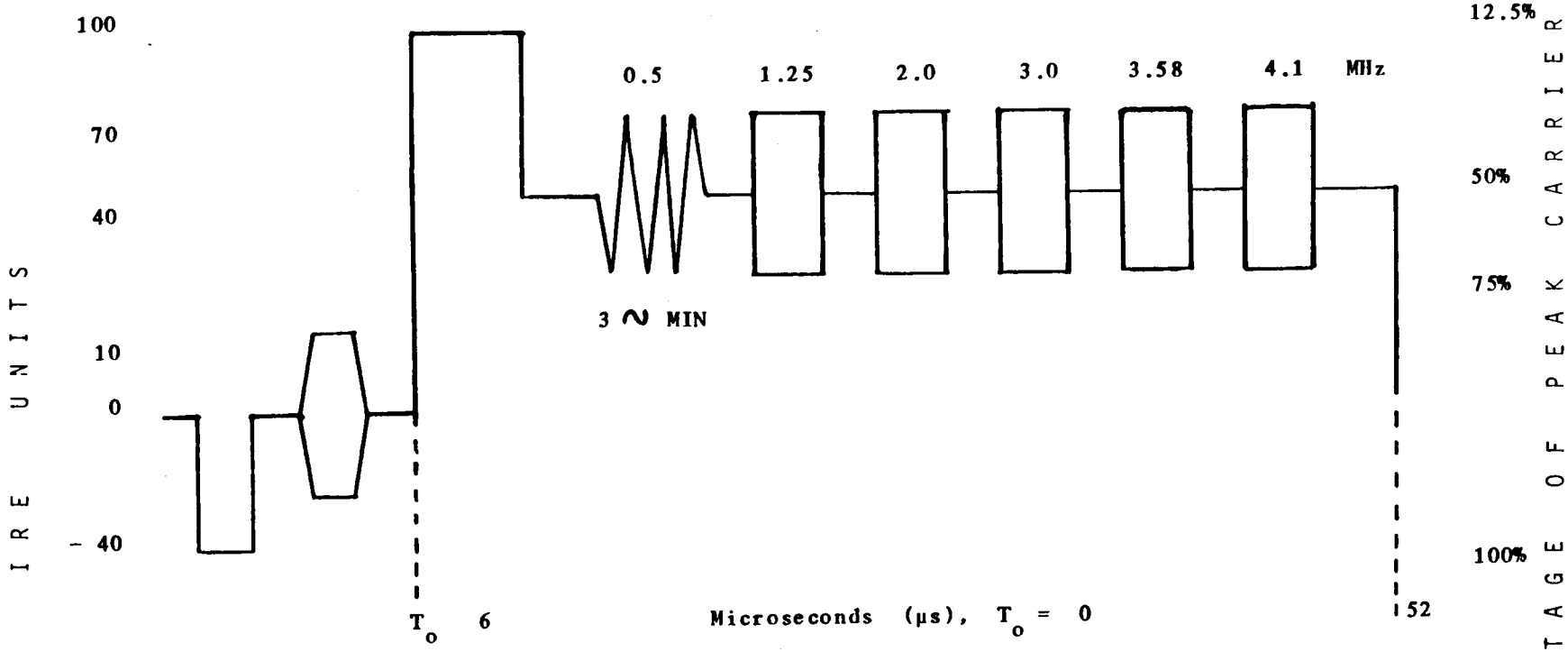


FIGURE 3 - CIRCUIT DIAGRAM OF LISN TO PROVIDE IMPEDANCE OF FIGURE 2 FOR THE 0.45-30 MHz FREQUENCY RANGE

FIGURE 4 - MULTIBURST TEST SIGNAL (FIELD 1, LINE 17)



Notes: 1. A breezeway, as shown between burst, is recommended. Each burst = 60 IRE units peak to peak.

2. T_o = Nominal start of active portion of line 17, field 1.

3. Rise and fall time of white bar shall have risetime of not less than 0.2 µs.

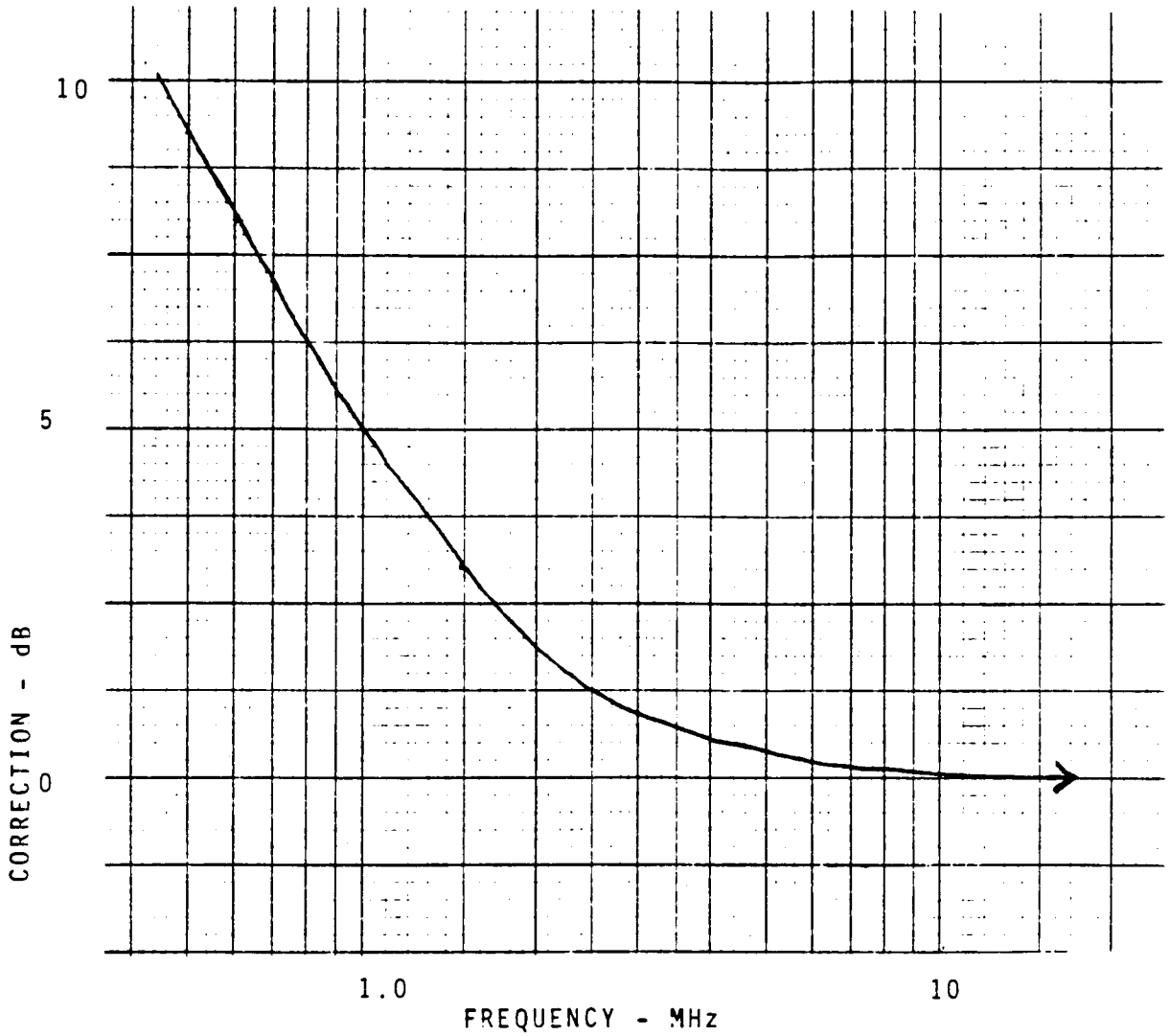


FIGURE 5 - Correction in dB for 50 µH LISN: Add to readings with 5 µH LISN obtain values equivalent to those that would be obtained with a 50 µH LISN

6.2.1 Ambient radio noise and signals

It is desirable that the conducted and radiated ambient radio noise and signal levels, measured at the test site with the test sample de-energized, be at least 6 dB below the allowable limit of the applicable specification or standard. However, in the event that the measured levels of the ambient plus EUT radio noise emissions are not above the applicable limit, the EUT shall be considered to be in accordance with the limit.

If the ambient field or the power line ambient level at some frequencies within the specified measurement ranges exceeds the applicable specification limit(s), other test methods may be used to show EUT compliance. The following would constitute some of the acceptable alternatives:

1) Perform measurements at closer than the specified distances and extrapolate the result(s) to the specified limit distance using and inverse distance linear attenuation factor; or
2) Perform measurements of critical frequency bands during hours when broadcast stations may be off the air and industrial ambients are lower; or

3) Resort to measurement in an enclosure or anechoic room (see 4.1.1.1 and 4.1.1.2 for conditions of use). Measurements made in a shielded (metal) enclosure are normally not acceptable for the purpose of determining compliance with radiated limits. However, by making observations in such an enclosure of the radiated levels of emissions affected by ambient interference and other EUT emissions in the same general frequency range, taken together with measurements on the test site (at reduced bandwidth where necessary) you can determine with reasonable accuracy the strength of the EUT emissions affected by ambient interference; or

4) Insert line filters between the power source and the LISN or between the power source and the EUT as appropriate for the particular measurement.

NOTE: In orienting the axis of a test site, it is desirable to consider the directions of strong ambient signals so that the orientation of the receiving antenna on the site discriminates against such signals as nearly possible.

6.2.2 Temperature

The ambient temperature of the testing location should preferably be within the range of 10 to 40 degrees C (50 to 104 °F) unless the individual equipment requirements specify testing over a wider temperature range. Measurements made in temperatures outside

these limits may be accepted, provided the EUT, radio noise meters, all indicating devices, and other equipment are at the testing location a sufficiently long time that their temperatures become stabilized with respect to the ambient temperature of the testing location. Evidence shall be given so that the calibrations of the measuring instruments are accurate at the temperatures at which they are used.

6.3 Arrangements of EUT (on test site)

The EUT shall be arranged to the extent practicable in a manner that simulates actual use, with the several units placed as nearly as possible in the worst-case setup found in preliminary tests per paragraph 4.2.5. An EUT that is normally operated on a table shall be placed on a non-conducting table having the approximate surface dimensions of 75 by 100 centimeters, its height above test site ground level being 1 meter. For ease of testing, the table may be placed on a rotatable platform, in which case the total height of the table plus the platform shall be approximately 1 meter above test site ground level. If the platform is elevated, it should be non-conducting.

For an EUT normally placed on the floor, the equipment should be placed on a rotatable platform. If the platform is elevated it should be non-conducting and have a height of not more than 0.5 meters above ground level.

The EUT shall be located in the center of the platform. If the EUT consists of two or more units, these shall be arranged around the center of the platform consistent with actual use, placed as nearly as possible in the worst-case setup, as determined during preliminary testing. See paragraph 4.2.5. The external video (multiburst) source, when used, shall be located as close to ground level as possible at the center of the turntable.

Power and signal distribution, grounding, interconnecting cables and physical placement of the units should simulate as nearly as possible typical application and use. Starting with the worst-case setup found pursuant to paragraph 4.2.5, the arrangement of units and interconnecting cables should be varied (within the range of positions likely to occur in actual use) to maximize the strength of the strongest emission of those present (using data from the paragraph 4.2.5 tests as guidance). A sufficient number of arrangements shall be investigated to insure that the maximum radiation is measured.

6.4 Ground plane

A ground screen is desirable, but not mandatory. It is pointed out, however, that open field sites are likely to need a ground screen when any of the following conditions exist at the site: the terrain is discontinuous; the terrain is subject to extreme seasonal variations in ground conductivity; there are unburied power or control cables; the site is located on pavement.

7.0 CONDUCTED POWERLINE MEASUREMENTS

Unless otherwise specified, measurements shall be made to determine the line-to-ground radio noise voltage that is conducted from the EUT power-input terminals that are directly connected to a public power network. The measurements are to be made with the EUT connected to such network through a nominal, standardized RF line impedance stabilization network (LISN). A network must be inserted in series with each current-carrying conductor in the EUT power cord.

NOTE: It is recommended that conducted powerline measurements be made before measurements of radiated radio noise emissions. This procedure is recommended because it is carried on indoors, requires little time as compared to radiation measurements, and can give some assurance that the shielding of the EUT is reasonably effective (at least at the lower frequencies).

7.1 Conducted powerline test configuration

The EUT shall be placed 40 centimeters from an earth grounded conducting surface at least 2 meters square unless it is floor-standing. In all cases, the EUT shall be kept at least 80 centimeters from any other earth grounded conducting surface. If the measurement is made in a shielded enclosure, the walls of the enclosure may be substituted for the 2 meter square conducting surface.

If the EUT is supplied without a flexible power lead, it shall be placed at a distance of 80 centimeters from the LISN's (or mains outlet where LISN's cannot be used) and connected thereto by a lead of length not greater than 1 meter.

If the EUT is supplied with a flexible power lead, the voltage shall be measured at the plug end of the power lead. The length of the power lead in excess of the 80 centimeters separating the EUT from the LISN shall be folded back and forth so as to form a bundle not exceeding 30 to 40 centimeters in length.

If the EUT is normally operated in the hand, measurements shall be made as if it is normally operated while placed on a table or desk. Measurements of power line conducted emanations are not required for devices capable of being operated only from internal batteries. If the EUT is fitted with a connection for operation directly or via separate transformer or power supply from public lines, measurements of power line conducted emanations shall be made.

In cases where accessories have their own provisions for connection to AC power, the accessories shall be connected to the LISN by connecting their AC power cords in parallel with that of the EUT. Where there are provisions for connection to ground, measurements shall be made with all units sharing a common ground with the LISN.

7.2 Line impedance stabilization network (LISN)

A line impedance stabilization network (LISN) having an impedance characteristic within the limits shown in Figure 2 is required for conducted radio noise measurements. Figure 3 shows a network that will provide the specified impedance over the frequency range 0.45-30 MHz. A coaxial-type connector shall be provided for connection of the measuring instrumentation by means of a 50-ohm terminating resistance across the 1000-ohm resistor. Provisions shall be made for electrically bonding the LISN enclosure to the ground plane used (see 6.4). If direct bond is not possible, for instance to a concrete floor, a metal sheet approximately 2 meters square shall be placed under the LISN and electrically bonded to the LISN by a short low impedance connection.

NOTE: LISN's designed to comply with the impedance characteristic of Figure 2, have limited availability on the market. As an interim measure, 5 microhenry LISN's may be used, provided that the readings obtained using these networks are increased by adding a correction to obtain a value equivalent to that which would have resulted had a 50 microhenry network been used in the measurement. This correction varies from +10 dB at 450 kHz to 0 dB at 2 MHz; values for frequencies between these limits may be obtained by reference to Figure 5. No correction is required above 2 MHz. This correction is based upon the relative values of the 50 and 5 microhenry LISN networks in the range 450 kHz to 30 MHz, and a presumption that the source impedance of the EUT power conductors in this range is slow as compared to that of the networks. The correction has limited validity due to wide variation in EUT impedances, so measurements should be made with the 50 microhenry LISN if at all possible.

7.3 Grounding

The LISN housing, measuring instrumentation case, ground plane, etc., shall be electrically bonded together in such a manner that they are at the same RF potential.

7.4 Measurement procedure

Measurements of powerline conducted radio noise shall be expressed as the voltage developed across the 50-ohm port terminated by a 50-ohm measuring instrument. All voltage measurements shall be made at the plug end of the EUT power cord, e.g., by the use of mating plugs and receptacles on the EUT and LISN.

7.4.1 EUT power leads

All EUT input power leads, except ground leads, shall be connected individually through the LISN to the input power source. All

unused 50-ohm connectors of the LISN shall be terminated with a 50-ohm resistance when not connected to the measuring instrument.

7.4.2 Shielded power leads

Equipment normally used with unshielded power leads shall be connected to the LISN and tested with unshielded leads. If the EUT is normally operated with shielded or armored leads, the tests shall be made using such leads. The applicant shall supply the same power lead and plug for testing with which the EUT will be marketed (whether these leads are permanently connected or installed by a technician or the purchaser).

8.0 RADIATED RADIO EMISSION MEASUREMENTS

Measurements of radiated radio emissions shall be made using the measuring instrumentation and antennas specified in 4.2 and 4.2.4, respectively. Radiation from the EUT including radiation from all signal and power cabling shall be measured. The EUT shall be set up and operated in a manner representative of actual use but not inconsistent with the provisions of Section 4 above.

8.1 Radiated emission tests

Radiated radio emission measurements shall be made at one of the test sites described in 4.1 above. An EUT subject to a radiated limit at 3 meters, shall be measured at a distance of 3 meters, unless impractical because of the size of the equipment, location, etc., in which case measurements may be made at a further distance of 10 meters and the results extrapolated downward utilizing an inverse distance extrapolation factor (i.e., 20 dB/decade). At a test distance of 10 meters the antenna shall be varied in height between 1 and 4 meters above ground to determine the maximum level of emission within this range. Both horizontal and vertical orientations of the search antenna shall be employed and maximum values reported. For vertical polarization the bottom end of the dipole shall be kept at least 25 cm above site ground per paragraph 4.2.4.

At a site other than an open field, it is permissible to replace continuous variation of antenna height with the setting of the antenna at one or more fixed heights, provided that it can be shown that equivalent results are obtained.

A typical test configuration for open field and alternate sites is shown in Figure 1. The LISN, installed for the powerline conducted radio noise measurements, may be left in place for radiated radio noise emission tests.

Radiated emission magnitudes shall be obtained in the azimuthal direction of maximum field strength for each predominate emission.

8.2 Electromagnetic field: 30 MHz to 1 GHz

Any equipment to which it is applicable shall be measured for radiated radio emissions from all units, cables, power lines and interconnecting wiring.

Antenna position in azimuth shall be varied during the measurement in order to determine maximum field strength. Measurement shall be made at the azimuth such that the maximum radiation levels will be detected.

The antenna(s) specified in 4.2.4 above, preferably shall be positioned at the specified distance from the EUT for the duration of this test. Other test distances may be used and data extrapolated to the specified distance per paragraph 8.1. Tests shall be made in both the horizontal and vertical planes of polarization.

The area of maximum radiation from the EUT may be initially determined by scanning the power leads and the equipment using the radio noise meter in conjuction with a short electric field antenna at a closer distance.

For recordkeeping purposes only the 6 highest emanations observed during the tests need to be recorded and maintained in the permanent record file.