Office of Science and Technology

Authorization and Standards Division

Federal Communications Commission

FCC METHODS OF MEASUREMENTS OF RADIO NOISE EMISSIONS FROM INDUSTRIAL, SCIENTIFIC, AND MEDICAL EQUIPMENT

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Introduction

This document sets forth uniform methods of measurements of radio noise emitted from ISM equipment, as defined in 47 CFR § 18.107 of the FCC Rules. The technical specifications for ISM equipment are contained in Part 18 of the FCC Rules. Methods of measurements of radiated, powerline conducted radio noise, frequency and power output (when applicable) are covered herein. Applicants for certification and parties subject to verification are encouraged to use these methods. Testing of ISM equipment by the FCC will be conducted in accordance with these methods of measurements, to the extent possible. This document has been separated in seven parts;

Part 1 - Definitions
Part 2 - General test conditions
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1.0 DEFINITIONS

The definitions in Parts 2 and 18 of the FCC Rules and the following shall apply to the use of this standard.

1.1 Ambient level

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

1.2 Emission

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

1.3 Equipment under test (EUT)

A representative piece of ISM equipment being tested or evaluated.

1.4 Ground plane

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

1.5 Radio noise

Electromagnetic energy in the radio frequency range that may be superimposed upon a wanted signal.

-- Radiated radio noise:

Radio noise radiated into space. Such noise may included both the radiation and induction components of the field.

-- Conducted radio noise:

Radio noise propagated from the device back into the public electrical power network via the supply cord.

-- Broadband radio noise:

Radio noise having a spectrum broad in width as compared to the nominal bandwidth of the measuring instrument, and whose spectral components are sufficiently close together in frequency and uniform that the measuring instrument cannot resolve them.

2.0 GENERAL TEST CONDITIONS

2.1 Test sites for certified equipment

For equipment subject to certification, an environment which assures valid, repeatable results shall be used. A measurement is valid to the extent that it is a true representation of the characteristic being measured, and when the same measurement procedure yields repeatable results. Measurements of radiated radio noise should be made in an open, flat area characteristic of cleared, level terrain, especially for measurements of emissions below 1 GHz. For details on how to set up a suitable site, see FCC Bulletin OST 55, "Characteristics of Open Field Test Sites", available from the FCC Consumers Assistance Office, Washington, D.C. 20554. Measurements made by the Commission will be performed on an open field site. A description of the test facility used for equipment subject to certification or when required by the Commission, shall be filed, pursuant to Section 18.205 of the FCC Rules.

As an alternative, testing may be made at another location such as a laboratory, factory, anechoic chamber, etc. only if it can be shown that the results obtained at such a location are correlatable to those made in an open field site. Sufficient tests shall be made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field.

2.1.1 Test sites for verified equipment

Verified equipment may be tested at any location, however, the following will be observed:

-- When testing is done at a location which does not have particular characteristics such as shielded walls, etc. and which yields repeatable results than the data obtained will be considered representative of how the equipment operates in general.

-- When testing is done on-premises (or in-situ), both the equipment and its location are considered the EUT. The radiated emission results may be unique to the installation because site containment properties affect the measurements. The conducted emanation results also may be unique to the installation.

-- If a location has unique characteristics such as shielded walls, the measurements taken will be considered representative of that installation only. For example, situations where the equipment is located in a building with metal walls or deep inside a building, with measurements taken outside that building, cannot be considered representative of how the equipment will perform at other installations where the same degree of shielding may not be present.

2.2 Measuring instrumentation

Radiated and conducted measurements shall be made with a radio noise meter that conforms with the American National Standard Specifications for Electromagnetic Interference and Field Strength Instrumentation 10 kHz to 1 GHz, ANSI C63.2-1980. Alternatively, a spectrum analyzer may be used, provided the results obtained can be accurately reproduced with a suitable radio noise meter and that it is used, when necessary, with appropriate accessories to insure sufficient sensitivity and overload protection. Other instruments may be used for certain restricted and specialized measurements when data so measured are correlatable to that achieved with C63.2 instrumentation. No specific standard will be required for instrumentation used to perform measurements above 1 GHz.

Note: Accessories needed would depend upon the measurement situation and could include preamplifiers for sensitivity improvement, filters and/or attenuators for overload protection, and additional quasi-peak detection circuitry (for testing RF lighting devices). Overload is defined as harmonic 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 analyzer and other instruments are also available from several manufacturers.

2.2.1 Measuring instrument calibration

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

2.2.2 Detector function selection and bandwidth

For radio noise meters or spectrum analyzers which include weighting circuits, the detector function shall be linear. The detector function selector shall be set to average, unless otherwise specified for a given device. For RF lighting devices, the measuring instrument 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:

- 200 Hz for measurements below 150 kHz
- 9 kHz for measurements from 150 kHz to 30 MHz
- 100 kHz for measurements from 30 to 1000 MHz
- 1 MHz for measurements above 1000 MHz

Post detector video filters, if used, shall be wide enough not to affect the peak detector reading. Alternatively, field strength meters and spectrum analyzers without weighting circuits may be employed, provided measurements are made on the peak basis and recorded as observed.

Notes: 1. The above specified bandwidths have tolerances as prescribed in ANSI standard C63.2 - 1980.
2. If bandwidths greater than those specified in B2.2 are used, higher readings may result for EUT's with broadband emanations.
3. Alternative methods of reading the average will be accepted by the FCC. Individuals should contact the FCC laboratory and discuss the appropriateness of alternate methods prior to undertaking them.

2.2.3 Units of measurements

Measurements of radiated emissions shall be reported in terms of microvolts per meter at a specified distance. The indicated readings on the spectrum analyzer or the radio noise meter shall be converted to microvolts per meter by use of appropriate conversion factors. Measurements of conducted emissions shall be reported in terms of microvolts.

2.2.4 Antennas

The following antennas shall be used for measuring the field strength:

-- below 18 MHz	shielded balanced loop
-- 18 to 30 MHz	shielded balanced loop or calibrated tuned half-wave dipole *
-- 30 to 1000 MHz	calibrated tuned half-wave dipole *
-- above 1 GHz	broadband linearly polarized horn antenna *

* Other linearly polarized antennas are acceptable provided the results obtained with such antennas are correlatable to levels obtained with a tuned dipole for measurements from 30 to 1000 MHz or a horn antenna for measurements above 1 GHz.

2.2.5 Antenna height variation

The measurement antenna must be varied in height above ground to obtain the maximum signal strength.

-- For a loop antenna. The antenna height shall be set at around 2 meters. Care should be taken to assure that readings are no taken in nulls.

-- For a dipole or equivalent antenna. 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.

-- For a horn or equivalent antenna. The antenna height shall be varied from about 1 to 4 meters. Antenna orientation and variations in height shall be such that readings are not taken in nulls.

These height scans apply for both horizontal and vertical polarization, 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 centimeters. Height variations might be constrained because of the location.

2.2.6 Antenna-to-test unit distance

Measurements shall be made at the distance at which the limits are specified, to the extent possible. Testing may be made at closer distances, especially for equipment for which the limits are specified at distances greater than 30 meters, provided a sufficient number of measurements are made to enable plotting of the polar radiation pattern and to assure the correct determination of the major lobes. Where conditions permit, these measurements shall be made at intervals of no more than 20 degrees in azimuth directions and at distances not exceeding the one at which the emission limit is specified. Where possible, field strength measurements shall be made along each radial at several intervals and an average curve shall be drawn for measured field strength in uV/m versus distance in meters. Where necessary, the average curve shall be extended to show the extrapolated field strength at the distance at which the emission limit is specified.

The Commission as an alternative shall accept measurements at a closer fixed distance, provided 1/d is used as an attenuation law factor (where d is the distance measured in appropriate units).

The measuring distance between the measuring set antenna and the EUT shall be measured from the closest point of the device or system, as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the EUT system. All intra-system cables and connecting devices shall be included within this boundary.

2.3 Frequency range to be scanned

(a) For field strength measurements:

Frequency band in which device operates (MHz)	Range of frequency measurements	
	Lowest frequency	Highest frequency
Below 1.705	lowest frequency generated in the device, but not lower than 9 kHz	30 MHz
1.705 to 30	lowest frequency generated in the device, but not lower than 9 kHz	400 MHz
30 to 500	lowest frequency generated in the device or 25 MHz, whichever is lower	tenth harmonic or 1000 MHz, whichever is higher
500 to 1000	lowest frequency generated in the device or 100 MHz, whichever is lower	tenth harmonic
above 1000	do	tenth harmonic or highest detectable emission

(b) For conducted powerline measurements, the frequency range over which the limits are specified will be scanned.

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.

2.4 Data-reporting format

The measurement results expressed in accordance with Section 2.2.3, and specific limits where applicable, shall be presented in tabular and/or graphical forms, or alternatively as recorder charts or photographs of a spectrum analyzer display, showing level vs. frequency. Since alternate test methods are provided, test data must identify the methods used. Instrumentation, instrument and bandwidth settings detector function, EUT arrangements, sample calculation with all conversion factors and all other pertinent details shall be included along with the measurement results.

3.0 GENERAL TESTS

3.1 Radiation hazard test

For ISM equipment operating on higher frequencies (above 900 MHz), in particular microwave ovens and medical diathermy equipment, radiation leakage should be measured in accordance with the current Bureau of Radiological Health standard, employing an electromagnetic radiation monitor. This test is made primarily to assure that personnel will not be exposed to radiation hazard in testing the equipment. Equipment submitted to the FCC which have radiation leakage apparently in excess of BRH limit will be reported to BRH for their evaluation. See FCC Bulletin OST 56, "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Radiation".

3.2 Frequency measurements

For ISM equipment designed to operate on one of the ISM frequencies, the maximum frequency deviation due to the load and normal operating conditions shall be measured and reported. These measurements may be performed indoors. The load effect on frequency variation is determined by finding the extreme values of frequency obtainable by adjustment of applicator spacings, external control settings, and varying loads, for each combination of applicators.

After a five-minute no-load warm-up from a cold start at room temperature, determine the maximum deviations from the ISM frequency (both above and below) by making measurements with different combinations of applicators, applicator spacings, control settings, and load.

Using that combination of applicators and load spacing which produces the maximum observable power output into the load, operate the equipment from a cold start at room temperature for a sufficient amount of time to approximate normal operating conditions. Measure the frequency at the beginning of the run and at frequent intervals until its completion.

After making the last measurement, once again adjust the controls of the equipment, vary the load, and change the applicator spacing, to find the combination that yields the worst deviation from the ISM frequency.

4.0 RADIATED EMISSIONS MEASUREMENTS FOR MICROWAVE OVENS AND MEDICAL DIATHERMY EQUIPMENT OPERATING ABOVE 900 MHz

4.1 Load for microwave ovens

For all measurements the energy developed by the oven is absorbed by a dummy load consisting of a quantity of tap water in a beaker. A polypropylene beaker or any other low-loss material shall be used as the container. If the oven is provided with a shelf or other utensil support, test shall be made with this support in its initial normal position. For ovens rated at 1000 watts or less power output, the beaker shall contain quantities of water as listed in the following subparagraphs. For ovens rated at more than 1000 watts output, each quantity shall be increased by 50% for each 500 watts or fraction thereof in excess of 1000 watts. Additional beakers are used if necessary.

-- Load for power output measurement: 1000 milliliters of water in the beaker located in the center of the oven.

-- Load for frequency measurement: 1000 milliliters of water in the beaker located in the center of the oven.

-- Load for measurement of radiation on second and third harmonic: Two loads, one of 700 and the other of 300 milliliters, of water are used. Each load is tested both with the beaker located in the center of the oven and with it in the right front corner.

-- Load for all other measurements: 700 milliliters of water, with the beaker located in the center of the oven.

4.2 Load for medical diathermy equipment

Most medical diathermy instruments are provided with more than one set of treatment applicators. These may either be inductive or capacitive in nature; i.e., they are intended to apply electric or magnetic fields to the area of the body to be treated. Since it it not advisable to use humans as test subjects when making radiation measurements on medical diathermy equipment, artificial loads must be used. The following loads have been used in the past, however, other loads may be used depending on the manufacturer's instructions:

-- Load for inductive applicators: the load consists of a flat spiral of three turns of 1/2" wide shield braid (6" I.D./ 10" O.D.) connected to two medium-base lamp sockets in series. The spiral is cemented between two 12" discs of insulating material for support, with the sockets attached near the center of the outer face of one disc. In use the assembly is coupled to the applicator at such a spacing and with that combination of lamps (one or two 100 watt, 200 watt, 300 watt/ 120 volt or 100 watt/32 volt lamps) whichever produces the greatest power output into the load. Where only one lamp is used, a plug fuse is inserted into the idle socket to complete the circuit. For cable applicators, a wooden spider is used to form the cable into a coil of dimensions similar to the spiral in the load.

-- Load for capacitive applicators: The load consists of two coplanar metal sheets (7" x 9", 15" c-c) cemented between two insulating sheets 10" x 23", and connected to two medium-base lamp sockets located along the center-line of the upper insulating sheet. The sockets are arranged so that they can be connected either in series or in parallel. In use, the load assembly is coupled to the applicators at such a spacing and with such a lamp combination as produces the greatest power output into the load, using either one or two lamps of the type listed for inductive applicators.

-- Load for contact applicators: the load consists of a three-gallon terra-cotta or glass jar containing about two gallons of physiological saline solution. The contact applicator is immersed in the solution and the jar is placed on the pad or other capacitive applicator required to complete the electrical circuit. This load may also be used for microwave diathermy tests if desired; however, it is not usual to test these in the loaded condition, since the radiation is greater for the unloaded condition (a load of this type placed in front of the applicator will absorb power both at the fundamental frequency and at harmonic frequencies).

4.3 Power output measurement for microwave ovens

The power output is measured by the calorimetric method, using the load specified in Section 4.1, computing the power output from the observed temperature rise of the load over a period of time. The measured value of power output is used to determine the allowable out-of-band field strength under the terms specified in Section 18.305 of the Rules. The ac power input to the oven is also measured to determine if the oven is operating in accordance with the manufacturer's specifications.

4.4 Power output measurement for medical diathermy equipment

The maximum power output for inductive or capacitive applicators can be determined by measuring the brightness of the bulbs with a light meter. The actual power output can be measured by using 60 hertz AC to give the same lamp brightness. For contact applicators, the power output can be computed from the temperature rise and the volume of water in the container.

4.5 Frequency measurements

For pulsed emissions, frequency measurements are made by beating a transfer oscillator against the fundamental emission of the EUT and measuring the frequency of the oscillator with a suitable frequency counter. Ordinary frequency counters cannot be used to measure the EUT frequency directly in a pulsed EUT. Continuous wave EUT's are measured either by the transfer oscillator method or by direct measurement with a frequency counter. Measurements are made of:

(a) The variation of frequency with time, using the load specified in Sections 4.1 or 4.2, starting with the EUT and load at room temperature and continuing until the load quantity has been reduced by evaporation to approximately 20% of the original quantity. This test is made with nominal rated ac supply voltage.

(b) The variation of frequency for line voltage variation from 80% to 125% of nominal rated voltage, starting with the EUT warm from at least 10 minutes use, with a load as specified in Sections 4.1 or 4.2, and with this load at room temperature at the beginning of the test.

4.6 Radiated emissions measurement

Initial measurements are made near the EUT with the measuring antenna 3 meters from the nearest part of the EUT. The dummy load specified in Sections 4.1 or 4.2 is used, as applicable. The EUT is rotated about its vertical axis on the turntable, and the polarization and height of the receiving antenna are varied to obtain the highest field strength on the particular frequency under observation. Measurements at the 3 meter distance are made in a large room or outdoors; with the equipment and antenna located so as to minimize effects due to reflections from the building structure or other items in the field. For measurements above 1GHz and at 3 meters, an antenna of small aperture (i.e., a small horn, without its reflector) is used, because the field over the area of a large antenna would be non-uniform, and such an antenna would not have the gain normally expected.

At each test frequency, the reading of the field strength meter is observed during the heating cycle as the following factors are varied:

(1) EUT orientation;
(2) antenna orientation;
(3) antenna polarization;
(4) at the second and third harmonics only for ovens, the two load sizes and load locations specified in Section 4.1, and;
(5) for EUT's employing mode stirrers,the test should include several cycles of stirrer rotation.

At the second and third harmonics, the recorded data should include the highest reading observed for each load size and load location. At other frequencies, the highest reading observed should be recorded.

When measuring sidebands close to the fundamental (near the edges of the ISM band frequency limits) great care must be taken to avoid errors caused by overload from the emission at the fundamental frequency. A tunable filter can be employed to reduce the level of the fundamental relative to that of the particular sideband if overload occurs. Overload can be detected by observing the relative change in indicated signal level for different values of input attenuation, either internal or external to the field intensity meter.

Since most microwave field strength meters have relatively little rejection at the image frequency, care should be taken to assure that apparent spurious emissions in the vicinity of the image frequency are really present. A tunable filter or bandpass filter can be used to attenuate the fundamental frequency as for the sidebands.

4.6.1 Computations to determine compliance

The measured field strength at 3 meters is converted to the field at 300 meters using the formula:

$$E_{300\ m} = K \times E_{3\ m}$$

where K is given by:

Frequency	K
1830 MHz	.0046
2745 MHz	.0070
3660 MHz	.0090
4575 MHz and above	.0100

For frequencies between those given in the table, the value of K is determined by linear interpolation.

The values of K given above were determined from measurements at the FCC laboratory test site. Over level terrain and limiting the height of the measuring antenna to 4 meters (12 feet), the measured values of K given above show good agreement with theory.

In the absence of actual measured values of attenuation at another site, the field may be extrapolated to 300 meters using inverse linear variation of field with distance to give conservative results.

While it is very unusual for microwave ovens to have strong radiated fields below 1 GHz, if the field strength values observed at 3 meters are strong enough to warrant concern over their values as extrapolated to 300 meters, it is suggested that additional measurements be made outdoors on an unobstructed level site at 30 meters or greater distance. This would eliminate any questions as to reflections from nearby objects or antenna aperture effects which might occur at these frequencies in measurements at 3 meters.

5.0 RADIATED EMISSIONS MEASUREMENTS FOR CERTIFIED EQUIPMENT

5.1 Preliminary testing and monitoring

Preliminary radiated measurements should be made inside, preferably in an enclosure, at a closer distance than specified for compliance to determine the emission characteristics of the EUT.

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 or relative levels of the emissions unless it can be shown that the results of tests made in the enclosure are correlatable to those made at an open field site. Conducted radio measurements made in a shielded enclosure are acceptable and, in fact, preferable.

If a spectrum analyzer is not used, radio noise measurements should be monitored using either a headset or loudspeaker as an aid in detecting ambient signals and selecting problem frequencies. Precautions shall be taken to ascertain that the use of a headset or speaker does not affect the radio noise meter indication during testing.

5.2 Configuration of EUT

The EUT shall be configured and operated in a manner which tends to maximize its emission characteristics in a typical application. Power and signal distribution, grounding, interconnecting cables and physical placement of the equipment or system shall simulate the typical application and usage in so far 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 Section 5.3.1. See Figure 1.

The configuration which tends to maximize the emissions is not usually intuitively obvious and in most instances selection will involve some trial and error testing. For example, interconnecting cables can be shifted or equipment reoriented during initial stages of testing and the effect on results observed. Trial and error type tests may better yield to experience and knowledge about the characteristics of the EUT. Only those configurations that are within the range of positions likely to occur in normal use need to be considered. In any event, there must be a definite justification for selecting a particular configuration.

5.2.1 Operating conditions

The EUT shall be operated at the specified load conditions (mechanical and/or electrical) for which it is designed. Loads may be actual or simulated as described in the individual equipment requirements. The power output should be measured in order to readjust the limits for equipment generating more than 500 watts, when permitted.

5.2.2 Conditioning of the EUT

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

5.2.3 Accessories and interconnecting cables

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.

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.

5.2.4 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 7.4).

5.3 Test environment

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

5.3.1 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. See Section 2.2.6.

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 Section 2.1 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 as possible.

5.3.2 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.

5.4 Test platform

An EUT which is normally operated on a table shall be placed on a non-conducting table having a height of 1 meter above test site ground level. 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, to the maximum extent practicable.

Measurements made on a test table of 80 centimeter height as called for in some international measurement standards will be accepted for proof of compliance. Although the results will probably be only marginally different than with the 1 meter height, the risk for discrepancies lies with the manufacturer. FCC test will be performed at a height of 1 meter.

In the event that not all of the units of an EUT system will fit on the table, one or more of these may be placed on non-conductive shelves below the table top for their placement. In selecting units placement on the shelf, first preference should be given to those normally not requiring frequent attention.

For an EUT normally placed on the floor, the equipment should, if practicable, be placed on a rotatable platform. If the platform is elevated it should be non-conducting to the maximum extent practicable 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.

5.5 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.

5.6 Radiated radio noise tests

Radiated radio noise measurements shall be made at one of the test sites described in Section 2.1, above, using the measuring instrumentation and antennas specified in 2.2.2 and 2.2.4, respectively. The EUT shall be rotated and measurement antenna height varied as prescribed in Section 2.2.5 in order to obtain maximum reading on the measurement instrument. Tests shall be made in both the horizontal and vertical plane of polarization.

Radiation from the EUT including radiation from all signal and power cabling shall be measured. Consistent with Section 2.0, above, the EUT shall be set up and operated in a manner representative of actual use. Radiated emission magnitudes shall be obtained in the azimuthal direction of maximum field strength for each predominate emission. It is preferable to rotate the EUT to determine the direction of maximum field strength. A turntable arrangement may be used for convenience.

For the fundamental frequency and all other frequencies having significant strength, that is within 20 dB of the limits, measurements shall be made rotating the platform (when applicable) to determine the orientation giving the maximum observable value. All recorded levels within 20 dB of the limits specified shall be recorded and maintained in the permanent record files.

6.0 RADIATED EMISSIONS MEASUREMENTS FOR VERIFIED EQUIPMENT

If due to the location of the equipment in a large city, or for some other reason, measurements as outlined in MP-5 are impractical because of large buildings or other objects, every effort should be made to obtain necessary measurements at the nearest clear locations.

6.1 Individual equipment test requirement

In some cases, it may be necessary to develop a set of explicit requirements specifying the test conditions, EUT operation, etc. to be used in testing a specific EUT or specific class of EUT's for radio noise emissions. Such requirements shall be documented in the report of measurements for the EUT and may be used in determining compliance with FCC limits. It would be advisable to obtain concurrence from the Commission that the special requirements and procedures to be followed are satisfactory before actually performing the measurement.

6.2 Radiated radio noise tests

Testing of the installed EUT may be performed on-premises or in-situ with the results generally regarded as unique to the EUT and installation environment. If no detailed instructions are given in the individual equipment requirements, measurements shall be made to locate the radial of maximum emission at which the limits are specified. Where measurements at the distance at which the limits are specified are impractical, they may be made at lesser distances per Section 2.2.6.

A ground plane need not be installed for testing at a user's installation unless it is to be a permanent part of the installation.

For large, heavy, and stationary equipment not readily rotated, the measuring instrument and test antenna may be moved around the EUT at as many points as are necessary to determine the direction of maximum field strength for each predominate emission.

7.0 CONDUCTED POWERLINE MEASUREMENTS

Conducted powerline measurements shall be made for equipment for which conducted voltage limits have been specified in the rules.

Unless otherwise specified, measurements shall be made to determine the line-to-ground radio noise voltage which 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 the power source through a nominal, standardized RF impedance which is to be provided by a 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 (e.g. the floor of the test chamber) and shall be kept at least 80 centimeters from any other earthed conducting surface. Floor standing equipment may of course be mounted on an earth grounded floor. If the measurement is made in a shielded enclosure, the walls of the enclosure may be substituted for the 2 meters 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.

7.1.1 Conducted powerline test configuration for ultrasonic equipment

The arrangement of the EUT varies to some extent with the configuration. For portable devices, a wooden table (1 x 3 meter or 3' x 10') is placed adjacent to the LISN assembly. Devices in one piece (such as nebulizers or cleaners) are placed on the end of the table nearest the network, and are connected to its power outlet. Devices for medical treatment are similarly placed, with the transducer immersed in a water bath (as a dummy load) over an ungrounded screen (1 x 2.5 meter or 3' x 8') placed on the table top with its nearest edge 30 centimeters or 1 foot from the ultrasonic generator. The bath container is of plastic, and the water in the bath is connected to the screen by a metal strip. If the device is provided with accessories intended to be applied to the patient (such as stimulator pads) these are wetted and placed in contact with the screen on the table. The ungrounded screen simulates the capacitance of the patient and medical technician to ground.

Non-portable or floor-mounted devices are placed on the floor between the LISN and the table. If the transducer or other accessories are ordinarily placed at table height, the table is used to support them; if not, they are placed on the floor in the area normally covered by the table. A rubber mat is normally used to prevent contact between the metal floor and the device under test and its accessories.

7.2 Line probe

A line probe may be used for voltage measurements under certain conditions (see 7.6). If an appropriate LISN which satisfies the impedance requirements of Figure 2, having the current capacity of the EUT is not commercially available, the method shown in Figure 4 may be used. The measurements should be made between each current-carrying conductor in the resistor such that the total resistance between line and ground is 1500 ohms. Since the line probe attenuates the radio noise voltage, appropriate calibration factors must be added to the measured values. Measurement results with the appropriate LISN shall take precedence over the method shown in Figure 4.

7.3 Line impedance stabilization network (LISN)

A line impedance stabilization network (LISN) having an impedance characteristic within the limits shown in Figures 2a or 2b shall be used for conducted radio noise measurements. Figures 3a, 3b, and 3c show networks which will provide the specified impedance. 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.
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: Measurements shall be made with the LISN at which the limits have been specified in the rules.

7.4 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.

7.5 Conducted emissions tests

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.

7.5.1 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.

7.5.2 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).

7.6 Conducted emission tests at user's installation (on-premises testing)

Testing for powerline conducted radio noise is permitted at user's installation site, provided that no disturbance to the normal EUT installation exists, except to make provisions for connection of the 1500-ohm line probe specified in 7.2 and Figure 4. Special precautions must be taken to establish a reference ground for the measurements. No LISN shall be used. The measurements are dependent on the impedance presented by the supply-mains and may vary with time to determine the variations in the supply-mains impedance. (It may be necessary to perform variation in measured values. The time period should be sufficient to cover all significant variations due to operating conditions at the installation.) Such measurements results should be regarded as unique to that EUT and installation environment.

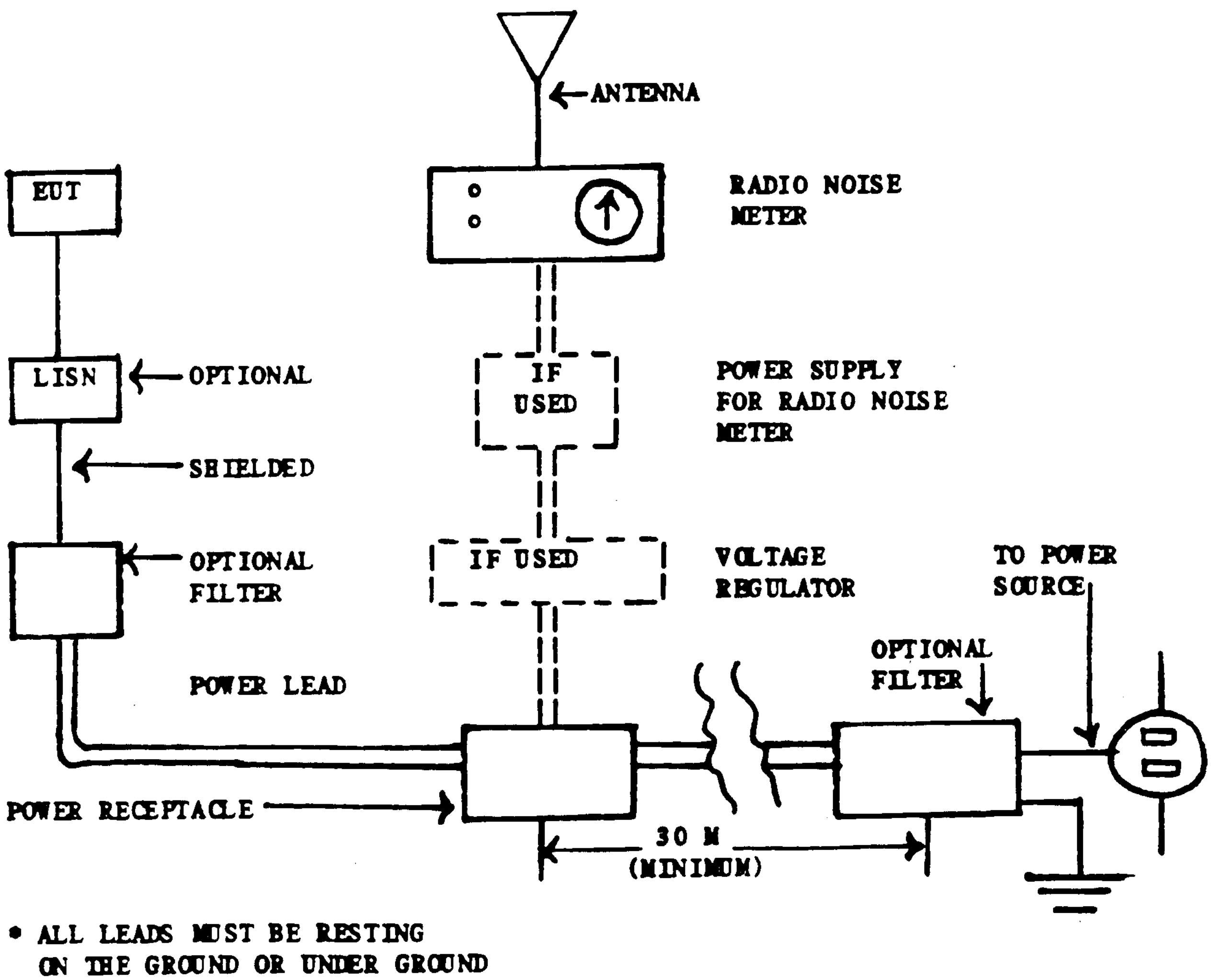

FIGURE 1 - SUGGESTED LAYOUT FOR

OPEN FIELD TESTS

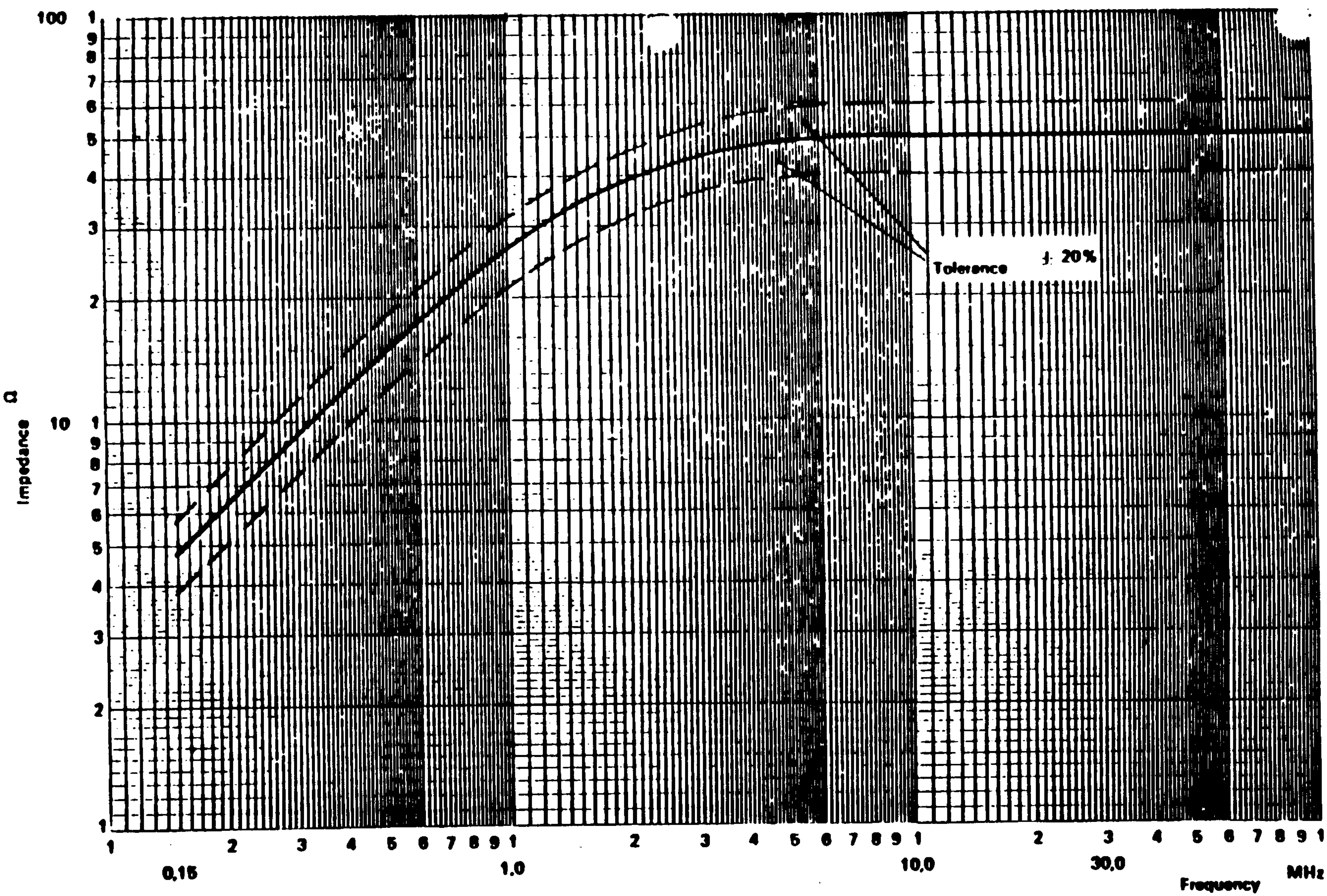

Figure 2A - Impedance Characteristics of 5 uH/50 ohm LISN

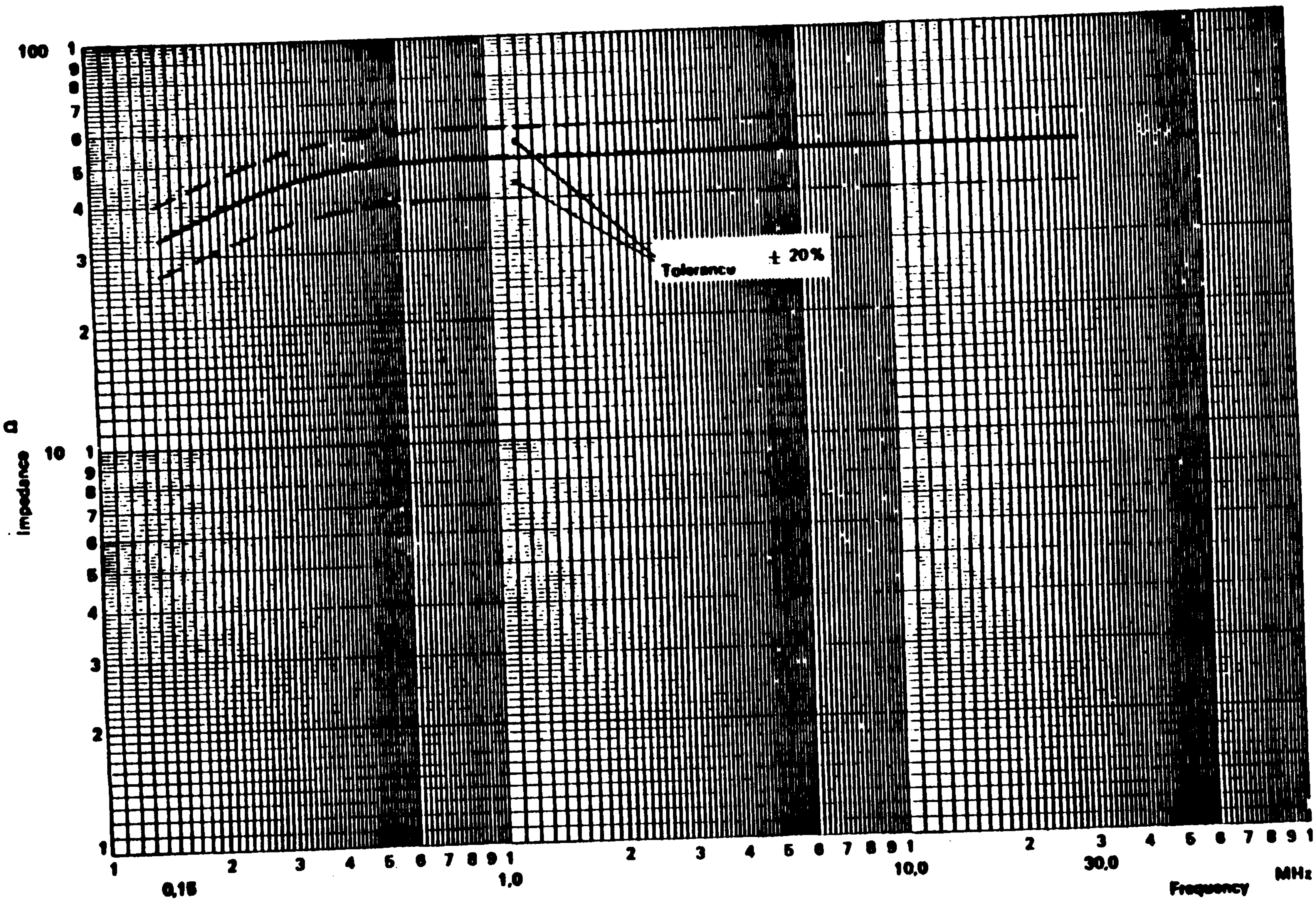

Figure 2B - Impedance Characteristics of 50 uH/50 ohm LISN

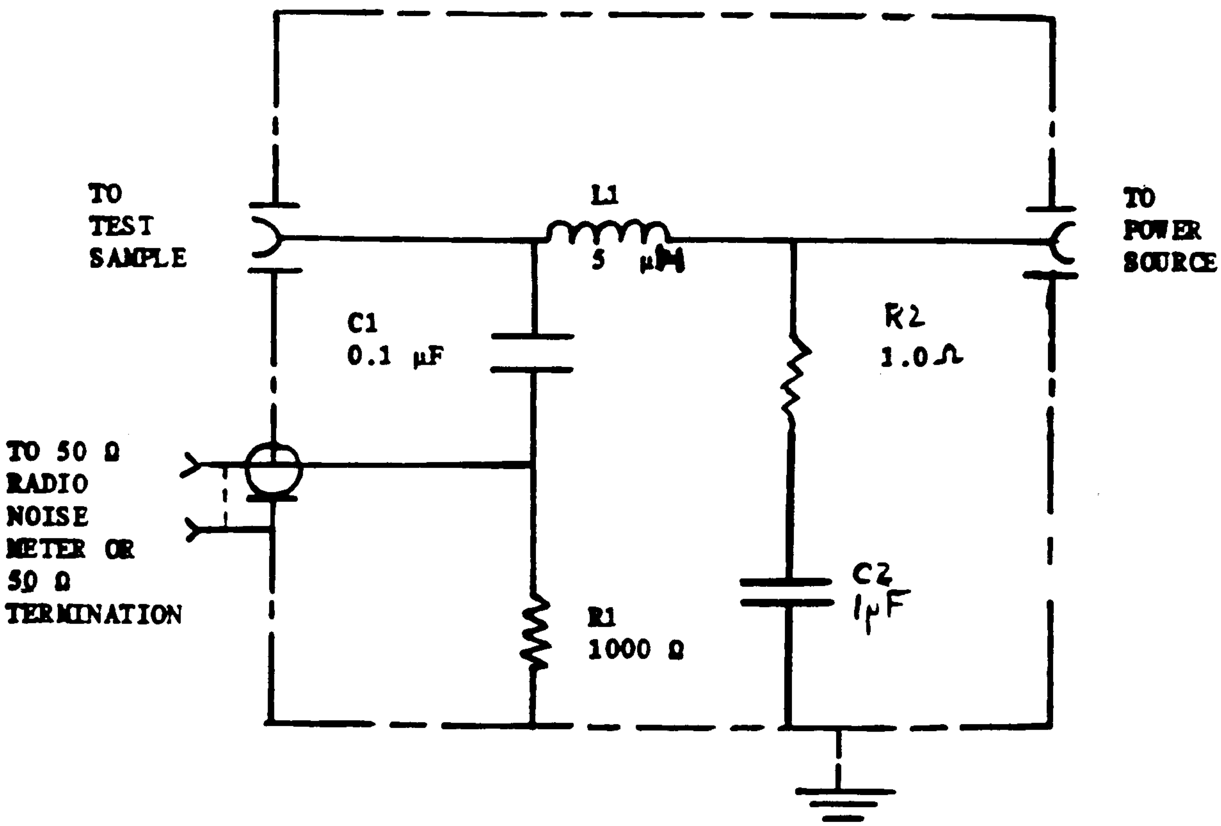

Figure 3A - Circuit Diagram for 5 uH/50 ohm LISN for low power measurements

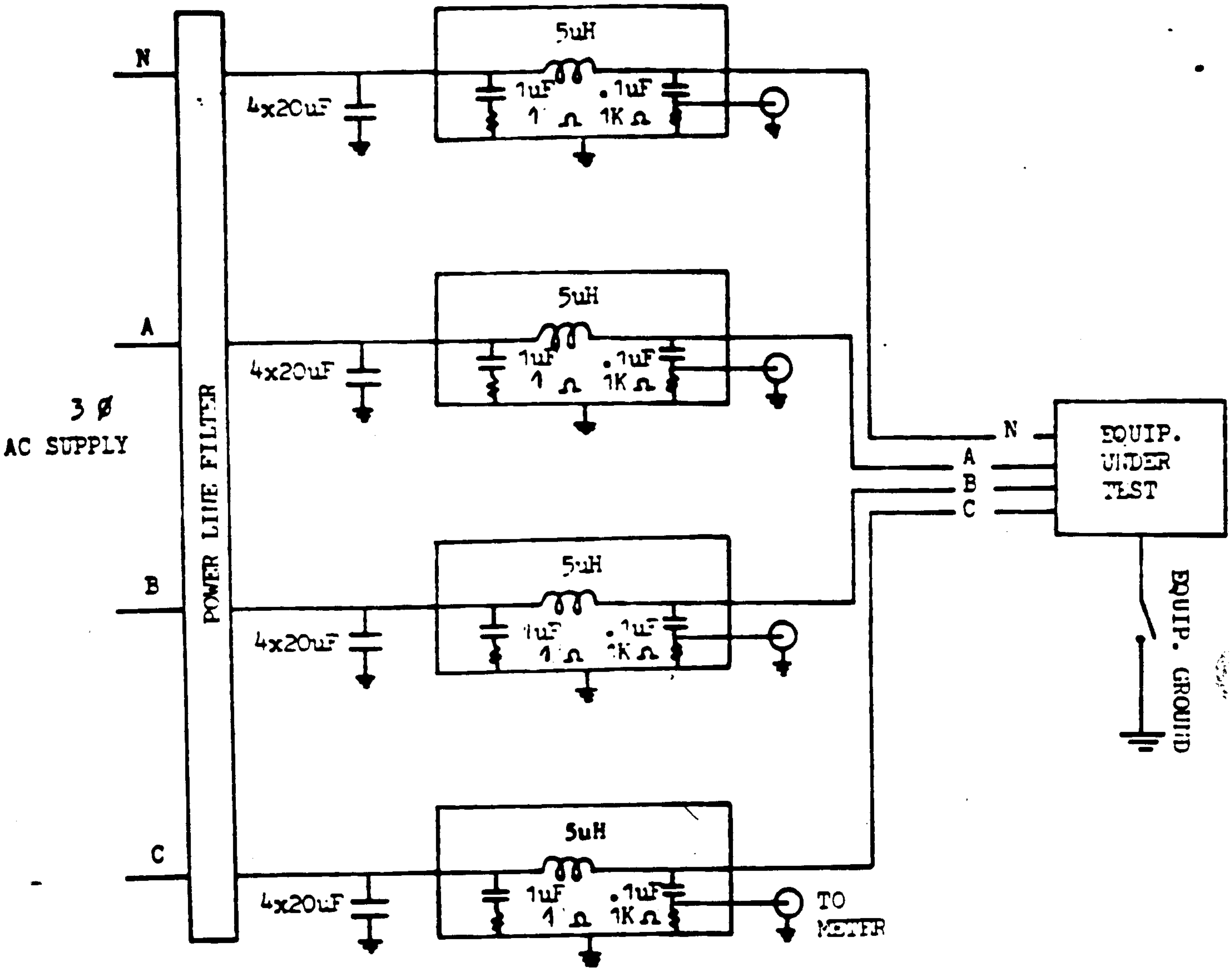

Figure 3B - Circuit Diagram for 5 uH/50 ohm LISN for high power measurements

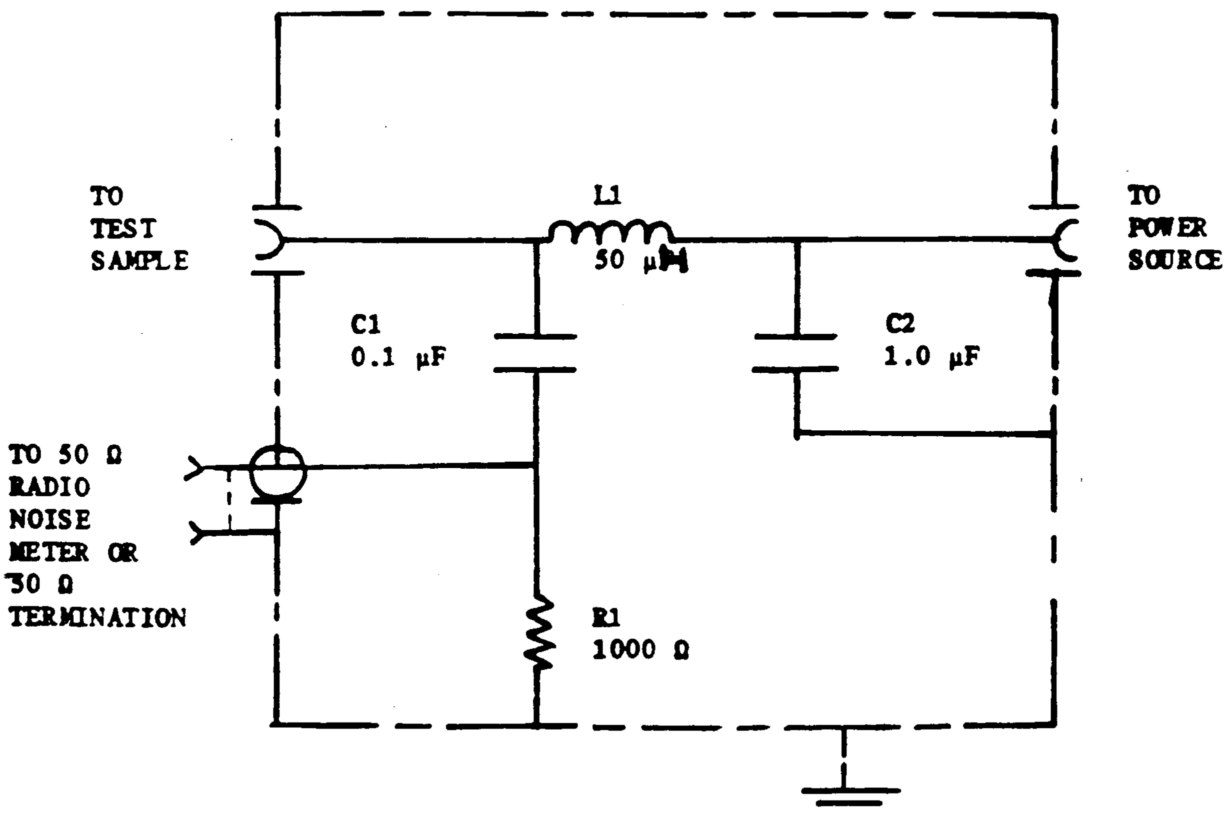

Figure 3C - Circuit Diagram for 50 uH/50 ohm LISN

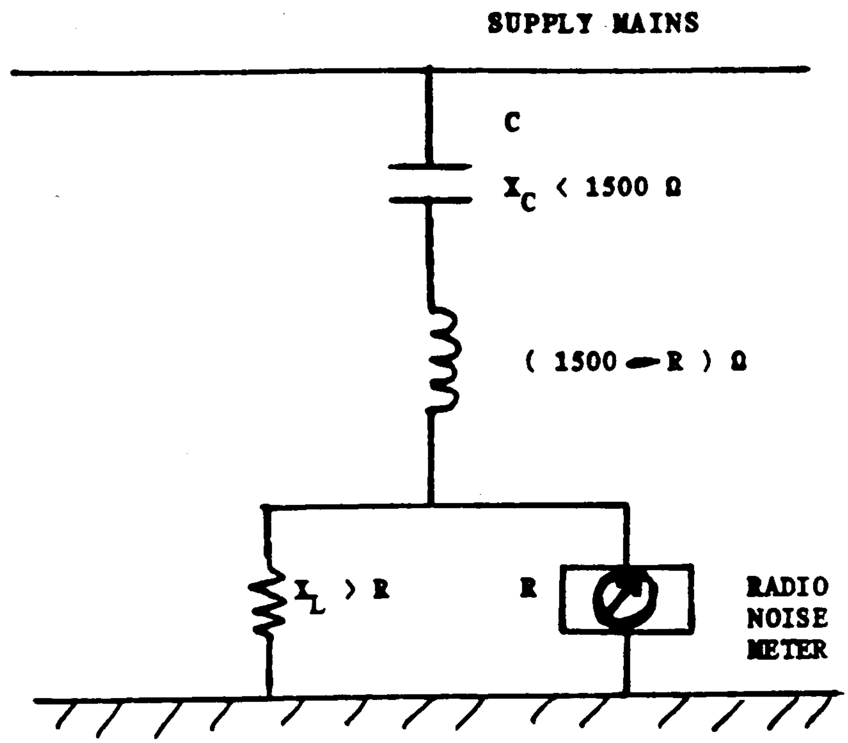

Figure 4 - Line Probe for Tests at Users's Installation