FEDERAL COMMUNICATIONS COMMISSION

FCC PROCEDURE FOR MEASURING RF EMISSIONS FROM COMPUTING DEVICES

Federal Communications Commission
Authorization and Evaluation Division
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1.0 Scope

This procedure sets forth uniform methods of measurement of radio noise emanating from computing devices as defined in Section 15.4 of Part 15 FCC Rules (47 CFR 15.4). Specifically ,it sets forth a uniform procedure, which will be used by the Federal Communications Commission, when measuring radiated and AC powerline conducted radio noise emanating from a computing device. Sample testing of a certified or a verified computing device by the FCC will be conducted in accordance with these methods of measurement.

2.0 Reference Standard

The following shall form a part of this standard to the extent applicable:

(1) American National Standard Specifications for Electromagnetic Interference and Field Strength Instrumentation 10 kHz to 10 GHz, ANSI C63.2(1980).

(2) American National Standard Methods of Measurement of Electromagnetic Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 10 kHz to 1 GHz, ANSI C63.4(1981).

(3) Part 15 of FCC Rules and Regulations (47 CFR Part 15).

3.0 Definitions

The definitions in Parts 2 and 15 of the FCC Rules and the following definitions shall apply to the use of this standard. The definitions in the IEEE Standard Dictionary of Electrical and Electronics Terms, 2nd Edition, IEEE-100-1977, will be used, except as noted below.

3.1 Equipment Under Test (EUT)

A representative sample of a computing device under test in a typical configuration.

3.2 Ground Plane

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

3.3 Line-Impedance Stabilization Network (LISN)

A network (sometimes called artificial mains network) inserted in the supply mains lead of the EUT that provides a specified measuring impedance to the EUT for AC powerline conducted measurements. It also isolates the EUT and measuring equipment from the supply mains at radio frequencies.

4.0 Test Site

Radiated and AC powerline conducted measurements shall be made in an environment which assures valid, repeatable measurement results. For radiated measurements, testing shall be conducted in an open field (see 4.1). Testing at other areas is unacceptable, unless it can be shown that the results of such measurements are equivalent to measurements made in an open field (see 4.1.1). For equipment which can only be tested in its place of use, and the conditions of 4.1.1 cannot be satisfied, the conditions of 4.1.3 shall apply. A description of the test facility used for testing computing devices subject to certification shall be filed with the Federal Communications Commission, pursuant to Section 15.38 of the FCC Rules (47 CFR Section 15.38).

4.1 Open Field Test Site

Measurements of radiated radio noise shall be made in an open, flat area characteristic of cleared, level terrain. 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, DC 20554. Radiated measurements made by the Commission will be performed on an open field test site.

4.1.1 Tests at Laboratory, Factory or Other Facilities

Compliance with the FCC limits for computing devices shall be based on tests being made on an open field test site, or equivalent, unless measurements are made at the user's premises for a unique installation per Section 4.1.3. Where it can be shown that the results of tests made in a laboratory, factory, anechoic room, dedicated factory site or other facility are correlatable to those made in an open field site, such test results will be considered acceptable. Sufficient tests over the entire frequency range of 30 to 1000 MHz shall be made to demonstrate that the alternative site produces results that correlate with the results of tests made in an open field. In the event that the Commission tests a sample device, measurements will be made in an open field and the results so obtained will determine compliance.

4.1.2 Testing in a Shielded Enclosure

Radiation measurements made in a shielded enclosure are suitable only for determining the frequency of each emission from an EUT. Because of multiple path reflections causing in-phase additions and out-of-phase cancellations to radiated emissions, the emission levels measured in a shielded enclosure are uncorrelatable to an open field test site. Care should be taken to assure that pre-scan emissions are not masked by cancellation. AC powerline conducted radio noise measurements made in a shielded enclosure are acceptable.

4.1.3 Testing at User's Installation (On-Premises Testing)

Testing is permitted at the end user's premises, if the equipment cannot be set-up on an open field test site. In this case, both the equipment and its location are considered the EUT. The radiated emission results are unique to the installation site because site containment properties affect the measurement. The AC powerline conducted emanation results also may be unique to the installation. However, where testing of a given system has been accomplished at three or more representative locations, the results can be considered representative of all sites for purposes of determining compliance with emission requirements. See 5.2 and 6.4.

4.1.4 Individual Equipment Test Requirements

For some computing devices, 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 FCC Laboratory that the special requirements and procedures to be followed are satisfactory before actually performing the measurement.

4.2 Measurement Instrumentation

Measurements of radiated and AC powerline conducted radio noise shall be made with a radio noise meter conforming to the quasi-peak instrumentation in reference (1) of 2.0. 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 emissions over the specified frequency range. Other instruments may be used for certain restricted and specialized measurements when data so measured is correlated to that achieved with the quasi-peak instrumentation in reference (1) of 2.0. For determination of compliance of a computing device, the Commission will use the quasi-peak instrumentation.

> Note: Accessories needed would depend upon the measurement situation and could include preamplifiers for sensitivity improvement, filters and attenuators for overload protection, and additional quasi-peak detection circuitry. Overload is defined as harmonic distortion, intermodulation, or gain compression of spectrum analyzer input signals. Post detector video filters shall not be used. 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.

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. Automatic scan techniques may be used, however, extreme caution must be exercised to insure that each emission is maximized

4.2.1. Calibration

The measuring instruments, antennas, test facility, Line Impedance Stabilization Network shall all be checked and calibrated, as necessary, to insure accuracy of measurements.

4.2.2 Detector Function and Selection of Bandwidth

During radiated and AC powerline conducted emission testing, radio noise meters, or spectrum analyzers which 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 measurements over the frequency range of 30 to 1000 MHz. The 6 dB bandwidth of the measuring instrument shall not be less than 9 kHz for AC powerline conducted testing over the frequency range 450 kHz to 30 Mhz. Other detector functions and bandwidths may be used for making the above measurements, provided data so taken is correlatable to data taken with the C63.2 instrumentation. Any deviation from using the specified C63.2 instrumentation must be justified in the test report for the EUT.

Notes:

1. Use of bandwidths greater than those specified above may produce higher readings for certain types of emissions.

2. For AC powerline conducted tests, the following option may be exercised if the EUT emission exceeds the limit when using the quasi-peak instrumentation. If the level of the emission measured using the quasi-peak instrumentation is 6 dB, or more, higher than the level of the same emission measured with instrumentation having an average detector and a 9 kHz minimum bandwidth, that emission is considered broadband and the level obtained with the quasi-peak instrumentation may be reduced by 13 dB for comparison to the limit. When exercising this option both of the following conditions shall be observed:

   (1) The measuring instrumentation with the average detector shall employ a linear IF amplifier.

   (2) Care must be taken not to exceed the dynamic range of the measuring instrument when measuring an emission with a low duty cycle.

4.3 Antennas

The FCC shall use a calibrated, tuned half-wave dipole antenna as a reference standard for measuring the level of radiated emissions from a computing device. Another linearly polarized antenna may be used, provided the result

obtained with such an antenna is correlatable to the level 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.

4.3.1 Antenna-to-Test Unit Distance

An EUT subject to a radiated limit at 3 meters shall be measured at a distance of 3 meters, unless doing so would be impractical because of size of the equipment, location, etc. In that case, measurements may be made at a further distance up to 30 meters and the results extrapolated inwards utilizing an inverse linear distance extrapolation factor (i.e., 20 dB/decade). Equipment subject to a limit at 30 meters may be measured at a distance of from 3 to 30 meters provided that the results are extrapolated to equivalent signal at 30 meters utilizing an inverse linear distance extrapolation factor (20 dB/decade). The Commission uses a distance of 30 meters for determining compliance of a Class A computing device.

The horizontal 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.

4.3.2 Antenna Height Variation

The antenna shall 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. At a distance of 30 meters, the height shall be varied from 2 to 6 meters. At intermediate distances from 10 to 30 meters, it may be necessary to adjust the minimum antenna height above ground down to 1 meter in order to maximize emissions. 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 antenna clears the site ground surface by at least 25 centimeters.

4.4 Frequency Range To Be Scanned

For radiated emission measurements, the frequency range shall be searched from 30 MHz to 1000 MHz. For AC powerline conducted measurements, the frequency range shall be searched from 450 kHz to 30 MHz.

4.5 Configuration of Equipment Under Test (EUT)

The components required to comprise a system are discussed in 4.5.1 and 4.5.2. The testing of multi-component systems shall satisfy the following two conditions:

1. The system is configured for use in a typical manner.

2. The system is configured in a manner that will maximize emissions.

The term system refers to the EUT, the components that are connected to the EUT, and all functional connecting cables.

The term configuration refers to the orientation of the EUT, the other components of the system, the interconnecting cables, and the AC power cords that comprise the system. During all measurements, the configuration of the system will be adjusted so that the two above conditions are maintained, within the guidelines described in the following sections.

The term typical is used to describe an arrangement of how the EUT will actually be used by the customer. Guidelines for setting up a typical configuration are outlined in sections 4.5.1, 4.5.2, 4.5.3 and 4.5.4.

4.5.1 Test Configuration of EUT

For computing devices designed to be part of a multi-unit system, the EUT shall be installed in a typical system and configured in accordance with the manufacturer's instructions. It shall also be operated in a manner that is representative of the typical usage for that EUT. During all tests, the EUT and all system components shall be manipulated within the confines of typical usage to maximize each emission.

A computing device containing interface ports shall have each port connected to an appropriate peripheral for the purposes of testing a typical configuration. If the EUT incorporates multiple interface ports for connection of identical peripherals, only one external peripheral of each type needs to be attached to the EUT during testing, provided it can be shown through testing that the use of any additional peripherals would not take the system out of compliance. Otherwise, all interface ports on the EUT shall have an external peripheral connected to it.

However, if the EUT is a Class B computing device that provides a unique interface port for a peripheral which is not yet available, the application for certification of the EUT must state the intended use of the unique interface port and when the peripheral device for it will be available. When the peripheral device becomes available, a Class II permissive change shall be filed for the EUT in accordance with Section 2.1043 of the FCC Rules. A new FCC ID may be required for the EUT if it is modified in order for the peripheral to comply with the computing device limits.

If the EUT is a Class A computing device that provides a unique interface port for a peripheral which is not yet available, see the guidelines in 4.5.5 regarding the use of simulators.

4.5.2 Test Configuration of a Personal Computer and Peripherals

A personal computer and/or peripherals for such devices shall be tested in a system containing the following minimum number of components:

1. Personal computer

2. Keyboard

3. External monitor

4. External peripheral for a serial interface port (internal modems do not satisfy the requirement for an external serial peripheral)

5. External peripheral for a parallel interface port.

If a personal computer (EUT) is not equipped with any of the specified interface ports, the ports must be added to the EUT to form a minimum system for the purposes of testing. If the EUT is equipped with more than the minimum required interface ports for external peripherals, peripherals shall be attached to all existing interface ports following the guidelines in 4.5.1. Personal computer peripherals shall be tested as a part of a minimum system as described above.

The following guidelines are to be used to configure the minimum system described above to maximize each emission:

1. The computer, keyboard and all peripherals will remain in one plane on top of a non-conducting table-top surface 1.0 x 1.5 meters in size. With the exception of the interface cables that are draped, the system will be confined to the table top surface. Movement of the computer and all peripherals will be limited by the size of table top.

2. The monitor will be placed on top of the computer when appropriate to do so and also moved to the right and left side of the computer. Movement of the monitor will be limited by the length of the video interface cable and the size of the table top.

3. The keyboard shall be positioned in the vicinity of the front of the monitor and shall remain within the boundaries defined by the front plane of the monitor and the boundaries of the table top surface.

4. Excess interface cable length between the EUT and other system components will be draped over the back edge of the non-conducting table top surface. If any draped cable is

closer than 50 centimeters to the ground plane, that interface cable shall be bundled in the center in a serpentine fashion using 30 to 40 centimeter lengths until the cable is at least 50 centimeters above the ground plane. Each interface cable shall be bundled individually. Bundled interface cables should be approximately 1 meter in length. Interface cables shorter than 1 meter in length shall not be bundled during testing. Interface cables less than 1 meter in length shall not be used for testing, unless marketed with the EUT.

5. AC power cords from the EUT and system components shall be draped over the back edge of the table-top and hang vertically down to the surface of the rotator which contains the AC power outlets. Excess power cord length shall lie unbundled on the surface of the rotator.

6. If the personal computer has an auxiliary AC outlet which can be used for providing power to an external monitor, then all measurements shall be made with the monitor powered from first the computer-mounted AC outlet and then a floor-mounted AC outlet.

4.5.3 Interface Cables within a System

Interface cables shall be connected to each interface port on the EUT. This includes standard interface bus ports (IEEE 488, RS-232-C) provided on computers and peripherals. The effect of varying the position of each cable shall be investigated to find the configuration that maximizes each emission.

Interface cables shall be of the type and length specified by the equipment manufacturer. If multiple lengths are used with the equipment, the test engineer shall select the cable length that is likely to produce maximum emissions.

Any excess length of each cable shall be separately bundled in a serpentine fashion at the approximate center of the cable with the bundle 30 to 40 cm in length. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at an user installation, disposition of the excess cable length is left to the discretion of the test engineer and should be noted in the test report.

Cables shall not be placed underneath or over the top of the EUT or any system components unless it is appropriate to do so, e.g., a cable is normally routed through overhead cable racks or under the ground plane for instance. Cables shall be positioned adjacent to the exterior cabinets of the EUT and all system components in an attempt to maximize emissions.

4.5.4 Operating Conditions of the EUT

If the EUT can be operated with different clock speeds or software that produces different data speeds, these different conditions of operation shall be checked to maximize each emission. Two modes of operation will be examined for every EUT:

1. The EUT powered on and awaiting data input/output.

2. The EUT receiving/sending data in a typical operation.

Each emission is to be maximized by varying the mode of operation, clock speed and software programming, where applicable.

If the EUT is a personal computer or a personal computer peripheral, in addition to the above conditions, the following is to be used for all testing:

1. A simple basic language program which generates a complete line of continuously repeating "H" (upper case h) pattern is used as the software test program. This pattern is alternately sent to the video port device, the parallel port device, the serial port device, and written (saved) and read (loaded) to the disk drives to observe which operating condition maximizes each emission. Each peripheral device must be exercised independently.

2. Monitors shall display the "H" pattern in white letters on a black background. Monitors that cannot display the "H" pattern this way shall display it using illuminated letters on a non-illuminated background.

3. Printers shall print the "H" pattern during testing.

4.5.5 Interfacing Units and Simulators

In situations when the EUT is required to functionally interact with other units, the following guidelines shall be used to determine whether a component or a simulator may be utilized to provide representative operating conditions.

(1) Simulators shall not be used for determining the compliance of a computing device subject to certification.

(2) If the EUT is a peripheral being separately measured for compliance, it shall be tested with at least one computer in a typical configuration.

(3) If a device is designed to be used with a specific computer or peripheral, it shall be tested with that computer or peripheral. It is not necessary to test the EUT with all compatible computers or peripherals.

(4) To the extent possible, the computer and/or the peripherals which form the test system for the EUT (support equipment) shall be equipment marketed by the individual or corporation held responsible for the EUT by the Commission. Support equipment for the EUT shall also be of a type typically used with the EUT.

(5) The support equipment for the EUT shall not be modified in order for the EUT to achieve compliance unless the modified device(s) will be packaged and marketed with the EUT.

(6) Equipment marketed as a system shall be tested as a system.

(7) Because of the added degree of measurement uncertainty when a simulator is used, such use should be avoided. However, if the EUT is a Class A device, a simulator may be used when the logistic circumstances of the equipment installation or the measurement facility would make the use of actual interfacing units impractical. However, it is important that any simulator used properly represent the electrical characteristics, such as, impedances and RF signals of the intended interfacing units. In addition, interaction due to mechanical characteristics should be identified and duplicated.

4.5.6 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 grounding terminal or internally-grounded lead which is to be connected in 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 AC line cord of the EUT shall be connected to ground through the utility power service (see also 5.0 and 5.2).

4.6 Test Environment

The environment at the test site should satisfy 4.6.1, 4.6.2 and 4.6.3.

4.6.1 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. It is recognized that desirable is not always realizable. However, in the event that the measuring levels of the ambient plus EUT radio noise emissions are not above the applicable limit, the EUT shall be considered to be in compliance with the limit.

If the ambient field or the powerline ambient level at some frequencies within the specified measurement ranges exceeds the applicable limit(s), the following alternatives may be used:

(1) Perform measurements at the closest distance permitted by 4.3.1 and extrapolate results to the specified limit distance.

(2) Perform measurements of critical frequency bands during hours when broadcast stations are off the air and ambients from industrial equipment are lower.

(3) Resort to measurement in an anechoic chamber or room (see 4.1.1 for conditions of use). Measurements made in a shielded (metal) enclosure are not acceptable for the purpose of determining compliance with the radiated emission limits (see 4.1.2).

(4) For AC powerline conducted measurements, insert suitable line filters between the power source and the LISN.

(5) In orienting the axis of an open field 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 insofar as possible.

4.6.2 Test Platform

For an EUT normally operated on top of a table, radiated emission tests will be performed with the EUT on a non-conducting table, the top of which is 1.0 meters by 1.5 meters in size (See figure 1). The table will be placed on a remotely controlled rotating platform constructed with non-conducting materials. The top of the rotating platform shall be less than 0.5 meters above the ground plane and the height of the table and platform together shall be approximately 1 meter above the ground plane.

An EUT normally placed on the floor will be tested for compliance on the floor. A flush-mounted rotating platform is useful in this situation, but not mandatory.

4.6.3 Ground Plane

A ground screen is highly recommended, but is not mandatory, for radiated emissions tests. 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. A ground screen is required if the test site is elevated above ground level, such as on a rooftop or raised platform. For AC powerline conducted measurements, an earth bonded ground plane shall be used as discussed in 5.3.

Note: A ground plane is optional for testing at a user's installation, unless it is a permanent part of the installation.

5.0 AC Powerline Conducted Measurements

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 (or via a separate transformer or power supply) connected to the public utility AC power lines. Measurements are to be made with the EUT connected to the public utility power lines through a nominal, standardized RF impedance, which is to be provided by a LISN.

If the EUT normally receives power from another device that connects to the public utility AC power lines, measurements shall be made on that device to insure that that device continues to comply with the appropriate FCC limits while providing the EUT with power. If the EUT is operated only from internal batteries, with no provisions for connection to the public utility AC power lines to operate the EUT, AC powerline conducted measurements are not required.

5.1 Line-Impedance Stabilization Network

A LISN having an impedance characteristic within the tolerances shown in Figure 2 is required for AC powerline conducted measurements. Figure 3 shows a network which will, if properly constructed, provide the specified impedance over the range 0.45-30 MHz. Any other network that provides the impedance characteristic in Figure 2 may also be used. A coaxial-type connector which provides a 50 ohm terminating impedance shall be provided for connection of the measuring instrumentation. One LISN shall be connected in series with each current-carrying conductor to the EUT. Provision shall be made for electrically bonding the LISN enclosures to the ground plane used (see 5.3). Power sockets or adapters provided to accept the plug of the EUT power cord shall be connected to the load terminals of the LISNs by low impedance connections as short as possible. Ground terminals of such sockets or adapters shall be bonded to the cases of the LISN by short, low impedance connections. The impedance of each LISN shall be measured once a year.

5.2 Line Probe

A line probe may be used for voltage measurements only when measurements are made at a user installation (see 4.1.3). For such measurements, the method shown in Figure 4 may be used where it is impractical to install an appropriate LISN. Special precautions must be taken to establish a reference ground for the measurements. An LISN shall not be used in conjunction with a line probe for measurements at a user installation. The measurements are dependent on the impedance presented by the supply mains and may vary with time and location due to variations in the supply mains. (It may be necessary to perform repeated measurements over a suitable period of time to determine the variation in measured values. The time period should be sufficient to cover all significant variations due to operating conditions at the

installation.) Such measurement results should be regarded as unique to that EUT and installation environment. The measurements should be made between each current-carrying conductor in the supply mains and the ground conductor with a blocking capacitor (C) and a resistor (R), shown in Figure 4, 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.

5.3 AC Powerline Conducted Test Set-up

A table mounted or hand-held EUT shall be placed on a non-conducting 1.0 by 1.5 meter table, which is 0.8 meters above an earth-grounded conducting surface approximately 2.5 by 3.0 meters square (e.g., the metal floor of a test chamber), and shall not be closer to any other earth-grounded surface than the distances shown in Figure 6. The entire ground plane shall be covered by insulating material 0.3 centimeters thick (e.g., rubber mat or floor tile). A floor standing EUT shall be placed directly on the insulating material for testing.

Power to the EUT shall be provided through the LISN arrangement specified in 5.1. Power to the LISN shall be filtered to eliminate ambient signal interference and this filter shall be bonded to the ground plane. Peripheral equipment required to provide a functional system (support equipment) for EUT testing shall be powered through a ganged, metal power outlet box which is bonded to the ground plane at the LISN. AC input power for the auxiliary power outlets shall be obtained from the same filtered source that provides input power to the LISN. Supply lines to the LISN and the ganged outlet box shall be the lengths specified in Figure 6 and shall be shielded. (See Figures 5 and 6.)

If the EUT is supplied with a flexible power cord, the power cord length in excess of the distance separating the EUT from the LISN shall be wrapped in a figure eight pattern around two non-metallic 9 centimeter high pegs approximately 2.0 centimeters in diameter, that are spaced 6 centimeters on center apart and are attached to the top of the LISN. If the EUT is provided with a permanently coiled power cord, bundling of the cord is not required.

If the EUT is supplied without a power cord, the EUT shall be connected to the LISN by a power cord of the type specified by the manufacturer which shall not be longer than 1 meter. The excess power cord shall be bundled as described above. If a non-flexible power cord is provided with the EUT, it shall be cut to the length necessary to attach the EUT to the LISN and shall not be bundled.

AC power cords of the support equipment shall be draped onto the insulating material which covers the ground plane. No power cords from support equipment shall be draped over the LISN. The EUT, any support equipment, and any interconnecting cables shall be arranged as described in Sections 4.5.2 and 4.5.3 and moved as shown in Figure 6 to maximize each emission.

6.0 Radiated Emission Measurements

Measurements of radiated radio noise shall be made using the measuring instrumentation and antennae specified in 4.2 and 4.3, respectively. All radiated emissions, including those from system components and connecting cables, shall be measured. Consistent with 4.5, above, the EUT shall be set up and operated in a manner representative of actual use.

6.1 Preliminary Testing and Monitoring

It is often valuable to perform preliminary radiated measurements at a closer distance than that specified for compliance to determine the emission characteristics of the EUT. At near 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. A site other than an open field may be used for this purpose, but the test engineer should be aware that alternate sites may not produce precisely correlatable results. A spectrum analyzer and broadband antennas are often useful in this type of testing. However, when 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 emissions from the EUT. Care must be taken not to miss any significant RF emissions during these preliminary tests.

6.2 Determination of Test Radial

The EUT shall be rotated to obtain the maximum level of radiated emissions from the system containing the EUT for each emission investigated. If the EUT cannot be rotated, measurements shall be made around the system. Each emission from the EUT must be independently investigated to determine its direction of maximum radiation.

A remote control turntable is recommended for accuracy and convenience in rotating the EUT to the azimuth of maximum field strength. A computing device subject to certification shall be rotated continuously through 360 degrees to assure this angle is found.

For larger and heavier computing devices, which cannot be easily rotated, the measuring instrument and test antenna may be moved at 20 degree intervals around the EUT to as many points as are necessary to determine the direction of maximum field intensity. Parties making measurements on test sites where the EUT is not rotated should understand that the minimum clearances for a test site with rotatable platform are not applicable (see FCC Bulletin OST-55); instead, the minimum clearance distance for a test site without a platform is a circular area centered on the EUT location and having a diameter of 3 times the maximum distance between the measuring set antenna and closest point of the EUT.

Where the EUT is not rotated on the site, measurements should be made of the strength of each of the emissions noted in the preliminary tests in the azimuthal direction determined in those tests.

6.3 Radiated Radio Noise Tests

Radiated radio noise measurements shall be made at a test site described in 4.1, above. The EUT shall be rotated as per 6.2 and measurement antenna height varied as prescribed in 4.3.2 in order to obtain a maximum reading on the measurement instrument. Tests shall be made in both the horizontal and vertical planes of polarization over the frequency range given in 4.4.

6.4 Radiated Emission Tests at User's Installation (IN-SITU)

Testing of the installed EUT may be performed at the end-user's installation with the results generally regarded as unique to the EUT and installation environment. However, where testing has been accomplished at three or more representative locations, the results can be considered representative of all sites for purposes of determining compliance with emanation limits. If no detailed instructions are given in the individual equipment requirements, measurements shall be made to locate the radial of maximum emission at a distance 30 meters from the equipment being tested. Where measurements at the 30 meter distance from the EUT are impractical, measurements may be made at lesser distances and extrapolated to the 30 meter distance from the EUT. A LISN shall not be used for testing of the user's installation in order that the measured radio noise voltage be representative of the specific site.

7.0 Data Recording Format

Measurements of radiated RF emissions shall be reported in terms of microvolts per meter at the distance specified in the FCC Rules. The indicated readings on the measuring instrument shall be converted to microvolts per meter by use of appropriate conversion factors. All formulas of conversions and conversion factors shall be included in the measurement report. Measurements of AC powerline conducted interference shall be reported in terms of microvolts. All radiated and AC powerline conducted emissions within 10 dB of the limits shall be reported.

The measurement results along with the appropriate limits for comparison shall be presented in tabular form. If an alternate test method is used, the test report must identify that method and justification for its use shall be provided. Instrumentation, 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. When automatic scan techniques are used, an explanation of how each emission from the EUT was maximized shall be included in the test report along with the scan rate used to obtain each level.

The justification for selecting a particular EUT configuration and a particular length of interface cable to produce maximized emissions must be documented in the test report. Photographs clearly showing the test set-up and interface cable arrangement for the highest radiated and line conducted emission measured shall be included.

Other items which shall be included in the test report are listed below:

1. The specific identification, including the FCC ID's if applicable, of the host device and any support equipment (including any internal add-on boards) which comprise the system containing the EUT.

2. Specify the construction of each interface cable as to shielded or unshielded, plastic or metallic hoods, ferrite bead on cable or not, etc.

3. Changes made to the EUT or other system components during compliance testing should be documented in the test report.

Note:

In the case of devices required to be certificated, refer also to Part 2 (Sections 2.909, 2.925, 2.926, 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.

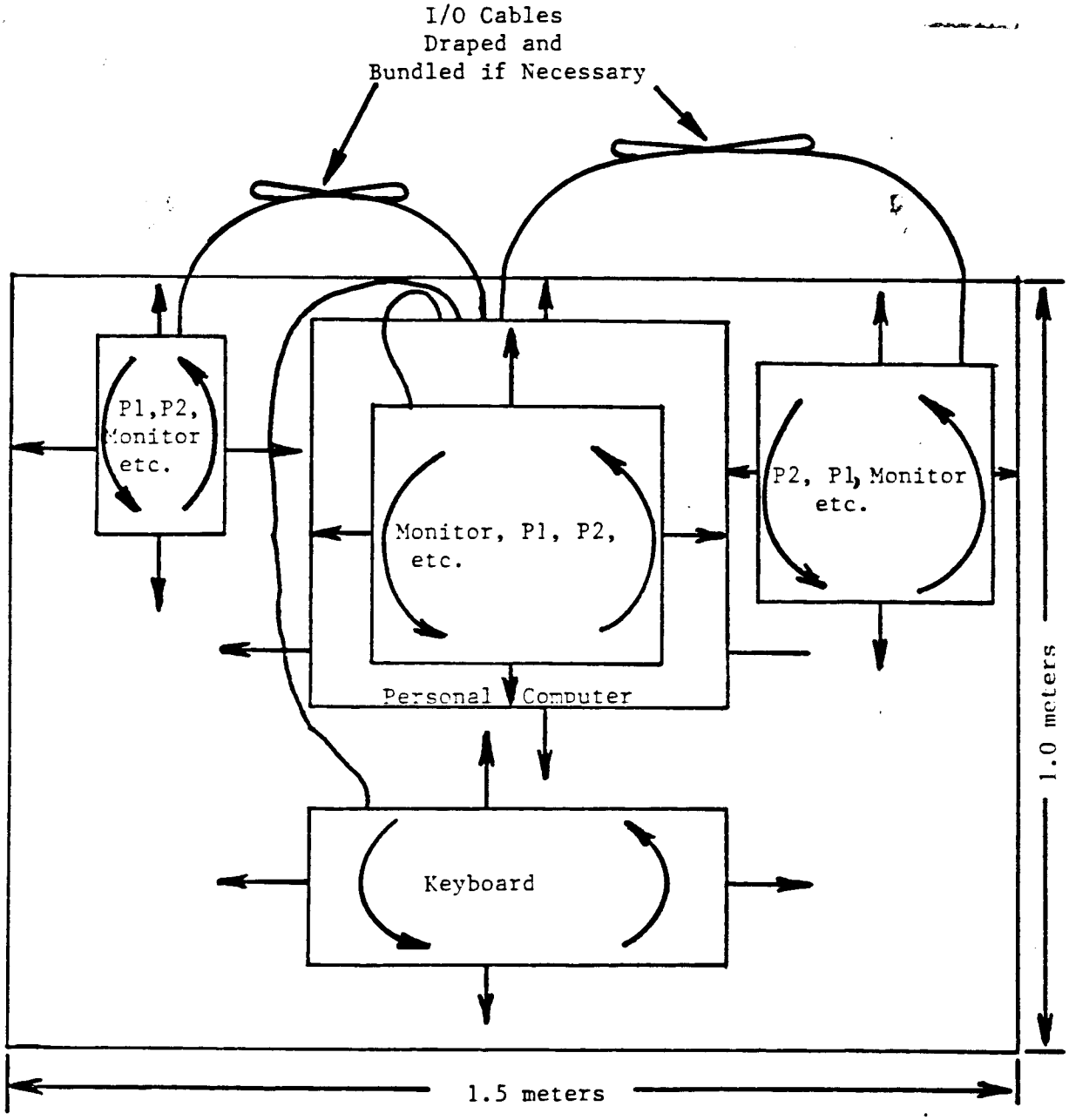

Figure 1 - Test platform for making radiated measurements of a Personal Computer System. (Top View showing interface cables only). See 4.6.2

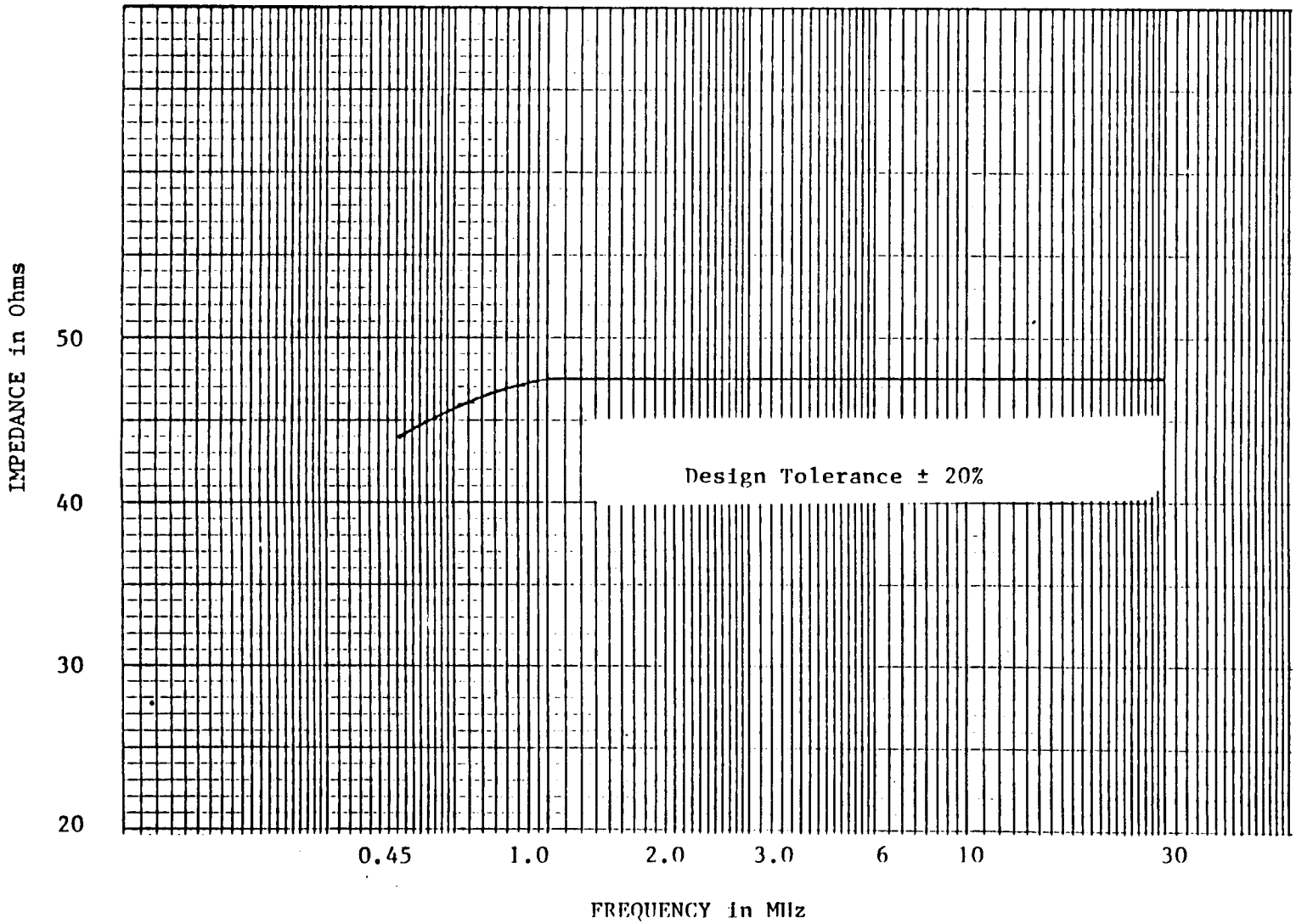

Figure 2 - Impedance vs Frequency Characteristic of desired Line Impedance Stabilization Network in the frequency range 0.45 to 30 MHz Sec 5.1

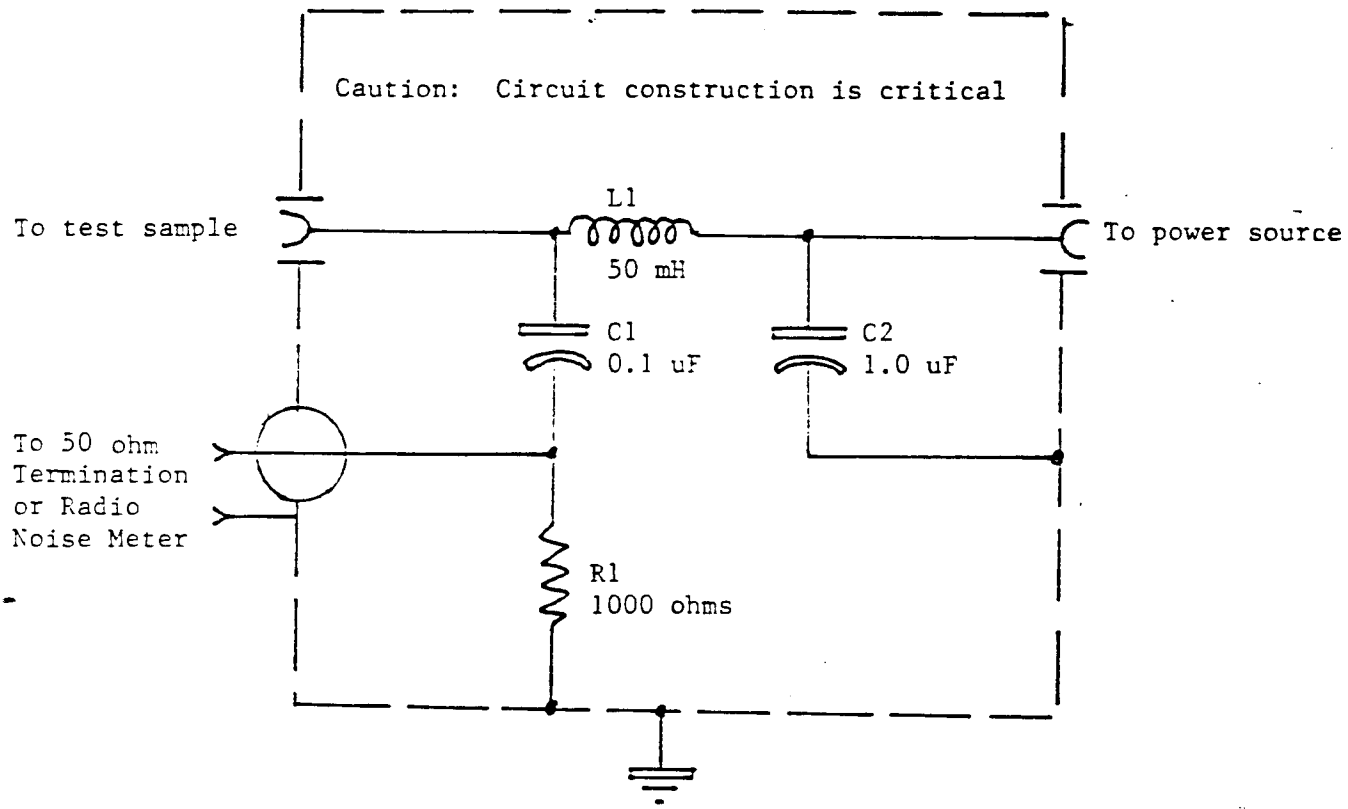

Figure 3 - Example of a circuit of a LISN capable of meeting the impedance characteristics in Figure 2 over the frequency range 0.45 to 30 MHz.
See 5.1

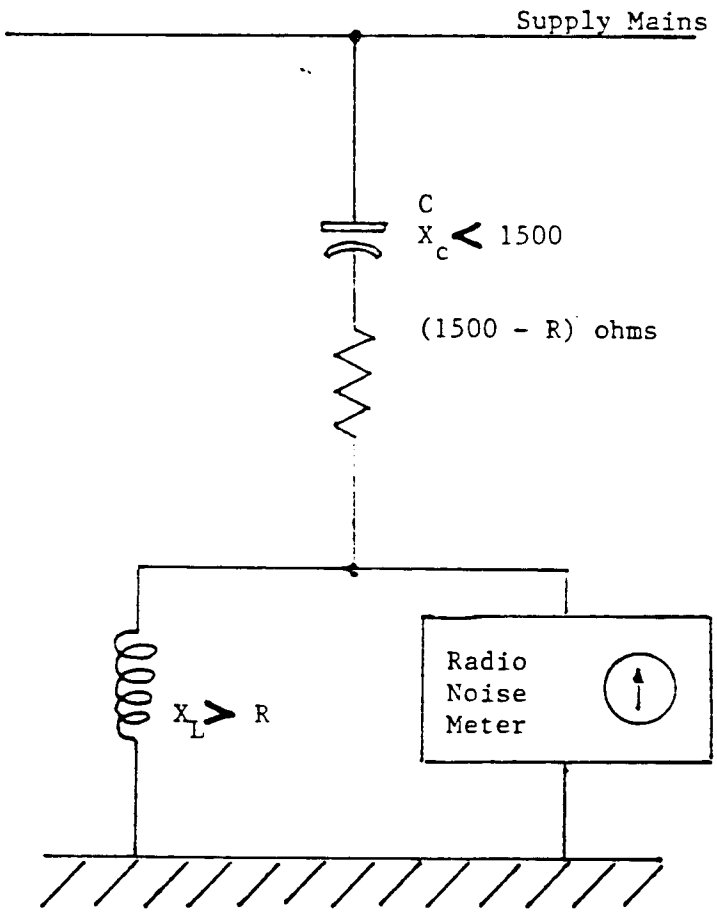

Figure 4 - Line probe for tests at user's installation.
See 5.2

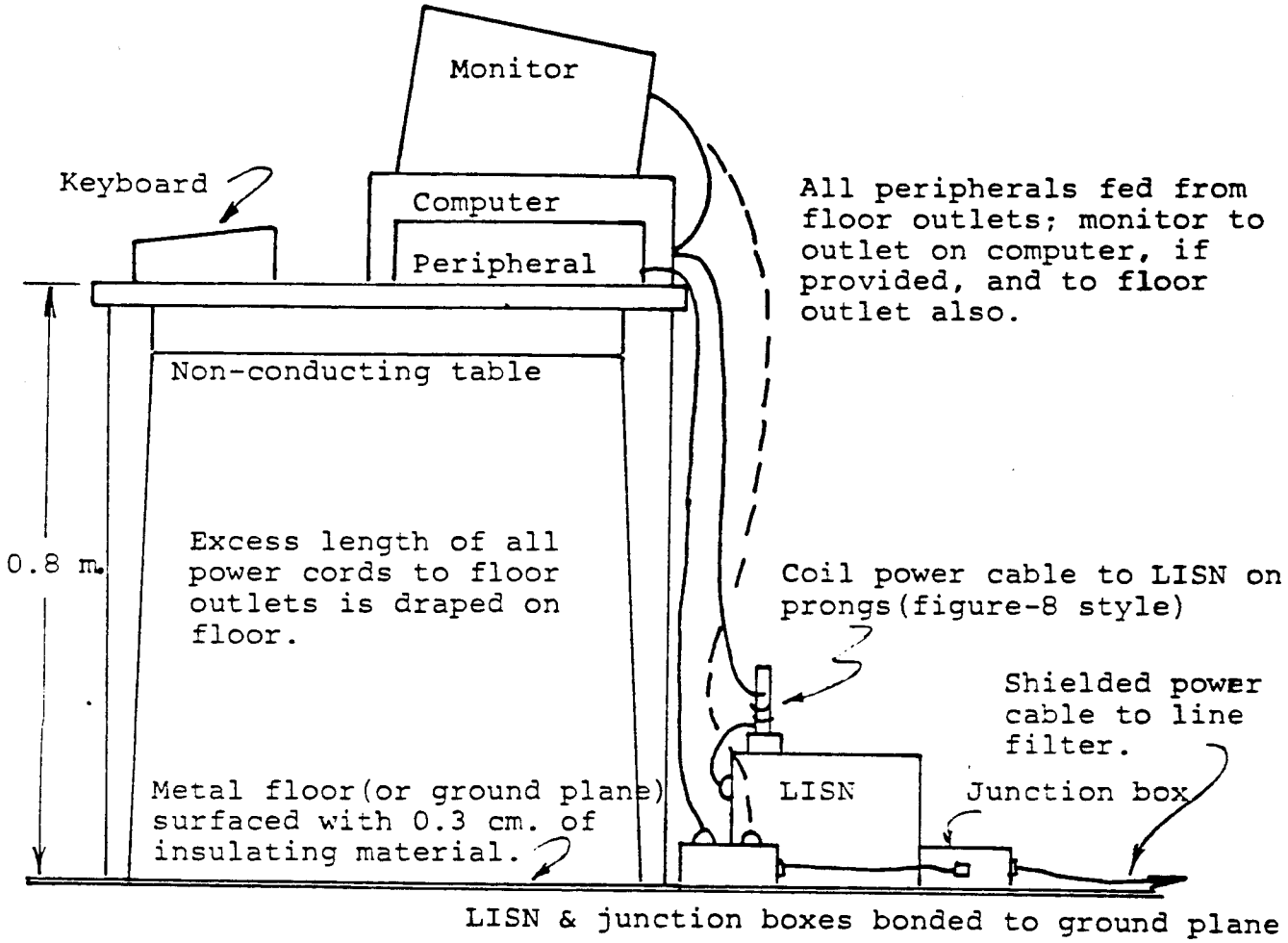

Figure 5 - Configuration of Personal Computer System for AC Powerline Conducted Measurements (Side view) See 5.3

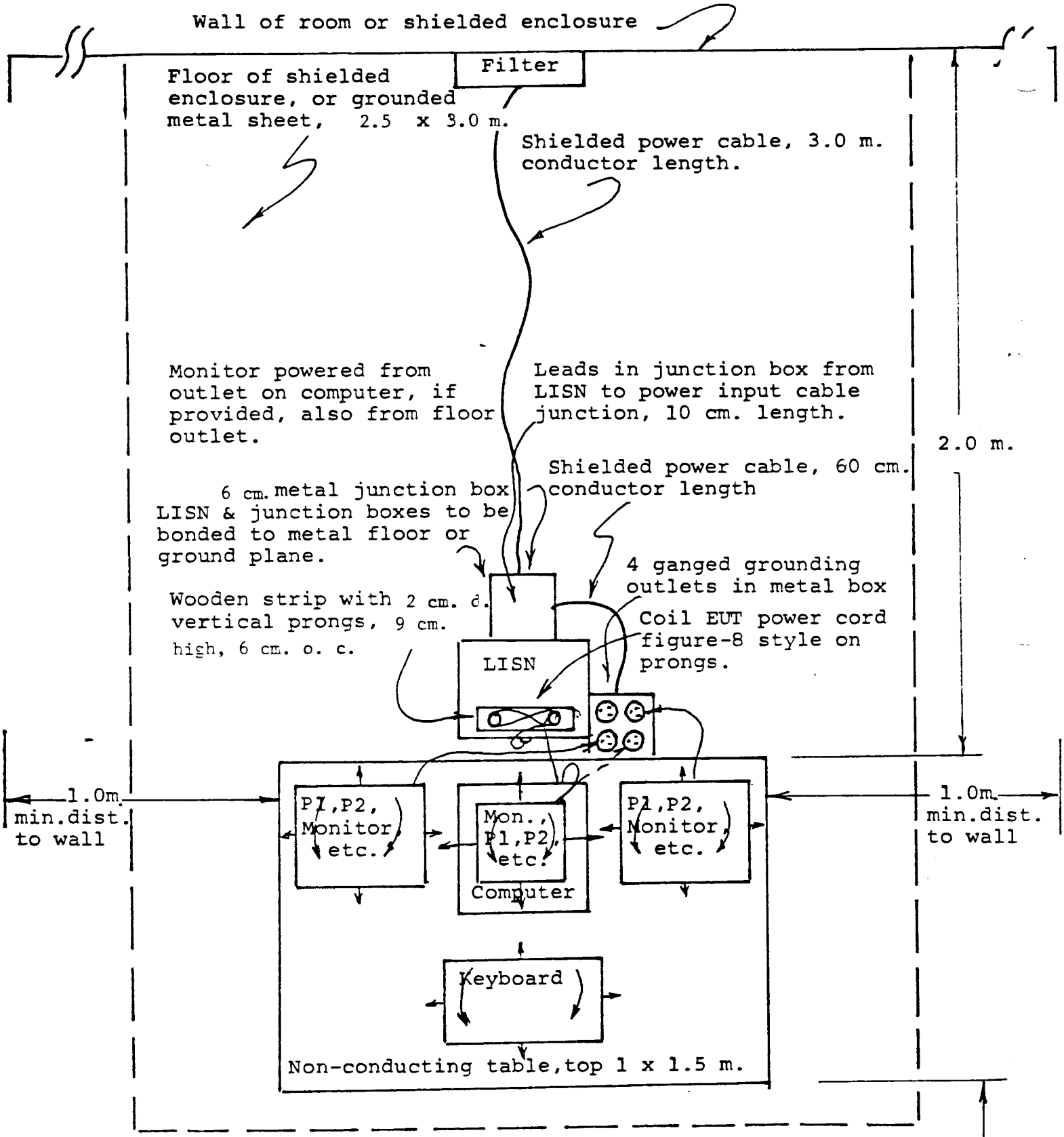

Figure 6 - Configuration of Personal Computer System for AC Powerline Conducted Measurements (Top view showing AC Power Cords only) See 5.3