INSTRUMENTATION FOR FCC-COMPLIANCE TESTING

Introduction

In September of 1979, the United States Federal Communications Commission issued Docket 20780, thereby modifying parts two and fifteen of the FCC rules by reducing the interference potential of electronic computing equipment. To comply with the new requirements, all Class B computing devices (for use in residential environments) first produced after January 1, 1981 were required to comply with new limits on both conducted and radiated interference. As of October 1, 1981, all Class A computing devices (commercial, industrial, or business environment) first produced after that date had to comply. By October 1, 1983, both Class A and Class B devices must comply, regardless of their dates of original manufacture.

In June of 1980, via Docket 80-284, the FCC proposed the method for measurements to determine whether computing devices satisfy the new requirements. Most of the respective strengths and weaknesses of spectrum analyzers and radio noise meters (also called "Tunable Voltmeters" and "Interference Analyzers") for making EMI measurements are well known. There are, however, two additional considerations deriving from the FCC specified characteristics for measurement instrumentation which could be of significance to some users. The first is the freedom to use either peak or CISPR (quasi-peak) detection, and the second is the specification of minimum bandwidths at or near the CISPR values. Of these options, the first effect to recognize is that the FCC specified instrumentation becomes identical to that of the German VDE (Verein Deutscher Elektro-Techniker) when CISPR (quasi-peak) detection is chosen. Any user interested in conforming to both FCC and VDE mandates could perform measurements for both agencies by using CISPR type quasi-peak instrumentation.

The second effect is that, in some instances, the conventional spectrum analyzer using peak detection will produce a higher reading than CISPR type quasi-peak instrumentation for the same interference. CISPR Quasi-peak detection is designed to produce a reduced reading as the repetition rate of a given level of impulsive noise is decreased (see Figure 1). Thus, designing a device based on interference readings using a peak detector could conceivably be at the expense of some overdesign, with regard to interference suppression.

The FCC requires two separate tests, line-conducted and radiated, on each test sample.

Power Line Conduction Measurements

The first test covering the frequency range of 450kHz-30MHz is the line-conducted test, which uses a line impedance stabilization network (LISN; see Figure 2) and an interference analyzer, or spectrum analyzer, to determine the interference level. The LISN is a relatively simple device which performs the functions of isolating the measurement from any interference already on the AC Mains, stabilizing the impedance presented and channeling the conducted interference to the meter for measurement. The main advantage of using a spectrum analyzer is the wide dispersion viewing allowing for a "quick look" at the entire frequency range from 450kHz-30MHz. If the spectrum analyzer is calibrated in microvolts, the resulting display can be photographed and used as part of the verification documentation. Line measurements should be made in a shielded enclosure to ensure that radiated ambient noise is not transmitted through the power leads of the article under test, thus making the final data incorrect. Each individual input line should have a LISN attached with its output terminated in 50 ohms (Figure 3). Instrumentation used for the line-conducted measurement should have a received bandwidth greater than 9kHz.

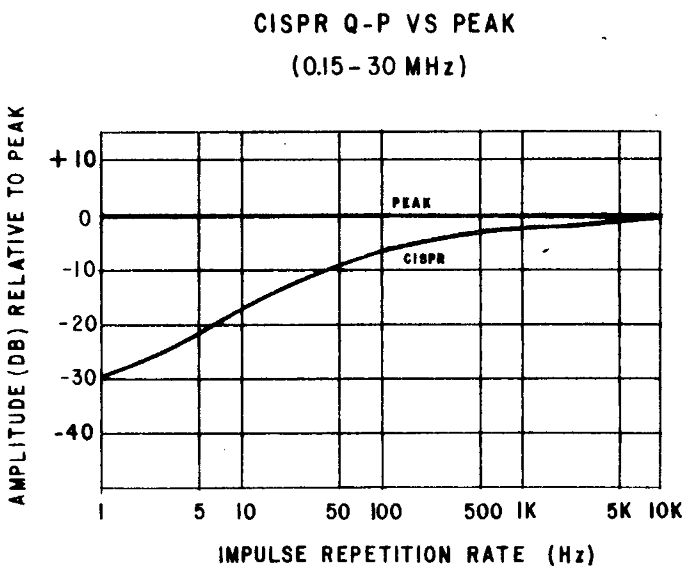

Figure 1.

A significant drawback to the use of a spectrum analyzer is the susceptibility of its front-end to overload. To reduce this possibility of overload, a band-pass filter can be used, limiting input signals to the frequency range of the test specification. If a receiver or interference analyzer is available for the line-conductive measurements, its advantages over a conventional spectrum analyzer are enhanced if it incorporates multiple detectors, including quasi-peak, as specified by ANSI and CISPR publications. In the conductive measurements, the FCC allows a 13dB relaxation factor if the peak or quasi-peak reading is significantly higher than the corresponding average reading. Characteristics of CISPR and ANSI require a receiver to have a 9kHz(-6dB) bandwidth, electrical charge time constant of one millisecond, discharge time constant of 160 milliseconds, incorporating a mechanical time constant for the meter of 160 milliseconds. If the repetition rate of the interference being generated by the article under test is below 100Hz, the difference between the peak response of a spectrum analyzer and that of a quasi-peak meter will be greater than 6dB. Because of the stringent constraints on both the line impedance stabilization network and the instrumentation used to measure the conducted interference, a conducted test is easily verified by the FCC or other regulating agency. This is not always the case for radiated measurements over the frequency range of 30MHz-1000MHz.

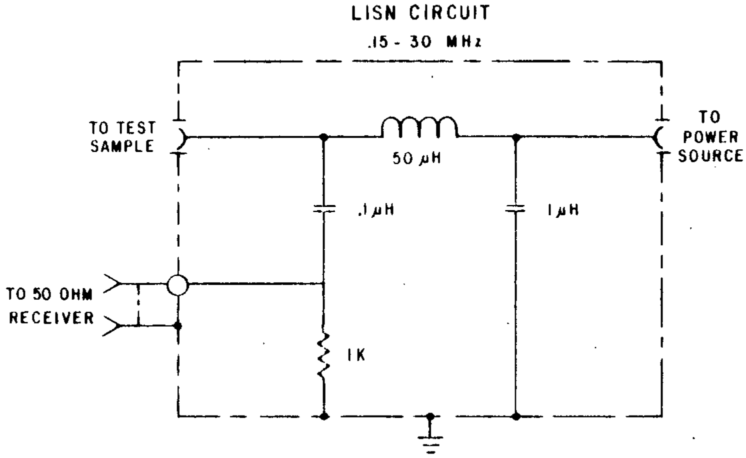

FIGURE 2A

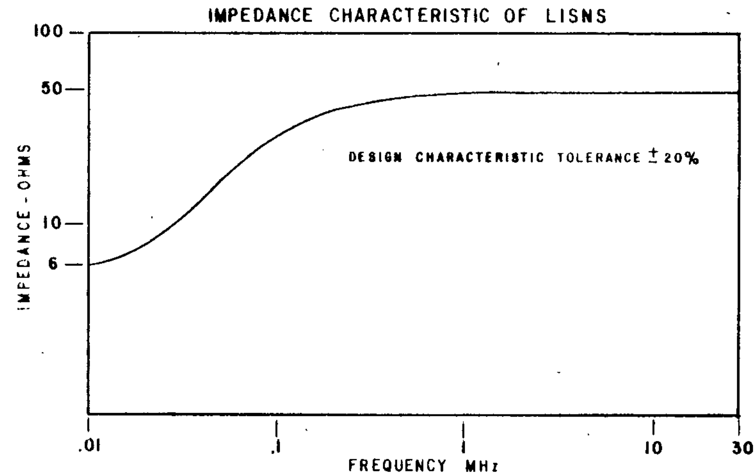

FIGURE 2B

Figure 2.

Radiated Measurements

In contrast to the shielded enclosure used for conducted measurements, radiated measurements require an open site with a ground plane. The ground plane should be clear of reflecting objects for at least twice the required distance from the antenna to the article under test. The required site layout is diagrammed in Figure 4. Background noise levels should be at least 6dB below the specified limits. The reference antenna for both FCC and VDE measurements is a tuned dipole. The FCC allows other linearly polarized antennas in the verification/certification process, as long as results are correlated to those obtained with a tuned diplole. Alternative antennas, such as the Bi-conical and Log Periodic, are also useful for measurements preparatory to VDE submission, as long as care is taken to assure accurate correlation to the VDE specified antenna. Using an inverse distance extrapolation factor, a 3-meter site can be used to verify the 30-meter limits by extrapolating the results. Both regulations specify 50 ohm input impedance for spectrum analyzer or radio noise meters as the measuring device.

For FCC radiated emissions testing, the bandwidth of the receiver or spectrum analyzer should be greater than 100kHz for all measurements above 30MHz. The advantage of using a spectrum analyzer with its wide dispersion viewing is somewhat limited in radiated emissions testing because of variations in antenna factors over their respective frequency ranges. When using a spectrum analyzer, it is recommended that a high-pass filter starting at 30MHz be used to limit the amount of interference reaching the front-end or mixing stages of the spectrum analyzer.

When used for radiated emissions, an appropriate EMI meter has several built-in advantages. The bandwidths and time constants required by the CISPR/FCC regulations are built-in to the receiver; and the receiver typically has front-end preselection over the entire frequency range. The RF sensitivity of the interference analyzer or spectrum analyzer should be such that when the antenna factor is added to its two-terminal sensitivity, the resulting dB micro-volts per meter level does not exceed the spec limit.

Most open field sites have an ambient RF environment that exceeds the FCC spec limit at several frequencies over the range from 30MHz-1000MHz. Using an EMI meter capable of tuned frequency accuracy greater than 0.1% allows for tabulation of test sample frequency data in an enclosed shielded environment. This data can then be taken to the open field site and, with the test instrument tuned to the specific frequencies previously tabulated in the shielded enclosure, the interference emitted from the article under test can be measured at the proper distances.

If the signal generated by the article being tested is at the exact frequency of a known transmission at the open field site, the data taken in the shielded enclosure can be correlated to the open field site by adding the difference in levels recorded at the nearest frequency to the known transmission. For example, suppose that interference signals are emitted from the article under test at 100MHz and also at 110MHz, and that at the open field site a known transmission is present at 100MHz. The signal measured in the shielded enclosure at 100MHz can be determined at the open field site by

POWER LINE CONDUCTION DIAGRAM

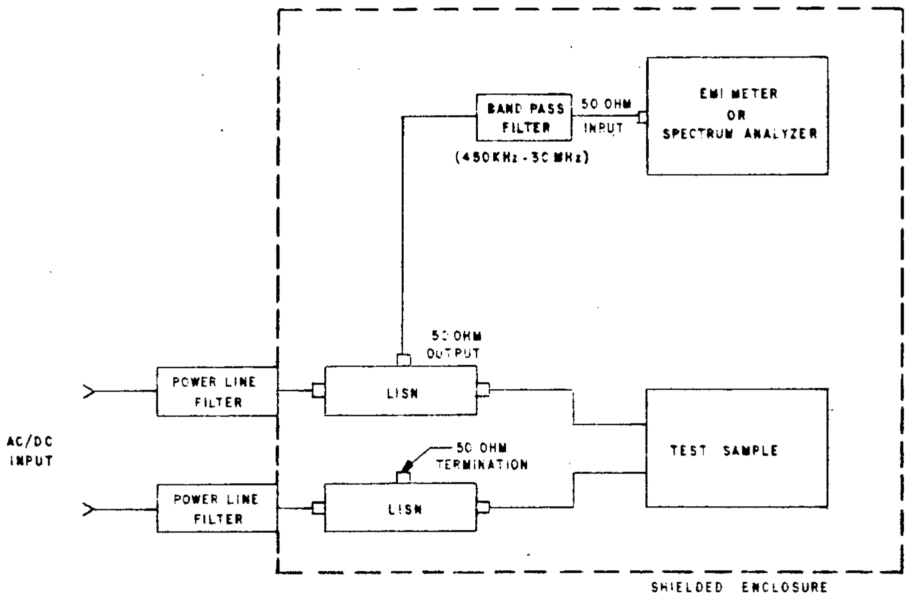

Figure 3.

comparing the levels measured at 110MHz in the shielded enclosure and at the open field site. The difference between these two measurements can be added to the measurement in the shielded enclosure at 100MHz to determine the dB microvolts per meter value of the 100MHz emission. In this case, the equipment can be certified to the best of the ability of the tester even though the emitted signal is augmented by a signal at the same frequency in the ambient of the test site.

The use of an anechoic chamber (a chamber with absorbing materials on its walls and ceiling) is under review by the FCC and is being proposed as a substitute to open field measurements by some manufacturers. The correlation of data taken at an open field site with that taken inside an anechoic chamber is necessary. Under the present specification, the use of an anechoic chamber can be extremely costly and difficult because of the requirement to raise and lower the antenna over a height of 1-4 meters at both 10-meter and 3-meter measurement distances. The second problem relative to ceiling height is that the polarization of the antenna must be changed between horizontal and vertical to determine the highest level of emissions.

OPEN-FIELD TEST SITE

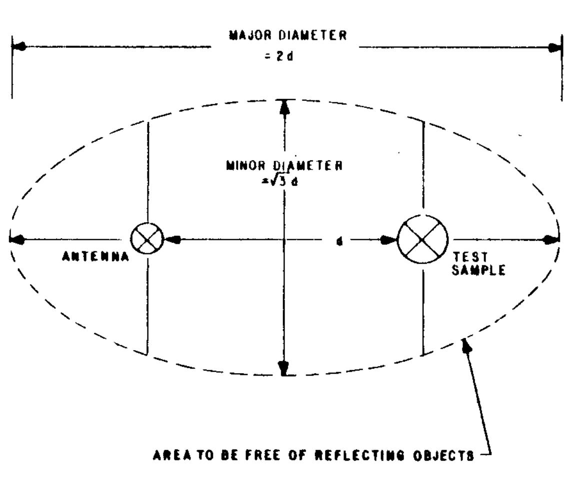

FIGURE 4

Automatic control of the antenna polarization and height is extremely difficult due to the mechanical factors involved in changing these parameters. Also, emanations from motor control lines and associated circuitry may introduce additional noise for pickup by the antenna. A final consideration in measuring radiated emissions is the fact that the article under test should be rotated 360 degrees around its axis so that, if the radiation from the back of the instrument is higher than that from the front, these signals will be measured at their highest levels.

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