SUSCEPTIBILITY TESTING

Introduction

How well equipment will perform in its intended present and future electromagnetic environment is often difficult to predict or evaluate. Too often, the performance of equipment in "normal" electromagnetic environments is left to chance. The Federal Communications Commission (FCC) is quite concerned about controlling the electromagnetic environment to reduce its adverse effects on communications. Due to legal and financial restraints, the FCC's concern is limited to communications. Thus, if a computer interferes with radio communications, there is recourse. But if the radio communications interfere with the computer, there is no regulatory authority.

The military protects its equipment by imposing the EMI susceptibility provisions of MIL-STD-461B. This is supplemented by MIL-HDBK-235A and other documents. However, there are no national standards to guide or recommend susceptibility criteria for commercial or consumer equipment outside the realm of the FCC.

FDA Attempts

As early as 1977, the Food and Drug Administration recognized the need to protect medical devices from this growing environmental threat, i.e., EMI. In a vain effort to circumvent the worsening of the problem, the FDA sponsored the development of Standard MDS-201-0004, which was published on October 1, 1979. However, partly due to the strong lobbying efforts of medical equipment manufacture associations, the standard was never placed into effect. Instead, the standard was referred to the American National Standards Institute Inc. where it now stands, for possible adoption as a ANSI standard. Some of the more prudent medical device manufacturers are using the standard as a design objective. (See brief article on Medical Electronics.)

FDA Measurement Methods

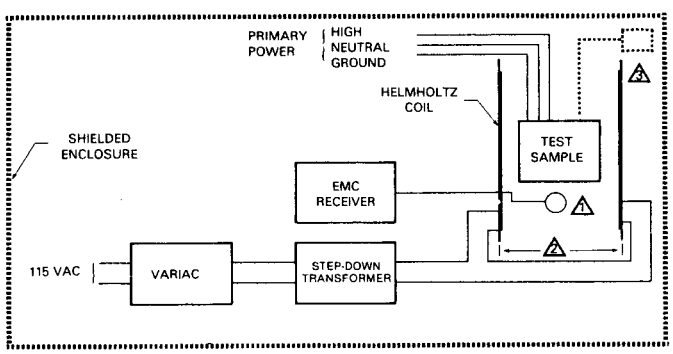
In an attempt to minimize the impact of their standard, the FDA adopted many of the test methods contained in MIL-STD-462. Unfortunately, MIL-STD-462 is of a 1967 vintage and doesn't represent the many advances in the state-of-the-art pertaining to susceptibility testing. Recognizing this, the FDA developed a non-military method for measuring the effects of 60 Hz magnetic fields. This method is shown in Figure 1.

The magnetic field susceptibility test uses a Helmholtz coil as the radiating element and a calibrated loop probe or antenna as a monitoring element. The diameter of the Helmholtz coils must be larger than the maximum dimension of the test sample which, in many cases, can be a problem when testing large equipment. Small equipment is mounted on a non-conductive stand so that the equipment under test is located in the center.

The need to perform this test in a shielded room is not clear. The Helmholtz works on the principle that most of the magnetic field will be confined to within its two parallel planes. External magnetic fields should be far lower than the generated field and most shielded enclosures are not effective at 60 Hz.

This test method may be extended to frequencies above 60 Hz, perhaps as high as 400 Hz. Some experimentation must be performed before going much higher in frequency to explore resonance effects and power consumption (efficiency).

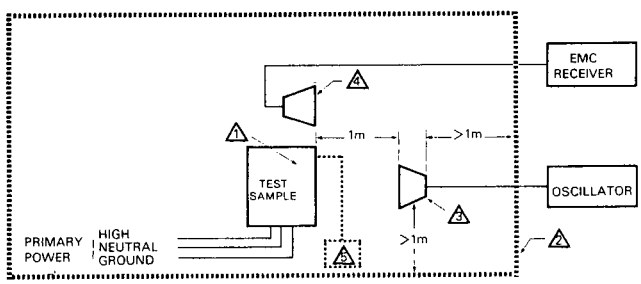
The FDA basically followed MIL-STD-462 for the remaining susceptibility tests with some minor improvements. Figure 2 shows the electric field radiated susceptibility test configurations. Here, a shielded room is specified in order to contain the high level electromagnetic radiation and to prevent it from affecting other equipment. The shielded room is also required to avoid the necessity of the tester to obtain a transmitting license from the FCC.



NOTES:

1. Loop Antenna
2. Coil separation is equal to the radius of the coils
3. Signal cables and load (if applicable)
4. If the test sample is comprised of more than 1 unit and the interconnecting cables are not supplied to the user, the interconnecting cables shall be at least 2 meters long. If interconnecting cables are supplied by the manufacturer to the user, then the supplied cables shall be used.

Figure 1. Radiated H-Field Susceptibility Test Configuration.



NOTES:

1. Area of greatest susceptibility
2. Shielded enclosure
3. Field generating antenna
4. Field monitoring antenna
5. Signal cables and load (if applicable)
6. If the test sample is comprised of more than 1 unit and the interconnecting cables are not supplied to the user, the interconnecting cables shall be at least 2 meters long. If interconnecting cables are supplied by the manufacturer to the user, then the supplied cables shall be used.

Figure 2. Radiated E-Field Susceptibility Test Configuration.

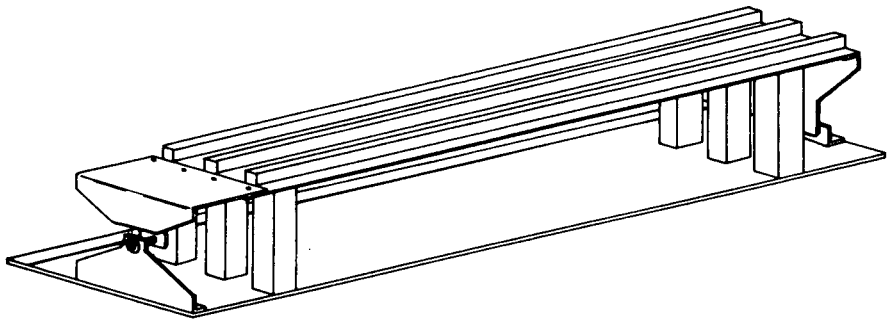


Figure 3. Parallel Strip Line for Radiated Susceptibility Tests.

Performing radiated susceptibility tests using antennas as radiating elements can certainly upset the operation of other nearby equipment, as well as interfering with radio communications, at a considerable distance. If the radiating happens to be on an aircraft navigation or communications frequency, the effects can be disastrous. The tester may also bring down the wrath of their local fire, police, and ambulance communication officers. Unfortunately, the standard shielded room is not an ideal environment in which to perform radiated susceptibility tests. Shielded rooms have an infinite number of resonances and support standing waves. Thus, the measured field intensity at one location will unlikely be the same at an adjacent location. In the configuration shown in Figure 2, the field intensity at the monitoring antenna can be as much as 20 dB higher or lower than that which is incident upon the test sample.

Test Method RSO4, as specified in MIL-STD-462, has many advantages over the standard radiating antenna method. One advantage is that most of the radiating field is confined between the parallel plates (see Figure 3). This characteristic provides for optimum radiated efficiency and the need for less power to generate the desired field. Furthermore, when testing to very high levels, the confinement of the field avoids any danger of exposing the test personnel to a possible radiation hazard condition. Up through 30 MHz, there should be no resonances within the plates or any standing waves. This test method may be extended as high as 1 GHz. When doing so, however, the tester will see many standing waves and resonances for which he must learn to recognize and to make appropriate adjustments. Figures 4 and 5 show additional details in the design and construction of the parallel plate to be used for susceptibility testing.

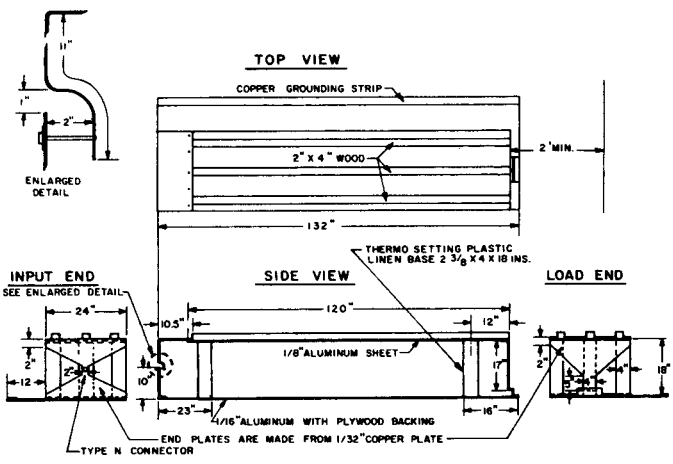


Figure 4. Parallel Strip Line for Radiated Susceptibility Tests (top and side views).

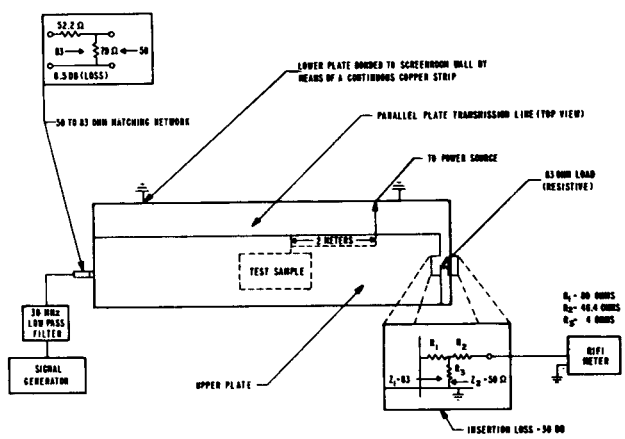
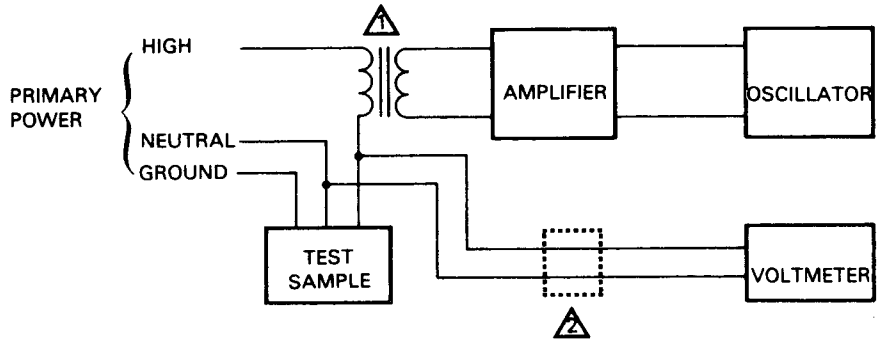


Figure 5. Setup for Susceptibility Tests Using Parallel Plate Line.

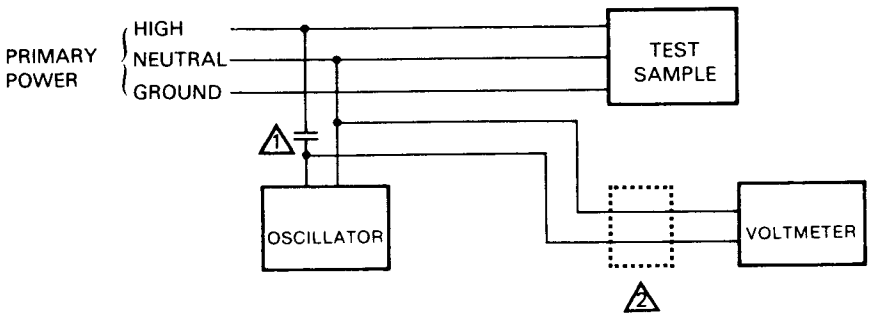


NOTES:

1. Isolation transformer
2. 60-Hz notch filter (optional)
3. The test sample and the EMC instrumentation shall derive their power from separate phases of the ac power source.
4. The EMC instrumentation shall be connected to the ac power source through an isolation transformer.
5. For the three-phase power, the susceptibility signal shall be supplied to each phase.

Figure 6. Conducted Susceptibility Test Configuration (100 Hz to 50 kHz).

The conducted susceptibility test configuration, as recommended by the FDA standard, is shown in Figures 6 and 7. Figure 6 shows the audio frequency conducted susceptibility configuration while monitoring the injected signal directly across the input lines of the test sample. A notch filter may also be required to reject the 60 Hz from feeding back into the power amplifier. Figure 7 shows the test configuration currently being used by MIL-STD-462 for Air Force and Navy procurements.



NOTES:

1. Coupling capacitor. The coupling capacitor may be changed during the test to maintain the required RF impedance of 5 ohms or less.
2. 60-Hz notch filter (optional)
3. The test sample and the EMC instrumentation shall derive their power from separate phases of the ac power source.
4. The EMC instrumentation shall be connected to the ac power source through an isolation transformer.
5. For three-phase power, the susceptibility signal shall be applied to each phase.

Figure 7. Conducted Susceptibility Test Configuration (50 kHz to 30 MHz).

NOTES:
(1)——FOR TWO WIRE POWER SYSTEMS, TEST HOT LEAD ONLY.
(2)——SPECIAL CAUTION SHOULD BE EXERCISED TO ASSURE THAT PROPER POWER LEAD IS GROUNDED, WHEN REQUIRED.

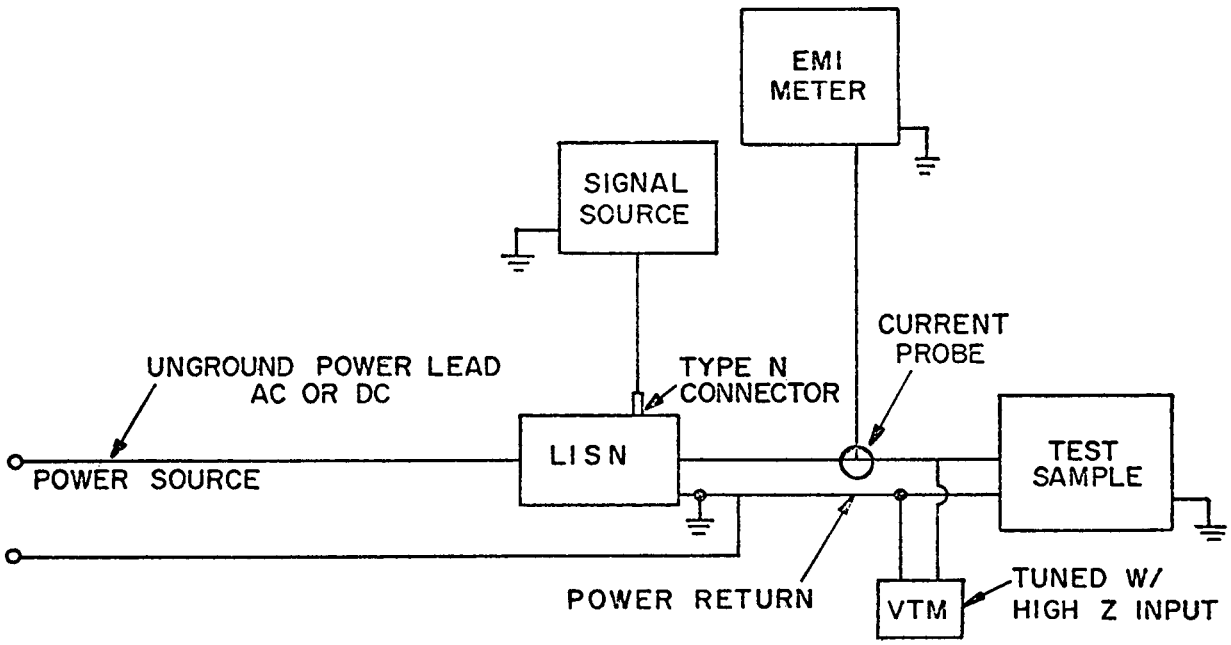


Figure 8. Conducted Susceptibility 50 kHz to 400 MHz.

For Army procurements, the test configuration shown in Figure 8 is applicable. Here, it should be noted that the Army specifies a specific power as a function of frequency in lieu of specifying a voltage as a funtion of frequency. Thus, the injected current must be measured using a current probe and EMI meter, and a volt meter is used to measure the injected voltage. The susceptibility power is injected from the signal source through a Line Impedence Stabilization Network (LISN) while the powerline impedence is raised to a nominal 50 ohms by the LISN.

MIL-STD-461B Testing

Recognizing the fact that the test specified in MIL-STD-462 is somewhat antiquated and often inadequate, MIL-STD-461B states that the equipment shall be tested in accordance with the methods described in MIL-STD-462 *or* the approved test plan. This infers, if not in fact, the right of the test planner to submit through his test plan proposed methods of performing the tests which deviate from the standard methods prescribed in MIL-STD-462. For Air Force and Navy procurements, alternate test methods are given serious consideration and are often approved if technically sound. Deviations from the test methods described in the Army procurements (Notice 3 to MIL-STD-462) are less apt to be accepted. This may indicate that the Army is satisfied with the test methods it has imposed through their issuance of Notice 3. However, the tester should not hesitate to deviate from these methods if he can provide technically justifiable rationale.

This article was prepared for ITEM by the technical & editorial staff of R & B Enterprises.