Using RF Power Meters for EMC Testing

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Abstract

The complexity of modern digital equipment has caused EMI/EMC susceptibility testing to become increasingly important. Many EMC standards have been created including MILSTD- 461, IEC 61000, ISO 11451 Automotive, EN 50, and FCC part 15 that provide specific guidelines for EMC and EMI test methodologies. Early standards required a CW carrier, or single tone with constant modulation as the disturbance test signal. In January of 2010, the International Electrotechnical Commission, or IEC approved the 61000-4-4-am1 (ed. 2) amendment allowing the use of burst testing on devices. Amendment 1 defines an impulse (spike frequency) of 100kHz and Edition 2 requires burst testing with either the traditional 5kHz spike or the new 100kHz spike frequency. The burst test emulates real world RF interference emitted by base station communication amplifiers and ground-based RADAR antennas. This article discusses how a peak power sensor can replace an average diode detector in a field probe to measure pulse power, improve repeatability and increase dynamic range of the power measurement.

Historical Background

Prior to the late 19th century, the primary sources of electromagnetic disturbance were lightning strikes and sunspots, but the growing popularity of electrical and radio equipment in the early 20th century generated the first artificial forms of interference from electric-powered equipment and competing radio transmitter towers around the world. This competition led to the creation of international regulatory agencies, like the FCC. This trend continued in the 1940's with the adoption of high-power industrial switch devices that caused coal mine explosions, automobile and airplane fuel station fires, and electrical grid outages. During the 1950's and 60's, ISM (industrial, scientific, & medical) unlicensed frequency bands were allocated by the FCC that allowed the generation of relatively high-power RF signals. Because emission in these bands was uncontrolled, a variety of interference issues were created due to sideband harmonic and broadband emissions. The impact of this interference resulted in the need to create new standards and laws to regulate these emissions. With the advent of digital circuitry in the 1970's, faster switching speeds had increased emissions and lower circuit voltage requirements increased susceptibility. The 1980's brought an increasing use of mobile communications and broadcast media channels creating pressure on the available spectrum space. Regulatory requirements for smaller band allocations demanded increasingly sophisticated EMC design methods. Although digital signals are often less susceptible to interference than analog systems, their operation at lower power levels reduces some of this immunity causing the need for increasingly complex EMC/EMI testing.

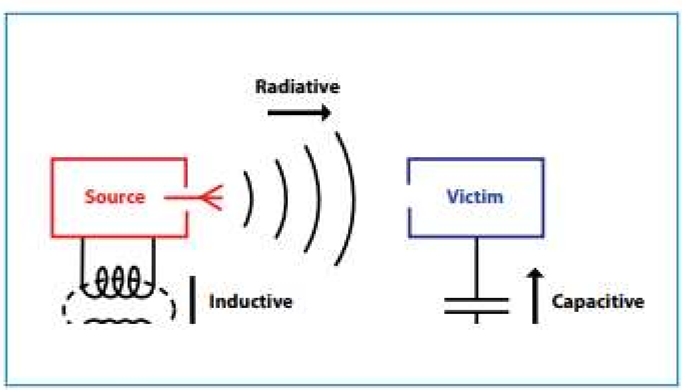


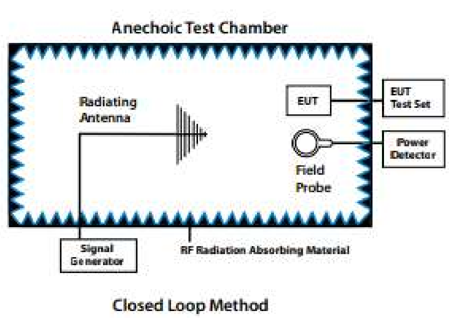
Figure 7.3.1. Electromagnetic Coupling paths

Electromagnetic Compatibility (EMC)

Electromagnetic compatibility (EMC) is a branch of electrical science that studies the unintentional generation, propagation and reception of electromagnetic energy from electromagnetic interference, EMI. An Emission is undesirable electromagnetic energy produced by a source, which may couple into other devices. Susceptibility or immunity is the inability or ability of a piece of electronic equipment, referred to as the victim, to operate correctly in the presence of nearby emissions or other electromagnetic interference signals. Electromagnetic compatibility is achieved by addressing both the emission and susceptibility aspects of an electronic device. The diagram in Figure 7.3.1 shows the four different types of electromagnetic coupling: radiative, inductive, capacitive, and conductive. The primary type of coupling discussed in this article will be radiative, in which a signal radiates through space as an electromagnetic wave with no physical connection or coupling between the source and victim. The purpose of immunity testing is to emu late the effect of real-world RF interference upon your electronic device or system. One example would be the automotive CANBUS system used for wired, digital communication between electronic subsystems in a motor vehicle. These systems are often used to monitor and control important performance and safety parameters of the vehicle including engine operation, braking, and the steering/stability systems. Their ability to operate correctly under all electrical interference conditions is crucial to passenger safety. Rigorous RF immunity has become a mandatory part of the automotive design process as well as most other systems where any sort of malfunction could result in injury or damage to people or property. Immunity testing is performed in a large anechoic chamber for isolation from external RF interference while testing the “EUT” (Equipment Under Test). One important requirement for the test is to apply a simulated interference signal with an accurately known amplitude. RF field strength is typically measured and characterized during or prior to the test using one of two test techniques: the closed-loop method or the substitution method. While each method has advantages, the IEC standard to which the test is being performed will often determine the method that must be used to measure the instruments signal amplitude.

The Closed Loop Method

The Closed Loop Method requires an RF field probe positioned in front, or on top of the EUT during susceptibility testing (see block diagram in Figure 7.3.2). The signal generators output power is adjusted at each of the specified frequency steps across the test band to achieve the desired RF field strength in the anechoic chamber. The word “probe” can have two meanings. One is the field probe assembly inside the test chamber and the other is a commonly used term for an average diode detector circuit. The average diode detector is a component of the field probe assembly and measures RF power via a coaxial cable for purposes of this discussion. The average diode detector in the field probe does not accurately measure the field strength of a modulated RF signal, so correction factors must be applied to the probe readings to account for the signal’s dynamic behavior. A CW signal can be used to estimate the power being delivered, but an additional correction factor must be applied to account for the modulation applied during the actual testing. This correction is adequate for simple AM modulation but is often insufficient for the narrow duty spikes required by today’s test standards. The simple diode detector can be replaced by a peak power sensor to accurately measure the interference signal’s true amplitude even in the presence of modulation. A peak power sensor can follow a signal’s power envelope and yield the true average and peak power, provided the envelope bandwidth remains within the maximum video bandwidth rating of the sensor and power meter. A good peak power sensor has temperature compensation and is linearized to increase its dynamic range. A peak power sensor eliminates the need to calculate the peak power value when a pulsed or modulated interfering signal measured using an average responding diode sensor. In cases where the modulating waveform is complex or has a narrow duty cycle pulse, a peak power sensor is a valuable tool to accurately measure the peak power of these waveforms instead of calculations when a conventional diode sensor is used in the probe.



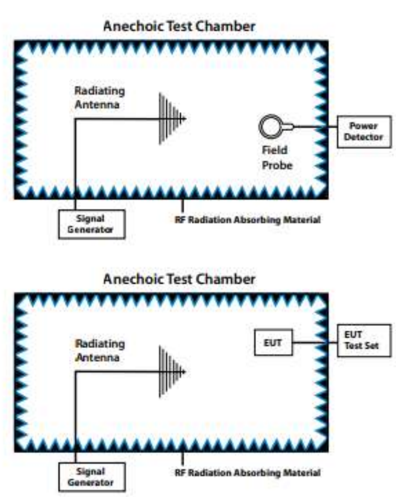


Figure 7.3.2. (Above) and Figure 7.3.3. (Right)

The Substitution Method

The Substution Method uses an RF field probe to characterize and calibrate the RF field strength in the anechoic chamber before the EUT is placed inside (see block diagram in Figure 7.3.3). The field strength is adjusted for each frequency step across the band and the EUT is positioned in the test environment. This method does not require field monitoring during the test and is referenced by some EMC test standards. While not required, a probe is often used during the test run just to monitor the RF field. This direct feedback ensures good system performance. Both the closed loop and substitution methods use a high-power signal generator connected to a radiating antenna for repeatable RF signal transmission while testing the EUT. The closed loop meth od requires the field probe during testing, while the substitution method only states it can be used to improve measurement quality. In either case, it is beneficial to use a calibrated peak power sensor rather than the average diode detector for testing the latest pulsed standards. This eliminates peak calculations, modulation correction factors, and the temperature compensation associated with the average diode detector. The peak sensor provides both peak and average measurements of the interference power for correlation with existing average measurements and more accurate values for the latest pulsed interference standards. Knowing the peak power values will help ascertain whether the EUT is being subjected to the necessary amount of interference to operate correctly in any environment.

Boonton Electronics is recognized as a leader in high-performance test instrumentation and sensors, dedicated to measuring the power of RF and microwave systems used in both military and commercial sectors. Boonton Electronics is a wholly owned subsidiary of Wireless Telecom Group, Inc. and manufactures test equipment used in multiple telecommunication markets. Boonton's diverse and innovative products, such as USB RF Power Sensors, are used to test terrestrial and satellite communication, radar, telemetry, electronic warfare (EW), electronic countermeasures (ECM), and an expanding number of wireless communications products.

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