Advisory Note:
Cavity Loading (Wave) Impedance May Impact Susceptibility Response! (*)

An electromagnetic wave propagates across spatial distance from a source. When this occurs, the wave exhibits parameters that are analogous to the propagation of any dynamic alternating electron movement through a media. There is a source impedance (the characteristics of the transmitting antenna), the parameters of Voltage (the field intensity related in “Volts/meter”) in the Electric Field vector, and current “field” vector (Amperes/meter). Together, these constitute: an impedance and power density profile for the electromagnetic wave itself; the impedance of the media (space) propagating the transmission of the wave; and, a “load” impedance to the electromagnetic wave that is represented by the system-product (with other environment factors) under test evaluation.
As in any transfer of energy in obedience to electrical behavior, there is also power-density that is derived from the values of Voltage (E-field), current (H-field), and impedances (source, media transporting the wave, and load). (Ref. 1) The power density may be expressed as “Watts/meter^2”.

In open space at (far field) distance from a source, the media constant is approximated as $120\ \pi$ Ohms (377 Ohms). When laboratory simulations of radiated electric CW fields and field intensities are performed across a delineated frequency range to evaluate a system-product for (susceptibility) immunity response, the specification for performance criteria may be stipulated in only one axis of the parametric electromagnetic field measurement. Electric fields are typically defined as a specified field intensity value, for example, of “Volts/meter”. In order to contain these “simulation fields” into a protected environment, various forms of shielded rooms or chambers would be required to enclose the field with the system-product in evaluation. It is noted that the shielded room (or chamber) may not be sufficiently characterized to present to the transmitting antenna the impedance of free space. This observation is based upon the assumption is that the goal of the simulation is to approximate free-space effects. Often (it has been empirically observed) the “chamber” impedance is significantly lower than would be anticipated in the systems-installation environment of free space.

If the electric field intensity (Volts/meter) is driven to a level in a chamber presenting a comparatively low impedance to the transmitting antenna and related wave propagation, the current of the H-Field component, in Amperes/meter, would be required to be driven to an amplitude sufficient to produce the required electric field intensity within the lower impedance presented by the media of the chamber. The implications of this observation is that a system-product could be subjected to immersion in a total radiated power density (Watts/meter^2) that would (in probability) be *significantly greater* than would be experienced in open far-field environments to achieve the same E-field value.

Extending this consideration yields another observation: should a system product comply with an immunity requirement of electric field intensity in a test environment that approaches the impedance constant of space, it might not retain compliance if re-evaluated while contained in a chamber with a low impedance due to the increased power density required. This observation suggests that factoring for “chamber impedance” may be appropriate to adjust the electric field potential value in order to equalize the performance results. Additionally, it is noted that there will typically be interaction that modifies the “chamber” impedance caused by the displacement within the chamber of the system-product itself, unless the dimensions of the system-product (including the linear lengths of cables) are very small with respect to the dimensions of the chamber. Under this consideration, the “normalization” of test environment impedances to those of free space, or comparatively from one test chamber environment to another, would be very complex.

Apart from the implications noted above, systems response may be more evident (more pronounced) when observed during field applications in a chamber-simulation, than found in a normal-use environment. This added effect is related to impedance comparisons between the electromagnetic wave propagating in the media impedance of the chamber, and the boundary impedance of the product under test as impacted by the wave. This interaction is implied because the first-order effect of a shield structure performance is caused by field reflection transmission losses at the initial boundary. The reflection losses are exhibited as a ratio of the shield surface boundary impedance against the value of the impinging electromagnetic wave impedance. Given that the media of the chamber would (particularly at frequencies below approximately 100 MHz) reduce the value of the wave impedance, the possibility is that the impinging wave may exhibit a closer match to the shield impedance, which in turn minimizes the applied performance of the shield. (Ref. 2)

(*) Extracted and expanded from EMCT: Electromagnetic Compatibility Tutorial, Module 2 (Design), Section E, (Immunity / Susceptibility Considerations).

Ref. 1: EMCT, Module 3 (Shielding), Section A (Conceptual Theory), Screens 9 – 26 (with sub-tier).

Ref. 2: EMCT, Module (Shielding), Section A (Conceptual Theory), Screens 27 – 69.