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Technical Notes - TN09-18

Selection of pulse simulators for NEMP test

Bertrand Daout, montena emc sa, 1728 Rossens, Switzerland

1. Phenomenology

During the explosion of an atomic bomb, electromagnetic field is radiated. Depending on the altitude of the explosion and on the position of the electronic equipment on earth, the amplitude, the waveform and the polarisation of the field near this equipment can vary. By example of the explosion of a high altitude bomb, the electric field is high and the polarisation is horizontal in the case the device is placed on earth under the explosion spot but the polarisation becomes more and more vertical if the device is moved away from this place. The influence of the soil is also a key point.

At a certain distance from the source, the field radiated by the explosion is a plane wave. That means that electric and magnetic fields are both present. The wave impedance is 377 ohm (= ratio between the electric and magnetic field). Both components of the electromagnetic field are perpendicular to the wave propagation.

The environment to be simulated is dependant on the EUT and can be categorised in 2 types [1]:

1) aerospace systems are concerned by free field electromagnetic pulses;
2) ground or sea systems: the transient wave is more complicated due to the addition of the incident and the reflected waves.

To simulate these environments, different EMP simulators are possible:

1) radiating simulators
2) bounded wave (or guided wave) simulators
3) hybrid (or HPD) simulators.

2. Simulators comparison

2.1 Radiating simulators

This type of test installation is adapted for simulation of free electromagnetic fields but also for ground or sea systems. The test area can be very large but the homogeneity of the field is low. The size of the antenna must be very large to achieve low frequency content of the radiated transient. Last disadvantage: the efficiency of this type of simulator is low (ratio field / voltage of the generator). The polarisation is mainly vertical.

Example of radiating simulator (conical)

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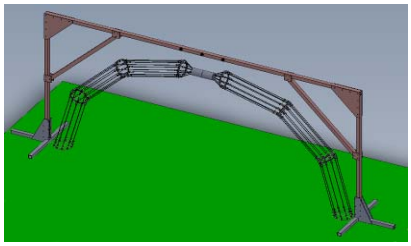
2.2 Bounded wave simulators

The bounded wave simulators are also named guided wave simulators. They consist of a HV pulse generator connected to a transmission line ended by a distributed resistance. The mode of the wave guided under the line is TEM (transverse electromagnetic). The polarisation is vertical. Different designs of the line are possible and a GTEM can also be used as a field generating structure. The bounded wave simulators have a good efficiency.

Line of a bounded wave simulator

2.3 Hybrid simulators

The name of hybrid comes from the property of this type of simulator to produce both reactive ("static") and radiating field. At low frequencies, quasi-static form of the field is applicable and the current flowing in the whole structure creates the field under and around the line. In high frequency the early time transient achieving the tested equipment is radiated by the part of the antenna placed in the vicinity of the generator. The polarisation of the field is mainly horizontal.



Hybrid simulator

3. Test simulators

A comparison between the different simulators is given below.

Specification	*radiating*	*bounded wave*	*hybrid*
Polarisation of the electric field	mainly vertical	vertical	mainly horizontal
Homogeneity of the field	fair to good	good	fair
Waveform	distorted (depends on the length of the antenna)	good	distorted (depends on the nature of the soil)
Influence of the ground	none (if a metallic ground plane is present)	none (metallic ground plane)	yes (the waveform depends on the nature of the soil)
Efficiency[1]	low (depends on the distance)	good	fair
Complexity (price)	high	fair	very high

[1] : *ratio: amplitude of the field / voltage of the generator*

Reference:

[1]: A brief survey of available EMP simulators, D. V. Giri, 1986.

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