Radiated Immunity Test System for Vehicles Using a Composited Dipole Antenna

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1. Introduction

The radiated immunity test is one of the important EMC test systems to radiate the intense electromagnetic wave to the electronic device under test in the anechoic chamber and test its resistance characteristics from interfering wave [1]. This test system for vehicles requests antennas to radiate the intense electric field of the components of horizontal and vertical polarized wave. Though vertical polarized wave can be excited easily, the horizontal polarized wave is seriously affected by the reflected wave from the ground. It is necessary to increase the radiated electric fields for both components. The antenna also requests to have wideband characteristics because the system measures automatically the resistance characteristics of device under test from interfering in wide range frequencies. Generically, this system uses a log-periodic antenna [2] more than 100 MHz, and a Biconical antenna [2] less than 100 MHz. However, the Biconical antenna becomes very large to use at low frequency range.

This paper presents a small and wideband antenna using a composited dipole antenna to operate from 20 MHz to 100 MHz and also demonstrates that the antenna radiate the intense electromagnetic wave over 100 V/m by changing the direction and position of the antenna. In the radiated immunity test system, as the influence of measurement environment such as an anechoic chamber should be taken into account, we also present that the proposed test system is suitable for the immunity test by the simulation including the measurement environment.

2. Antenna model

In this section we present a wideband antenna with the size of 1 m × 1 m × 4 m using a composited dipole antenna in the frequencies from 20 MHz to 100 MHz. The composited dipole antenna is an antenna consisted of several pairs of arms with different lengths, to operate at multiband and wideband as a log-periodic antenna. As the composited dipole antenna has discrete resonance points, it has a problem the increase of VSWRs between resonances. Then, we need many resonance points by using multi arms in order to keep VSWRs low.

We show the structure of the proposed antenna in Fig. 1, where five pairs of arms are arrayed in the point symmetry. Since elements resonating at low frequencies are folded to restrict its size, the frequency bandwidth of each element at lower frequencies is narrow. Then we keep the VSWRs low by increasing the number of elements at lower frequencies. In high frequency range, we can reduce the number of elements by using the third harmonic resonances of elements used for lower frequencies.

Fig. 3 shows the VSWR of the proposed antenna simulated by FEKO [3]. From 20 MHz to 100 MHz, the VSWRs are less than 3. The resonating points A-G shown in Fig. 3 denote the resonances of arms A-G as shown in Fig.1. In addition, C’ and D’ in Fig. 3 are the third harmonic resonances of C and D. In comparison of frequency bandwidth with a Biconical antenna at the same size as shown in Fig.2, the bandwidth of the composited dipole antenna is wider than that of the

Biconical antenna, and the composited dipole antenna can be used at lower frequencies than the Biconical antenna.

Figs. 4 and 5 show the radiation patterns of the composited dipole antenna at every resonant frequency. Though the radiation patterns are basically similar to those of dipole antenna, the cross polarizations are large at lower frequencies because the elements are folded. And the radiation patterns at higher frequencies are different from those of dipole antennas because of the harmonic resonances. As the radiated immunity test system requests antennas to radiate stable electric field strength, we need to consider the position and direction of the antenna in each frequency.

3. Simulation including the test environment

This section presents the optimum environment in the anechoic chamber by simulation, using the composited antenna designed in the previous section, in order to radiate the intense electric field. At first, we present the electric field distributions, setting the antenna in the anechoic chamber. Shown in Fig. 6 (a), we put the antenna at 3 m high from the floor of concrete, assuming the 10 kW electric power supply, and monitor the horizontal polarization component of the electric field at the 1 m and 3 m height from the antenna. The simulation results are shown in Fig. 7. The electronic field intensity is over 100 V/m at most frequencies, but it is not over 100 V/m at 20 MHz, 40 MHz, and 60 MHz. This is caused by the distortion of radiation patterns in each frequency shown in the previous section. Comparing with the model without the anechoic chamber (i.e. open site except the concrete ground), the electric field intensity in the anechoic chamber is less than that at open site in most frequency ranges.

Then, we change the position and direction of the antenna to increase the electric field in these frequencies. As shown in Fig. 6, rotating the antenna by 90-degree in a horizontal direction at 20 MHz, tilting the antenna by 45-degree at 40 MHz, and shifting the antenna by 2 m along y-axis at 60 MHz enhance the electric field.

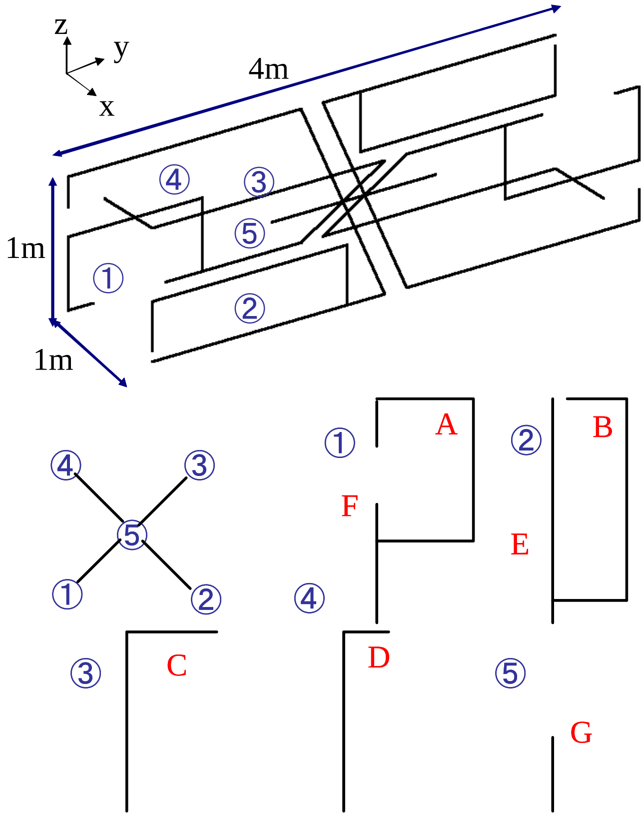
In order to enhance the electric field at whole frequencies without changing the position of the antenna, we consider putting down the electric absorbers on the floor as shown in Fig. 6 (b). We set the absorbers covering the floor of concrete around the vehicle under test. Fig. 7 shows that the absorbers on the floor reduce the reflection from the ground and radiate the intense electric field without changing the position and direction of antenna in all the frequency ranges.

4. Conclusion

In this paper, we presented a wideband antenna for the radiated immunity test system, using a composited dipole antenna in order to resonate at the lower frequencies than the Biconical antenna. We used the antenna with multi-arm of various lengths to keep VSWRs low at lower frequencies and reduce the number of elements by applying the third harmonic resonances at higher frequencies. We also presented that the radiated immunity test system using the composited dipole antenna to radiate 100 V/m by changing the direction and the position in each frequency in the simulation including the effect of anechoic chamber. In addition, we presented that using electric absorbers on the floor enhance the electric field. The experimental verification will be the future problem.

References

[1] ISO 11451 "Road vehicles - Electrical disturbances by narrowband radiated electromagnetic energy - Vehicle test methods”.
[2] IEICE, “Antenna Engineering Handbook (2nd edition)”, Ohm Press, 2009.
[3] FEKO suite 5.4, EM Software and Systems (www.feko.info), 2009.



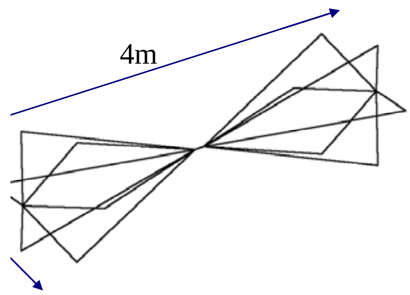


Fig. 2: Biconical antenna

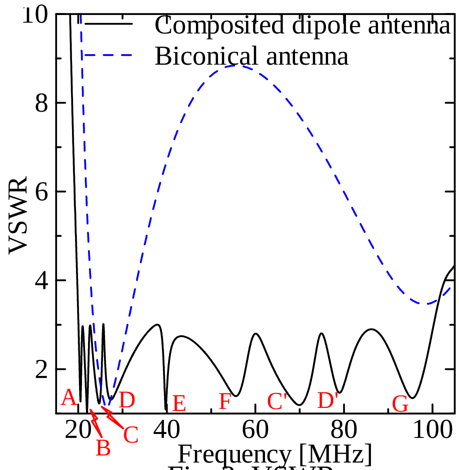


Fig. 1: Composited dipole antenna

Fig. 3: VSWR

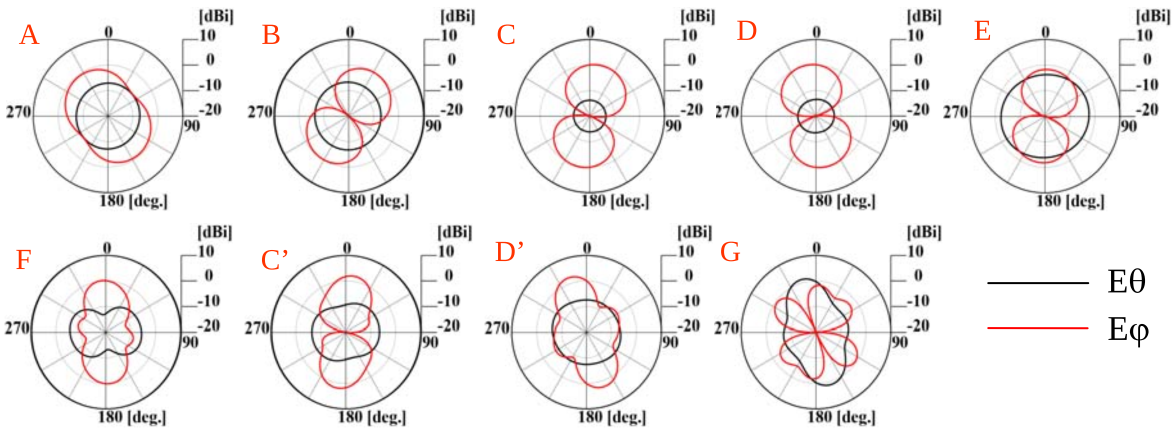


Fig. 4: Radiation patterns (xy-plane)

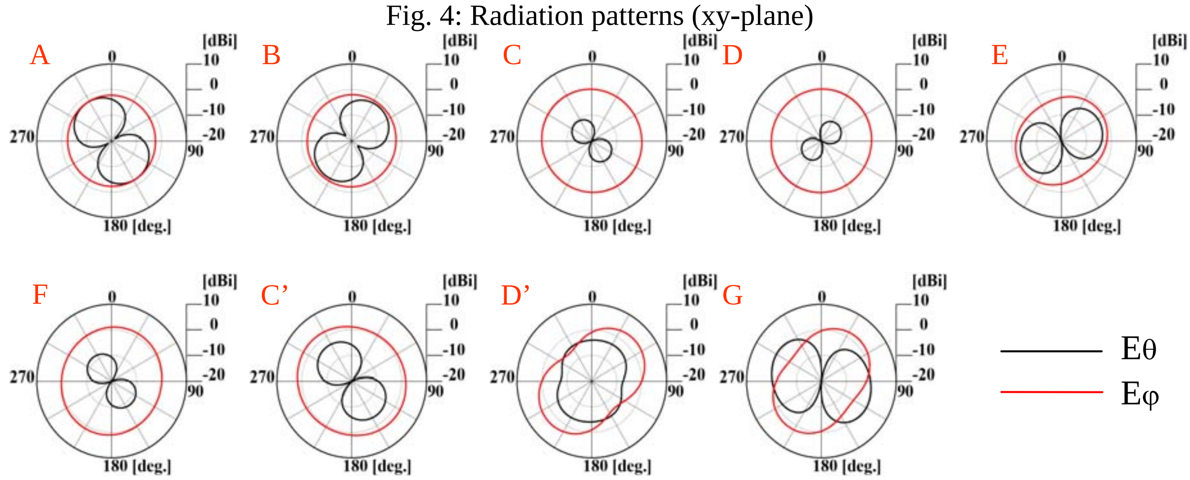
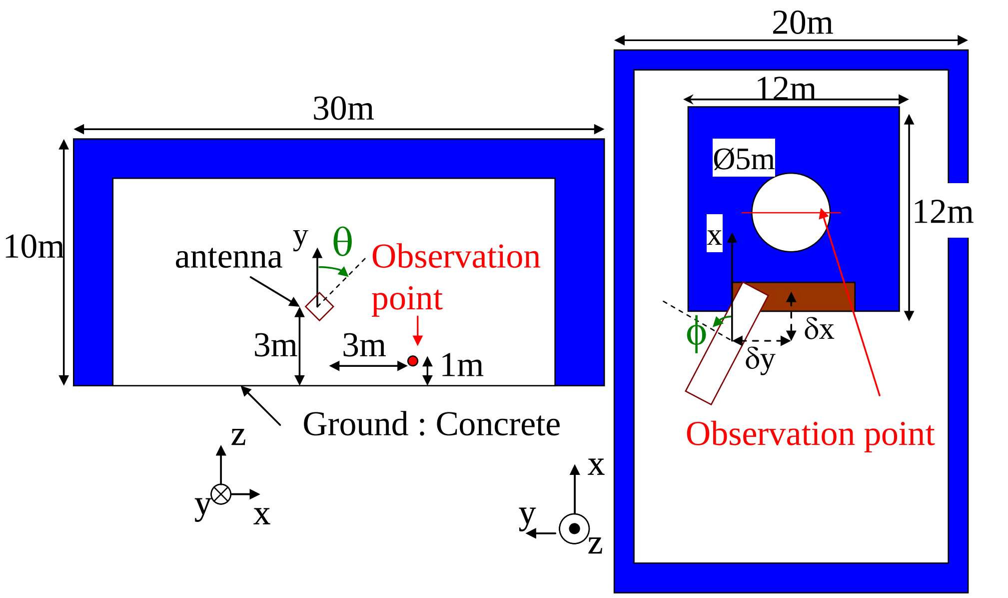
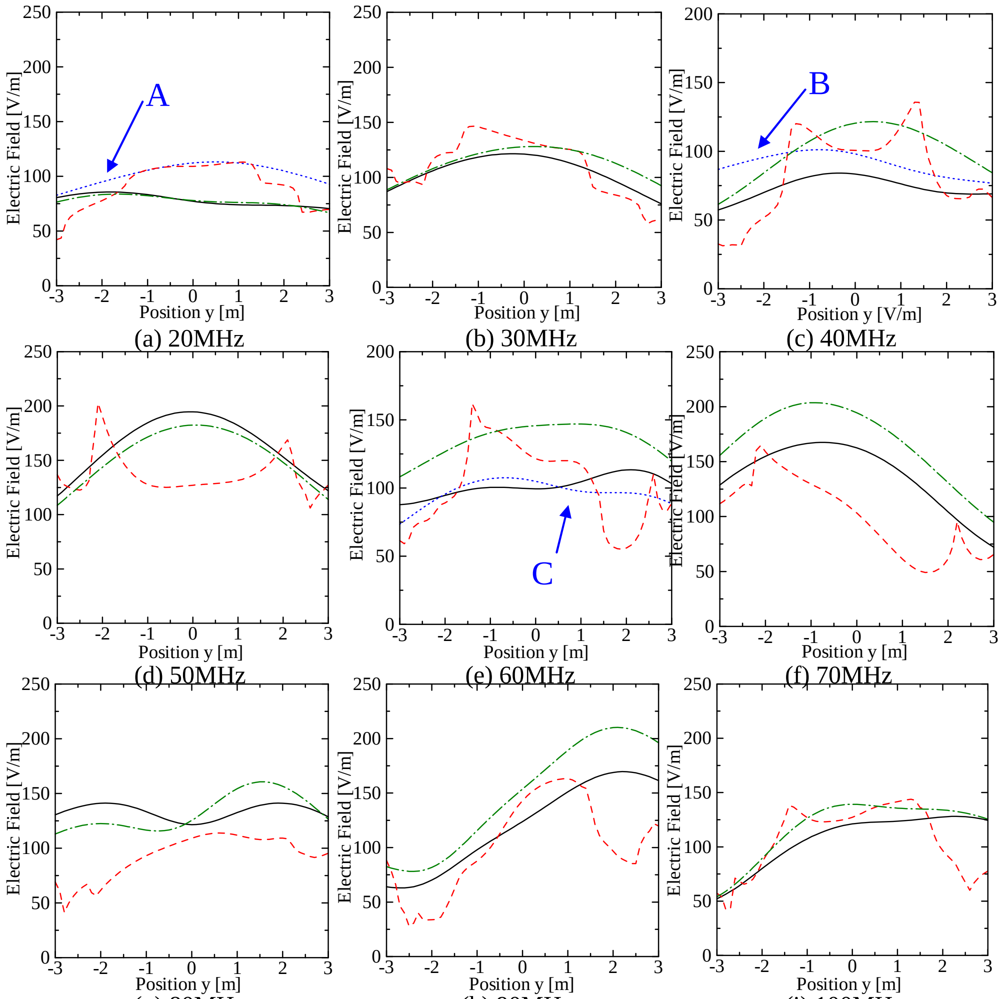


Fig.5: radiation patterns (yz-plane)



(a) Anechoic chamber (b) Putting on absorbers on the floor

Fig. 6: Simulation model



(a) 20MHz (b) 30MHz (c) 40MHz

(d) 50MHz (e) 60MHz (f) 70MHz

(g) 80MHz (h) 90MHz (i) 100MHz

Fig. 7: Electric Field distributions

normal; Changing the position; Putting absorbers on the floor; normal (open site)

A: θ = 0 deg., ϕ = 90 deg., δ x =2 m, δy = 0 m. B: θ = 45 deg., ϕ = 0 deg., δ x = δy = 0 m.
C: θ = ϕ = 0 deg., δ x = 0 m, δy = 2 m. Others: θ = ϕ = 0 deg., δ x = δy = 0 m.