Planar Dipole Antenna Within a Rectangular Parallelepiped Cavity for UWB System

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1. Introduction

The authors have analyzed the resistance-loaded planar monopole antenna located within a rectangular parallelepiped cavity for impulse radar and shown the broadband operation of input impedance for the frequencies from 0.5 GHz to 4.5 GHz [1][2]. This antenna is fed by a coaxial probe from the wall of the rectangular cavity of 48 mm by 44 mm by 44 mm in dimensions. Then, we have designed the geometry of this antenna for the UWB system from 3.1 GHz to 10.6 GHz [3]. Although the broadband operation of input impedance is obtained, the main beam of this antenna tilts as frequency becomes higher.

In this paper, the resistance-loaded planar dipole antenna within a rectangular parallelepiped cavity is proposed for the UWB system and numerically analyzed. In order to suppress the beam tilt, the balanced-feed is adopted in this antenna. The input impedance and radiation characteristics of this antenna is calculated by using the electromagnetic simulator "IE3D" based on the Method of Moment [4] for shortening the calculation time. The structure of this antenna is optimized by using IE3D. The time-response of current distribution of this antenna and the transmission loss characteristics between the transmitting and receiving antennas are calculated by using the electromagnetic simulator "Fidelity" based on the FDTD method [5].

2. Structure of antenna

Figure 1 shows the structure of the resistance-loaded planar dipole antenna within a rectangular parallelepiped cavity. The center-fed planar dipole antenna is located within a rectangular cavity of 17 mm by 37 mm by 20 mm in dimensions. The dipole antenna is placed 5 mm behind from the aperture of cavity. The conducting plate of 67 mm by 47 mm in size is attached at the aperture of cavity to reduce the backward radiation. Two resistances R are loaded between both ends of dipole and the wall of cavity for suppressing the ringing within antenna structure.

In the numerical analysis by IE3D, the cell size is set to 1.43 mm and the edge cell size is 0.015 mm. In the numerical analysis by Fidelity, the space steps are set to 0.25 mm to 1.5 mm (non-uniform mesh). The minimum cell size 0.25 mm is $\lambda_{\mathrm{high}}/113$. Where, λ_{high} is the wavelength at the highest frequency 10.6 GHz. The time step is 4.197×10^{-13}sec. As the absorbing boundary, the perfectly matched layer of six-layer and fourth-order is used.

3. Numerical results and Discussion

Figure 2 shows the calculated VSWR characteristics for the resistances R=68 Ω, 82 Ω and 100 Ω. VSWR is normalized by 150 Ω. For all cases, VSWR less than 1.5 is obtained for the UWB frequencies from 3.1 GHz to 10.6 GHz. Figure 3 and 4 show the electric field radiation patterns in the horizontal and vertical plane, respectively. The loaded resistance is R=82 Ω. In the case of monopole antenna in the reference [3], the main beam direction in the vertical plane tilts toward x direction from z direction as the frequency becomes higher. However, in Figure 4, the main beam direction does not change for all frequencies.

Figure 5 shows the time response of current amplitude at the feed point of dipole antenna. In the calculation by Fidelity, the incident voltage at the feed point is assumed as the sine wave modulated with Gaussian pulse. In the figure, the incident waveform of voltage is shown for comparison. By loading the resistance 82Ω, the ringing is remarkably suppressed. Figure 6 shows the frequency characteristics of transmission loss between the transmitting and receiving antennas. Two same antennas are located face to face. The distance between transmitting and receiving antennas r is 100 mm, 300 mm and 500 mm. When the distance r is 100 mm, the ripple is

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observed. This may be due to the mutual coupling between the transmitting and receiving antennas. Since, in this antenna, the resistance is loaded between the antenna end and the cavity wall, the radiation efficiency becomes worse at the lower frequencies [3]. Therefore, the transmission loss $|S_{21}|$ between the transmitting and receiving antennas becomes worse at the lower frequencies.

4. Conclusion

The resistance-loaded planar dipole antenna located within a rectangular cavity has been analyzed. The broadband operation of input impedance and radiation characteristics have been shown at the UWB system frequencies from 3.1 GHz to 10.6 GHz. This antenna is promising for the antenna of the UWB system. The measurement of this antenna will be the future subject.

References

[1] M. Taguchi, Y. Matsuoka, Y. Toguchi and K. Tanaka, "Cavity-backed Resistance-loaded Planar Monopole Antenna", Proc. Of IEEE AP-S Int. Symp., 3, pp. 438-441, June 2002.

[2] M. Muramoto, Y. Toguchi, K. Tanaka and M. Taguchi, "Transmitting Active Antenna for Impulse Radar", Proc. of 2003 IEICE General Conference, B-1-58, March 2003 (*in Japanese*).

[3] T. Ohashi, K. Tanaka and M. Taguchi, "Analysis of Ultra-Wideband Antenna", Proc. of 2003 IEICE Society Conference, B-1-143, Sep. 2003 (*in Japanese*).

[4] "IE3D User's Manual, Release 9", Zeland Software, March 2002.

[5] "Fidelity User's Manual", Zeland Software, Inc., April 2000.

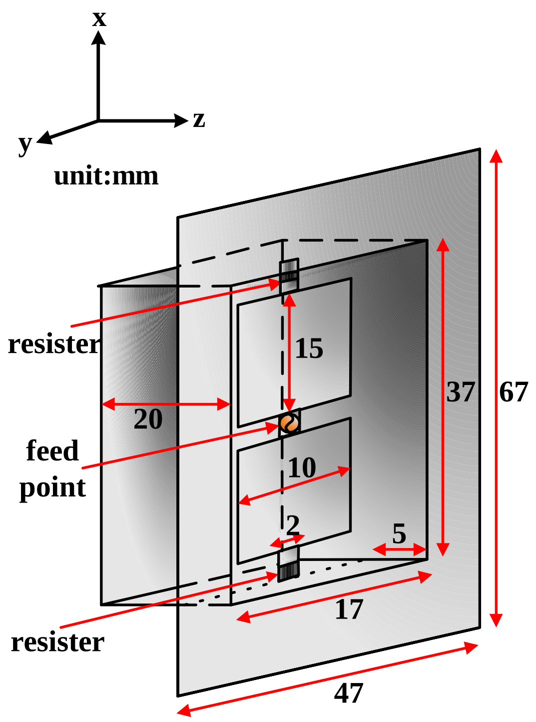


Figure 1 Analytical model

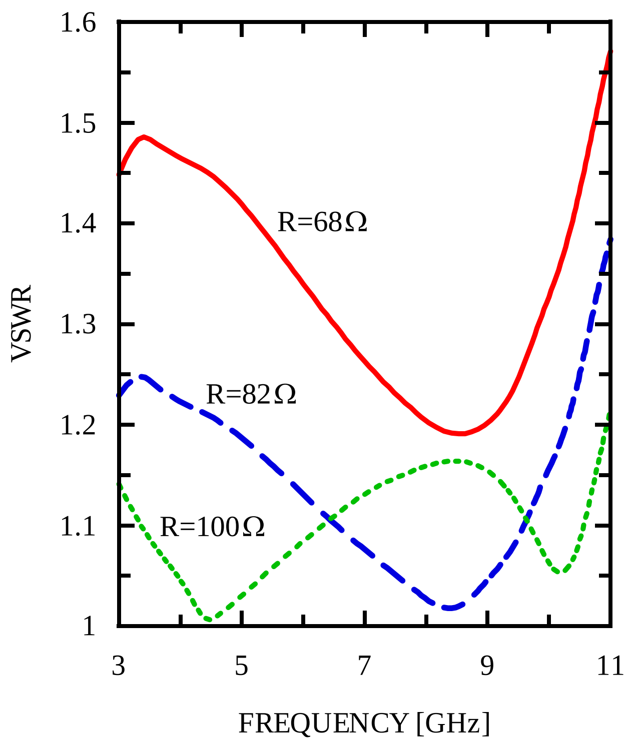
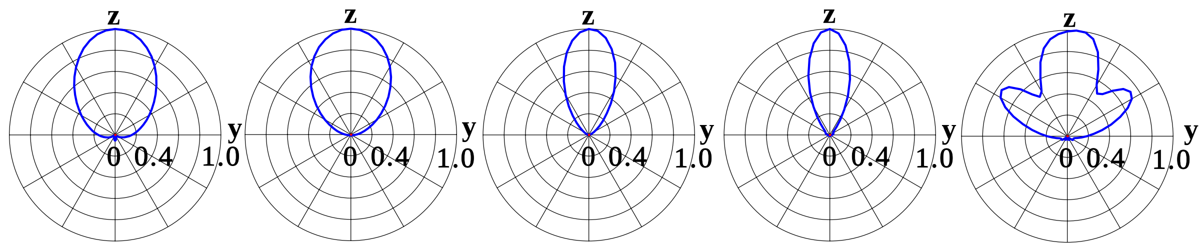
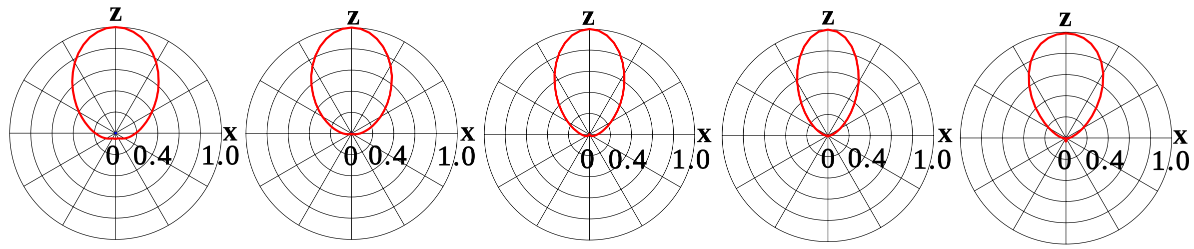


Figure 2 VSWR normalized by 150 Ω



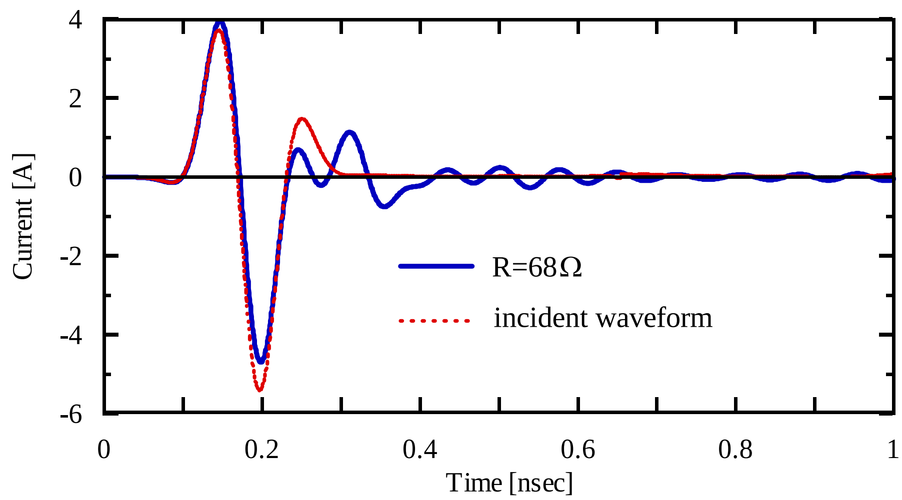
(a) 3.0 GHz (b) 5.0 GHz (c) 7.0 GHz (d) 9.0 GHz (e) 10.5 GHz

Figure 3 Electric field radiation patterns in horizontal plane (E_θ , R=82Ω)

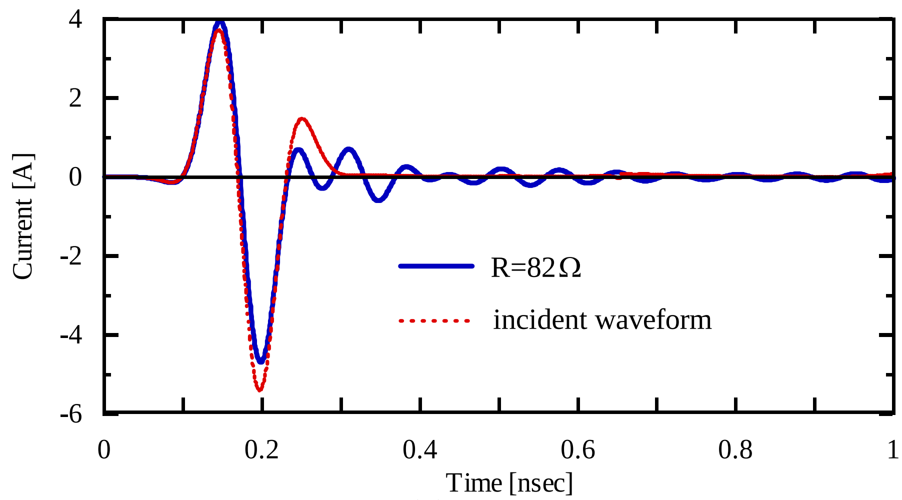


(a) 3.0 GHz (b) 5.0 GHz (c) 7.0 GHz (d) 9.0 GHz (e) 10.5 GHz

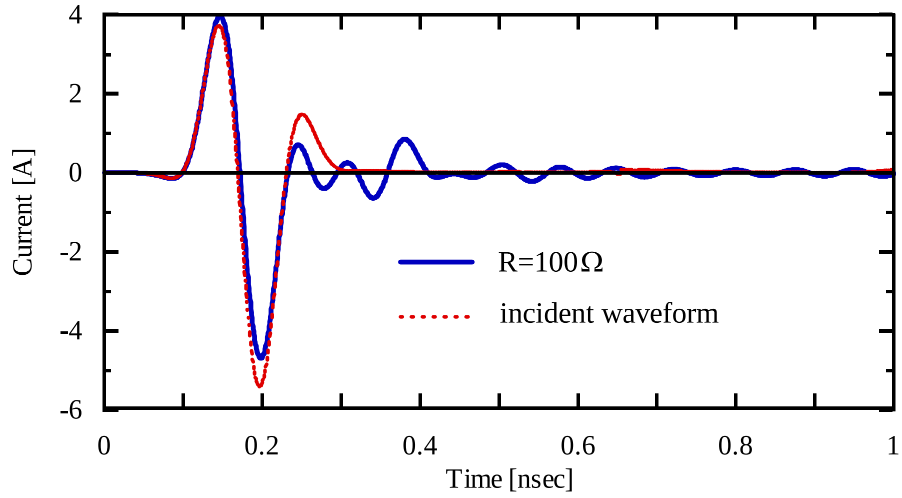
Figure 4 Electric field radiation patterns in vertical plane (E_ϕ , R=82Ω)



(a) R=68Ω



(b) R=82Ω



(c) R=100Ω

Figure 5 Time response of current amplitude at feed point.

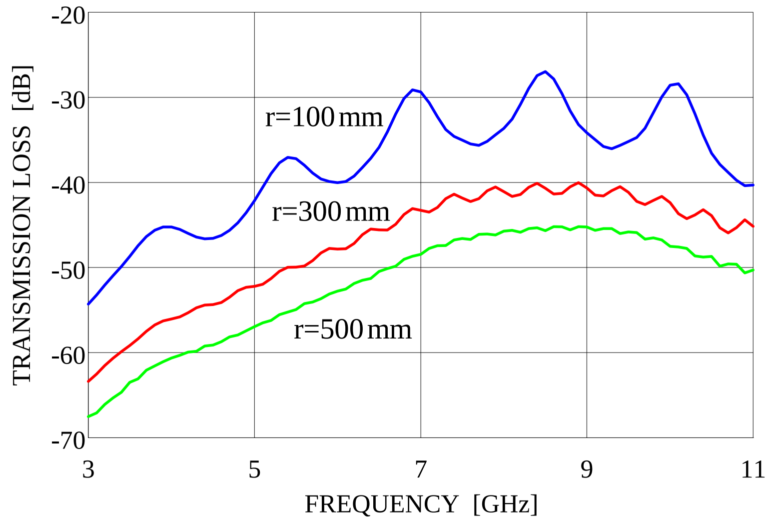


Figure 6 Transmission loss characteristics (R=82Ω)