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Cavity-backed Resistance-loaded Monopole Antenna for Impulse Radar

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Introduction

An antenna must operate effectively over a wide range of frequencies and have the reduced ringing within the antenna structure in many applications, such as the impulse radar which transmit and receive impulse signal. For the ground penetrating radar antenna, a T-bar fed slot antenna has suitable characteristics such as wide-band operation, low multiple reflection without absorber [1], [2]. However, the dimension of this antenna is not small compared with the wavelength at the center frequency. The cavity-backed monopole antenna is relatively small and used for the impulse radar [3].

In this paper, the cavity-backed resistance-loaded monopole antenna is analyzed and its broadband operations of input impedance and radiation characteristics are examined. In the numerical analysis, the electromagnetic simulator "Fidelity" based on the finite-difference time-domain (FDTD) method is used [4]-[6].

Structure of resistance-loaded monopole antenna

Figure 1 shows the structure of cavity-backed resistance-loaded monopole antenna. The monopole antenna is located within a rectangular cavity of $C_x = 48\text{mm}$ by $C_y = 44\text{mm}$ by $C_z = 44\text{mm}$ in dimensions. The conducting plate $30\text{cm}$ by $30\text{cm}$ in size is attached at the aperture of cavity. In order to improve the impedance characteristics in the wide frequency range, the planar monopole antenna is adopted. The resistance $R$ is loaded between the top of monopole and the wall of cavity for reducing ringing within antenna structure. In the numerical analysis, the perfectly matched layer of six-layer and fourth-order is used as the absorbing boundary condition. Space steps are from $1\text{ mm}$ to $4\text{ mm}$.
(non-uniform mesh). The calculation region is 140mm by 130mm by 136mm in dimensions. The resistor is replaced to a conducting material with conductivity \( \sigma \) such as [7],

\[
\sigma = \frac{\Delta z}{R \Delta x \Delta y},
\]

where, \( \Delta x, \Delta y \) and \( \Delta z \) are the space steps in the x, y, and z-direction, respectively.

**Numerical and experimental results**

Figure 2 show the input impedance characteristics of antenna. The width of monopole is \( W = 24\text{mm} \). The loaded resistance is 100\( \Omega \) or 220\( \Omega \). The calculated input impedances agree well with the measured data. Figure 3 show the calculated input impedance characteristics for \( W = 36\text{mm} \). Figure 4 shows the directivity characteristics for \( W = 24\text{mm} \) and \( W = 36\text{mm} \). Figure 5 and 6 show the electric field radiation patterns in the xz- and yz-plane, respectively. When \( W = 36\text{mm} \) and the resistance \( R = 68\Omega \), the input impedance characteristics show the broadband operation for 0.5GHz to 4.5GHz.

**Conclusion**

The cavity-backed resistance-loaded planar monopole antenna has been analyzed and its broadband operation has been shown for the frequencies from 0.5GHz to 4.5GHz. The time response of this antenna for the impulse excitation will be shown in the next opportunity.
Fig. 2 Input impedance characteristics.  W=24mm

- - - calculated
□ □ △ △ measured

Fig. 3 Calculated input impedance characteristics.  W=36mm,

References
Fig. 4 Calculated directivity characteristics.

(a) W=24mm

(b) W=36mm

Fig. 5 Calculated electric field radiation patterns in xz-plane.

W=36mm, R=68Ω

--- φ component ---- θ component

Fig. 6 Calculated electric field radiation patterns in yz-plane.

W=36mm, R=68Ω

----- θ component

