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ANALYSIS OF SCATTERING BY BURIED OBJECTS USING FD-TD METHOD AND SPECTRUM SEPARATE CALCULATION METHOD

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Abstract

Calculation of the scattering waveform induced the target buried invisible medium is described using FD-TD(Finite-Difference Time-Domain) method and SSC(Spectrum Separate Calculation) method. Although the results of FD-TD method are obtained field pattern more accurately than SSC method, by using the later, we can evaluate the field distribution in a short time. The purpose of the calculation of the scattering waveform is to get the position of the target clearly using a signal processing of the subsurface radar.

1. INTRODUCTION

The detection of artificial products or ruins at shallow depth of the underground is important. To make clear the space of the underground, various detection methods have been proposed and the development of apparatus and a signal processing have still been improved. Using a subsurface radar, it becomes advantageous because of non-destruction and non-contact.[1),2)] However, the estimation of the scattering waveform of the target observed by subsurface radar still continues for the improvement of the apparatus or the signal processing of it. In this paper, calculation methods of the scattering waveform using FD-TD[3)] and SSC[4)] one are stated. The result of the electric field pattern is shown under the following condition: exciting monopulse current is applied and the target is conductor or air gap surrounded by invisible media.

2.THEORY

2.1 FD-TD Method[5)]

Fig.1 shows the analysis model. The target is homogeneous medium having arbitrary form parallel to y-direction. The electric field component of x-, z-direction Ex, Ez and magnetic component of y-direction Hy get to zero as the exciting source locates parallel to the target.
Maxwell's equations are presented the finite difference form and the boundary conditions are respectively treated as analytical area, and absorbing boundary. Eqs.(1)-(4) are presented the conditions of absorbing boundary.

$$E_y^{n+1/2}(1,j)=E_y^{n-1/2}(2,j)+\alpha_5\{E_y^{n+1/2}(2,j)-E_y^{n-1/2}(1,j)\} \quad (1)$$

$$E_y^{n+1/2}(Ni,j)=E_y^{n-1/2}(Ni,j)+\alpha_5\{E_y^{n+1/2}(Ni,j)-E_y^{n-1/2}(Ni,j)\} \quad (2)$$

$$E_y^{n+1/2}(i,1)=E_y^{n-1/2}(i,1)+\alpha_5\{E_y^{n+1/2}(i,1)-E_y^{n-1/2}(i,1)\} \quad (3)$$

$$E_y^{n+1/2}(i,Nj)=E_y^{n-1/2}(i,Nj)+\alpha_5\{E_y^{n+1/2}(i,Nj)-E_y^{n-1/2}(i,Nj)\} \quad (4)$$

where $\alpha_5=(v\Delta t-\delta)/(v\Delta t+\delta)$ (5)

v:ray velocity in medium, Δ t:calculation time step($<\delta/\sqrt{2}v$) δ :lattice length.

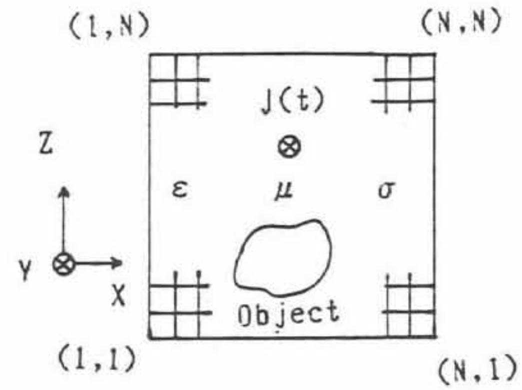


Fig. 1 Analysis model used at FD-TD Method.

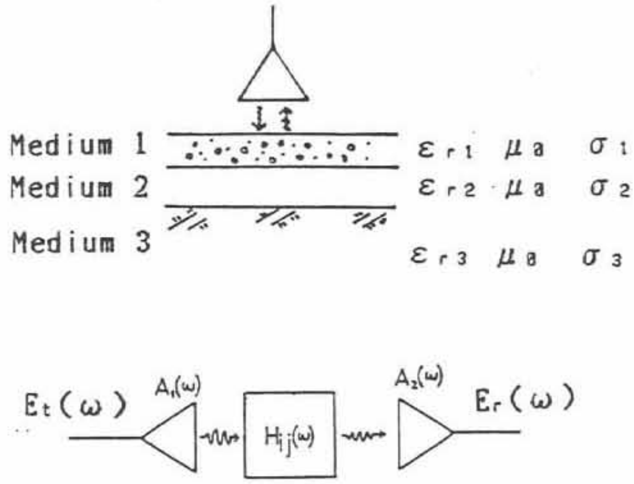


Fig. 2 Model used at SSC Method.

2.2 SSC Method

Fig.2 shows the model of one-dimensional structure of multi-layered dielectrics, and transmitted monopulse wave travels perpendicularly to the surface of the top of the structure. The scattering wave is calculated as follows: The spectrum of received signal $E_r(\omega)$ is represented by products of the spectrum of incident wave $E_i(\omega)$, the frequency property of antenna $A_t(\omega)$,$A_r(\omega)$ and transfer function of medium $H_{ij}(\omega)$. The waveform of the received signal can be obtained by inverse Fourier transform.

$$e_r(t)=\mathcal{F}^{-1}\{E_r(\omega)\}=\mathcal{F}^{-1}\{E_t(\omega)A_t(\omega)H_{ij}(\omega)A_r(\omega)\} \quad (6)$$

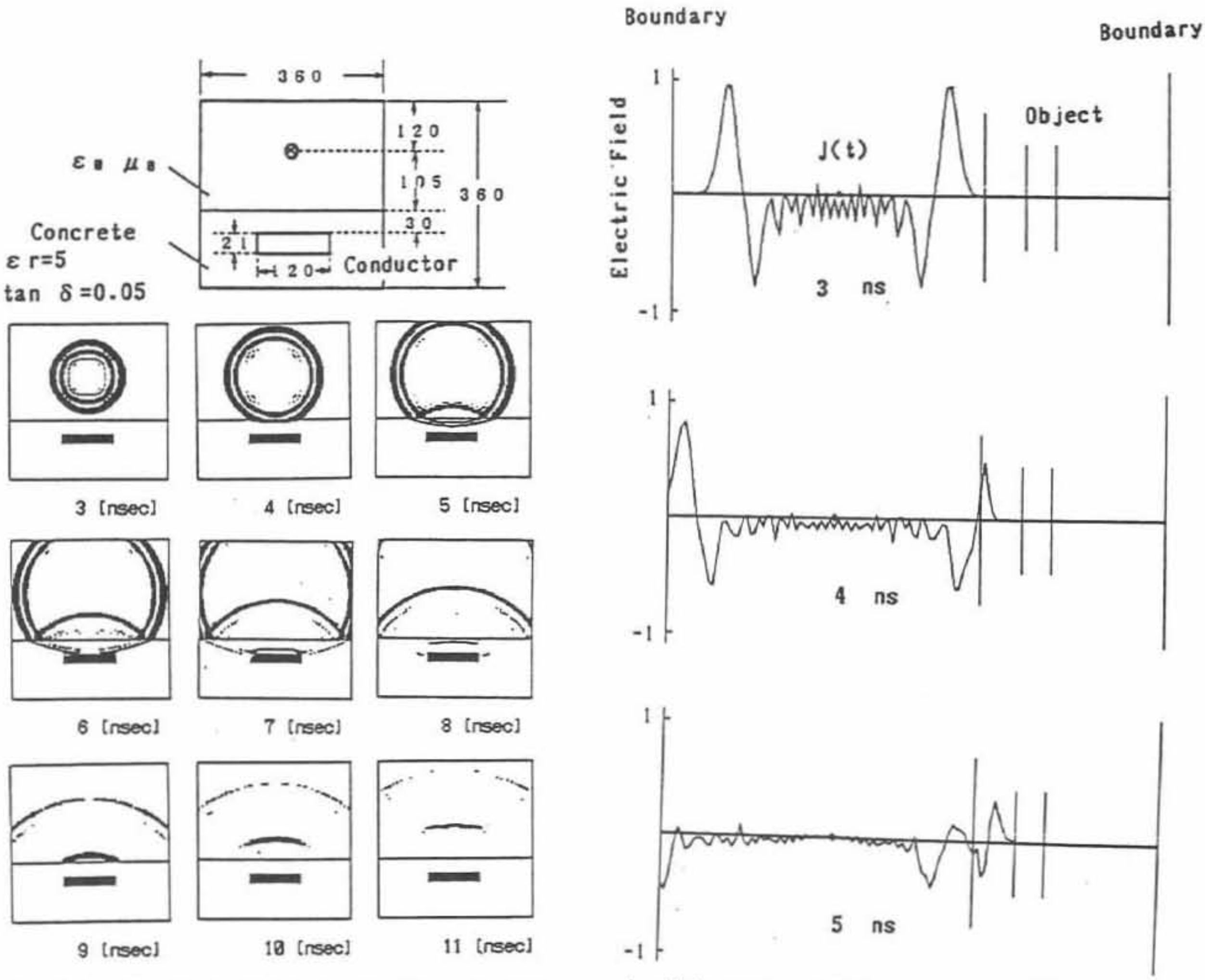
3. CALCULATED RESULTS AND DISCUSSIONS

Fig.3(a) shows distributions of the electric field that are calculated under the following condition: Exciting sources is set at 105 cm above from the top surface of concrete that contains a rectangular conductor object. An exciting current is expressed as in eq.(7).

$$J(t)=\sin(\pi t/T) \quad 0=< t <= T \qquad (7)$$
$$=0 \qquad \text{otherwise}$$

where T=1 ns. Other constants are Δ t=0.05 ns, δ = 3 cm and numbers of lattice N=120*120, in consequence the size of the analytic have been al area becomes 3.6 m square.

Fig.3(b) shows the space distribution of electric field at x= δ N/2. We recognize the scattering state of changing with time. Fig.4 shows the electric field of the receiving signal that excited monopulse wave and calculated by SSC method.[6]



Band in figure indicates relative strength of electricfield E_y above 0.2

In this case, exciting source J(t) exists at one point.

(a)Distribution of electric field E_y.

(b)Space distribution of electric field.

Fig. 3 Example of calculated by FD-TD Method.

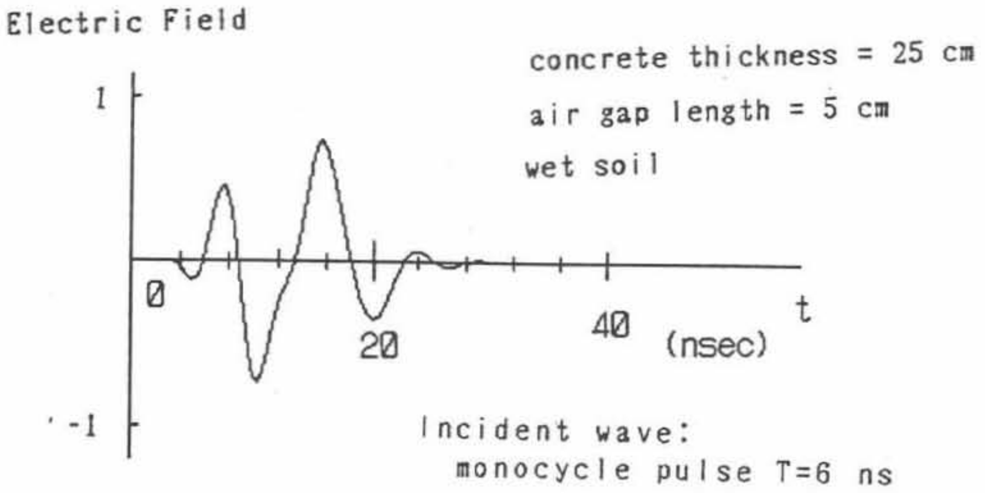


Fig. 4 Example of calculated by SSC Method.

4. CONCLUSIONS

The state of the scattering electric field by the target surrounded with invisible media has been evaluated by two calculation methods. The exciting current shown in eq.(7) creates the electric field pattern as shown in Fig. 3(b) similar the wave that passing through the antenna of monopulse exciting current. Therefore, two calculation methods consider that the evaluation of characteristics of the scattering wave contributes together at the signal processing of the subsurface radar.

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REFERENCES

1)T.Suzuki:Probing Buried Objects by Underground Radar. J.IEICE,67,3 pp.308-311(Mar. 1984).

2)I.Arai, T.Suzuki:Advaned Subsurface Radars. CICR-91,PL3-1,-6(1991).

3)R.Sakuma,K.Ooishi,T.Morita:Analysis of Electromagnetic Scattering Problems Using the Finite-Difference Time-Domain Method. Tech. Rep. IEE Japan and IEICE Japan, EMT-91-63, pp.81-90(1991).

4)Y.He, T.Uno, S.Adachi:Two-Dimensional FDTD Analysis of Transient Scattering of Cylindrical Wave by Conducting Objects Buried Underground. Tech. Rep. IEE Japan and IEICE Japan, EMT-91-130, pp.41-48(1991).

5)K.Taketomi, Y.Miyazaki:Monopulse Measurement on Dielectric Layers Structures using Spectrum Separate Calculation Method. Proc. of ISAP'89, 2D2-3, pp.465-468(1989).

6)K.Taketomi, Y.Miyazaki:Reflection Characteristics of Monocycle Pulse Measurement on Dielectric Layers Structure. International Symp. EMC, 8p3-A7, pp.334-337(1989).