Monopulse Measurement on Dielectric Layers Structures using Spectrum Separate Calculation Method

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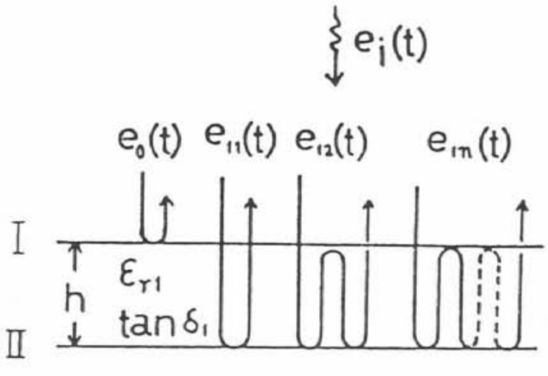
Abstract

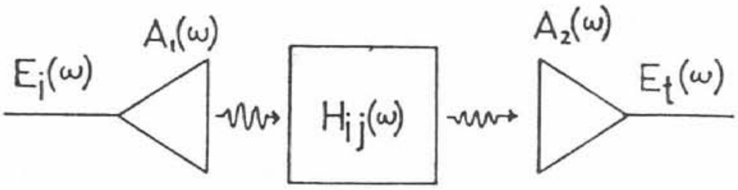
It is generally difficult to estimate the inside profile of dielectric layers structure using monocycle pulse which does not obtain a carrier frequency. The reflected wave of monocycle pulse from a dielectric structure consists of many elements passing through the layers.

If we could decompose the reflected wave into elementary component,it is easy to presume the inside profile.

As shown in Fig.1(a), we consider a monopulse measurement model, where the wave is normal incident to homogeneous dielectric layers.



(A) Elementary reflected wave



(B) Model under culculation

Fig. 1 Monopulse measurement

The reflection and transmission of the wave occurs at the discontinuous plane Ⅰ, Ⅱ shown in Fig.1, where we put the reflected wave in $e_0(t)$, one reflection path in $e_{11}(t)$, two reflection paths in $e_{12}(t)$, ...
Each elementary reflection waves are expressed by the following equations.

$$\left.\begin{array}{l} e_0(t)=\mathcal{F}^{-1}\{E_i(\omega)\,A_1(\omega)\,H_0(\omega)\,A_2(\omega)\} \\ e_{11}(t)=\mathcal{F}^{-1}\{E_i(\omega)\,A_1(\omega)\,H_{11}(\omega)\,A_2(\omega)\} \\ \text{-----} \\ e_{1n}(t)=\mathcal{F}^{-1}\{E_i(\omega)\,A_1(\omega)\,H_{1n}(\omega)\,A_2(\omega)\} \end{array}\right\} \quad (1)$$

where F^{-1} denotes the inverse Fourier transform, $E_i(\omega)$ is the spectrum of the incident wave, $H_0(\omega)$ is the transfer function of the elementary reflection wave path and $A_1(\omega)$,$A_2(\omega)$ are transfer functions of antennas as shown in Fig.1(B).

As a result, the receiving wave $e_r(t)$ are represented by the sum of each elementary reflected wave.

$$e_r(t) = e_0(t) + e_{11}(t) + \cdots + e_{1n}(t) \qquad \cdots(2)$$

Now, we consider the spectrum separation method. By dividing the incident pulse into positive and negative parts as shown in Fig.2, we can rewrite

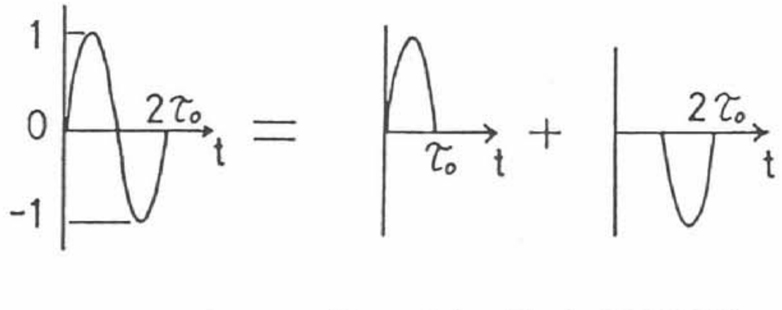


Fig. 2 Separation of incident monopulse

eq.(1) as

$$\begin{aligned} e_0(t) &= \mathcal{F}^{-1}\{ (1-\exp(-j\omega\tau_0))\, Eil(\omega)\, A_1(\omega) \\ &\qquad H_0(\omega)\, A_2(\omega)\} \\ &= \mathcal{F}^{-1}\{ Eil(\omega)\, A_1(\omega)\, H_0(\omega)\, A_2(\omega)\} \\ &\quad - \mathcal{F}^{-1}\{\exp(-j\omega\tau_0)\, Eil(\omega)\, A_1(\omega) \\ &\qquad H_0(\omega)\, A_2(\omega)\} \quad \text{----} (3) \end{aligned}$$

where spectrum Eil(ω) means positive part of $e_i(t)$. Then, we can decompose the wave $e_0(t)$ into two parts.

It is possible to express the same form in regard to $e_{11}(t), e_{12}(t), \ldots$

The observed wave forms are complicated due to various factors.

In monopulse measurement, it is necessary to separate the observed wave into elementary waves.

For that reason, we have considered the method which enables the decomposition of that observed wave.

At first step, we consider the head part of the synthesized signal response $f_0^0(t)$, because that potion contains the major parts of the surface reflected wave, as is shown in Fig.3. We can derive the surface wave using eq.(4).

$$e_0(t) = \mathcal{F}^{-1}\{Eil(\omega)\, A_1(\omega)\, F_0^0(\omega)\, A_2(\omega)\} \qquad (4)$$

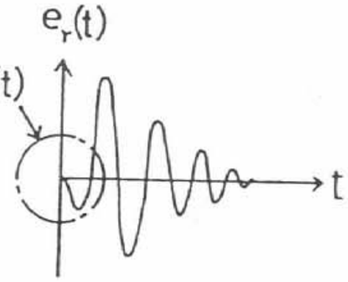
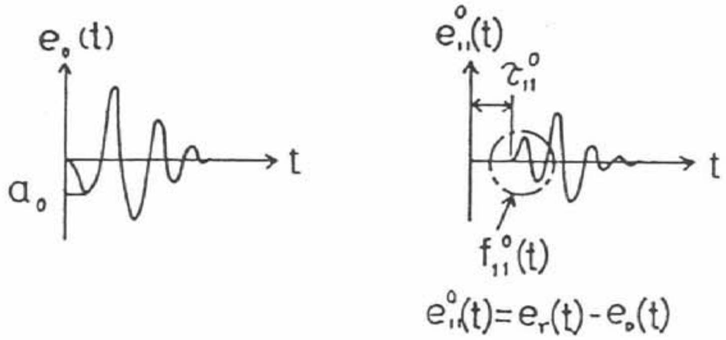


Fig. 3 Synthesized wave form

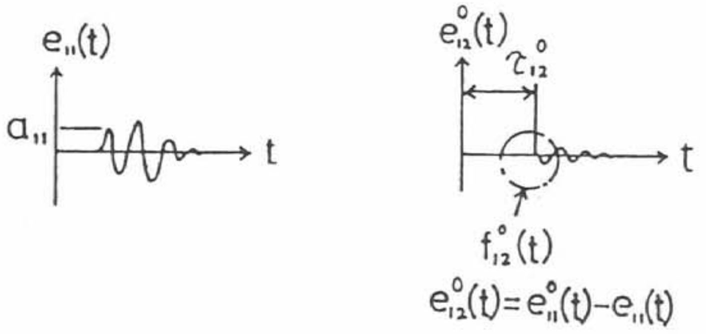
In the next step, we can get the wave form $e_{11}^0(t)$ by subtracting $e_0(t)$ from $e_r(t)$, and we can obtain two quantities of $f_{11}^0(t)$ and τ_{11}^0 as shown in Fig.4. According to the same processing, we can separate to elementary reflection wave as shown in Fig.5.



(A) Elementary reflected wave $e_0(t)$

(B) Wave form $e_{11}(t)$

Fig. 4 Decomposition of wave form 1



(A) Elementary reflected wave $e_{11}(t)$

(B) Wave form $e_{12}(t)$

Fig. 5 Decomposition of wave form 2

References

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