Reconstruction of 3-D Dielectric Objects from Experimental Data in the Time Domain

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Many nonlinear inversion techniques have been proposed for imaging high-contrast objects both in the frequency domain and in the time domain. Since the use of a broad-band pulse allows a large amount of information about unknown scattering objects than a single frequency scattering data, we have proposed a time-domain inverse scattering imaging technique, the forward-backward time-stepping (FBTS) method, to reconstruct the electrical parameter (the permittivity and conductivity) profiles of the scattering objects. We have also shown its effectiveness in several numerical simulations for inhomogeneous anisotropic as well as isotropic objects in the previous works.

This paper reports the 3-D reconstruction of the relative permittivity profile of an unknown object from the experimental data in the time domain. Eight antenna elements are placed equally spaced in a measurement circle. One of the antenna elements are used as a transmitting antenna and emits a pulsed wave. The scattered wave by the object is collected by the rest of them. Instead of using a pulse generator, we use a vector network analyzer which generates a stepped-frequency signal. The time domain representation of the scattering data is attained via the inverse Fourier Transform. All the transmission response $S_{ji}(j \neq i)$ between the ith transmitting antenna and the jth receiving antenna (i, $j = 1, 2 \ldots, 8$) are measured. Then, we change the transmitter point to the next antenna point and repeat the same measurement until all the antenna positions are used as a transmitter point. Next we move the measurement circle in the vertical direction and continue the measurement in the same way. We change the height of the measurement circle twice, so that we get 168 scattered field data. These data S_{ji} are multiplied by the spectrum of an incident pulse. Then taking the inverse Fourier transform of the resultant spectrum, we get the time domain scattering data to apply the FBTS method to the reconstruction of the relative permittivity profile of the unknown object. The FBTS method was tested on the experimental data from a wooden hollow cylinder. The 3-D shape and the relative permittivity profile of the cylinder were successfully obtained.