Advances in Through-Wall Imaging Using Impulse SAR

Giorgio Franceschetti*(1), James Tatoian(1), David Clark(1), John McVay(1) ,
George Gibbs(2),
(1) Eureka *A*erospace, Pasadena, CA, 91107, http://www.eurekaaerospace.com
(2) MARCORSYSCOM, Quantico, Virginia 22134

A simple closed form solution for the impulse response, for both the transmission and reflection from a single wall as a function of wall material characteristics, including wall thickness, dielectric constant and conductivity was obtained, which can be applied directly to realistic scenarios. A single useful parameter, $\tau = \frac{\varepsilon_0 \varepsilon_r}{\sigma}$, called a relaxation time of the wall, characterizing the material properties of the wall is studied, where ε_0 is the permittivity of free-space and ε_r and σ are the relative dielectric constant and the conductivity of the wall material, respectively. It can be shown that when the relaxation time of the wall material exceeds the pulse width of the incident waveform, the reflected and transmitted waveform deformations due to attenuation and dispersion are negligible. The results are validated using numerical calculations using the Finite Difference Time Domain (FDTD) engine. Multi-wall interference models were developed based on the results obtained for single wall impulse response functions for the transmission and reflection. A systematic straightforward procedure was developed for multi-wall clutter interference assessment in terms of cascading suitable transmission and reflection convolution operators. The procedure allows for the computation of the multi-wall clutter interference for an arbitrary incident waveform. Examples showing multi-wall interference effects as applied to two different scenarios, involving two and four walls, are presented. In addition, time-domain analysis of the early-time and late-time response from two canonical targets, namely a sphere and a cylinder, was carried out. The early-time and late-time responses were separated analytically to show their physical significance separately, which will play a significant role in the future development of optimal processing algorithms for through-wall target detection and identification.