Pulse Shaping Approach to the Generation of Highly Focused and Slowly Decaying Localized Waves

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Recent trends in communication, target location and identification, remote sensing and other applications have been toward the use of ultra wide-band electromagnetic waves. Localized waves are newly developed solutions of the wave equation. They are carrier-free, ultra wide-band pulsed wave fields consisting of a highly focused central portion embedded in a sparse low-intensity background. Most previous studies of localized wave's solutions were focused on the general properties of such wave solutions, their different representations, their causality and the possibility of generating approximate forms of such wave solutions. In this thesis, most of our work is concentrated toward the study of the propagation of these pulses in the near-far field region. Special attention is given to the pulse shaping and its influence on decay properties and several approaches will be investigated for slowing down the rate of decay in the near-far field region. We extend the idea of generating localized wave pulses from dynamic apertures to the case of the localized wave's solutions that might appear to have a missile effect such as the modified focused X-wave (MFXW) pulse and the X-wave.

It is shown that highly focused pulses can be shaped by exciting a finite aperture using an outspread pulse train of X-waves. The proposed scheme is based on the fact that the peaks of X-waves, characterized by different apex angles, travel at different velocities. This property allows one to vary the time instants of the initial excitations of a sequence of X-waves so that all their peaks meet at an a priori chosen focusing point. It is demonstrated that this simple criterion can be effective in producing a highly focused composite X-wave pulse, exhibiting a slower decay behavior than the individual X-wave components used in synthesizing it.

A scheme is introduced for focusing pulses generated in one medium at a position in a second medium. The analysis is carried out for the general case of oblique incidence on a planar interface separating the two media. This method depends on constructing a composite pulse from a train of X-waves traveling at different speeds. The initial temporal separation between the individual X-waves is chosen such that the resulting field is focused underneath a surface of discontinuity separating two different media.

This proposed time-focusing technique is extended for the case of a multi-layered structure below the upper air-dielectric interface, the transmitted X-wave is multiply reflected inside each layer and the reflected X-wave is reconstructed into free space. In this thesis, special attention is given for the biological medium (fat-muscle layered medium) and focusing method is used for tumor treatments. The advocated method is based on transmitting a train of individual X-waves in such a way that a highly focused CXW at the tumor location.