Bandwidth and Low-frequency Effects on Brillouin Precursors

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It has been shown theoretically and experimentally that Brillouin precursor arises when an ultrawideband (UWB) electromagnetic wave propagates through a dispersive media under certain conditions. It is further verified experimentally that the Brillouin precursor attenuates algebraically as compared to the exponential decay experienced by the carrier. This property of the precursor field can be exploited to design remote sensing system for imaging through dispersive medium that can reach longer propagation distances due to the lower power attenuation.

For practical systems, however, two considerations must be made: namely, the overall total finite bandwidth and the starting low frequency of that bandwidth. For microwave and millimetric UWB systems, the low frequency of the bandwidth is of utmost importance. This paper discusses the effects of both low frequency and bandwidth limitations on precursor formation.

For simulation purposes, we consider triply distilled water wet loamy soil characterized by Debye models. Frequency dependent attenuation constant α_k and the phase constant β_k are then obtained through this model. In our formulation, we use a band-limited sine-modulated pulse which is decomposed into its orthogonal frequency components such that if only a limited set of $2M+1$ frequency components are considered around its carrier frequency f_0, the time-domain transmitted signal $x(z=0,t)$ can be re-constructed with significant accuracy. Assuming the amplitude of the k-th frequency component $A_k(z) = |X_k| e^{-\alpha_k z}$ at a distance z, and ϕ_k its phase, the reconstructed signal can be represented as in (1):

$$\tilde{x}(z,t) = \frac{1}{2M+1} \sum_{k=-M}^{M} A_k(z) \cos\left(2\pi f_k t - \beta_k z + \phi_k\right) \quad (1)$$

Using the above formulation, results pertaining to experimentally obtained data through wet loamy soil and tap water are presented.