Photonics-Based Electromagnetic Pulse Shapers and Mitigation of the Dispersive Phase Response of Radio-Frequency Antennas

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For ultra-wideband (UWB) applications, which utilize large fractional bandwidth impulsive signals, control of phase distortions (dispersion) is critical. The pulse broadening that arises from radiation from broadband antennas, for example, could significantly decrease the achievable data rates in impulse radio schemes and degrade spatial resolution for applications such as impulse radar. While methods to compensate for the dispersion of broadband antennas under impulsive excitation have been thoroughly analyzed theoretically (D. M. Pozar, IEEE Trans. Antennas Propagat. **51**, 2335-2345, 2003), such techniques have yet to be implemented electronically due to the limited capabilities of electronic arbitrary waveform generators. To our knowledge, we present the first experimental demonstration of compensation of antenna dispersion effects on multi-gigahertz impulsive UWB signals.

In this work, our interest is in compensating for the dispersive phase response of highly-directional broadband antenna structures. To ensure our measurements reflect only the response of our antennas, our experiments are designed to focus on the line-of-sight response of a wireless link in the absence of multipath interference. In our technique, we first extract the RF spectral phase contribution $\phi_a(\omega)$ from a pair of broadband antennas via the Fourier transform of a time-domain impulse response measurement. We then exploit the capabilities of an electromagnetic pulse shaper, based on optical arbitrary waveform generation technology and optical-to-electrical conversion (I. Lin et al, IEEE Microwave Wireless Compon. Lett., **15**, 226-228, 2005), to synthesize excitation waveforms that exhibit the opposite RF spectral phase to that arising from our antennas ($\phi_e(\omega) = -\phi_a(\omega)$). For waveforms with this spectral phase characteristic the dispersive phase response of the antennas is removed and the received waveform in the wireless link is compressed to a short pulse.

For a variety of excitation waveforms with frequency content in the ~1 - 10 GHz range, we demonstrate that phase precompensation leads to temporal compression and reduced ringing levels in the received signal as compared to the link response under impulsive excitation. To illustrate the applicability of our technique, we present data from several link geometries. In particular, we have performed experiments on links consisting of similar (two ridged horn antennas) and dissimilar (one ridged horn, one log-periodic) antenna structures. Based on our results, we believe our technique could provide new front-end capability in UWB systems.