Optical Pulse Shaping for Time-Domain Characterization of Broadband Antenna Structures

Jason D. McKinney, Dimitrios Peroulis, and Andrew M. Weiner
School of Electrical and Computer Engineering, Purdue University,
West Lafayette, IN 47907-2035

The Archimedean spiral, like many frequency-independent antennas, is known to exhibit a strong temporal dispersion under impulsive excitation. In general, several techniques can be used to extract the frequency-domain phase properties that characterize this dispersion. The radio-frequency (RF) spectral phase $\phi(\omega)$ may be extracted directly from vector network analyzer (VNA) measurements or via the Fourier transform of time-domain impulse response measurements. In practice however, both of the above measurements may be complicated due to the presence of reflections (either multipath interference or reflections within the feed network of the antenna structure). In this work we characterize the transient response of a homemade broadband Archimedean spiral antenna by utilizing 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). Our apparatus enables us to extract the dispersive properties of our spiral antenna and reflections within the antenna feed network via time-resolved frequency-dependent measurements of a wireless link.

In contrast to VNA or time-domain impulse response measurements geared to determine the RF spectral phase $\phi(\omega)$ directly, one may alternatively measure the frequency-dependent delay $\tau(\omega) = -d\phi(\omega)/d\omega$. To extract $\tau(\omega)$, amplitude-modulated gaussian pulses are applied to our transmitting antenna. Then, $\tau(\omega)$ is determined by measuring shifts in the temporal location of the peak in the received waveform as a function of the pulse center frequency. Our electromagnetic pulse shaper provides the functionality required to perform this measurement over a frequency range of ∼1 - 11 GHz in a time-resolved manner - with center frequency agility and bandwidth tunability - without requiring any RF source electronics. Several example excitation waveforms from our pulse shaper (7 GHz and 2 GHz) and the resulting delayed received waveforms are shown in Figure 1. We illustrate that, by adjusting the duration of our excitation waveforms, we are able to resolve the effects of reflections occurring within the antenna feed network, thereby achieving a time-resolved measurement of the frequency dependent delay $\tau(\omega)$.

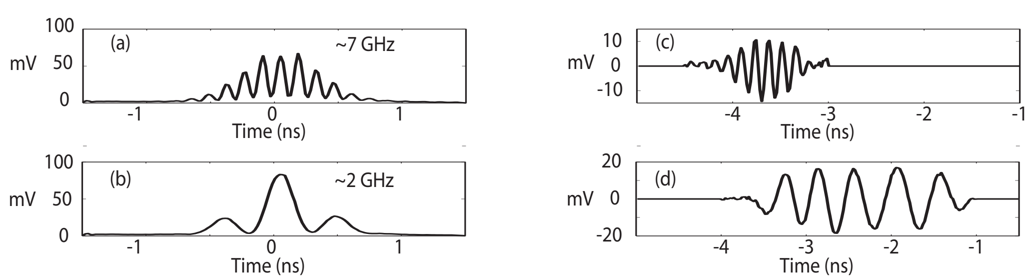

Figure 1: (a),(b) Example excitation waveforms and (c),(d) received waveforms used to determine the frequency-dependent delay $\tau(\omega)$.