A Novel MIMO Multicarrier Free Space Superposition Technique Based On Wavelet Transform Decomposition

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Recently, MIMO multi-carrier systems for radar and communications have gained traction in the research community due to their potential and proven performance benefits over other architectures. Research focus, however, has been primarily on the signal processing aspects of these systems, rather than the electromagnetic analysis of the superposed multi-carrier signals in free space. Consideration and control of this superposition used in tandem with signal processing techniques can yield signal security and resilience unachievable through other means. Here, an electromagnetic wave superposition scheme for application in secure MIMO wireless communications and radar is proposed and discussed. It is shown through simulation that a group of scaled, mixed, and phase shifted EM signals at different frequencies can be linearly combined to create specified waveforms at arbitrary target locations. Based on transmitter properties and configuration, this specified waveform can be designed to exist at one or multiple positions.

In order to determine the scaling coefficients of the constituent signals, a decomposition method based on the wavelet transform is used. By definition, a wavelet can be used as a basis function to construct any square integrable function, much like sines and cosines in the fourier regime. What makes the wavelet transform unique is its ability to characterize a signal in terms of both frequency and time with resolutions that outperform both the fourier and windowed-fourier transforms when considering non-stationary signals. Because of this, the wavelet transform allows a wide range of signal types to be represented.

The proposed method creates constituent signals by taking the wavelet transform of a discretized input signal using a sub-band coding filter bank or a simple arithmetic algorithm. Each frequency band level output is then multiplied by a sine wave at some frequency within that band (the sine wave approximates the summation of shifted basis wavelets). Adding these output signals results in the desired waveform.

In particular, this method is discussed with regard to sinusoidal signals, as transmitter implementation is most straightforward in this case. The identity of the signal during propagation is also modeled and analyzed while considering both omnidirectional and directive antenna configurations. Finally, target location reconfigurability through array beam steering and general signal phase shifting is discussed.