Over the Air Validation of an HF Broadband Direct Antenna Modulation Transmitter

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Electrically small antennas are limited by well-known physical bounds. These bounds restrict the ability of a small antenna to transmit or receive broadband signals, thus also enforcing a maximum rate of data throughput under specific environmental conditions. A key feature of such bounds is the assumption that the electrically small antenna is linear, passive, and time-invariant. Breaking these assumptions through the use of time-varying elements presents the opportunity to circumvent the classical bounds and open up a new class of electromagnetic devices. When applied to electrically small transmitting antennas, the use of non-linear and time-varying components to transmit high bandwidth signals is known as direct antenna modulation. Several methods for direct antenna modulation were proposed in the 1960's (e.g., Galejs, IEEE Trans. on Comm. Sys. 1963) and rediscovered in recent years (e.g., Xu, IEEE AP-S 2006; Salehi, PIER 2013). However, few experimental results have been reported validating these schemes and their impact on communications-level performance metrics, such as bit error rate.

In this presentation, a direct antenna modulation scheme for on-off-key transmissions originally proposed in (Galejs, IEEE Trans. on Comm. Sys. 1963) is studied in detail using a variety of modern techniques. The proposed method is based on using a switched matching network to transmit extremely broadband pulses via an electrically small dipole antenna. We will cover the fundamental principles of the method, challenges which previously prevented its implementation, and new insight gained from a novel transient analysis procedure. The presentation will also include the details of an over-the-air experiment designed to compare the performance of a conventional, linear time-invariant system with one using direct antenna modulation. We discuss validation of the direct antenna modulation method, as well as its limitations.