Impact of radiation quality factor on the transient radiation from a directly modulated antenna

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The lower limit on the quality factor of an electrically small antenna (defined by the Chu-Harrington limit) restricts the maximum value of its bandwidth-efficiency product, which in turn limits the maximum realizable data rate of any communication system. This limit presumes the antenna is static device which is typically characterized through its several steady state parameters. Recently, attempts have been made to break this limit by using the transient properties of the antenna. In this approach, the information bit sequence is directly modulated by applying a baseband modulation signal to an active element on the antenna aperture. This approach is referred as direct antenna modulation and both amplitude and frequency shift keying have been studied using this approach. Several qualitative results in the literature have demonstrated that a more broadband signal can be transmitted with this method compared to conventional modulation techniques. However, it remains unclear whether this wider transmitted spectrum results into a quantifiable improvement of the received information signal.

In this study, we analyze the effect of the most fundamental antenna parameters in a direct modulation scheme through simulation with the finite difference time domain method. An amplitude keyed pulse is applied to a diode on the antenna aperture to modulate the radiated signal, but the received signal consists of harmonics and intermodulation products far from the carrier frequency. Simulations indicate that the response of the radiated signal depends on the quality factor of the antenna. Thus, the bandwidth of the directly modulated system is not independent of the radiation quality factor as implied in some recent work. Equivalent circuit model to map the behavior for quicker analysis and performance metric calculations has also been developed. We compare the impact of the antenna quality factor in the directly modulated system with its effect in a conventional modulated transmitter in order to understand the potential advantages and limitations of this direct modulation approach.