Frequency Independent Antennas - Perceptions and Reality of Engineering Thereof

Dejan S. Filipovic[(1)]
(1) University of Colorado, Boulder, CO, USA, 80309-0425

The performance of frequency-independent (FI) antennas, including spirals, sinuous, and log-periodic antennas, remains consistent over wide instantaneous bandwidth, the limits of which are determined by the fidelity of the feed and overall antenna size. For flush-mounting, the aperture of an FI antenna is backed by an absorber-filled cavity, which among other things, limits their power handling capability to tens of watts and renders their use to low-power communications and receive-only electronic support systems. However, this lossy backing ensures a high-quality single mode radiated field; provided aperture and beamformer network are well designed. The number of useful FI modes is equal to N-1 for spirals and the integer value of N/2 where N is the number of arms for dual-polarized sinuous or log-periodic antennas. Tightly wrapped spirals have excellent frequency domain characteristics, but they are highly dispersive when excited by wideband pulses. Finally, to operate in millimeter and sub-millimeter-waves, the bolometers or diodes need to be integrated within the feed region of FI antennas.

In this paper, we demonstrate that there is much more to the spiral, sinuous, and log-periodic antennas than what is conventionally accepted. Specifically, we show that the planar spiral, sinuous, and log-periodic antennas can be designed and developed to handle 100s of Watts of CW over multiple octaves with minimal compromise in the quality of their far-field. Arrays of high-power spirals are also developed with good performance over at least two octaves. We also demonstrate that a fine quality mode 2 alongside inherent modes ±1 can be achieved from an over 40 years old, yet seldom used or discussed four-arm FI antenna. Next, we debunk a common perception that the spiral antennas are poor time-domain radiators unless their frequency domain performance is severely compromised. Starting from first principles, a new spiral aperture is developed that works extremely well in time and frequency domains. Finally, we show that the recent developments in surface micromachining can be exploited to design and build high-performance FI antennas deep into millimeter waves. Spiral and log-periodic antennas operating anywhere from 18 GHz to 110GHz with direct RF feeds are built and measured.

In summary, though the FI antennas have been known for a long time, there are still many open topics to research and questions to answer. Often, the conventionally accepted ‘truths’ are just perceptions.