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Super-Wide Bandwidth Dipole Antenna with Dual Resonance Phenomenon

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Abstract : This research article discusses a recently discovered dipole antenna theory and principles, and a super-wide bandwidth dipole antenna design based on this novel theory. The super-wide bandwidth antenna design offers ~130% fractional bandwidth without utilizing bandwidth-enhancing electronic devices such as balun or matching networks. The research expands on a dual resonance phenomenon that was observed for a three-dimensional VHF dipole antenna in previous research. It was discovered that a simple planar dipole antenna exhibits a dual resonance when the antenna's length-to-width ratio is about ~2.6, and the feed location is at 30% of the width from the edge. When the length-to-width ratio is 2.6, the antenna's width is approximately equal to a quarter-wavelength corresponding to the second resonant frequency. A super-wide bandwidth VHF dipole antenna was modeled with length and width of 26 in. and 10 in., respectively, and the antenna was fed at 3 in. from the antenna edge. The antenna exhibited a distinct dual resonance with S11 lower than -10 dB over the wide operating frequency range of 164-424 MHz. The antenna resonated at 191 MHz with a super-wide bandwidth of 260 MHz. The radiation pattern at the first resonance was doughnut-shaped, similar to that of a typical dipole antenna in both the azimuth plane and elevation plane. The second resonance was observed at 358 MHz, and the radiation patterns at the second resonance were found to be more directive in the zenith and nadir directions. Simulated parametric analyses were conducted using Ansys Electronics Desktop software, where the antenna's physical parameters, including length, height, width, feed location, and length-to-width ratio, were varied, and their impact on the antenna's bandwidth performance was measured. In a parametric analysis, the dipole antenna's length-to-width ratio of ~2.6 was kept constant, and the length parameter was varied to operate the antenna at HF to SHF frequencies, and these antennas offered similar fractional bandwidth performance regardless of the frequency bands. With the constant length-to-width ratio, antenna width can also be varied to adjust the second resonant frequency and bandwidth. Regardless of the operating frequency band in the radio spectrum and physical shape, a dual resonance was achieved for both two-dimensional planar and three-dimensional structural dipole antennas operating in low HF to SHF band. By maintaining the length-to-width ratio of ~2.6, similar bandwidth performance was achieved for 3D structural antennas with open cross-sections, such as C-channel and I-channel. Simulated results were in good agreement with prototype experimental results from previous studies. With super-wide bandwidth performance, multifunctional structural antennas can be integrated into aircraft systems and space structures for remote sensing. The super-wide antenna bandwidth can play a crucial role in achieving finer resolution for remote sensing as well as ground penetrating radars and many other scientific applications and fields. Wider bandwidth would also offer versatility in radar applications and significantly improve signal processing with a better performance trade-off.

Keywords : planar dipole antenna, dual resonance, super-wide bandwidth, multi-functional structural antenna
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