A Systematic Investigation on Patch Antenna Bending Effects for Wearable Applications

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Recent advances in the field of wearable technology have fostered an increasing need for the development of reliable and robust wearable antennas. Generally, there are two major challenges in designing wearable antennas. First, the proximity of lossy human tissue results in a reduction of antenna efficiency and limits the maximum transmit power due to heating concern. Secondly, the bending effects degrade the performance of antennas compared to their flat condition. And even if the antenna is designed for a fixed bending condition, the inter-person bending variation can be significant in determining the antenna performance.

In this work, we present a systematic investigation on the bending effects of wearable rectangular patch antennas. The resonant frequency and radiation pattern variations have been studied by simulating patch antennas in a full-wave model. The objective of this work is to generate useful design curves to help antenna designers for wearable applications to incorporate the effects of bending more efficiently.

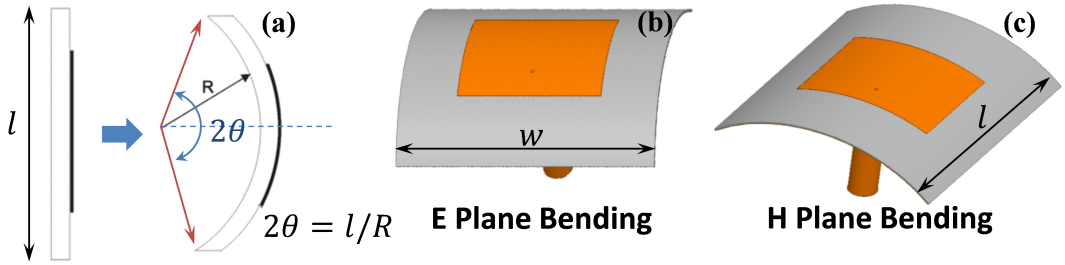

Figure 1: Characterization of patch antenna bending effects. (a) The illustration of bending angle, (b) E plane bending and (c) H plane bending.

We studied the effects of frequency shift as the antenna being bent by different angle along the E and H plane. The bending angle has been varied from 0° to 180°, and resonant frequency f_{res} has been normalized by the flat condition resonant frequency f_0 and studied for each case. By simulating and comparing antennas that are scaled for different frequency of operation, we proved that the bending angle vs. normalized frequency shift is a universal criteria that remains consistent over frequency scaling, and is thus suitable to be used as a merit to compare the bending robustness among various types of antennas. The effects of antenna bending on radiation pattern and efficiency are studied by simulations as well.

Additional works on this subject include study of bending effects on other aspects of antenna performances, comparison of bending robustness among various types of commonly used antennas candidates, generating simple formulas to estimate the potential bending effects for antenna performance degradations, and wearable antenna optimization incorporating bending analysis.