A Flexible High Gain Wide-Band Antenna for Wireless and Wearable Applications

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A Flexible High Gain Wide-Band Antenna for Wireless and Wearable Applications

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***Abstract*—A wideband, flexible printed antenna, fed via the Co-Planar Waveguide (CPW) geometry, with high gain is presented in this paper. The high gain was realized by using a reflector on the same level with the radiator and around it. The high gain performance of the antenna was observed throughout the whole wide spectrum of 1.53 GHz to 2.74 GHz, with a percentage bandwidth of approximately 57%. For flexibility, the antenna was printed on the flexible Rogers Ultralam 3850 substrate. With such characteristics, the antenna can be recognized in a number of wireless applications; such as, WLAN, WI-Max and RFID, as well as, wearable applications.**

***Keywords*—high gain antennna; flexible; wearable antenna; wideband antenna; wireless applications; wearable applications**

I. Introduction

Nowadays, the field of flexible antenna is witnessing remarkable progress and evolution in research, design and fabrication [1]. At the same time, the progress in wireless devices has produced many of interesting designs of antennas that can be bent and fixed on non-planar objects [1]-[3]. However, the antenna that is designed on flexible substrate is most susceptible to performance deterioration. This is because the deformation of the substrate has direct effects on the radiation pattern property of the antenna [2]. Based on that, flexible antennas are under continuous analysis and studies. Although traditional microstrip antennas have many advantages; such as, uni-directional pattern field in addition to low complexity and low cost in fabrication, but as a result of their substrate thickness and dielectric constant (relative permittivity), they produce very narrow bandwidths which is not preferred in wireless and wearable applications [4]. On the other side, low profile Co-planar Waveguide (CPW)-fed antennas provide a wide bandwidth to serve the demand of different wireless and wearable applications [4]-[6]. There is an urgent need and high demand for flexible high gain antennas dedicated to wireless and wearable applications. High gain antennas can be achieved by several methods such as using Artificial Magnetic Conductors (AMCs), metamaterial or a horn reflector [4], [7]-[8].

An ultrathin, flexible, wideband antenna with high gain is proposed in this paper. By using a reflector, attached to the ground, printed on the same side of the antenna, high gain was achieved. Due to its wide bandwidth, the proposed antenna serves certain wireless and wearable applications.

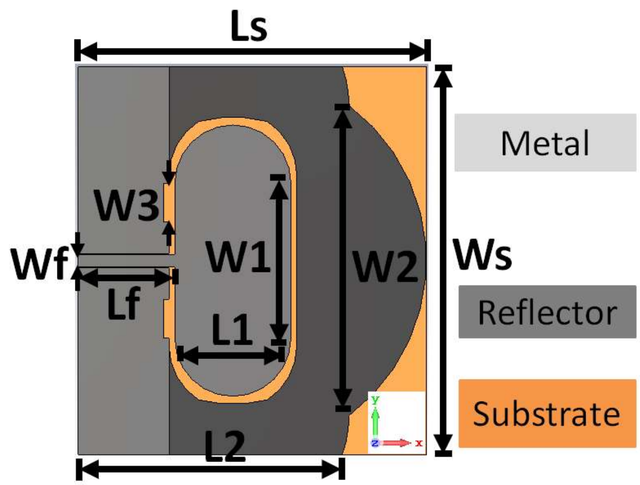

Fig. 1. The proposed antenna 2D layout.

II. Antenna Design and Configuration

Since the proposed antenna was designed to be flexible and bendable without affecting its performance under thermal and endurance conditions; therefore, Rogers Ultralam 3850, with dielectric constant of 2.9, was the best choice to achieve the desired results. It consists of Liquid Crystalline Polymer (LCP) with a thickness of 100 µm and loss tangent of 0.0025. The proposed antenna 2D layout configuration, shown in Fig. 1, where its dimensions are specified in Table I, was modelled and simulated by using the 3D full-wave simulator, Computer Simulation Technology (CST) software. The layout of the antenna is comprised of the radiating element, reflector, and the CPW, which was used for feeding the antenna as it provides a single side fabrication. The radiating element is a wide oval shape inspired from integrating rectangular and circular monopole patches together, which offers a wide bandwidth based on its operating frequency. The reflector surrounding the radiating element, which is considered the main contributor to this work, achieved high gain. To increase and enhance the matching of the proposed antenna along its whole wide bandwidth, two slots, symmetric by the feed-line, were employed in the CPW. The CPW feed-line's width and spacing, between the ground and feed-line, of 0.2 mm were used to achieve the 50Ω excitation for the proposed antenna.

TABLE I. PARAMETERS AND DIMENSIONS OF THE 2D LAYOUT

Antenna layout parameters in mm						
Parameter	*Ls*	*Ws*	*L1*	*W1*	*L2*	*W2*
Dimension	*90*	*100*	*30*	*40*	*68.28*	*80*
Parameter	*W3*	*Lf*	*Wf*	-	-	-
Dimension	*10*	*25*	*3.255*	-	-	-

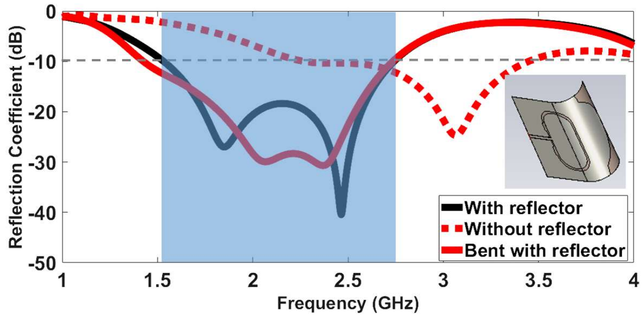

Fig. 2. Comparison between the simulated reflection coefficient of the structures, including the reflector, without it and when bent, against frequency.

III. SIMULATION RESULTS AND DISCUSSION

To study the impact of the reflector and the performance of the antenna while bending, the reflection coefficient of the proposed antenna was simulated and analyzed, with and without the reflector, in addition to bending it over a cylinder of radius of 20 mm. As is shown in Fig. 2, first the antenna displayed good matching impedance in the case of flat and with reflector, as it exhibited a wide bandwidth from 1.53 GHz to 2.74 GHz; i.e. 57%, instead of the case without the reflector with 40% bandwidth. In addition, it is noticeable that the matching performance of the antenna during bending was not affected, when bent along the x and y axes. In addition, the gain had to be studied, realizing the impact of including the reflector, as illustrated in Fig. 3. The gain of the proposed antenna, with and without the reflector, was plotted at the left hand side, while the radiation efficiency performance of the suggested antenna was plotted at the right hand side. The gain of the proposed antenna was 5.63 dBi and almost constant over the entire wide-band compared to 2.9 dBi for the antenna without the reflector; thus, an enhancement by 2.73 dBi. The radiation efficiency of the high gain antenna was approximately 0 dB; i.e. 100%, along the whole wide bandwidth. Finally, at 2.45 GHz, which was specifically selected due to the vast number of applications served at this frequency, the radiation pattern of the proposed antenna was plotted in polar form, as shown in Fig. 4. A comparison between the flat and bent condition was conducted at 2.45 GHz, displaying a high agreement in both X-Z and Y-Z planes. For the bent scenario, there was a slight rotation observed in the figure-of-eight in the X-Z plane.

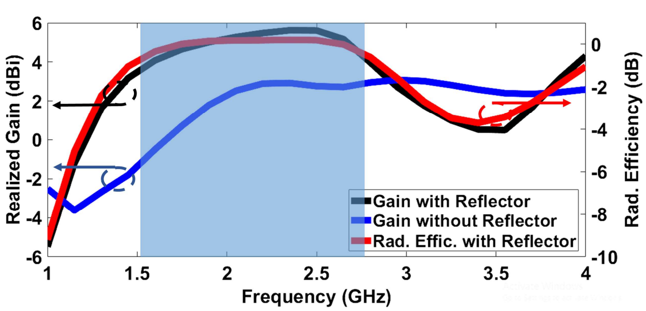

Fig. 3. Realized gain and radiation efficiency against frequency.

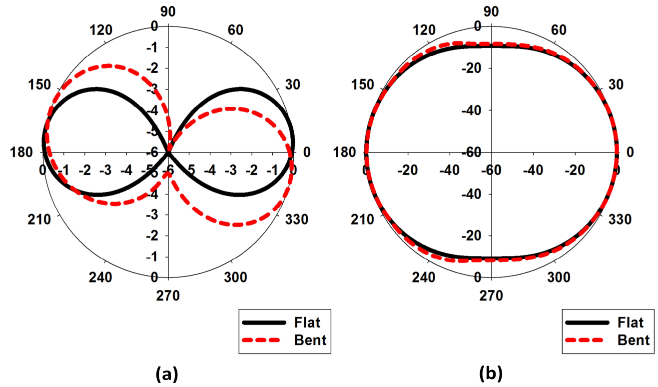

Fig. 4. Comparison between the radiation patterns, at 2.45 GHz, in polar plot demonstration, of the structures, including the reflector and when bent, for: (a) X-Z plane; (b) Y-Z plane.

IV. CONCLUSION

An analysis of the performance of a flexible, wideband antenna with high gain was presented. High gain and radiation efficiency of 5.63 dBi and 0 dB; respectively, were achieved, by using unique shape of reflector around the radiator, along the wide bandwidth from 1.53 GHz to 2.74 GHz. Furthermore, the proposed antenna performed well, in terms of matching, as well as, preserved the omnidirectional radiation pattern, while bent, at 2.45 GHz. As a result of these properties, the antenna can be realized in wearable and wireless applications.

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