Dual Polarized, Broadband, and High Gain Semi-Flexible Antenna for RFEH Applications in 5G Millimetre Wave Environment

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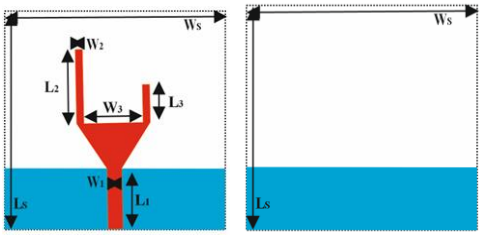
Abstract—This article presents a compact, broadband, and circularly polarized high-gain antenna using a semi-flexible Rogers 5870 substrate with dimensions of 15×15×0.7 mm^3. The proposed antenna features a triangular-shaped radiator and a partial ground layer. Additionally, two dissimilar rectangular stubs are introduced over the antenna radiator to achieve a broad operational bandwidth. A 50-Ω microstrip line is used for exciting purposes. With these arrangements, the proposed antenna resonates at 24 GHz and 33.25 GHz with a bandwidth of 14.29 GHz. The proposed antenna also achieved a maximum gain of 4.17 dBi and 5.2 dBi at the resonating frequencies. Besides, the suggested antenna offers circularly polarized radiation characteristics at 33.25 GHz with a 3-dB axial ratio (AR) of 1.4 GHz. Finally, the performance of the reported antenna structure is compared with the existing literature.

Keywords—Compact antenna, circular polarization, fifth generation, millimeter wave, RF energy harvesting

The proposed antenna design, aimed at achieving high gain characteristics using the dual-slot technique, is illustrated in Figure 1 and the step-wise design process is given in Figure 2. The design process involves the initial conceptualization of a conventional rectangular microstrip antenna (referred to as Ant #1), which illustrates the geometrical description of the proposed antenna structure. The antenna geometry is realized with a triangular-shaped structure, consisting of two dissimilar rectangular stubs at the top of the substrate, and the bottom layer consists of a partial ground plane. The designed antenna structure utilizes a semi-flexible Rogers 5870 substrate with dimensions measuring 15×15×0.7 mm^3, and other dimensions (in mm) are as follows: $L_S = 15$, $W_S = 15$, $L_1 = 4$, $w_1 = 1$ $L_2 = 4.9 = W_2 = 0.5$, $L_3 = 2.5$, $W_3 = 4$. The step-wise evolution of the proposed antenna is shown in Fig. 3(a) while its corresponding return loss plots, gain plot, and axial ratio plots are shown in Fig. 3(b) and Fig. 3(c), respectively. Finally, all the results that were obtained while performing the step-wise evolution are summarized in Table I.



(a) Top-view (b) Bottom-view

Figure 1. Proposed Geometry

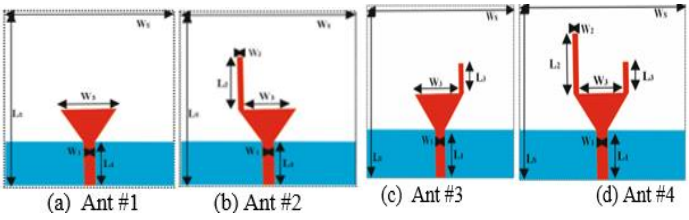
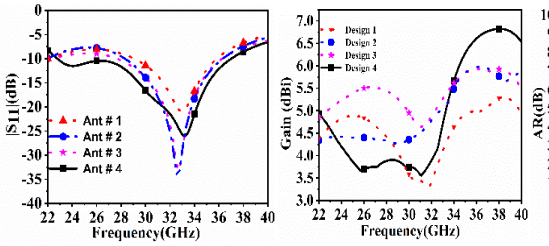


Figure 2. Step-by-Step Design Procedure



(a) $|S_{11}|$ (b) Gain (c) Axial Ratio (AR)

Figure 3. Antenna Performance Comparison

Table I: Performance Comparison

	Ant #1	**Ant #2**	**Ant #3**	**Ant #4**
Freq (GHz)	32.99	32.67	32.73	**24/ 33.25**
BW (GHz)	6.85	7.94	8.45	**14.29**
$\|S_{11}\|$ (dB)	-21.07	-34.5	-33.16	**-11.50/ -25.96**
Gain (dBi)	-4.14	4.94	5	**5.15**
AR (dB)	61.60	32.8	27.37	**2.1**