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An Upgraded Design of High-Performance Dual-Band Metal Strip Antenna

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Abstract. This paper presents an analytical study and an upgrade of reference metal-strip antenna for laptop applications. In recent years, the laptop industry has seen a trend towards more compact designs. This orientation posed new limitations to both designers and manufacturers. Thus, the volume allocated to the internal antenna must be reduced. The results demonstrated in this proposal were obtained through a comprehensive study of the reference design dimensions.

Keywords: Dual-Band Metal Strip; Antenna; radiation; efficiency; Wide bands

1. Introduction

Generally, these antennas are required to operate at 2.4GHz (2.402~2.483) and 5GHz (5.150~5.875) bands. The proposed antenna compromises a feed strip, a first strip, a second strip, a third strip, and a parasitic part in the shape of a shorted T monopole [1]. With over 21 design parameters tested and optimized, it was deduced that only four dimensions' can considerably change the pattern in which the antenna performs [2]. In the next section, an experimental study using simulation for the following design parameters will be addressed: ground plate length (Ground), the first strip width, the second strip width, and the chief height [3].

2. Experimental Study Of The Antenna Substantial Parameters

The dimensions of the ground plate discussed where, overall volume occupied by the antenna but also in the radiation pattern and matching impedance for the desired frequency bands [4]. It was found that the length of the ground plate has more effect on the upper band 5GHz than the 2.4GHz band. The colored curves illustrate the changes in the s11 parameter [5]. Figure 1 explains how the ground plate's length can be critical in determining the center frequency for the 5GHz band. Four lengths (20.5mm, 41mm, 42mm, and 58mm) were examined to obtain the following graph [6].



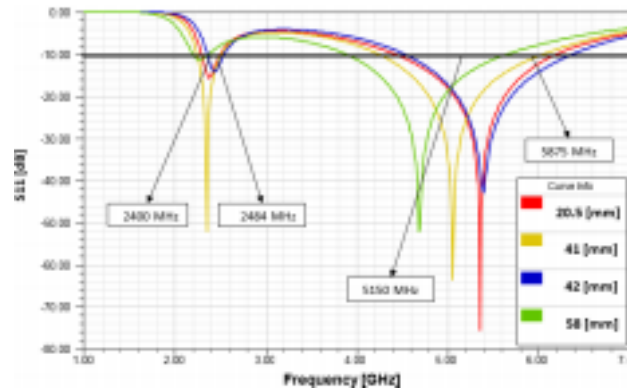


Figure 1: The effect of the ground plate's length has on the center frequency for both bands in S11.

The dimensions of the first, second, and third strips were remarked to be influential. It stands out from Figure 2 that the first strip is connected directly to the feed strip. While the second and third strips are attached with the parasitic strip, which is folded in the

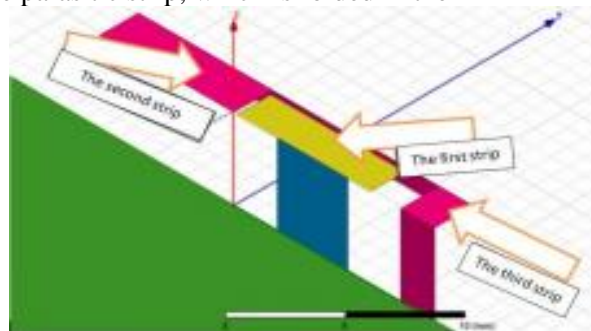


Figure 2: Front view of main strips constituting the antenna

Same plane with the ground plate[9-12]. The impact of changing the first strip's width was examined within the range (6.7mm~9.8mm), and a value of 8.5mm was chosen for the final design. According to data obtained from Figure 3, by selecting different values (6.633mm, 8.133mm, 8.533mm, and 9.233mm) to be tested, the first strip controls the upper band center frequency [7]. What can also be noticed is that the center frequency of the upper band 5GHz is proportional to free spaces between the first strip and the other two strips. However, the lower band has seen a negligible change[8].

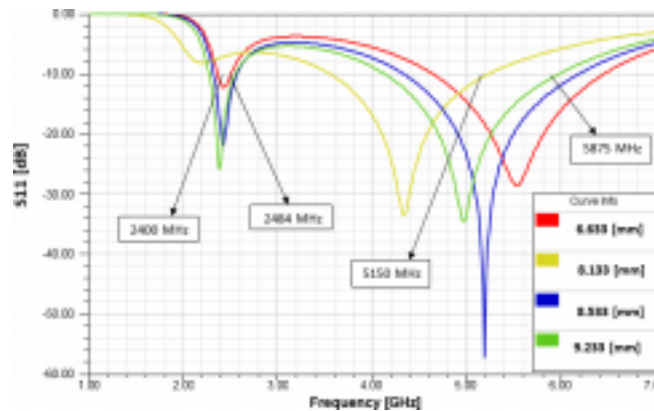


Figure 3: The effect that the width of the first strip has on the center frequency for both bands in terms of S11

The simulation conducted on the second strip width illustrated in Figure 4 reveals a connection between the impedance matching and different parameter values.

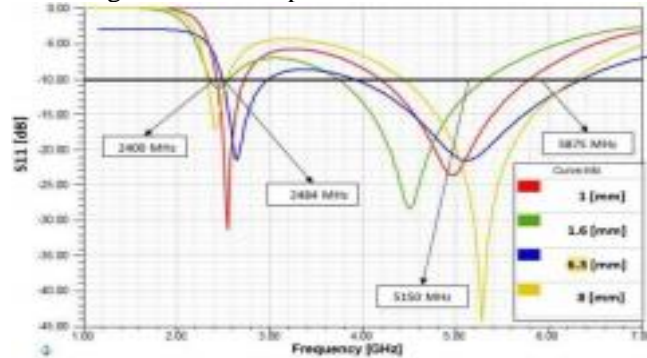


Figure 4: The effect that the second strip’s width has on the center frequency for both bands in terms of S11

A group of values starting from 1mm ending with 8mm was tested. Four different widths were chosen to show the contrast between the four curves[9]. The three previous design parameters' analysis[10] showed that the major effects were seen by the upper band, either by the shift of the center frequency or the return loss coefficient S11[11]. The next optimization process covers the most critical dimension in the antenna structure. Different values of the height were examined[12] in order to reach optimal performance. Figure 5 shows a front view of the antenna with an indication of the structure's thickness in general.

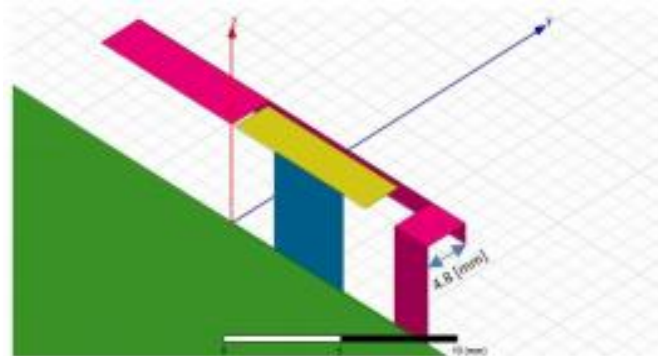


Figure 5: Front view of the structure with a sign of the height value

The results showed both the center frequency and impedance matching of the desired bands were affected by testing different heights, as shown in Figure 6.

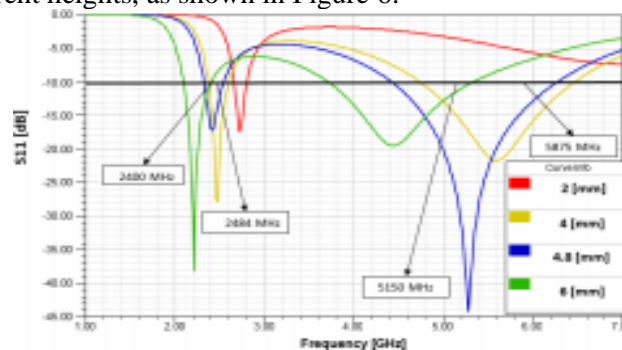


Figure 6: The effect that the height has on the center frequency and impedance matching for both bands in terms of S11

It can be seen that the four curves, each representing a different value for the height (2mm, 4mm, 4.8mm, 6mm), demonstrate a fluctuation in the center frequencies[13]. Additionally, a variation in the return loss coefficient S11 has also been witnessed[14].

As shown in Figure 7, wide bands (2.3GHz~2.5GHz in the lower band and 4.4GHz~6.2GHz for the upper band) together with a perfect impedance matching in terms of S11 (-22dB at 2.4GHz and -58dB at 5.2GHz) were approached. A unidirectional radiation pattern is acquired when embedding an antenna in each corner of the laptop's lid part [15]. The radiation patterns are measured using simulation at 2.4GHz in Figure 8 and 5.2GHz in Figure 9.

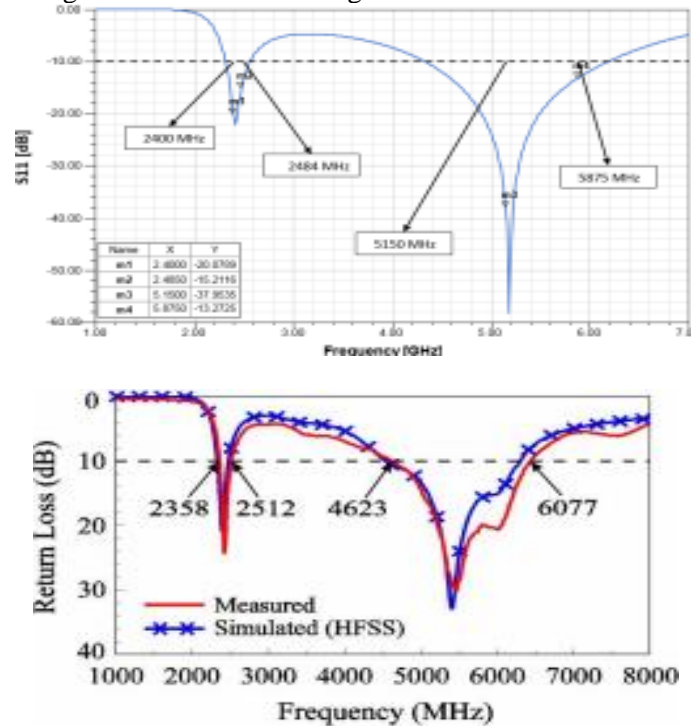


Figure 7: Simulated return loss of the reference antenna and the upgraded antenna design

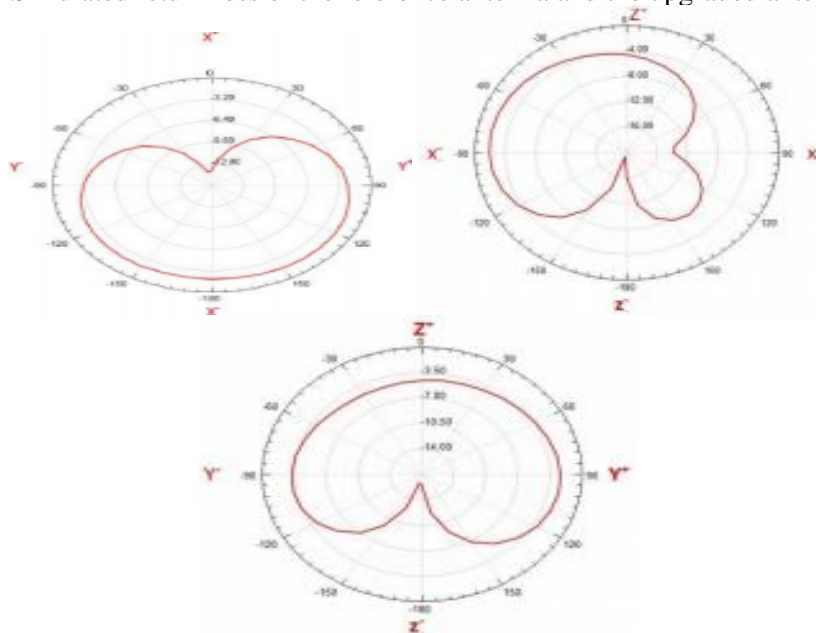


Figure 8: Simulated radiation patterns at 2.4 GHz

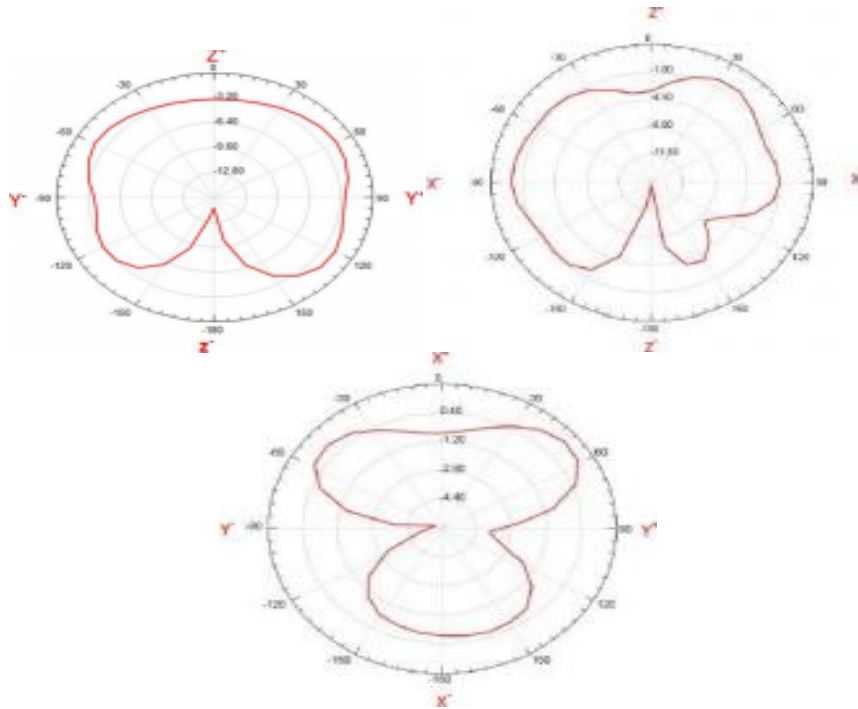


Figure9: Simulated radiation patterns at 5.2 GHz

The radiation efficiency is measured at 2.4-2.5GHz and 5.1-5.9GHz with a constant and enhanced efficiency compared to the reference design, as shown in Figure 10 (a) and (b)

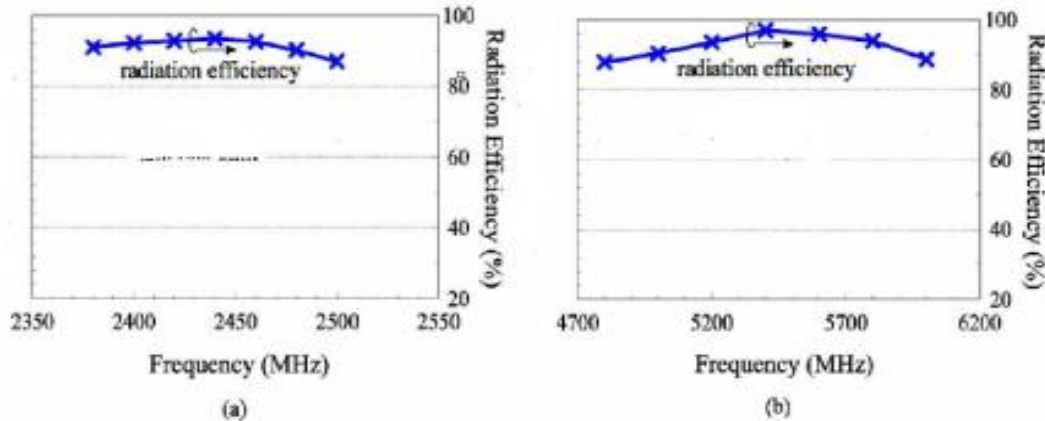


Figure 10: Radiation efficiency of the reference antenna

3. Conclusion

Wide bands (2.3GHz~2.5GHz and 4.4GHz~6.2GHz) together with a perfect impedance matching in terms of S11 (-22dB at 2.4GHz and - 58dB at 5.2GHz) were approached. The radiation patterns are measured using simulation at 2.4GHz and 5.2GHz, where a unidirectional radiation pattern can be done when embedding an antenna in each corner of the laptop's lid part. The radiation efficiency is considerably enhanced compared to the reference design.

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