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G-Shaped Antenna Mounted On USB Dongle Optimized For MIMO Applications Under WLAN 5.2/5.8/5.9

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Abstract – In this study, we used a G-shaped antenna due to its ease of integration into the overall design. The basic structure was adapted from a model proposed by W.-C. Liu. Then, we integrated it into a USB dongle, then added another antenna element to use it for MIMO applications in WLAN networks. A neutralization line is added between these two antenna elements to increase insulation.
Keywords – Patch, Antenna, Insulation, MIMO, LTE, WLAN.

I. Introduction

New trends from telecom operators are increasing the demand for modern mobile communication systems and wireless networks for bandwidth and highest data rates. It is because of this growing need that researchers are turning to the integration of multiple antennas into the same user equipment [1]–[3].

Applications are rapidly evolving toward multiple input-output (MIMO) technology from single input output (SISO) and single input multiple output (SIMO) systems. This is because this technique allows a wireless device to transmit or receive data at a higher data rate. Moreover, IEEE 802.11n and Long Term Evolution (LTE) require LAN devices and mobile devices to support MIMO technology [4]–[6].

The origin of MIMO began at Bell Laboratories from 1997 to 2002, under the name BLAST "Bell Labs Layered Spacetime".

II. Methodology and Results

In this study, we used a G-shaped antenna due to its ease of integration into the overall design. The basic structure was adapted from a model proposed by W.-C. Liu [7]. Then, we integrated it into a USB dongle, then added another antenna element to use it for MIMO applications in WLAN networks.

However, the challenge for this work is that the two antenna elements must be closely located in a small area of the USB dongle. The available area for mounting the antennas is approximately $12\,x\,20\,mm^2$, as shown in Figure 1.

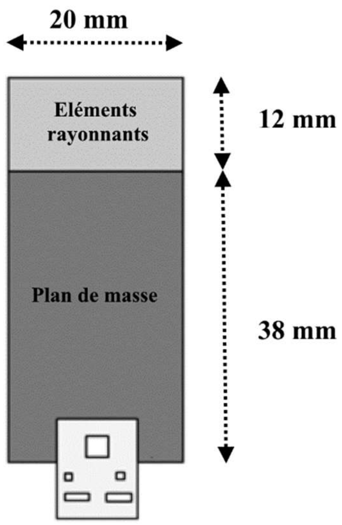

Fig. 1. USB dongle layout

2.1. G-SHAPED BASIC STRUCTURE FOR WLAN 2.4/4.9/5.2/5.8/5.9

It is a G-shaped antenna mounted on an FR4 type substrate (thickness 0.4 mm, constant 4.3, and loss tangent 0.02), placed in the same surface of the ground plane with a spacing of g=1.5 mm. The thickness of each side of the radiating element is 0.7 mm.

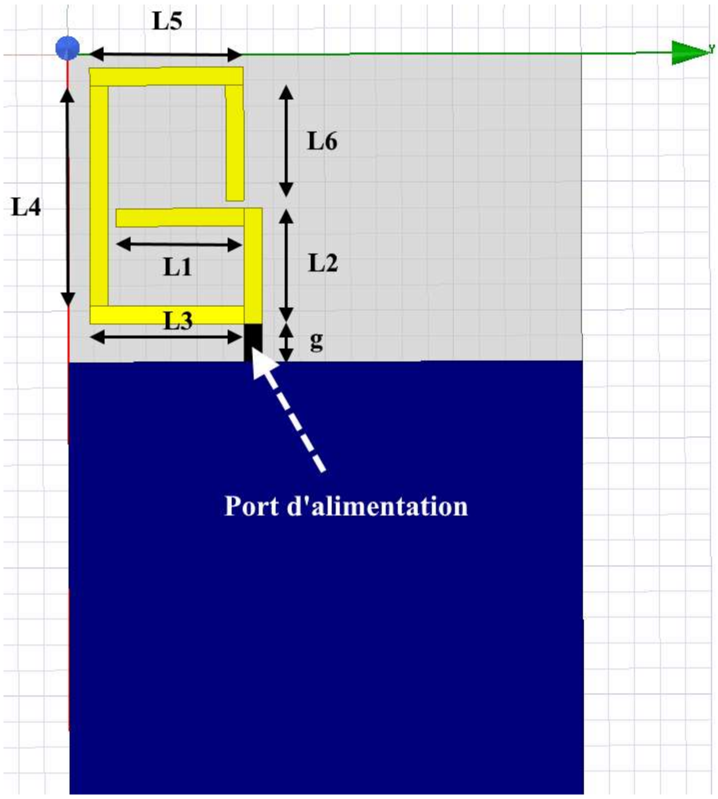

Fig. 2. Basic Antenna

All other parameters are reported in the following table:

Table 1. Basic Antenna Settings

L1	L2	L3	L4	L5	L6
5 mm	4.5 mm	6 mm	8.6 mm	6 mm	4.5 mm

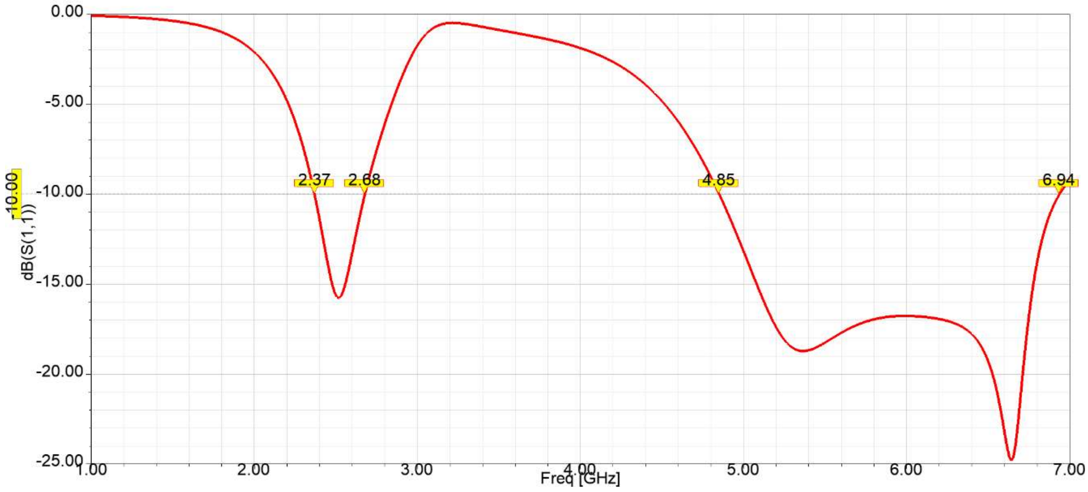

Fig. 3. Base antenna reflection coefficient

As the reflection coefficient curve shows, this antenna operates in both bands [2.37-2.68 GHz] and [4.85-6.94 GHz], therefore for WLAN 2.4/4.9/5.2/5.8/5.9 wireless networks. In the following, we are only interested in the MIMO application in the upper band.

2.2. Optimized structure for MIMO applications under WLAN 5.2/5.8/5.9 networks

The first design attempt led to the structure proposed in figure 6. This antenna has two similar G-shaped elements which are located at a small distance g from the PCB card of the USB dongle.

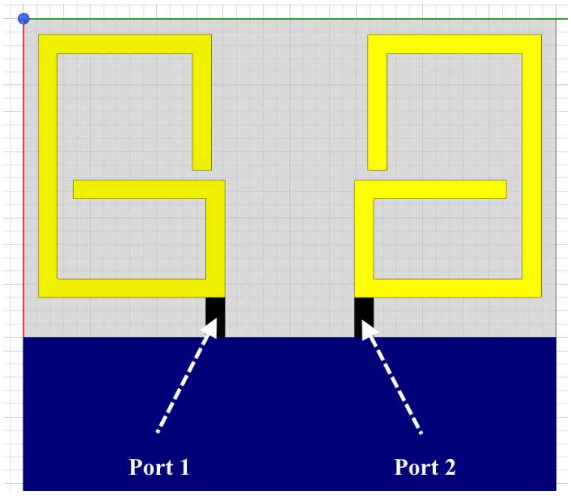

Fig. 4. Antenna proposed for MIMO applications without isolation technique

Based on the concept proposed in [8], a neutralization line is added between these two antenna elements to increase the isolation. According to [8], the location of the neutralization line must be chosen where the surface current is maximum.

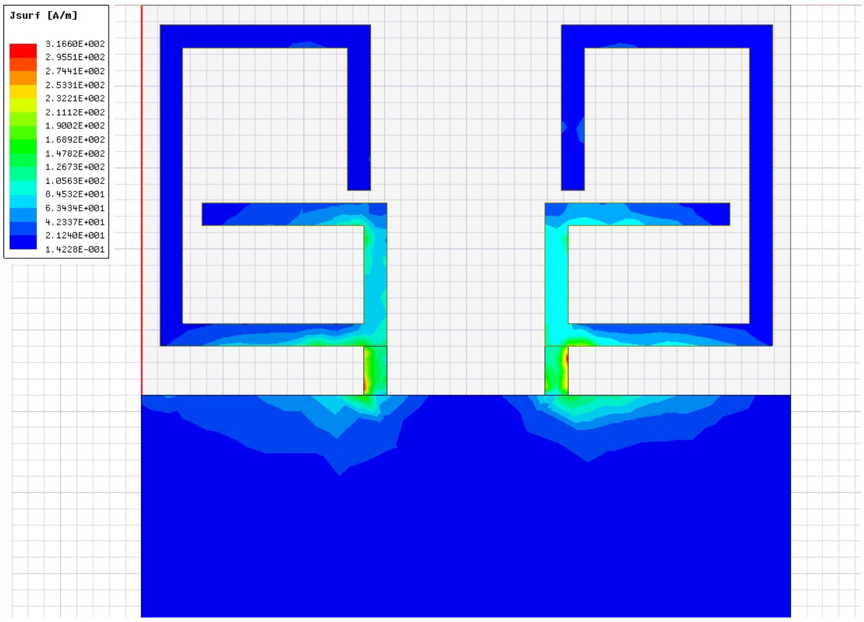

Fig. 5. Surface current distribution at 5.5 GHz frequency

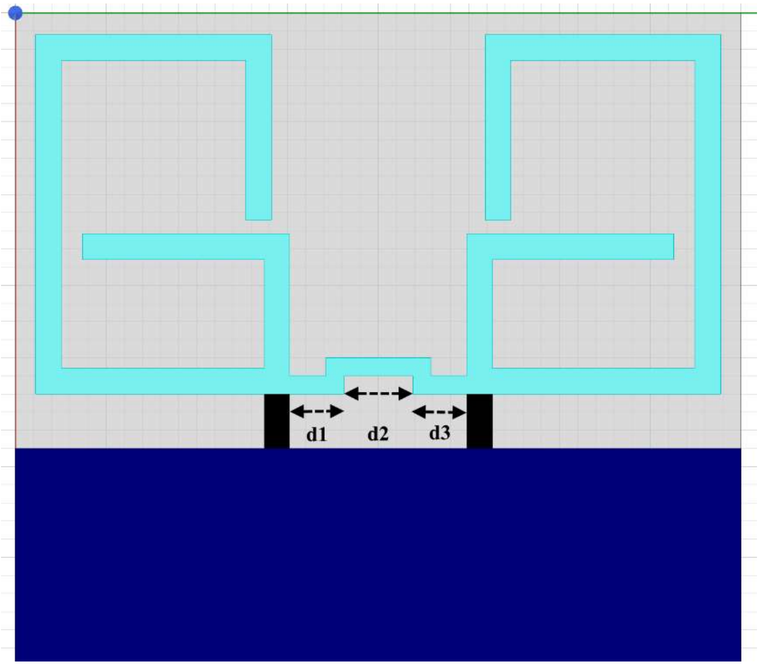

Fig. 6. Antenna proposed for MIMO applications with isolation technique

We choose $d_1 = 1.5\,mm$, $d_2 = 1.9\,mm$, et $d_3 = 1.5\,mm$. The thickness is 0.5 mm.

Figure 7 shows the simulated reflection losses of the proposed antenna array. The results claim that the proposed structure has a bandwidth ranging from 5.17 GHz to over 7 GHz, which is more than the precision required for the frequency band of interest WLAN 5.2/5.8/5.9 (5150-5925 GHz). This makes the proposed antenna more robust during integration, thus providing some margin against proximity effects from other components inside the package that may cause certain frequency changes.

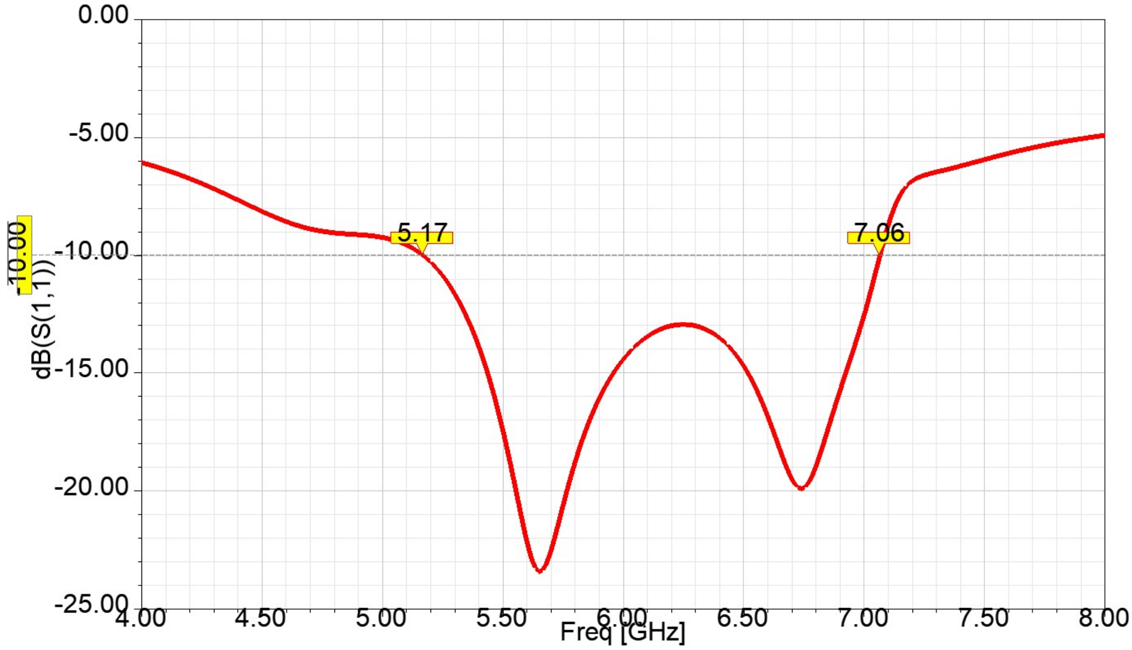

Fig. 7. Reflection coefficient of the proposed antenna with the neutralizing line

We also see that the isolation between the two antenna elements is always better than -10 dB from 5.0 to 6.0 GHz encompassing the desired WLAN operating band (Figure 8).

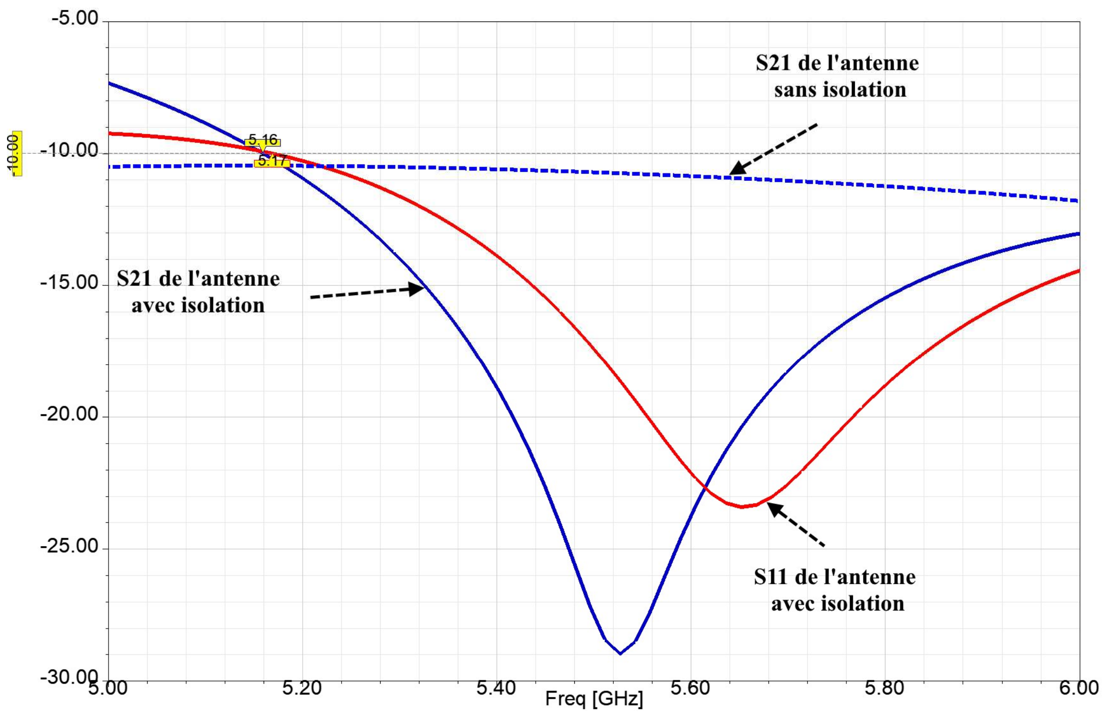

Fig. 8. Comparison of S21 coefficients with and without insulation technique

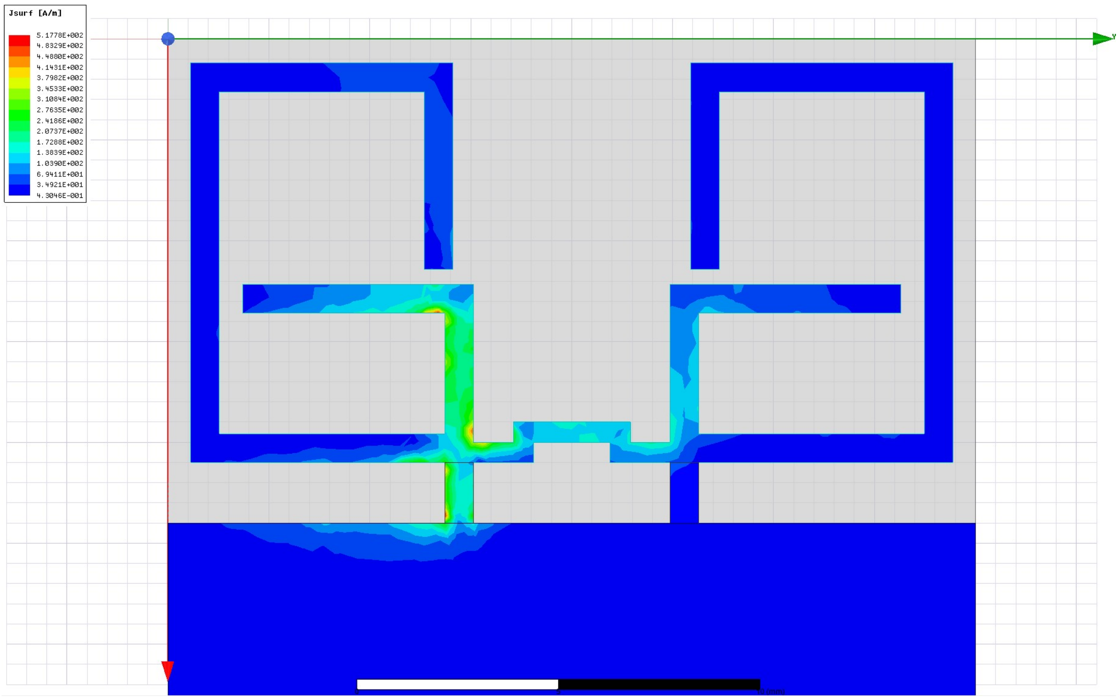

Fig. 9. Surface Current Distribution (Port 1 Energized)

Figure 9 shows the simulated surface current distribution of the proposed antenna array at 5.5 GHz. It can be seen that at the resonant frequency, when the first antenna element resonates (Port 1 energized), little current dissipates to the port of the other antenna element (Port 2). Instead, the current is concentrated on the radiating antenna itself and the neutralization line as well as a minimal part of the second antenna.

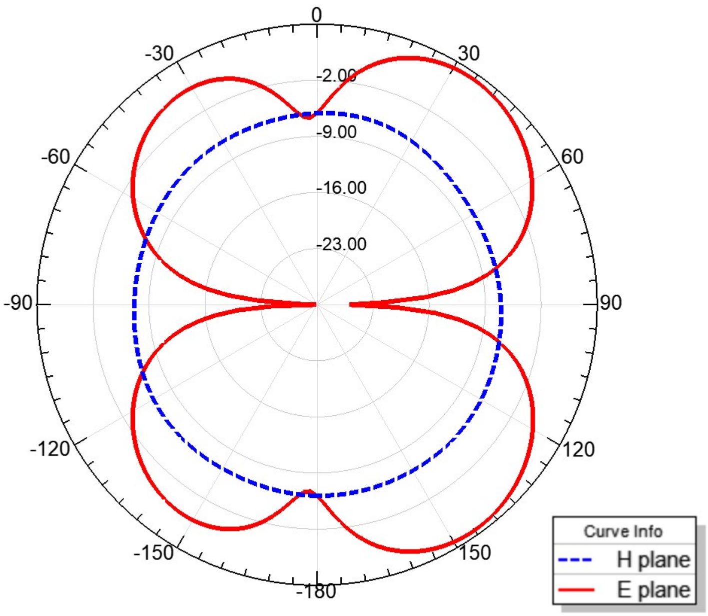

Fig. 10. Radiation patterns on planes E and H

The figure above represents the radiation patterns on planes E and H. Also, we note that the antenna reaches the maximum gain of 4.4 dBi at the frequency 5.1 GHz.

III. Conclusion

In this research, a G-shaped antenna was employed for its seamless integration into the overarching design.

The foundational structure was derived from a design put forth by W.-C. Liu. Subsequently, we incorporated it into a USB dongle and introduced an additional antenna element to facilitate its utilization in MIMO applications within WLAN networks. To enhance insulation, a neutralization line was introduced between these two antenna elements.

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