UMBRELLA MONOPOLE ANTENNA FOR 5G APPLICATIONS

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Abstract – Umbrella Monopole Antenna (UMA) proposed in this paper for 5G application. We designed four models of UMA, i.e: UMA-A, UMA-B, UMA-C, and UMA-D. The antenna has a curvature in the patch as an umbrella shape with a feeding shape a microstrip feed line. Four variations of the patch antenna have been designed and get different performance in VSWR, surface current, and directivity. The proposed antenna has a wide bandwidth that operates 8 GHz – 30 GHz with VSWR <2 dB. The Increasing of directivity is reached for UMA-A, UMA-C, UMA-D, and UMA-B, i.e: 6.38 dBi, 7.97 dBi, 8,84dBi, and 9,15 dBi respectively at 24 GHz. The maximum gain has been reached for UMA-B of 9.15. The lowest frequency that has a return loss of 10 dB has resulted for UMA-D in the frequency around 5 GHz. All of the UMA antennas can be applied for 5G mmwave applications at 24 GHz and 28 GHz.

Keywords: umbrella monopole antenna, 5G applications, wideband, milimeter

I. INTRODUCTION

For some decades, the wireless mobile communication field has been developing. There are five generations of mobile communication systems from first-generation (1G), second-generation (2G), third-generation (3G), fourth-generation (4G), and fifth-generation (5G). The development of wireless communication networks has increased the demand for available bandwidth to provide high data rates [1].

Next-generation, 5G has become center stage in the wireless communication field. 5G technology is expected to have low latency and low power consumption. It is also desirable to provide high data rates, solid security, and high-quality transmission for various applications [2]. Some of the 5G applications use the band of high-band in 28 GHz and 24 GHz bands, Mid-band in 2.5 GHz, 3.5 GHz, and 3.7-4.2 GHz bands, and Low-band in 600 MHz, 800 MHz, and 900 MHz [3] [4]. The antenna is one of the components of 5G generation. Accordingly, the antenna should meet the requirements include large impedance bandwidth, very high gain, narrow beam-width, and bream steerability [5]. Various antennas for 5G generation have been proposed [6]-[8]. In [6], a low-profile and wideband antenna with a measured bandwidth of 58.3% from 2.84 GHz to 5.17 GHz. T- shaped patch antenna uses to cover impedance bandwidth of 26-40 GHz [7]. A transparent dual-polarized antenna array for 5G smartphone applications [8] achieved a wide frequency band of 23.5-32 GHz.

A monopole antenna is a good candidate. It can support wide impedance bandwidth, radiation stability, compact size, and omnidirectional radiation pattern. Various shapes of monopole antenna with coaxial, microstrip, or planar waveguide feeds have been proposed as candidates to fulfill these requirements [9]. In the literature, various researches have been done on UWB monopole antenna [10] [11] [12].

The choice of monopole antenna in various researches is because this type of antenna is easily modified and supported by wideband. One of the monopole antenna modifications uses the umbrella shape. It can increase the impedance bandwidth of monopole antenna such as [13] [14]. Ultra-wide bandwidth microstrip monopole antenna provides wide impedance bandwidth [13]. In [14], monopole antenna shows high potential for multi-band communication application.

In this paper, we designed and developed an umbrella monopole antenna for 5G applications. The proposed antenna has VSWR < 2 dB, bandwidth of more than 10 GHz and the radiation patterns are omnidirectional UWB. The antenna is simulated VSWR, surface current, and directivity.

II. ANTENNA DESIGN

The proposed geometry of the umbrella monopole antenna at the design of 2-30 GHz is presented in Figure 1. The proposed antenna has a dimension of 50 mm x 50 mm x 1.6 mm. The result of the development of four antennas is shown in Figure 2. The antenna geometry is designed on an FR4 substrate having εr = 4.4, tanδ = 0.02, with a substrate thickness of 1.6 mm. To obtain antennas with wide bandwidth and high gain, we designed four different models of Umbrella Monopole Antenna. They have different curvatures of umbrella patches.

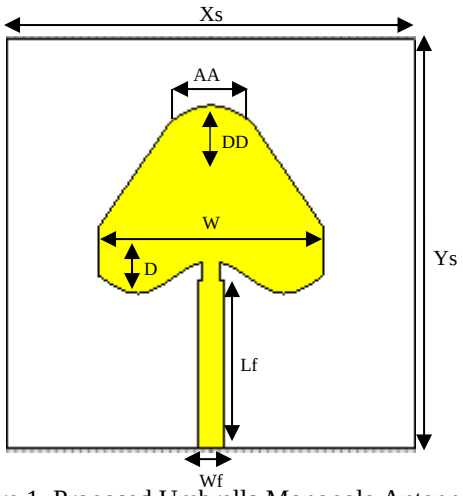


Figure 1. Proposed Umbrella Monopole Antenna

Table 1. Dimensions and Parameters of Umbrella Monopole Antenna

Dimension Parameters (mm)			
Ys	50	D	1.25
Xs	50	W	27.5
A	20	D	4
Wf	3	Lf	28.1
tsub	1.6	tpatch	0.035

The curvature of the patch follows the equation:

$$y(t) = A(B + C\cos\left(\frac{D\pi t}{W}\right) \quad (1)$$

A, B, C, D, and W is the constant, that has a different value for UMA-A, UMA-B, UMA-C, and UMA-D. Figure 2. (c) describes the UMA-C. It has the widest umbrella width. It has the largest value of W. It has W = 40 mm. Figure 2(d) shows the UMA-D with W = 40, A = 22.5 mm, and D = 1 mm. A is the constant that influences the height of the curvature and D interferes with the deep of curvature.

UMA-A, UMA-B, UMA-C, and UMA-D have different values of A, B, C, D, and W constant as shown in equation (1), but they have the same width of microstrip line feed.

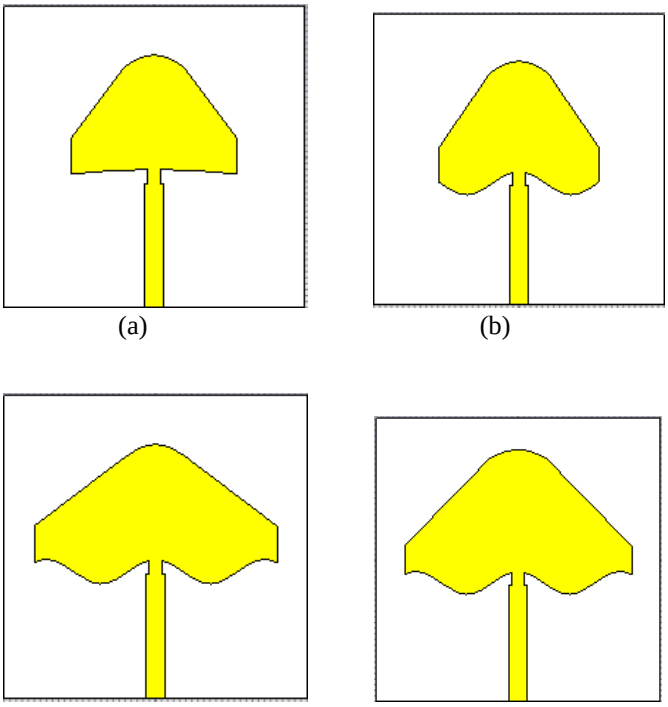


Figure 2. (a) UMA-A (b) UMA-B, (c) UMA-C, (d) UMA-D

III. RESULT AND DISCUSSION

The proposed umbrella monopole antenna is designed and simulated with CST Studio 2019. This antenna has covered from 2 GHz to 30 GHz.

- VSWR

VSWR(Voltage Standing Waves Ratio) is the parameter of the antenna that determines the impedance bandwidth of the antenna.

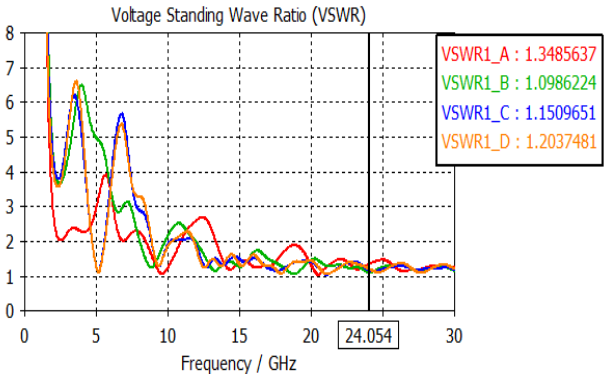
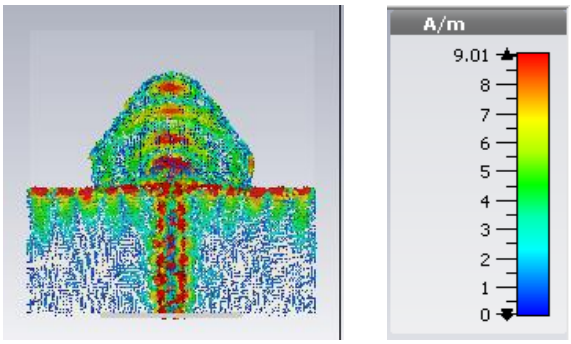


Figure 3. VSWR result of umbrella monopole antenna

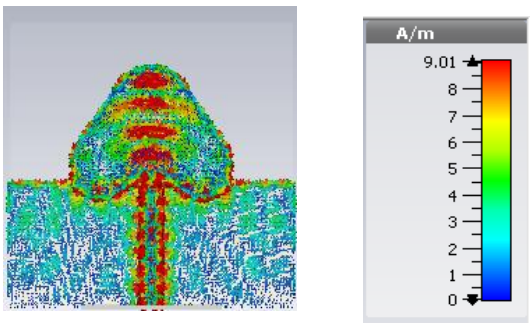
Figure 3. shows the VSWR for umbrella monopole antenna design UMA-A, UMA-B, UMA-C, and UMA-D. The value of the antenna is less than 2 dB in the frequency of 8 GHz – 30 GHz (VSWR <2). But UMA-D has an impedance bandwidth of around 5 GHz. The simulation shows that the purposed antenna is suitable for 5G applications (base on ITU standard) [15].

- Surface Current

The surface current distribution is studied to understand the flowing of electric charge in the patch. The simulated surface current of UMA-A and UMA-B at 24.5 GHz is shown in Figure 4. (a) and (b). Figure 4. (a) is shown that the primary current is on the ground and feeder.



(a)



(b)

Figure 4. surface current (a) UMA-A, (b) UMA-B

In Figure 4. (b), by making a curve umbrella antenna patch in the bottom of umbrella, it increases the surface current density.

- Directivity

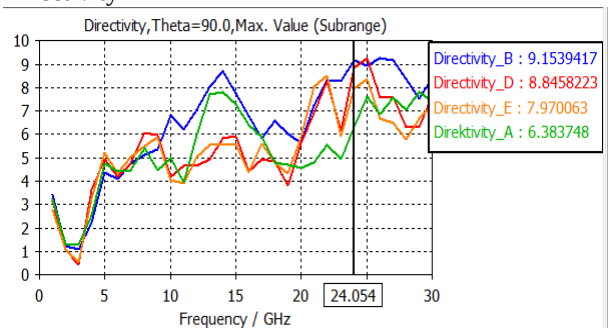


Figure 5. directivity result of umbrella monopole antenna

The simulation result of the directivity of the umbrella monopole antenna is shown in Figure 5. The Increasing of directivity is reached for UMA-A, UMA-C, UMA-D, and UMA-B, i.e: 6.38 dBi, 7.97 dBi, 8,84dBi, and 9,15 dBi respectively at 24 GHz. The wider umbrella width the worst directivity. The curvature of the antenna also influences the directivity of the antenna.

A comparison of the proposed antenna and other antennas is listed below.

Table 2. Comparison of proposed antenna with other antenna

No	Size (mm^2)	Substrate	Bandwidth (GHz)
[16]	65x65	-	1.84 – 3.6
[17]	150x75X1.6	FR-4	3.4-5.1
[18]	90x90x1.6	FR-4	3 - 9
Proposed antenna	50x50x1.6	FR-4	8 - 30

IV. CONCLUSION

In this paper, an Umbrella Monopole Antenna (UMA) is designed, i.e: UMA-A, UMA-B, UMA-C, and UMA-D for 5G application. The proposed monopole antenna has a wide bandwidth. It operates at a frequency of 8 GHz to 30 GHz with VSWR < 2 dB. An umbrella monopole antenna gets high directivity of 9.15 dBi at 24.05 GHz. The proposed antenna can support for 5G applications at frequency 24 GHz and 28 GHz.

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