Conference Paper

Ultra wideband antenna for future 5G

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Ultra Wideband Antenna for Future 5G

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Abstract – An ultra-wideband miniature antenna based on circular patch with circular slots has been presented for future generation mm-wave indoor wireless applications. The proposed miniature antenna is fed by probe feed and, the maximum realized gain and the total efficiency throughout the three bands are 7.7 dBi in an upper higher band and 97% in the lower band, respectively. This proposed antenna covers the seven bands (five bands are in the existing allocation to mobile, and the other two bands are to be considered for allocation) for 5G higher bands and lower band covers uplink Ku-band (14GHz - 14.5GHz) for satellite communication. The proposed antenna in ultra-wideband has the impedance bandwidth of 31.8 GHz and the fractional bandwidth of 60.61%.

Keywords—ultra wide band, mm-wave, 5G, MSPA, miniature antenna

I. INTRODUCTION

The expected mobile population will be increasing day-by-day shortly, which in turn will demand higher data rates, bandwidth, and channel usage capacity. To meet these requirements, the Federal Communication Commission (FCC) specifies the different frequency bands in the mm-wave range 30GHz to 300GHz [1]. The upcoming fifth-generation (5G) to acknowledge the fast transmission has been concentrating broadly. As indicated by the arrangement of 5G, 2020 will most likely be the principal business year for 5G. In July 2016, the Federal Communications Commission (FCC) had characterized the millimeter-wave groups: 24 GHz, 37 GHz, 39 GHz, and 47 GHz bands. All of these frequency bands have been discussed in the World Radiocommunication Conference 2015 (WRC-15). These frequency bands include 24.25 GHz to 27.5 GHz, 31.8 GHz to 33.4 GHz, 37 GHz to 40.5 GHz, 40.5 GHz to 42.5 GHz, 42.5 GHz to 43.5 GHz, 45.5 GHz to 47 GHz, 47 GHz to 47.2 GHz, 47.2 GHz to 50.2 GHz, 50.4 GHz to 52.6 GHz, 66 GHz to 76 GHz and 81 GHz to 86 GHz [2]. The frequency bands as mentioned earlier, will also lie in the agenda of WRC-19 for further recommendation [3].

In mm-wave frequency range, the higher frequency bands are issued for different applications, like, for the mobile communication, and the industrial, scientific and medical (ISM) usage (61GHz – 61.5GHz) [4],[5]. And the future trend is to achieve a higher gain and a bandwidth of an antenna for millimeter-wave communication, i.e., Wireless Gigabit Alliance (WiGig or 60 GHz Wi-Fi), which is also the requirement of current mobile users. The devices used for WiGig can communicate with multi-gigabit speed, and its frequency band range is 57 GHz to 71 GHz, which includes the Wi-Fi standards like IEEE 802.11ad currently, and also the upcoming IEEE 802.11ay [6].

The suitable antennas for higher band of the mm-wave system are circularly polarized (CP) antennas, due to the effect of polarization mismatch and multipath reduction [7]. The wide axial ratio (AR) bandwidth be achieved by using the sequential rotate technique (SRT) in the CP antenna array [8]. In [9], a design comprising four array antennas with circular polarization based on substrate integrated waveguide configuration was presented. The achieved AR bandwidth and maximum gain are 14% and 15.9 dBi respectively. The narrower AR bandwidth of CP antennas can be broadened by employing SRT technique [10], [11]. The partial ground plane technique used in [12], to improve the gain and bandwidth of microstrip patch antenna (MSPA). The compact antennas for future generation are presented, they have more size than in the presenting paper [13]-[16].

In this paper, the ultra-wideband circular antenna with circular slots is presented, which covers more than 80% mm-wave frequency bands of future 5G, one from the ISM band (61.25 GHz) and also covers around 80 % of WiGig band (57 GHz to 71 GHz). The final optimized antenna shows three notches (triple band), the lowest band covers the uplink frequency of Ku band, the second band covers 35.45% of first mm-wave band of 24 GHz, and the third one is ultra-wideband, which covers seven-band of mm-wave. The antenna design, parametric analysis and its results will be presented in the coming sections and subsections.

II. ANTENNA DESIGN

The proposed ultra-wide band antenna is shown in the Fig.1 and Fig. 2.

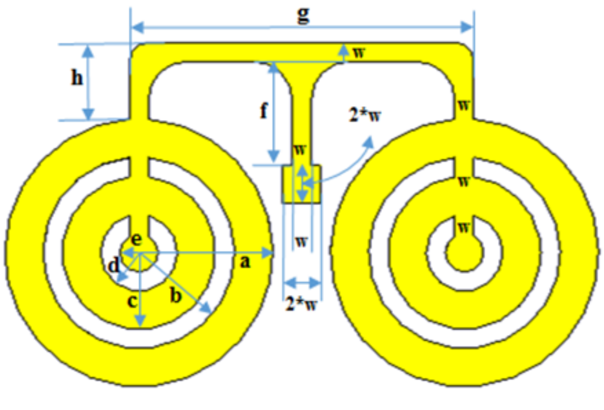


Fig. 1. Front View of the proposed antenna.

The optimized dimension of the proposed antenna is 16.5 × 10 mm². The Rogers RT5880 is used as substrate material with a thickness of 0.787 mm. The ultra-wideband of the presented antenna covers the seven-bands of future 5G, five of them are in existing allocation, which is 37 GHz to 40.5 GHz, 42.5 GHz to 43.5 GHz, 45.5 GHz to 47 GHz, 47.2 GHz to 50.2 GHz and 50.4 GHz to 52.6 GHz, and other two are to be considered for allocation, i.e., 40.5 GHz to 42.5 GHz and 47 GHz to 47.2 GHz, by WRC-15. The parameters of the antenna mentioned in Fig. 1 and Fig. 2 are shown in Table. I.

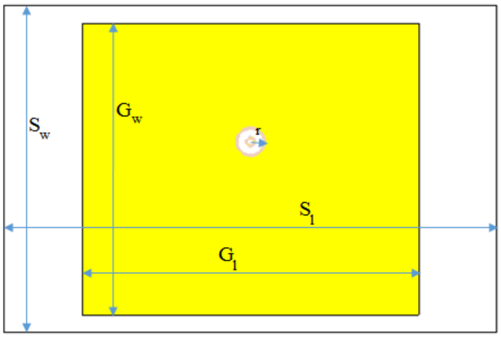


Fig. 2. Rare View of the proposed antenna.

TABLE I. PARAMETERS

Parameter	Value(mm)	Parameter	Value(mm)
a	3.5	B	2.5
c	2	D	1
e	0.5	F	2.7
g	9	H	2
r	0.5	W	0.5
G_l	12.3, 11.5	G_w	10.7, 9.5
S_l	18, 16.5	S_w	12, 10

III. RESULTS

The simulation is done using CST MW Studio 2018. S-parameter of the proposed antenna without changing the parameters is shown in Fig. 3. In this situation, the maximum efficiency is 95.8%, the maximum gain is 7.77 dBi, and the voltage standing wave ratio (VSWR) is 3:1 (impedance bandwidth is taken as -6dB).

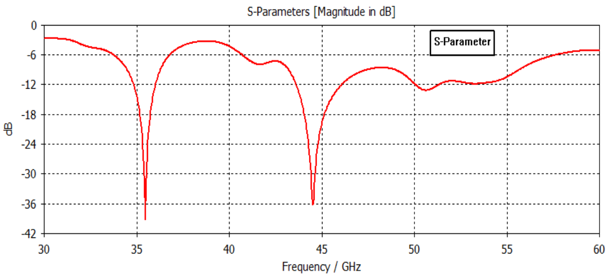


Fig. 3. S-parameter of the firstly designed antenna without any changings in substrate and the ground.

To attain the triple-band, the dimension of the substrate and ground is varied and explained in the subsection below.

$S_w = 12$, $S_l = 18$, $G_w = 10.7$ and $G_l = 12.3$

The parameters S_l and S_w defines the substrate length and substrate width. The parameters G_l and G_w defining the ground length and ground width. Substrate length and width kept fix for this subsection as mentioned above, by decreasing the ground width, the reflection coefficient gets improved in sense of VSWR, and by decreasing the ground length, the reflection coefficient becomes wider from dual band. The optimised values of ground length and width are 12.3 and 10.7 respectively. For different values of ground length and width, reflection coefficient is shown in Fig. 4 and Fig. 5.

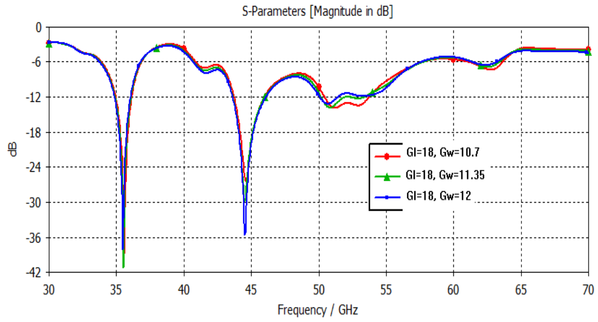


Fig. 4. Reflection co-efficient for fixed ground length with varying ground width (Case-I).

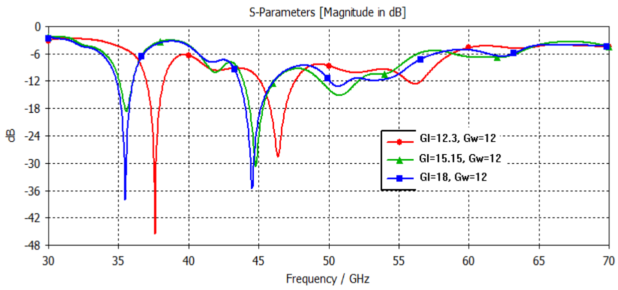


Fig. 5. Reflection co-efficient for fixed ground width with varying ground length (Case-I).

$S_w = 10$, $S_l = 16.5$, $G_w = 9.5$ and $G_l = 11.5$

The substrate width and length are reduced from 12 to 10 and 18 to 16.5 respectively, by reducing, the reflection co-efficient shows multiple bands (triple band) instead of single or ultra-wideband. After reducing the substrate dimensions, ground dimensions also goes down from 10.7 to 9.5 (width) and 12.3 to 11.5 (length), to get the required multiple bands. The reflection co-efficient of this case is depicted in Fig. 6.

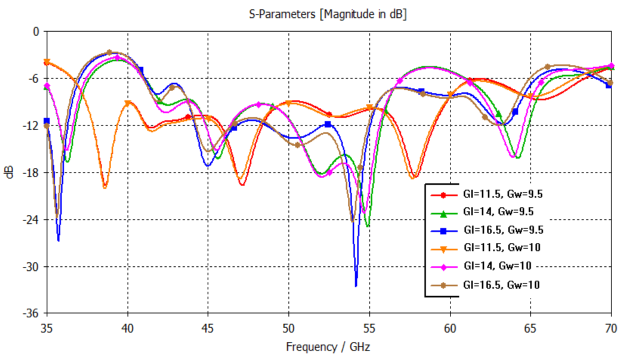


Fig. 6. Reflection co-efficient for different values of ground length and ground width (Case-II).

The proposed antenna is compared to some published papers; the proposed antenna has one drawback to previous ones, which is due to size but has effective advantages, like, high gain and bandwidth to previous ones. The comparison is shown in Table II. The final optimized circular antenna attains the three bands. First two low-frequency bands are Ku uplink and the second one is covering the some part of first mm-wave band 24 GHz, presented in Fig. 7. The third band is ultra-wideband, having a bandwidth of 31.7 GHz, which

TABLE II. COMPARATIVE ANALYSIS

Ref	Technique	Frequency	Size (m³)	BW (GHz)	Gain (dBi)
[9]	Partial ground plane	32.56	10x10x0.254	2.95	6.12
[10]	EBG structure	28/38	5.5x20x0.787	0.45/2.2	5.2/5.9
[11]	Slotted antenna	30.5/41.5	10x10x0.762	1.5	N/A
[12]	Teaching learning optimization (TLBO)	25/37	4.96x6.86x0.762	2/6	6.71/7.12
[13]	Inset feeding	37/54	7.2x5x0.787	5.5/8.67	5.5/6
Proposed Antenna	Partial ground plane	15.6/24.7/41.4	10x16.5x0.787	3.1/1.1/31.7	4.6/6.95/7.7

covers the multiple bands of future 5G communication for handheld devices. The ultra-wideband also covers the 61.25 GHz ISM band and the maximum portion of WiGig communication band (57 GHz to 68.36 GHz). The maximum realized gain obtained in the first band is 4.6 dB, 6.95 dB in second band, and in the ultra-wideband, it is 7.7 dB.

The radiation pattern at different frequencies in all the three bands is shown in Fig. 9.

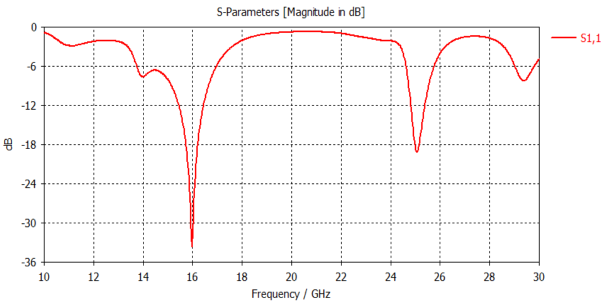


Fig. 7. Reflection Coefficient of the first two bands

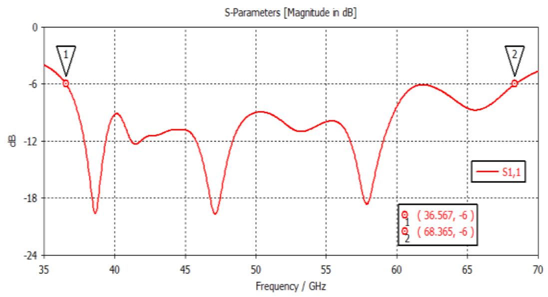


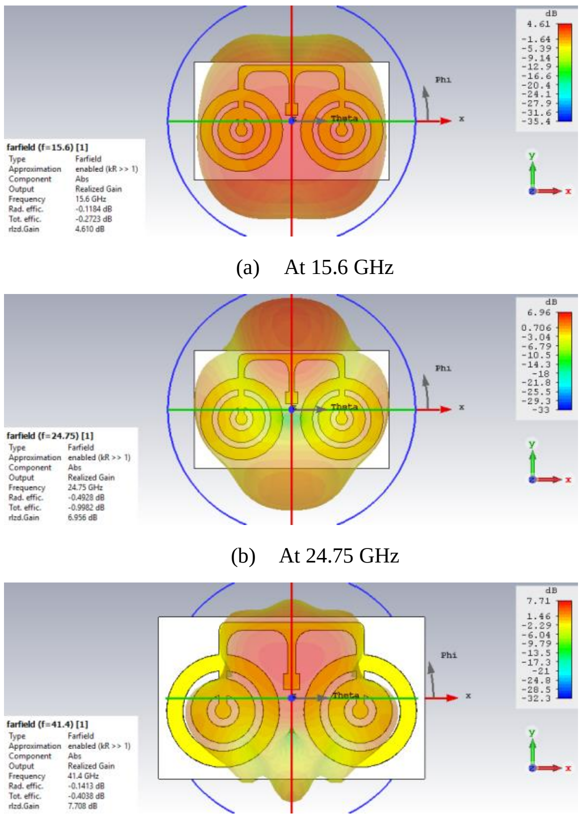
Fig. 8. Reflection co-efficient of ultra-wideband

IV. CONCLUSION

In this paper, the ultra-wideband antenna is proposed that cover three bands, two of which are narrow bands (low) and the third one is ultra-wideband (high). The UWB antenna will be the future candidate, in aspects of, high bandwidth and data rate. The maximum and the minimum observed gain are 7.7 dBi and 3.4 dBi in the ultra-wideband, and the maximum total efficiency is 95.5% and the total efficiency is greater 75.5% throughout the UWB.

V. FUTURE WORK

In the future, this proposed antenna will go through fabrication and testing phase and will further be optimized to improve its realized gain and efficiency.



(a) At 15.6 GHz

(b) At 24.75 GHz

(c) At 41.4 GHz

Fig. 9. Radiation pattern of the circular patch at different frequencies.

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