Effect of Feedline Tapering on the performance of Super Ultra-Wideband Circular Monopole Microstrip Antenna

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***Abstract*—This paper proposes a novel Super Ultra Wideband (S-UWB) monopole printed microstrip antenna. Analysis of tapering the feedline of S-UWB antenna is done to study the various parameters like return loss (S_{11}), Voltage Standing Wave Ratio (VSWR), Gain and radiation pattern. Study shows the improved performance of S_{11}, VSWR as well as gain by tapering the feedline. The associated 10 dB bandwidth of the proposed antenna is from 1 - 35 GHz. The volume of the proposed antenna is 40 x 50 x 1.6 mm^3 with substrate as FR-4 epoxy having the permittivity 4.4 and loss tangent 0.02. The return loss (S_{11}) less than -10dB), VSWR and radiation pattern shows in good agreement with the bandwidth. The proposed antenna is designed, simulated and optimized using HFSS commercial software. Investigation of S_{11} and VSWR is done for various tapered feedline to study the effect on its 10dB bandwidth. This proposed antenna is capable of covering the satellite navigation, UMTS, Bluetooth, PCS, WiMAX2500, LTE2600 Surveillance RADAR and UWB/S-UWB applications.**

Keywords*—*Circular monopole microstrip antenna; HFSS software; Super ultrawide band; tapered feed

I. INTRODUCTION

With the emergence of new wireless technology like 5G, RADAR technology, etc., there is tremendous increase in huge research interest among researchers in the Super Ultra Wideband (S-UWB) printed microstrip antenna (PMA). S-UWB PMA owes to low cost, small size and volume, simplicity of fabrication along with exceedingly wideband omni-directional radiation pattern and characteristics [1].

In this study, a novel S-UWB antenna has been proposed. The volume of the proposed antenna is 40 x 50 x 1.6 mm^3. The analysis of tapering of feedline is done to improve and optimize the impedance matching and thereby gaining the associated 10dB bandwidth [2]. The bandwidth i.e. the frequency range of antenna is from 1 GHz to 35 GHz and is appropriate for several applications like satellite navigation, WLAN, medical application, Bluetooth, surveillance RADAR and UWB/SWB applications etc. because of its bandwidth and desired gain [4].

In the proposed antenna, the ground is made partial for impedance matching and thereby inclusion of lower frequency in 10 dB bandwidth [3,4]. Further for the inclusion of frequency from 1 GHz to 5 GHz in the 10 dB bandwidth, semicircular rings are removed from the ground as shown in fig.4. [5].

Section II shows all the design parameters of proposed S-UWB PMA including the front view, side view as well as back view. While section III shows the performance parameters of antenna as Return loss (S_{11}), Voltage standing wave ratio (VSWR) as well as Radiation pattern. The results and conclusion is discussed in section IV.

II. ANTENNA DESIGN

The proposed design of circular monopole microstrip S-UWB antenna is shown in three parts namely front view, side view and back view as shown in fig. 1,2 and 3 respectively. The dimension of the proposed antenna is shown in Table I. To study the effect of tapering of feedline for the improvement of different parameters like S_{11} and VSWR different values of l_i is taken in the range 1.5 mm $\leq l_i$ (mm) $\leq$ 4.2 mm. l_i belongs to {1.5, 1.8, 2.6, 3.8, 4.2 (in mm)}.

A. Front view (Patch)

The proposed antenna consists of a circular patch of copper sheet of radius (R) 12 mm attached with trapezoidal feedline having the constant base width (W_b) 3.8 mm and varying upper width (l_i = 1.5,1.8, 2.6, 3.8, 4.2 (in mm)) as shown in fig. 1. The height (H = 16.5 mm) of the feedline is kept constant during the analysis. The tapered feed has been done to improve and optimize the matching of impedance at higher frequencies [2].

B. Substrate

Flame Retardant (FR) type 4 epoxy material having permittivity of 4.4 and loss tangent of 0.02 has been used. Fig.

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2 shows the substrate having the dimensions as W x L x H_S (40mm x 50mm x 1.6mm).

C. *Back view (ground)*

Fig.3 depicts the partial ground consisting of copper sheet of width (W) 40 mm and height (H_G) 16 mm. The partial ground is done for the impedance matching as it helps in tuning the input impedance [3,4].

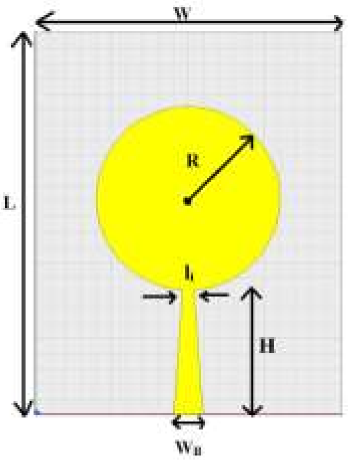

Fig. 1. Front View (Patch)

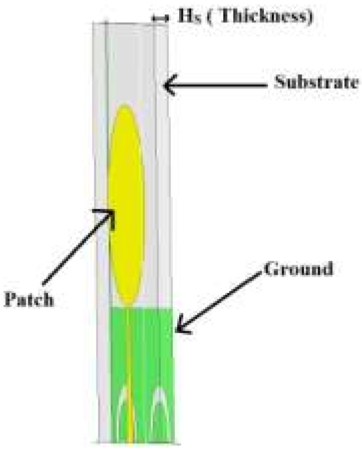

Fig. 2. Side View

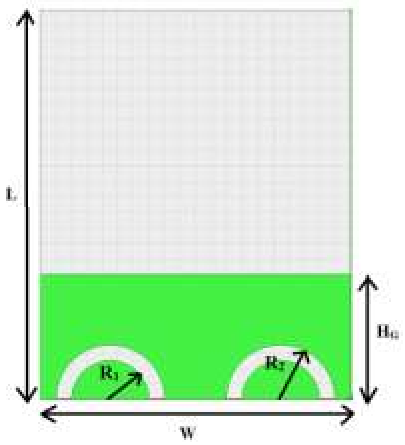

Fig. 3. Back View (Ground)

TABLE I. DIMENTIONAL PARAMETERS OF ANTENNA

Serial No.	Front view (Patch)	
	Parameters	***Values (in mm)***
1	R	12
2	H	16.5
3	W_B	3.8
4	L_i	1.5,1.8,2.6,3.8,4.2
Substrate		
1	L	50
2	W	40
3	H_S	1.6
Back view (Ground)		
1	H_G	16
2	R_2/R_1	7/5
3	W_G	40

For the inclusion of 1 GHz to 5 GHz of bandwidth, two semi-circular rings having radius (R2 and R1) has been removed from the ground. The proposed ratio is

$$R_2/R_1 = 7/5 \tag{1}$$

III. RETURN LOSS, VSWR, RADIATION PATTERN AND GAIN

In Fig. 4(a) and fig. 4(b), the return loss of antenna having partial ground and partial ground with circular rings slot is shown respectively. Frequency from 1 GHz to 5 GHz is included for the antenna having circular rings slot in partial ground. The effect of semicircular rings slot on the 10 dB bandwidth is shown in fig. 4. Fig. 5 shows the return loss S_{11} of designed S-UWB PMA for all the values of l_i. It can be seen that as l_i decreases from 4.2 mm to 1.5 mm and therefore tapering increases, the corresponding S_{11} shifts downwards and thereby improving the 10dB bandwidth. It can be clearly seen from the return loss, the frequency range is from 1 GHz to 35 GHz.

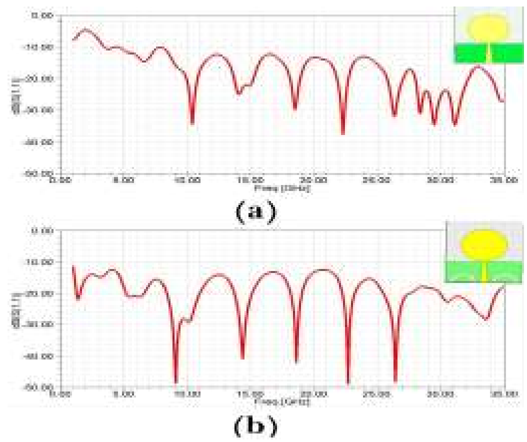

Fig. 4. (a) Return loss of antenna having partial ground (b) Return loss of antenna after removing circular rings from partial ground.

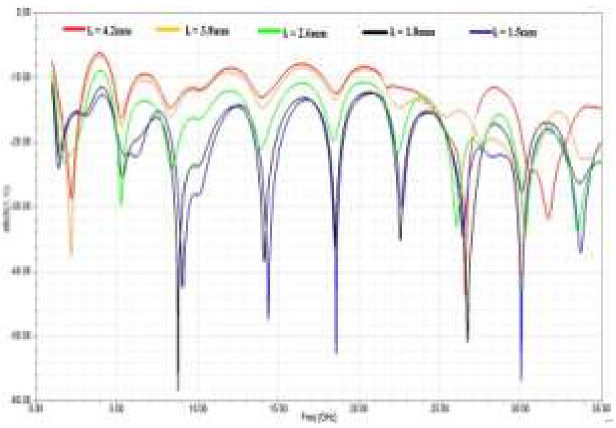

Fig. 5. Return loss of proposed S-UWB PMA for different l_i

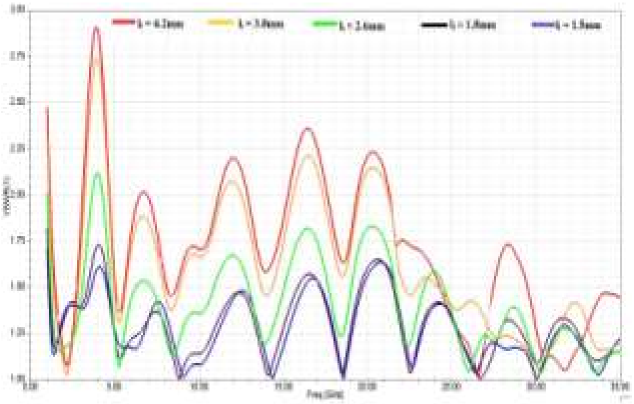

Fig. 6. VSWR of proposed S-UWB PMA for different l_i

Fig. 6 shows the corresponding Voltage standing wave ratio (VSWR) which clearly shows the effect of tapering the feedline by decreasing the values of l_i. Fig. 7-12 shows the simulated radiation pattern for several different frequencies (1.30 GHz, 9.04 GHz, 14.34 GHz, 18.54 GHz, 22.64 GHz and 30 GHz). The antenna become more directional at higher frequencies due to increase in the number of lobes as seen in fig. 8-12. Gain versus frequency for different value of l_i is shown in fig. 13.

IV. RESULTS AND CONCLUSION

The super ultra-wideband monopole antenna having tapered trapezoidal feed is designed and investigated to see the effect of tapering on the bandwidth and on return loss S_{11} as well as gain and VSWR. The designed antenna's impedance bandwidth is very wide ranging from 1 GHz to 35 GHz with the desired return loss of less than -10dB. The proposed antenna is very simple, compact and relatively easy to fabricate The volume of the designed antenna is 50 x 40 x 1.6 mm^3. In this study, the effect of tapering i.e. l_i the upper width of feedline is decreased from 4.2 mm to 1.5 mm and keeping the lower width as constant. As seen from the return loss, there is improvement in the antenna's impedance bandwidth. Also, the VSWR confirms the same. This proposed antenna is capable of covering the satellite navigation, UMTS, Bluetooth,

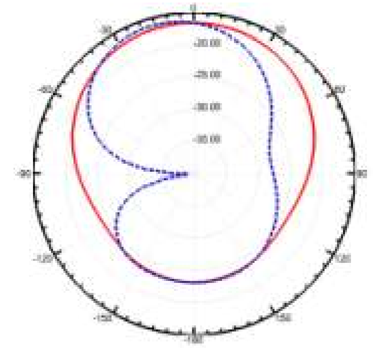

Fig. 7. Antenna radiation pattern at 1.30 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

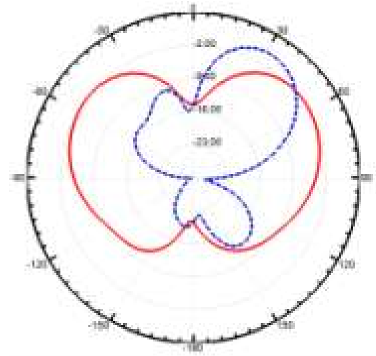

Fig. 8. Antenna radiation pattern at 9.04 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

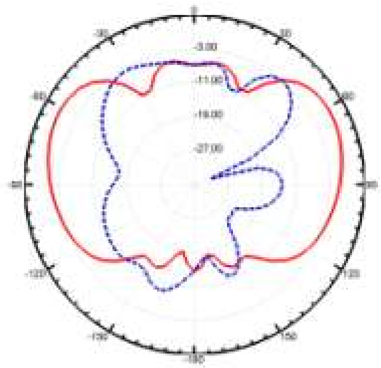

Fig. 9. Antenna radiation pattern at 14.34 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

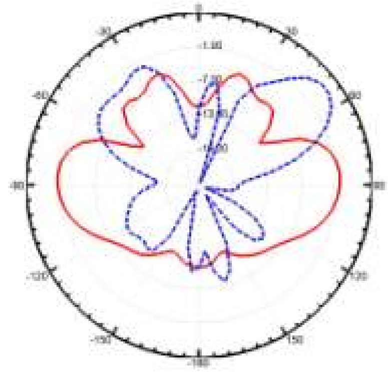

Fig. 10. Antenna radiation pattern at 18.54 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

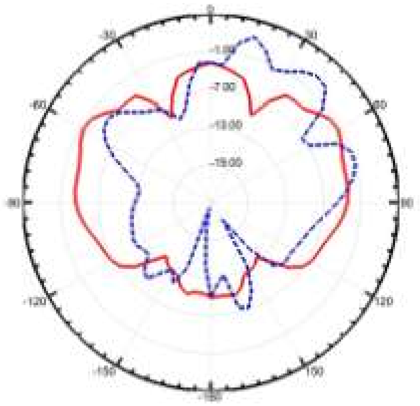

Fig. 11. Antenna radiation pattern at 22.64 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

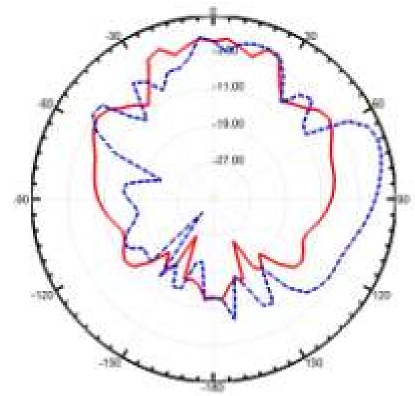

Fig. 12. Antenna radiation pattern at 30.00 GHz. Dashed and solid line represents H-plane and E- Plane respectively.

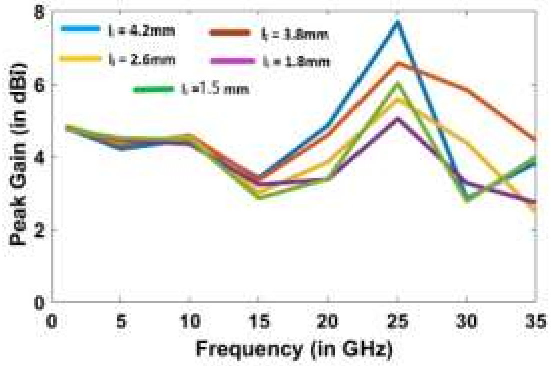

Fig.12. Gain against Frequency

PCS, WiMAX2500, LTE2600 Surveillance RADAR and UWB/S-UWB applications.

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