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Compact Self Complementary UWB Antenna with Triple Band Notch Characteristics for Wireless Communications

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Abstract: the objective of this paper is to design and analysis of the Ultra wide Band Micro strip Patch Antenna which covers the Ultra Wide Band 2.9 to 21.5 GHz. To get an optimum results and performance of the projected self complementary UWB antenna depends on the study of dissimilar methods for optimizing the different parameters of the radiating patch along with notch dimensions. The proposed self complementary UWB antenna with overlapped rectangular shape patch and Defected DGS is designed with C-Slot in the radiating patch element and ground with L shaped slot which covers the whole UWB frequency band apart from band notches WLAN (5.125-5.825 GHz) ,Satellite Communications (7.9-8.5 GHz) and Ku band 13.4-14.5GHz.The UWB antenna performance is improved in terms of the Bandwidth by including Rectangular shaped slit between feeding element and the radiating patch. Now a days it is important to avoid existing wireless communication networks from the design of UWB antenna. The self complementary UWB antenna impedance bandwidth from 2.9 GHz to 21.5 GHz with a maximum of return loss S11 -43 dB at operating frequency10.5 GHz and with a Gain of 5.64dB.

Keywords: DGS, Impedance Bandwidth, Self Complementary, UWB Antenna.

I. INTRODUCTION

In at the present day's antennas become a part of human being life. The some of the equipments around are using wireless communication networks. For the any wireless communication system antenna is the heart of the system. Micro strip patch antennas are low profile and planar in nature so they can provide a consistent communication. The UWB technology has knowledgeable lots of important developments in recent years. However, present there are still challengers in making this technology survive to its full probable. In that one of the challenge is the UWB antenna design. The major challenge while designing the uwb antenna is high radiation efficiency entire UWB impedance bandwidth. Throughout literature survey, there are many design considerations in UWB radio systems. From the definition of an UWB antenna must be operable over the entire frequency range from 3.1 GHz to 10.6 GHz, therefore, the UWB with a impedance bandwidth of 7.5GHz.In previous years while designing micro strip patch antennas facing a serious limitation was the narrow bandwidth due to frequently used antenna elements for example slots and dipoles. With the proper impedance matching constraint was effectively removed and bandwidth is achieved able to 90%.The bandwidth of antennas is to increased due to impedance matching, feeding techniques, volume ,size and height. From the literature survey ultra wideband achieved with the square patch with slots and ground plane consists of inverted T-shaped slot provides a impedance bandwidth of 120% and also fractional bandwidth depends on the gap between feed and patch, the sizes of two rectangular slots and T slot in ground plane [1] are optimized by parametric analysis to obtain more fractional bandwidth. To attain the polarization diversity and band notches arc shaped slots are inserted in monopoles. As a result of that antenna achieved a fractional bandwidth from 3-11 GHz with band notched realized from 5 -6 GHz. And also provides the better isolation (40dB) between two ports using differential driven method [2]. To achieve polarization diversity, isolation, antenna elements are arranged perpendicular to each other [3]. And due to the pair of L shaped slits on the ground plane antenna achieved a fractional bandwidth from 3.08-11.8 GHz with band notched realized from 5.03-5.97 GHz along with a compact size of 38.5×38.5×1.6 mm3.To achieve the ultra wideband with common mode suppression [4] and dual sharp selectivity notched bands, antenna with a differential stepped slot and feeding micro strip. The size of the compact antenna was 28×18×0.8 mm3 and dielectric constant of 2.55, loss tangent 0.0029 with substrate height 0.8mm was achieved a fractional impedance bandwidth from 3-10.8 GHz ,band notches from 5.1-6.0 GHz and 7.83– 8.47 GHz. To achieve triple band notches and to remove existing wireless systems from the Ultra wideband frequency band, UWB antenna with are realized with the electronic ring resonator, circular patch fed by a CPW. And UWB antenna achieved a fractional bandwidth from 2.5-15 GHz with a band notches from WiMax and WLAN.To achieve UWB antenna with double polarization and wide axial ratio bandwidth [6], antenna used hexagonal along with rectangular stub in the ground and hexagonal wide slot in radiating patch. Antenna achieved a fractional bandwidth from 3.1-10.8 GHz and axial ratio bandwidth of 67.76% frequency from 4-8.1 GHz.

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To achieve UWB antenna band notch characteristics for MIMO applications J shaped slits [7] are etched in the bottom plane. The UWB antenna achieved bandwidth from 3.1 -35 GHz with a band notches WLAN and ITU.
Similarly compact UWB antenna with high isolation [8] and triple band notches characteristics are obtained with a band notches from WiMax, WLAN and X
band 7.1- 7.9 GHz and impedance bandwidth from 2.3-13.75GHz.Compact UWB antenna is achieved with band notches at WiMax and WLAN using Slitted Electromagnetic Band Gap [9]. To filter the undesired wireless communication system like WiMax and WLAN, antenna consists of a Defective ground structure. Similarly a compact circular monopole antenna achieved a band notches from WLAN and ITU (7.8- 8.4 GHz) with a circular monopole that has two parasitic resonators Iron shaped and inverted U [10] are located in the bottom plane. The UWB antenna consists of rectangular patches are overlapped with each other, Defective ground structure (DGS) with self complementary technique is proposed to get impedance bandwidth from 3.0- 11.5 GHz along with that band notches from 5.1- 5.825 GHz and 7.5 GHz -8.4 GHz, Axial Ratio Bandwidth of 2 GHz from 3.1-5.4 GHz and the proposed antenna UWB characteristics are achieved by parametric Analysis. Several design methods have been reported to challenge these limitations. Those are arranged into following categories. 1. First method involves modification in the shape of bottom plane. To produce new resonance at higher frequencies with help of the dumble shaped slot, E shaped slot and Hexagonal shaped slot cuts in the bottom plane.2. Second method involves modification slots in the patch. To achieve UWB band radiating patch with different slots and stepped impedance feed line. However, it disgraces the electric performance of the UWB antenna.3. Third method involves in radiating patch with Fractal geometry and Electromagnetic band gap is used to design UWB antennas. 4. Fourth method involves self complementary and DGS are used to design UWB Antennas.

II. ANTENNA DESIGN

The proposed UWB antenna consists of rectangular patches overlaps with each other, defective ground structure and self complementary methods are used to achieve a fractional impedance bandwidth from 2.9 to 21.5 GHz with band notches WiFi (5.125 – 5.825 GHz) , satellite communications (7.9-8.5 GHz) and Ku Band is designed on substrate epoxy FR4 with a dielectric constant of 4.4 and loss tangent 0.0002.The proposed UWB antenna exhibits an impedance bandwidth of 18.6 GHz due to the self complementary technique and DGS with a edge feeding technique. From the literature survey band notches are achieved with different shapes of slot cuts in patch and bottom plane.

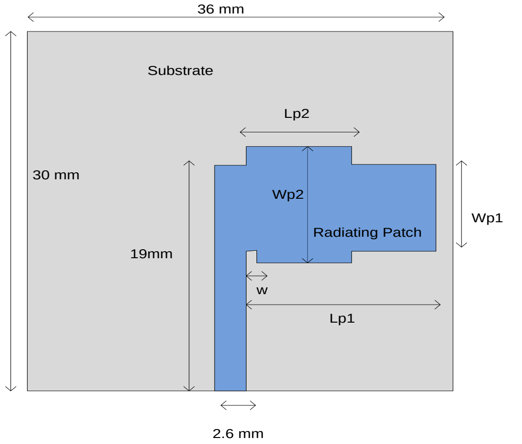

Figure 1: Antenna 1 Top View of the UWB antenna

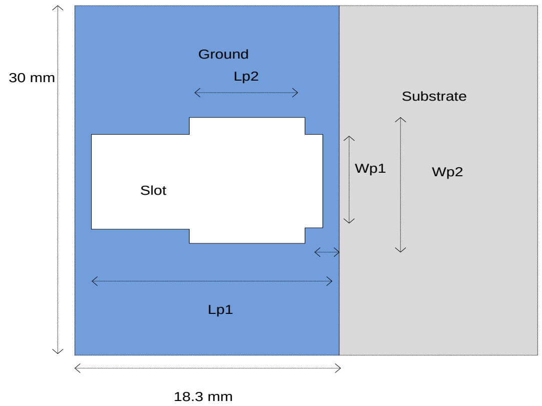

Figure 2: Antenna 1 Bottom View of the UWB antenna

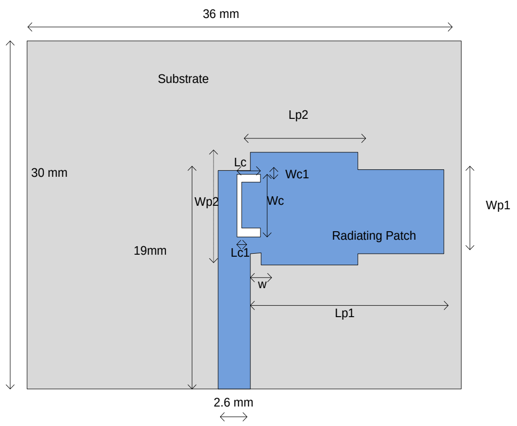

Figure 3: Antenna 2 Top View of the UWB antenna

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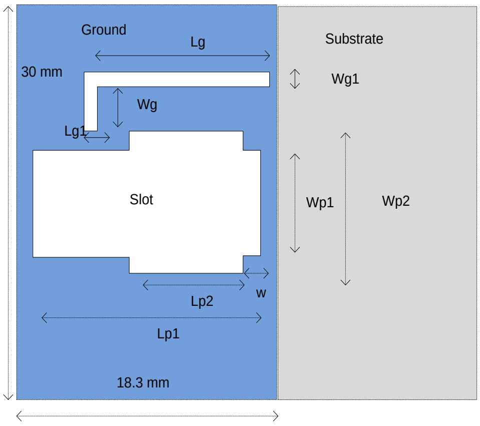

Figure 4: Antenna 2 Bottom View of the UWB antenna

In this paper projected antenna used C-Slot in the Radiating patch consists of rectangular patches overlaps with each other and one more slot Placed in the Ground plane to get the band notches from WLAN (5.125- 5.825) GHz and satellite communication (7.9- 8.5 GHz) accordingly. The proposed UWB antenna with dimensions of 30 × 36 ×1.6 mm^3.Now, the proposed UWB antenna produced the optimum output and performance.

Figure 1: from the Antenna1 Two Rectangular Patches are overlapped each other, One rectangular patch with a dimensions of 9 × 17.1 mm^2 and other one dimensions of 11.8 × 11.5 mm2 are placed on the fr4 epoxy with a dimensions of 30 × 36 × 1.6 mm^3. Similarly Antenna 1 bottom layer consists of Defective Ground structure of 30 × 36 mm^2 and radiating patch is etched from the ground. This technique is called as a self complementary technique. Due to DGS and Self complementary technique antenna exhibits an Ultra wide band.

III. RESULTS AND DISCUSSION

The Self Complementary UWB antenna without slots optimum results and performance are depends on dimensions of the radiating patch length and width. The below figures 3 and 4 shows the impedance Bandwidth of Self Complementary antenna for the values of lengths and widths of the Radiating patch element.

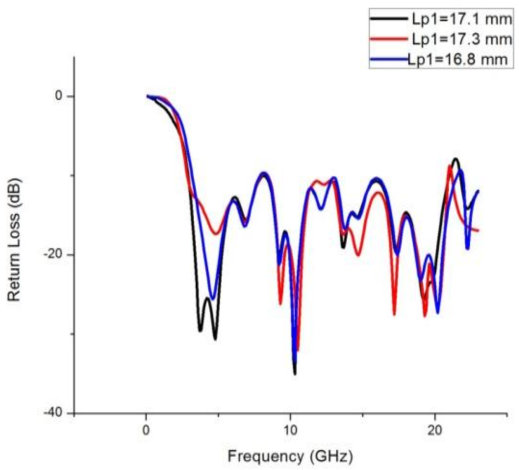

Figure 3: The Proposed Self Complementary UWB Bandwidth variation with patch length Lp1

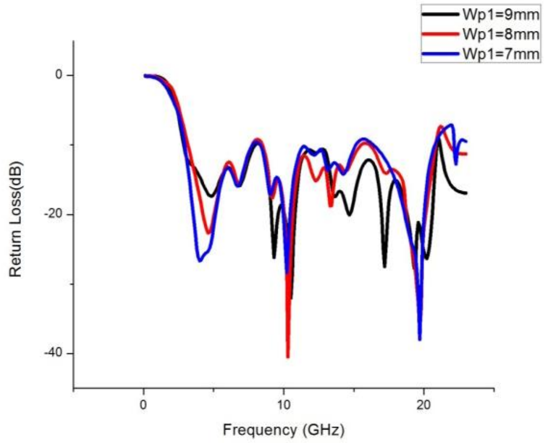

Figure 4: The Proposed Self Complementary UWB Bandwidth variation with patch width Wp1

From the Figure 3 and Figure 4, the self complementary UWB without slots achieved an impedance BW of 18.6 GHz starting 2.9-21.5 GHz.

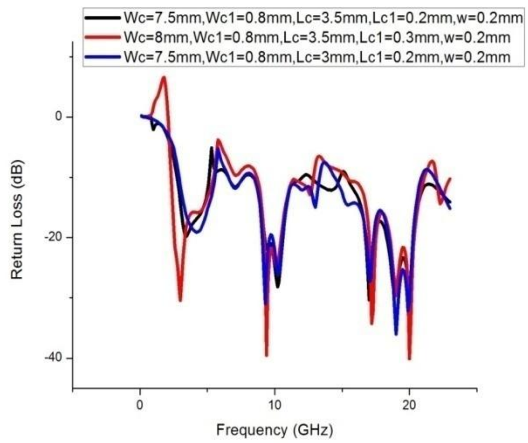

Figure 5: Bandwidth of the proposed UWB antenna with Slots

From the figure 5, Antenna exhibits an impedance BW around 18.6 GHz from 2.9-21.5 GHz with band notches WLAN ,ITU and Ku Band for the variation of C-slot dimensions along with the fixed values of L-shaped parameters Lg=12 mm, Wg=3 mm, Wg1=0.3 mm and Lg1=0.5 mm.When the slot dimensions are Wc=7.5mm, Wc1=0.8mm,Lc=3.5mm,Lc1=0.2mm and w=0.2mm, the proposed antenna exhibits the bandwidth of 18.6 GHz with a band notches WLAN (5.1-6.6 GHz) and ITU (7.7-8.5 GHz).When the slot dimensions are Wc =8mm, Wc1=0.8mm, Lc=3.5mm, Lc1=0.3mm and w=0.2mm, the proposed antenna exhibits the bandwidth of 18.6 GHz with a band notch from 5.5-8.7 GHz. It notches WLAN and ITU Communication systems.

When the slot dimensions are Wc =7.5mm, Wc1=0.8mm, Lc=3mm, Lc1=0.2mm and w=0.2mm, the proposed antenna exhibits the bandwidth of 17.8 GHz with a band notches from 5.5-6.6 GHz,7.6-8.5 GHz and 13.3-14.5 GHz. It notches WLAN, Ku Band and ITU Communication systems.

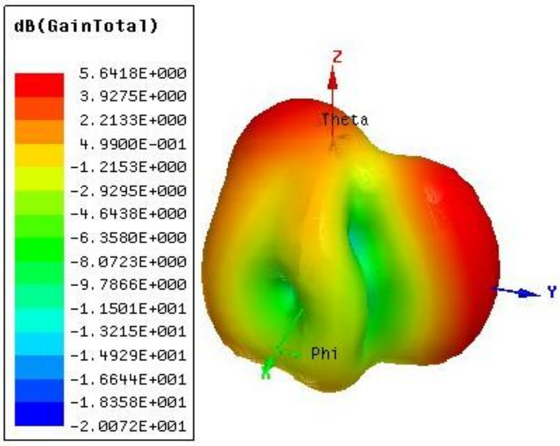

Figure 6: The Gain of the UWB Antenna

Table 1: Comparison Reported Different Band Notched UWB Antennas

Design	Size (mm^3)	Operating Band(GHz)	Band Notch1(GHz)	Band Notch2(GHz)	Band Notch 3(GHz)	Ground
[1]	18 × 12 × 1.6	3.12–12.73	-	-	-	Inverted T shaped Notch
[2]	64 × 64 × 1.5	3-11	5- 6.1	-	-	Irregular Octagonal Shaped
[3]	38.5 × 38.5 × 1.6	3.08 - 11.8	5.03- 5.97	-	-	Rhombic Shape with Slots
[4]	28 × 18 × 0.8	1-2	5.1- 6.0	7.83–8.47	-	Stepped Slot etching
[5]	50 × 50 × 1.52	2.5-12	3.8	5.8	7.5	Coplanar and DVC
[6]	25 × 25 × 1.6	3.1-10.8	-	-	-	Rectangular spiral stub
[7]	26 × 15 × 1.6	3.1-35	5.1- 5.8	6.7- 7.1	-	Capacitive loaded with Monopole
[8]	39 × 39 × 1.6	2.3-13.75	3.25- 3.75	5.08–5.9	7.06-7.96	Rectangular Defected
[9]	18 × 40 × 1.6	2.23 – 13	4.92 – 5.56	-	-	Rectangular
[10]	32 × 24 × 1.6	3.1-13	7.8- 8.4	-	-	Defected Structure with Parasitic Elements
[11]	28 × 30 × 1.6	2.7-10.6	3.3 - 3.7	7.25–7.745		Defective Ground Structure
[12]	27 × 30.5 × 1.6	3.1-10.6	3.3- 3.88	4.96–6.23	7.9-8.7	Truncated Ground Plane
[13]	32 × 35 × 0.508	2.6-12	3.3- 3.6	5.1–5.8	8.0-8.4	Defective Ground Structure
[14]	26 × 36.6 × 1.6	3-11	3.4- 3.7	5.15–5.825	7.25-8.395	A partially slotted Ground plane
[15]	35 × 26 × 1.5	2.55-12	3.15- 3.85	5.4–6.1	7.8-9.3	Defective Ground Structure
[16]	35 × 35 × 1.6	3-11	3.3- 3.8	5.15–5.85	7.9-8.4	Elliptical Shape
[17]	30 × 35 × 1.6	2.78-12.3	5.2- 6.0			Coplanar
[18]	34 × 34 × 1.6	3.1-10.6	5- 6			Rectangular Grooved Ground Plane
[19]	50 × 50 × 1.575	2.6-10.8	6.38			Square SRR
[20]	50 × 22.5 × 1.575	2.8-11				Coplanar Ground Plane
[21]	35 × 49.4 × 1.6	3.1-10.6	3.3- 3.6	5.15–5.35	5.725-5.825	Coplanar
[22]	50 × 50 × 1.575	3.1-10.6	6.2- 7.02	7.9/ 7.95		SRR pairs are inductively coupled
[23]	27 × 33 × 1.6	2.55-10.86	3.21- 3.86	4.93 –6.13	7.87- 8.89	CSRR etched from the Ground
[24]	48 × 48 × 0.8	2.5- 12	5.5			Rectangular stub Extended
[25]	38.5 × 38.5 × 1.6	3.08- 11.8	5.03-5.97			Rectangular slot and two L Shaped slits
[26]	30 × 40 × 0.8	3.1-10.6	3.4- 3.7	5.15–5.75		Metal strips on the Ground Plane
[27]	30 × 35 × 0.8	2.78 -12.3	5.2- 6.3			Coplanar
[28]	23 ×39.8 × 1.524	2- 12	5- 6			Two Ground planes Connected
[29]	22 ×36 × 1.524	3.1- 11	5.15- 5.85			T- Shaped Ground stub Extruded
[30]	18 ×36 × 1.6	2.9- 20	3.62- 4.77			T- Shaped Ground stub Extruded
[31]	29 ×20.5 × 1.6	2.98- 10.76	3.3-3.7	5.15-5.825		Defective Ground Structure
[32]	26 ×30 × 1.6	2.1- 20	3.1- 4	5.1-6.1		Etching Two L-Shaped Slots
[33]	33 × 25 × 1.14	3.07- 10.61	3.41- 3.68	5.37- 6.01		Partially Truncated Ground Pinane

[34]	46.4 × 38.5 × 1.524	2- 12.5	5- 5.5	7.2-7.6		Coplanar and Ground meandered
[35]	36 ×38 × 1.6	2.86- 13.3	3.45- 4	5.15- 5.9	6.77- 8.00 and 8.3-9.1	C slot on the Ground plane
Proposed Antenna	30 × 36× 1.6	2.8-21.5 GHz	5- 6	7.5–8	13.3-14.7	Defective Ground Structure and Self Complementary Technique

From Table 1, before reported band notched UWB antennas are compared with the proposed antenna. The ground plane with a defective ground structure, self complementary techniques are used to get UWB frequency band from 2.9 -21.5 GHz with a impedance bandwidth of 18.6 GHz on substrate with a dimensions of 30 × 36×1.6 mm^3. The UWB antenna with C and L Slots in the patch and Ground plane correspondingly to achieves a gain 5.64 dB along with that it overcomes interference from the existing wireless networks WLAN (5.125 – 5.825 GHz), Satellite communications (7.9-8.5 GHz) and Ku Band (13.4- 14.5 GHz).

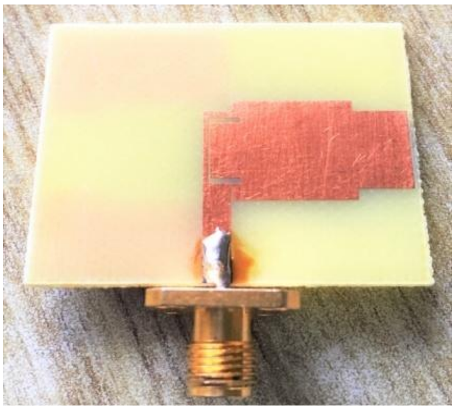

Figure 7: Top view of the UWB Antenna

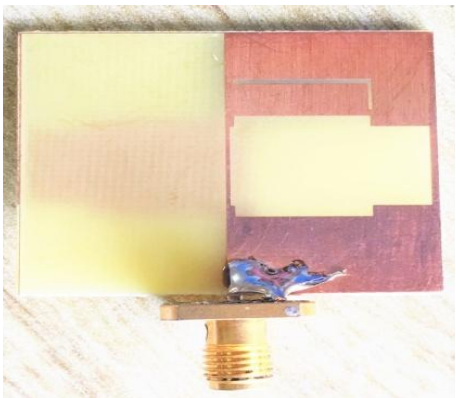

Figure 8: Bottom View of the UWB Antenna

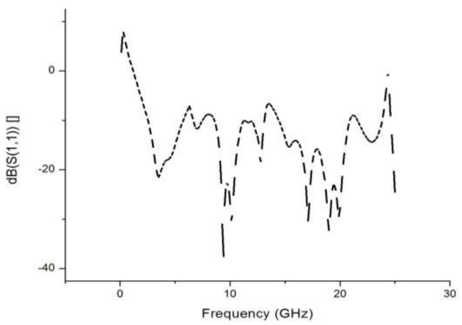

Figure 9: Proposed UWB Antenna measured return loss

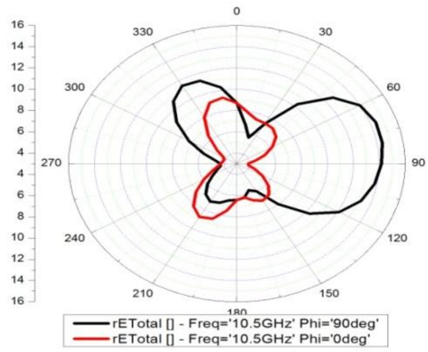

Figure 9: Proposed UWB Antenna measured Radiation pattern E-plane.

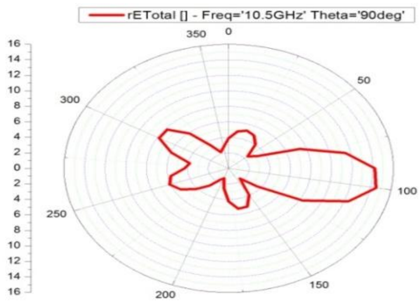

Figure 10: Proposed UWB Antenna measured Radiation Pattern H-plane.

IV. CONCLUSION

A compact micro strip feed line Defective Ground Structure and self complementary UWB antenna with C and L shaped slots in the Patch and ground plane respectively. The antenna is fabricated on a FR4 epoxy with dimensions of 30×36×1.6 mm^3.The Proposed self complementary UWB defective ground structured antenna attains Radiation pattern, gain and impedance matching over an operating frequency band from 2.9 -21.5 GHz with a gain 5.64dB . It is suitable for UWB communication applications.

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