Bandwidth Enhancement With Proximity Coupled Stacked Circular Patch Configuration with Defected Ground Structures for WLAN Applications

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Abstract

This paper propose configuration of new wideband microstrip patch antenna for wireless communication such as WLAN. A new novel stacked with circular shape patch is presented with wide impedance bandwidth of 19.14 % is achieved. The antenna structure is designed and simulated. Simulated results for return loss, impedance bandwidth and surface current distributions are discussed. Due to stack configuration of microstrip patch antenna it gives more impedance bandwidth and size reduction is achieved through defected ground structure (DGS). The proposed antenna is simple in structure with proximity coupled feeding can well feet for WLAN application.

Keywords: Wideband antenna, proximity coupled feed, stack configuration, DGS, microstrip antenna,WLAN

1. Introduction

Due to rapid progress in wireless communication system, broadband antennas are of great demand. Microstrip patch antennas are widely used in a variety of wireless communication devices. Even though microstrip antennas have a lot advantages like high gain, low profile, and ease of fabrication, compatibility with monolithic integrated circuits (MMICs) their usage is limited by their inherent narrow bandwidth.[1]Various techniques have been proposed to enhance the bandwidth of microstrip patch antenna.

Several techniques such as stack configuration and coplanar parasitic patch were proposed to enhance bandwidth.[5] This paper present a novel stacked circular shape patch with proximity coupled feeding technique with DGS (defected ground structure) is represented, which satisfy wide bandwidth of 1.06GHz (VSWR≤ 2). Defected ground structure, as name implies, refers to some compact geometries which etched out as a single defect or in periodic configuration with small period number on a ground plane of microstrip patch antenna.[4] Defected ground structure shows good impedance matching over wideband. In stack configuration, two or more patches on different or same layer of the dielectric substrate are stacked on each other. Based on coupling mechanism microstrip patch antenna can be categorized as electromagnetically coupled (proximity coupled) or aperture coupled microstrip antenna. In this paper, electronically coupling or proximity coupling is used. In proximity coupling, one or more patches on same or different dielectric layers are electromagnetically coupled to feed line located at one bottom dielectric layer. There are many advantages of stack configuration

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like, stacking does not increase the surface area occupied by the element compare to coplanar parasitic elements. Also, the radiation pattern and phase center of stacked element remains symmetrical over its operating band so it is important to use it in reflector feed, and for array application.[2]

2. Antenna Geometry

In this section, the design procedure of a stacked patch antenna with DGS is described. A circular patch shape is chosen due to its smaller size and other advantages such as easily modified to produce a range of impedance values, radiation pattern and frequency of operation. As for feeding technique, proximity coupling feed is used.

Radius (a) of circular patch for particular height (h) and dielectric material of substrate on which patch is placed is calculated from [2]

The design is started with single conventional circular patch with radius 6.55mm set to resonate at 5.8 GHz with proximity coupled feeding. The dimension of substrate is 28 mm×28 mm. For proximity coupled feeding two substrates are to be used, one for microstrip feeding line and another for patch as shown in figure 1. Dielectric substrates to be used is Gil GML 1034 with ε_r is equal to 3.38 and height (h) equal to 1.524mm.Second dielectric layer is same as first dielectric layer.

Then, bandwidth enhancement technique is applied using stacked configuration. In which one more layer of substrate is placed on previous design and on that substrate one more circular patch is placed of slightly high value of radius i.e 6.7 mm as shown in figure 2.

The dimensions of upper and lower patches are very critical for broad bandwidth. The size of upper patch is slightly different from lower patch to obtain slightly different resonance frequency and hence broad bandwidth. Further bandwidth can be improved by defected ground structure (DGS). Two dumbbell shape slots are etched in ground plane for further impedance matching to get wide bandwidth. Bigger dumbbell circle has radius of 1.5mm and smaller dumbbell circle has radius of 1.1mm. The position of DGS is very much important to get good impedance matching and hence broad bandwidth. The exact position of dumbbell shape DGS is as shown in figure 3. The location of DGS is optimized to get the proper position of DGS for broad bandwidth of microstrip patch antenna.

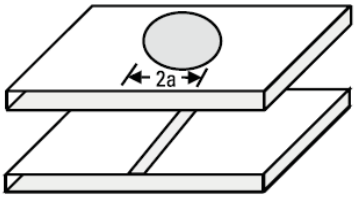

Fig. 1. Single circular patch proximity coupled microstrip antenna

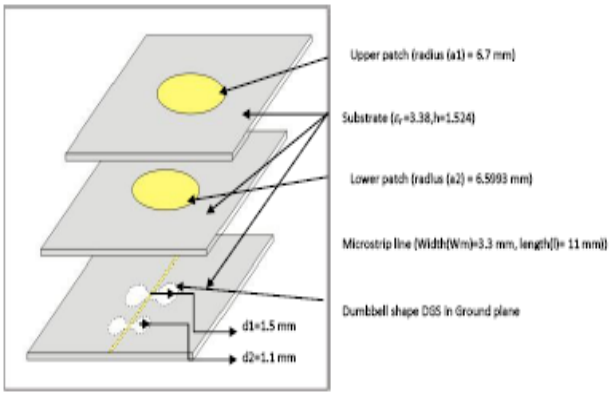

Fig.2. Proximity coupled Stack configuration circular patch Antenna with defected ground structure

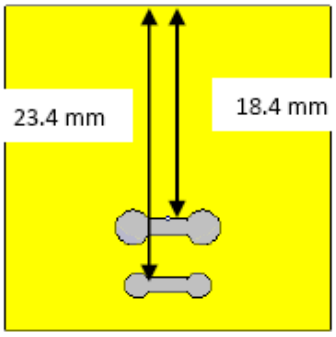

Fig.3. Position of dumbbell shape DGS

3. Results and Discussion

Simulation is carried out in computer simulator technology (CST) to observe the performance of proposed antenna.

Figure 4 shows the graph of simulated return losses. Simple proximity coupled circular patch antenna has impedance bandwidth of 9.23% or 0.54 GHz for return loss ≤ -10 dB.

For stack configuration without DGS, it has dual band with center frequencies 5.5 GHz and 6.5 GHz having

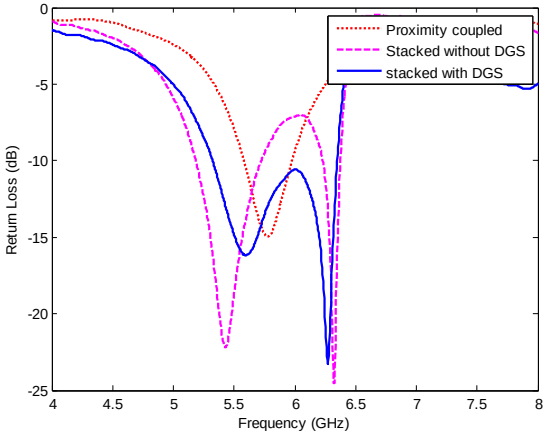

Fig. 4. Simulated Return losses

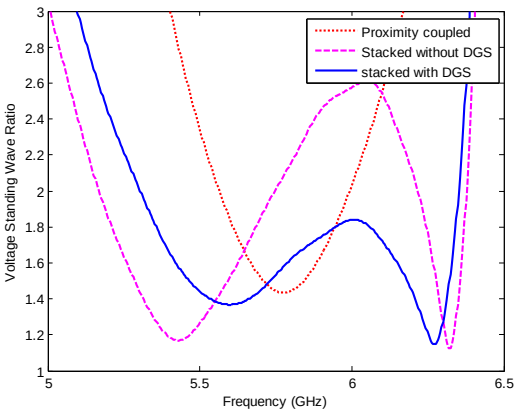

Fig. 5. Simulated Voltage standing wave ratio (VSWR)

impedance bandwidth of 9.8 % and 2 % respectively.

For stack configuration with DGS, it covers whole range of frequency from 5.3 GHz to 6.35 GHz band having impedance bandwidth of 18% or 1.05 GHz.

Figure 5 and figure 6 shows the graphs of simulated voltage standing wave ratio (VSWR) and input impedance of proposed antenna as a function of frequency respectively. VSWR of this antenna for entire bandwidth is well between 1≤ VSWR ≤ 2. VSWR at 5.58GHz frequency is 1.369 and at 6.27 GHZ is 1.14. The simulated input impedance at 6.27 GHz frequency is (42.67, -4.674) ohm which is close to 50 ohm impedance of feed line. The simulated VSWR and input impedance variation indicate excellence matching between feed network and proposed stack configuration.

In return loss graph of stack configuration without DGS, because of two patches of slight difference in radius there is dual band. By introducing two dumbbell shapes DGS structure, further whole band of 1.05 GHz can be achieved.

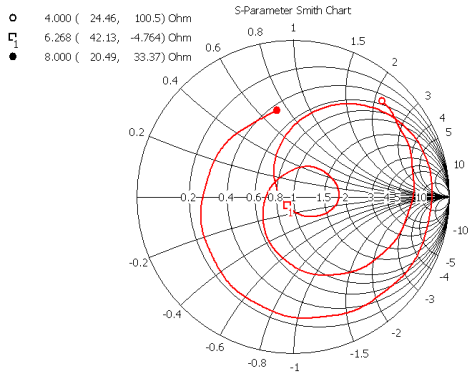

Fig.6. Variation of input impedance with frequency for stack configuration with DGS proposed Antenna

Figure 5 shows 3-D radiation pattern of proposed antenna. The maximum simulated gain of antenna is 5.82 dB. The two dimensional normalized E-plane and H-plane elevation radiation pattern of at 5.6 GHz resonance frequency is shown in figure 6 and figure 7

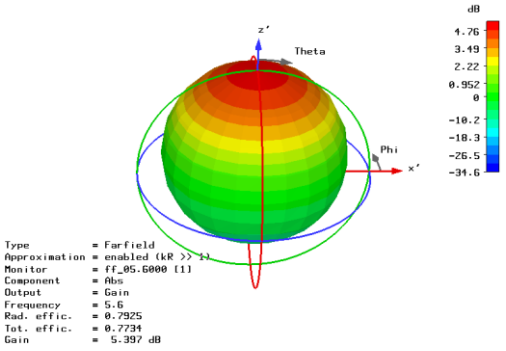

Fig.7. 3-D Radiation pattern of proposed Antenna

Table 2. Comparison Table of Results

Type of Antenna	Frequency (GHz)	Return loss (dB)	VSWR	Bandwidth (%)	Gain (dB)
Proximity coupled single patch antenna Without DGS	5.7	-14.96	1.435	9.23	5.926
Proximity coupled stack configuration without DGS	5.5	-22.33	1.164	9.8	5.7
	6.5	-19.09	1.250	2	5.475
Proximity coupled stack configuration with DGS	---	-23.3	1.147	18 (5.3 GHz to 6.35 GHz)	5.82

respectively. At this resonance frequency, E plane pattern is marginally more directive than H plane pattern.

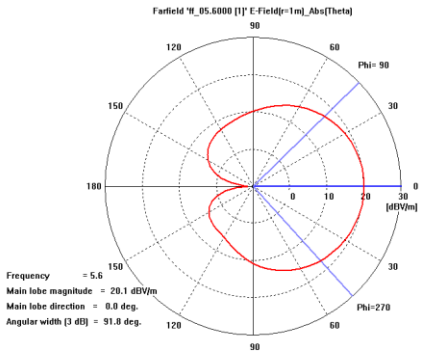

Fig.8. E-field radiation pattern of proposed Antenna

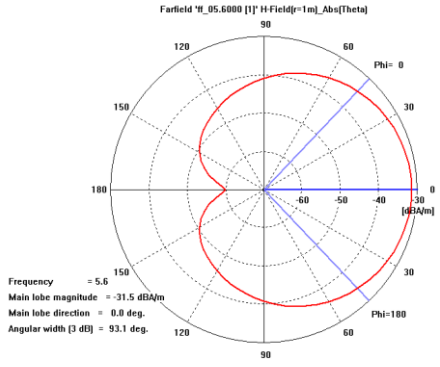

Fig.9. H-field radiation pattern of proposed Antenna

4. Conclusion

In this paper, a novel design technique for microstrip antenna is proposed. The antenna has been design for bandwidth enhancement using stack configuration with DGS. Study of simulation results shows that proposed antenna covers frequency range of 5.3 GHz to 6.35 GHz. The impedance Bandwidth is 18% at -10dB return loss. The maximum achievable gain of antenna is 5.82 dB. The size of patch and substrate is compact. The composite effect of integrating these, offer a low profile, broadband, high gain and compact antenna element suitable for broadband application.

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