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Design Analysis and Performance Comparison of Microstrip and CPW Antenna at UHF Band

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ABSTRACT
Microwave-frequency signals are conveyed by using the Microstrip antennas. It is capable of dual and triple frequency operations and has light weight and low cost. Similarly, larger bandwidth can be achieved by Coplanar Waveguide (CPW) structure. Gain can be enhanced using the Defected Ground Structure (DGS). This paper presents the performance comparison of the design of a microstrip antenna and the coplanar waveguide antenna at the frequencies of 900MHz and 2.4GHz. This is used for the RFID short – range reading applications.

Keywords: Coplanar wave guide (CPW), Fractal antennas, Microstrip Antenna (MSA), Radio Frequency Identification (RFID), Ultra–high frequency (UHF).

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I. INTRODUCTION

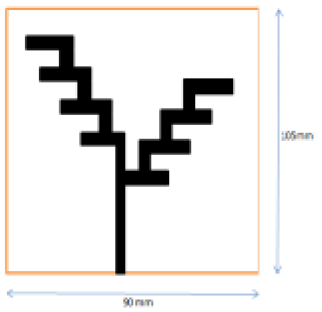
Radio Frequency Identification (RFID) is a technology that provides wireless identification and tracking capability. It consists of two components i.e., tag for product information transmission and reader for data reception. RFIDs are operated in different types of frequencies such as low frequency, high frequency, microwave frequency and ultra high frequency bands respectively. Among all these frequency bands, the UHF band is more popular RFID domain for its long read range. It is used for many applications like distribution logistics, pallet tracking, manufacturing companies, parking lot access and electronic toll collection, etc.

Globally, each country has its own frequency ranges for UHF RFID applications, e.g., 866-869MHz in Europe, 902-928MHz band in North and South of America, 866-869 and 920-925MHz in Singapore, 840.5-844.5 and 920.5-924.5MHz in China, and 952-955MHz in Japan. So that the UHF RFID frequency ranges from 840.5 to 955MHz (a fractional bandwidth of 12.75%) [10].

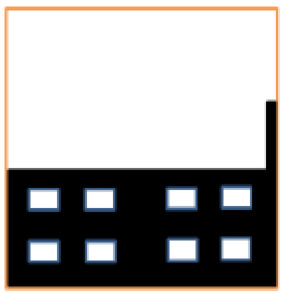
Microstrip antennas are also known as the patch or printed antennas. This antenna is a patch connected to the feed on a flat surface and this whole patch is printed on a rectangular flat surface which is called the ground plane. The substrate is the dielectric layer that separates both the patch and the ground plane. The CPW is a type of feeding technique where the center strip line (feed) carries the signal and the side-plane conductor is ground. In this paper, the CPW is used to get wider bandwidth covers from 900MHz to 2.4GHz. Enhancement of bandwidth and gain are achieved by using the fractal structure [4] and DGS [11, 12]. The read range distance can be calculated by using the formula [5].

II. ANTENNA CONFIGURATION

Fig.1 represents the geometry of the antenna FR-4 (relative dielectric constant=4.3, thickness=1.6mm, loss tangent=0.025) is considered as substrate and its overall dimension is 90 mm x 105 mm. The fractals are used as the radiating elements and also to increase the perimeter or to maximize the length of material that can receive or transmit electromagnetic radiation within a given (total surface area or volume) frequency. The Microstrip antenna with the DGS is designed with fractal structure to get better results of return loss and gain when compared to the microstrip antenna without DGS. The DGS of Microstrip Antenna with front view and back view are shown in Fig.1(a) and Fig.1(b). Similarly, the CPW antenna with the DGS is designed with fractal structure to get better results of return loss and gain when compared to the CPW antenna without DGS as shown in Fig.1(c) and Fig.1(d). The main advantage of CPW is that the ground and signal configurations can be achieved on the same plane. A stub of length L=30mm and width 3mm is projected out from the CPW plane to bring down the axial ratio to 0dB from 3dB. Fig.1(a), Fig.1(b) and Fig.1(d) represents the geometry of the proposed antenna. It used the Defected Ground Structure to increase the low gain and to get better result compared to the antenna without DGS.



(a)



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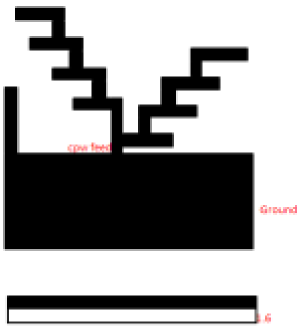

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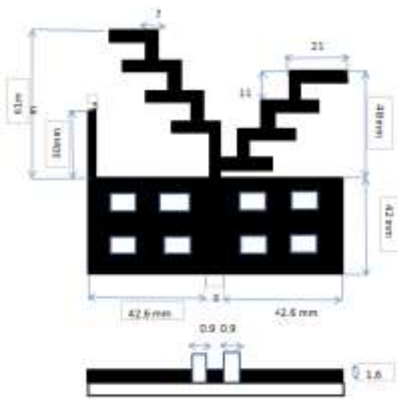


(d)

Fig.1.(a) Microstrip Antenna with DGS front view, (b) Microstrip Antenna with DGS back view, (c) CPW antenna with fractal structure without DGS and (d) CPW antenna with fractal structure with DGS.

In the proposed system, the Defected Ground Structure is placed on the ground plane to increase the gain. The Microstrip Antenna with the Defected Ground Structure is placed on the ground which is placed on the other side of the substrate. In the CPW antenna with the DGS, the ground is placed on the two sides of the side-plane conductor. The antenna is designed for 50Ω transmission line.

III. RESULTS AND MEASUREMENTS

The CPW structure with DGS is compared to the general monopole CPW structure. So, the simulated and measured reflection coefficient of the proposed structure is shown in Fig 2. The measured results exhibits a bandwidth (S_{11}< -10dB) which covers the total UHF band i.e., 840-955MHz at the central frequencies of 900MHz and 2.4GHz. The resultant bandwidth is very large due to the CPW and also the S_{11} parameter is less than -10dB.

In Fig.3 at 900MHz, the circular polarization is achieved by using the fractal technique and also the resultant gain is better due to the DGS in the proposed structure when compared to the existing structure.

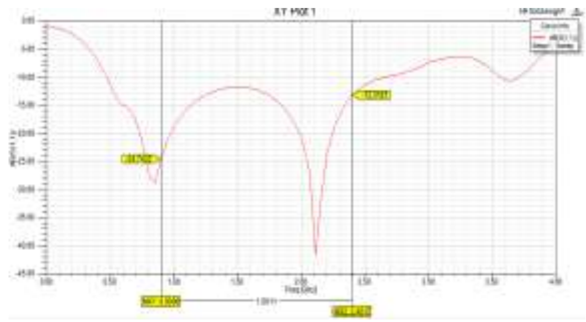


Fig. 2 Return Loss curve S_{11} in dB

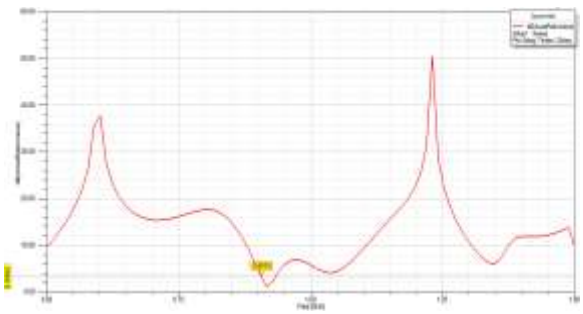
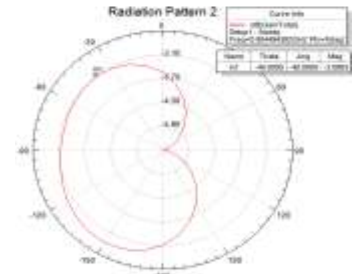
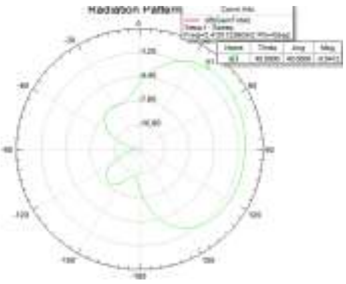


Fig.3 Circular Polarization for 900MHz

The radiation patterns are observed at the center frequency of applications.



(a)



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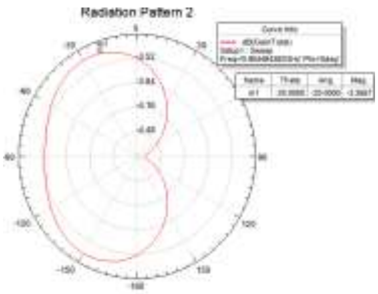

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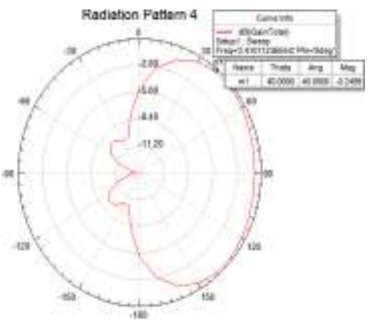
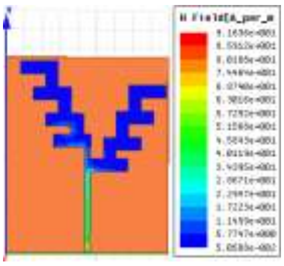


(d)

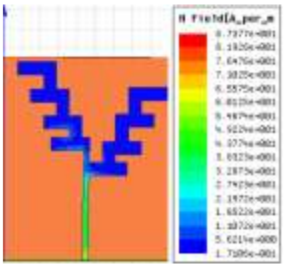
Fig.4.(a) Radiation Pattern at 900MHz at DGS of MSA, (b) Radiation Pattern at 2.4GHz at DGS of MSA, (c) Radiation Pattern at 900MHz at DGS of CPW and (d) Radiation Pattern at 2.4GHz at DGS of CPW.

From Fig.4 (a), at 900MHz in MSA, the maximum gain is –3dB observed in ϕ = -40°, ϴ = -40° direction. Fig.4 (b), at 2.4GHz in MSA, the maximum gain is –0.04dB observed in ϕ = 40°, ϴ = 40° direction. Fig.4(c), at 900MHz in CPW, the maximum gain is –3.3dB observed in ϕ = -20°, ϴ = -20° direction. Fig.4 (d), at 2.4GHz in CPW, the maximum gain is –0.24dB observed in ϕ = 40°, ϴ = 40° direction.

The surface current distributions of the antenna are plotted at the frequencies 900MHz and 2.4GHz to analyze the current distribution of the antenna at different resonant frequencies at the DGS of Microstrip and CPW.



(a)



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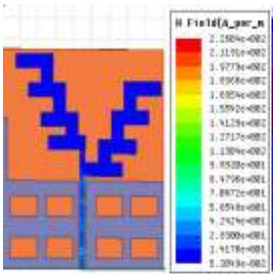

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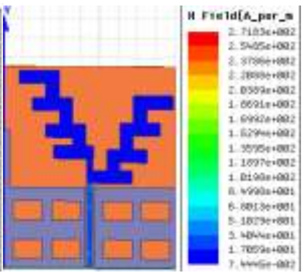

(d)

Fig.5 Simulated current distributions at (a) 900MHz at DGS of Microstrip, (b) 2.4GHz at DGS of Microstrip, (c) 900MHz at DGS of CPW and (d) 2.4GHz at DGS of CPW.

The microstrip antenna with Defected Ground Structure has the better gain, return loss and impedance values when compared to the microstrip antenna without the DGS as shown in Table-1.

TABLE – I: PERFORMANCE ANALYSIS OF MICROSTRIP ANTENNA WITH AND WITHOUT DGS

Parameters	**With Increased Length And Width**		**With Defected Ground Structure**	
	For 900MHz	**For 2.4GHz**	**For 900MHz**	**For 2.4GHz**
Return Loss(dB)	-6.4	-1.8	-13.10	-12.95
Gain(dB)	-16.9	-10.6	-3.0	-0.04
Impedance (□)	27	297	32.2	63.4

The coplanar waveguide structure has the wider bandwidth which covers the UHF band range (i.e., 840-955MHz) at both the frequencies 900MHz and 2.4GHz. And at 900MHz, it has the circular polarization. The proposed antenna (DGS with 4 slots and DGS with 8 slots) with Defected Ground

Structure has better gain and return loss when compared to the CPW antenna without DGS as shown in Table-2.

TABLE – II: PERFORMANCE ANALYSIS OF CPW WITH AND WITHOUT DGS WITH SLOTS

Parameters		Return Loss (dB)	Gain (dB)	Impedance (Ω)
Existing System	For 900 MHz	-24.8	-4	51
	For 2.4 GHz	-13.2	-0.6	71
Proposed System	For 900 MHz	-19.4	-3.3	58.5
	For 2.4 GHz	-14	-0.24	70.5
	For 900 MHz	-20.3	-3.6	58
	For 2.4 GHz	-13.5	-0.30	49

A. Read Range

The assumed read range distances can be calculated from transmitted power (Pt) as 4W and received power (Pr) as 1mW and gain of the receiver antenna (Gr) is 1 dBi are considered. The below equation is used to calculate the read range distance for different frequencies.

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \text{-------------- (1)}$$

$$R = \frac{c}{4\pi f}\sqrt{\frac{P_t \quad G_t \quad G_r}{P_r}} \text{----------(2)}$$

$$\lambda = \frac{c}{f}$$

Where c is the velocity of light = 3 x $10^8\ m/sec$

λ is the wavelength

f is the frequency

R is the read range

The comparison of read range values at the frequencies 900MHz and 2.4GHz are shown in the Table-3.

TABLE-III: PERFORMANCE ANALYSIS OF MICROSTRIP AND COPLANAR WAVE GUIDE WITH SLOTS FOR RFID APPLICATIONS (READ RANGE DISTANCES FOR DIFFERENT FREQUENCIES)

S.No	Parameters	For 900 MHz	For 2.4 GHz
1	Microstrip Antenna	0.26m	0.20m
2	Microstrip Antenna with DGS	1.3m	0.7m
3	Coplanar Wave Guide (for existing system)	1.1m	0.6m
4	Coplanar with 4 slots DGS	1.2m	0.69m
5	Coplanar with 8 slots DGS	1.2m	0.6m

IV. CONCLUSION

The main benefit of this proposed reader is its wider bandwidth that covers the entire UHF band range at the frequencies 900MHz & 2.4GHz and better gain due to the DGS and its additional advantage is the circular polarization (<3dB) from 907 to 930 MHz with central frequency of 900 MHz. The maximum read distance of the proposed reader antenna is 1.3 m for the Microstrip antenna with DGS and 1.2m for the CPW antenna with DGS with the reference of a general (1dBi) omnidirectional tag antenna. So the proposed structure is precisely suitable for the short-range RFID reading applications at 900MHz and for the Bluetooth, Wi-Fi Networks, ZigBee and so on at the 2.4GHz. The size of the antenna can be further miniaturized by the fractal concepts and enhancement of gain by using other feeding techniques.

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