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DESIGN AND ANALYSIS OF SQUARE SHAPE COMPACT MICROSTRIP ANTENNA USING DGS TECHNIQUE AT GSM-900 BAND

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ABSTRACT

In this paper A Square Shape Compact Microstrip Antenna which is suitable for the Mobile Communication i.e. GSM 900 IEEE Band is proposed. To compact the size of Microstrip antenna (MSA), the technique proposed in this paper is meandering the radiating patch and Defected Ground Structure (DGS) technique. In this paper the antenna contains a triangular- slot on the corner of the radiating patch and a square-slot on the ground plane. By using these techniques the size of the proposed antenna is reduced nearly by 90%. The parameters of the designed compact microstrip patch antenna like return loss, VSWR, Gain have been compared with the conventional Microstrip Patch Antenna at the operating frequency of 900 MHz. The performance of the proposed compact antenna is theoretically analysed using CST software and verified experimentally.

KEYWORDS: Microstrip Antenna (MSA), Defected Ground Structure (DGS), Triangular-Slot, Square slot, GSM900 IEEE Band, CST software.

INTRODUCTION

Conventional Microstrip patch antenna consists of a pair of parallel conducting layers separated by a dielectric medium, referred to as the substrate. The source of radiation is the upper conducting layer known as the patch layer. The lower conducting layer acts as a perfectly reflecting ground plane [2]. The development of microstrip patch antennas has made serious advancements in the 1970's and is currently probably the most dynamic field in antenna research and development. As conventional antenna is often bulky and costly part of an electronic system, the microstrip antenna based on photolithographic technology [8] are considered as Engineering. MSAs should be preferred due to their light weight, conformability, low cost, easy to manufacture and robust. Some other advantages of microstrip antennas are that they are conformable to planar and non-planar surfaces, easily fabricated using printed circuit technology [11]. Microstrip patches are resonant type antennas. Thus, impedance bandwidths are narrow. The other disadvantages of microstrip antennas are having low efficiency, low power handling, and spurious feed radiation

An ever-increasing growth of wireless communications has empowered broad research in the field of antennas. One major area of wireless communications where there is a rapid growth is the mobile communications. The mobile devices that can operate using different standards but in this paper the proposed antenna is designed at GSM-900 band (890-960 MHz). Because of smaller frequency, the size of microstrip patch antenna (MSA) becomes large [4], making it unsuitable for mounting in handheld transreceivers.

The Compact Microstrip Patch Antenna (MSA) is generally achieved by using different reducing methods such as modifying shape of radiating patch, DGS technique i.e. defected ground technique, use of high permittivity substrate, use of shorting pins and a combination of any of above techniques[1-5]. However, each of these techniques has their own advantages and disadvantages. Modification of the radiating patch shapes and defected ground techniques are the easiest one and also allow considerable size reduction. Apart from this while designing from these techniques antenna are small size and low volume antennas which have low manufacturing cost with thin profile configuration [2], which can be made conformal but it causes removal of radiating patch area reducing gain and affecting radiation pattern. CST MW studio software has been used for designing and simulation.

DESIGN OF ANTENNA

To design a Rectangular Microstrip Patch Antenna (RMPA) there are some basic design parameters are required which can be calculated by the antenna design equations [2]. Figure 2.1 shows the rectangular patch antenna with microstrip feed line where L, W, Y_0, W_0 are the length, width of patch, inset feed position and width of microstrip feed line respectively.

Table 1 Design specifications for Basic RMPA

S. no.	Parameters	Value
1.	Frequency(f)	900 MHz
2.	Substrate	FR4
3.	Dielectric constant (ϵ_r)	4.3
4.	Loss Tangent (δ)	0.025
5.	Substrate Height (h)	1.6mm
6.	Patch thickness	0.038mm

But before designing the rectangular microstrip patch antenna some specification should be taken into consideration. These specifications are listed in Table 1. The Basic design of the Rectangular Microstrip Patch Antenna shown in figure 2.1

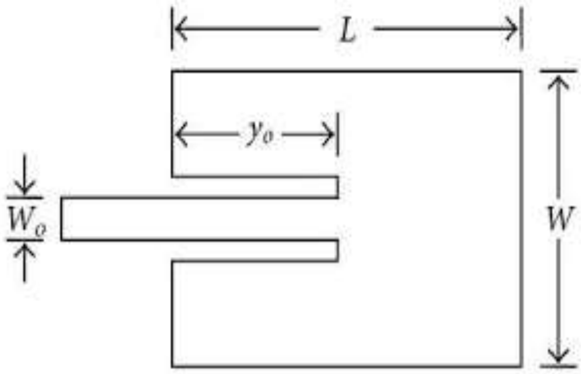

Figure 2.1 Geometry of Basic Rectangular Microstrip Patch Antenna with inset feeding

Where, L= length of the patch
W= width of the patch
Y_0= distance where the impedance is 50 Ω
W_0= width of the feed line
The above parameters for the rectangular patch antenna is calculated by following equations

The length L of the antenna is calculated by

$$L = L_{eff} - 2\Delta L$$

Where, $L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$

And $\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}-0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}-0.8\right)}$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Where, L_{eff} = Effective length of antenna
ΔL = Additional length of antenna
h = Height of the substrate

f_o = Resonant frequency

C = Velocity of light

And width of the antenna is calculated by

$$W = \frac{C}{2f_o\sqrt{\frac{\varepsilon_r+1}{2}}}$$

DESIGNING OF SIMPLE PATCH ANTENNA

After using above equations the calculated length and width for patch and feed at 900 MHz frequency is given below in Table 2. The dimensions of the ground plane and substrate are also mentioned in this Table 2.

Table 2 Dimensions of conventional RMPA at 900MHz

LAYERS	**LENGTH (mm)**	**WIDTH (mm)**	**MATERIAL**
Ground	115	120	PEC
Substrate	115	120	FR4
Patch	80.1806	102.3825	PEC
Cut	27.96	6.6	Vacuum
Feed line	79.96	4.8	PEC

By using these dimensions, Antenna is designed in CST software which is described in this section. First step is to design a ground plane of 115X120 mm and the height of the ground plane is taken as 0.038mm and the material is used here is PEC. After that a FR4 lossy substrate is placed above the ground plane whose dimensions is same as the ground plane, height is 1.6mm and dielectric constant is 4.3. Above the substrate a rectangular patch is designed whose dimensions are 80.1806X102.3825 and the height of the patch is 0.038mm whose material is also a PEC. In the patch a cut of length 27.96 mm is made where the impedance of patch is 50Ω. The feed of length 79.96 mm is connected to the patch. After this a discrete port is inserted and the simulation carried out. The designed geometry of rectangular patch antenna in CST software is shown below in Figure 2.2

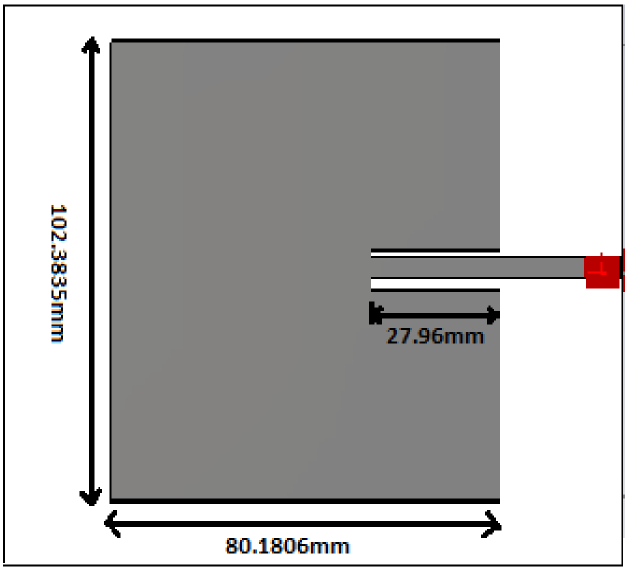

Figure 2.2 Front view of simple patch antenna designed using CST software.

The simulated results of the above design are shown below in figure 2.3 and 2.4:-

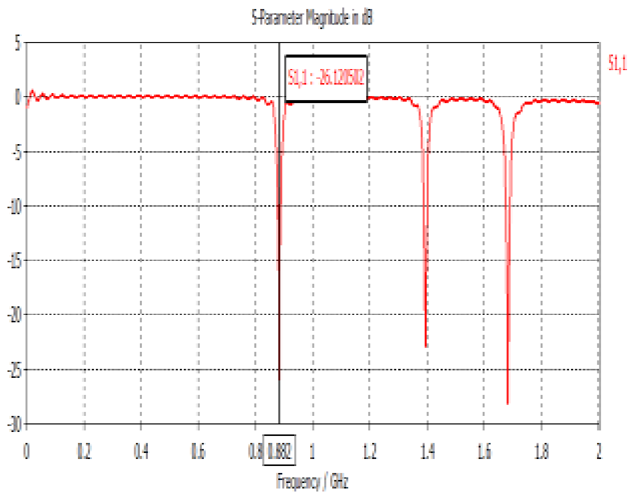

Figure 2.3 Return loss Vs frequency plot at 900 MHz

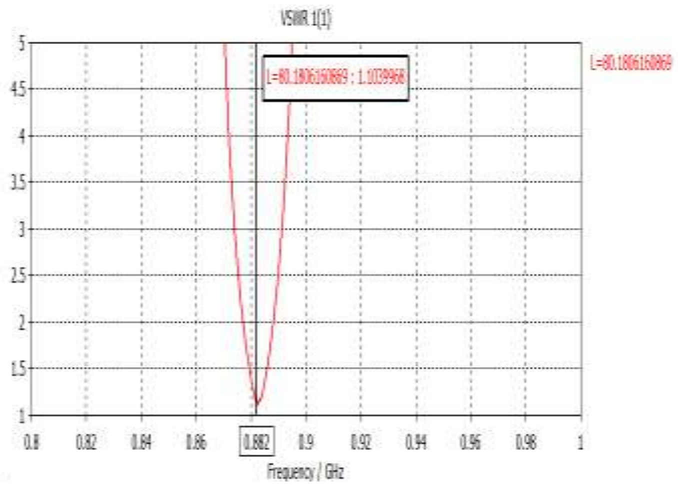

Figure 2.4 VSWR Vs frequency plot at 900 MHz

The above figure 2.3 shows that the reflection coefficient (S_{11}) of the simple patch antenna is -26.12 i.e. the return loss 26.12 approximately at 900MHz and Figure 2.4 shows that the VSWR is 1.103 which is <2 that means matching is perfect.

DESIGNING OF COMPACT RMPA

This section presents the design of compact microstrip patch antenna which is operating at GSM 900 band. To design a compact antenna first one is to choose the basic shape of the radiators. Here the reference antenna is chosen to be a rectangular shaped microstrip patch antenna operating in the GSM 900 band of the frequency spectrum. There are different techniques are used to compact the size of the antenna but in this paper meandering the radiating patch and Defected Ground Structure (DGS) technique are used. So, by the first technique the size of the patch is reduces i.e. the length and width of the antenna is reduced by hit and trial method as well as making a triangular slot in the radiating patch. So, the modification in front view i.e. radiating patch of the compact RMPA is listed in Table 3:-

Table 3 Design Parameters for Front view of Compact RMPA at 900 MHz

Parameters	**Unit(mm)**
L_1	23.7
L_2	12.6

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W_1	11.22
W_2	19.5

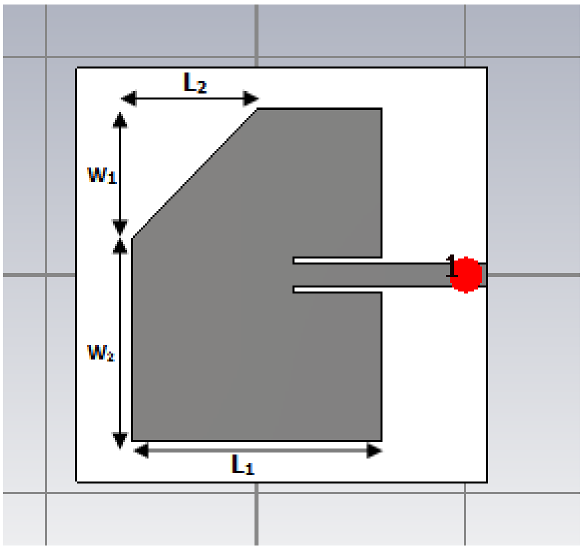

Figure 2.5 Front view of Compact RMPA at 900 MHz

Second modification in the antenna is done by using DGS technique. By using DGS technique making a Square slot in the ground plane. The design parameters of the back view i.e. ground plane of the compact RMPA is listed in Table 4:-

Table 4 Design Parameters for Back view of the Compact RMPA at 900 MHz

Parameters	**Unit(mm)**
L_3	39
L_4	6.5
W_3	38
a	24
d	33.84

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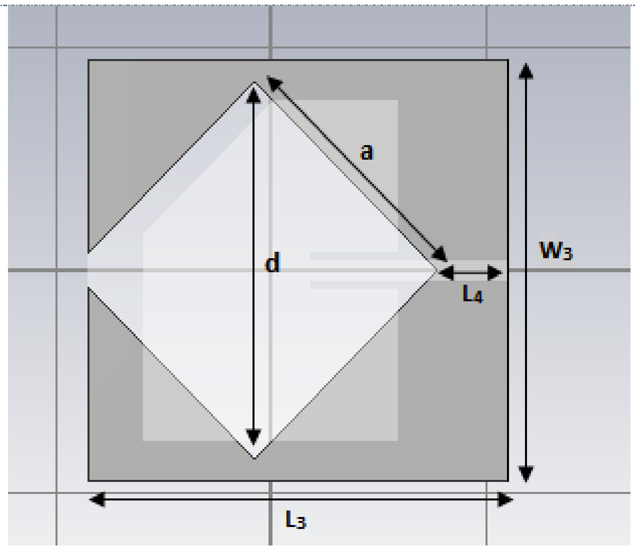

Figure 2.6 Back view of Compact RMPA at 900 MHz

The simulated results of the compact RMPA is shown below in Figure 2.7,2.8 & 2.9:-

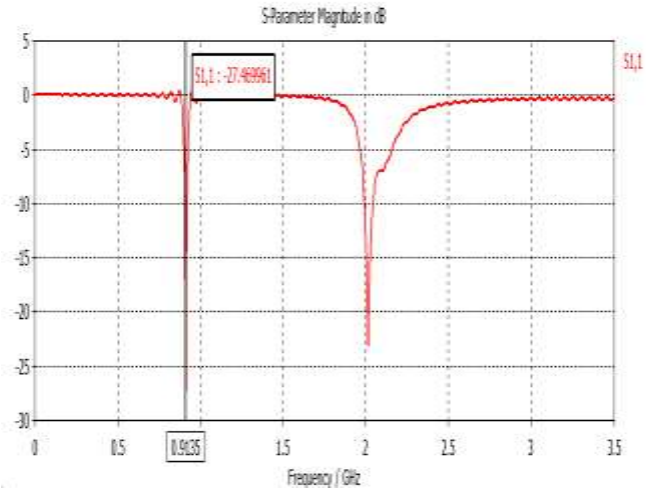

Figure 2.7 Return loss Vs frequency plot of compact RMPA at 900 MHz

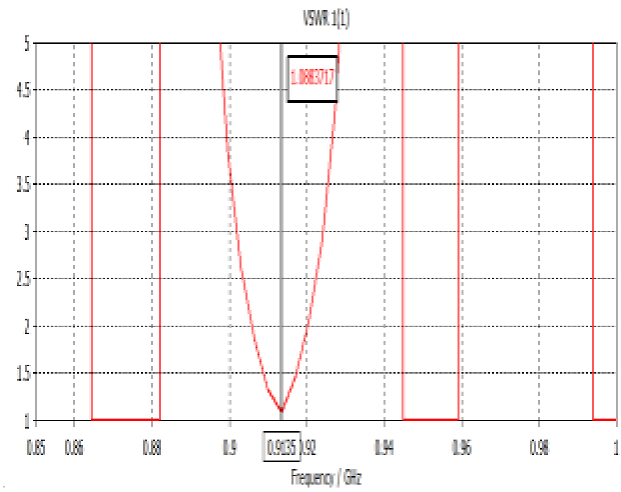

Figure 2.8 VSWR Vs frequency plot of compact RMPA at 900 MHz

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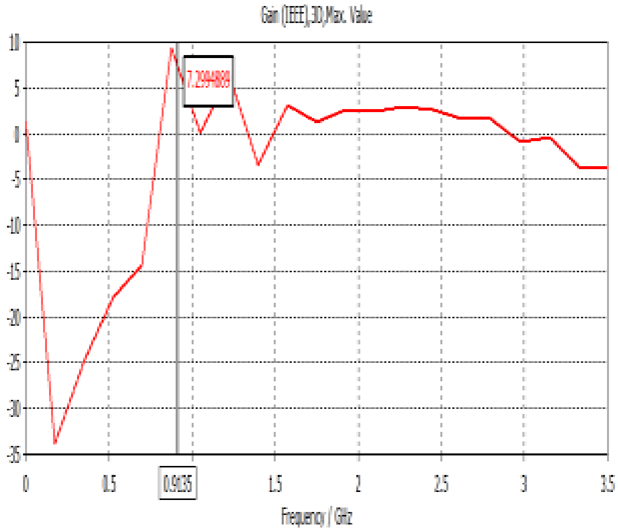

Figure 2.9 Gain plot of Compact RMPA at 900 MHz

In the above Figure 2.7 indicates that the Return loss of rectangular slot antenna with defected ground plane at 900MHz is 27.46 dB i.e. reflection coefficient is -27.46 dB. This indicates that the antenna is working properly at the desired frequency.

The above Figure 2.8 shows the VSWR of simulated triangular slot antenna at 900 MHz which is <2 i.e. 1.08 which shows that the matching is perfect of the antenna. The above figures indicates that the simulated and fabricated results are approximately equal that means the antenna is properly designed at 900MHz.

In Figure 2.9 indicates the Gain IEEE of triangular slot antenna with defected ground plane at 900MHz is 7.299 dBi which means the gain is decreased nearly 1dBi as compare to conventional antenna.

The fabricated compact RMPA is shown in figure 2.10 which shows the compactness of the antenna. The size of the antenna is nearly reduces 89% of the basic antenna.

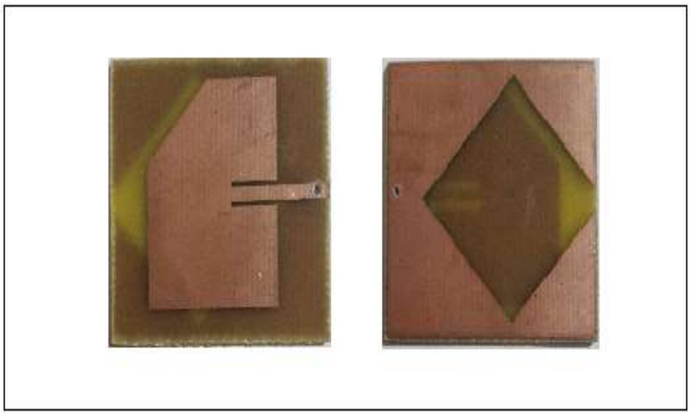

Figure 2.10 Fabricated Compact RMPA at 900 MHz

The fabricated result of the compact RMPA is shown below in figure 2.11:-

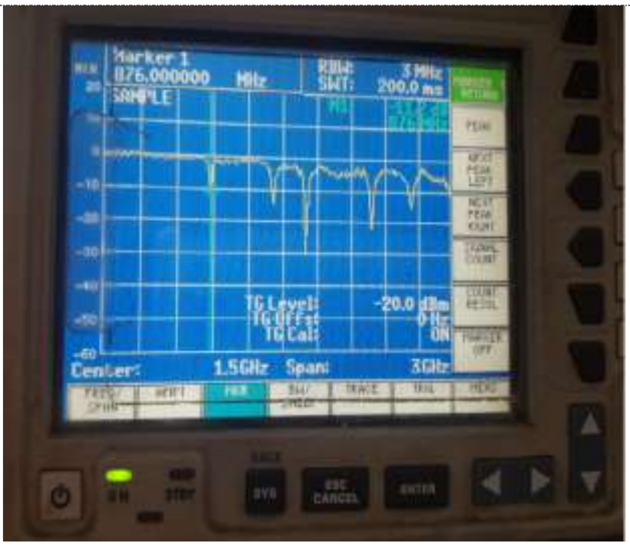

Figure 2.11 Fabricated results of compact RMPA at 900 MHz

In above Figures 2.7 reflection coefficient is measures by the spectrum analyzer. By comparing Figures 2.7 & 2.11 the simulated and fabricated results are experimentally verified.

CONCLUSION

On the basis of above results, it is observed that the size of the antenna is reduced by 89% which shows that antenna can be suitable for mobile communication. The compact MSA is working at 900 MHz same as the basic RMPA. The parameters like return loss, VSWR and gain of the compact antenna is increased compare than to the basic antenna. So the performance of compact antenna is improved.

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