An Insight on the Swastika Shaped Antenna Design

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Abstract.

This work proposes a study of an innovative compact monopole antenna comprising with a microstrip patch engraved in the shape of a Swastika design. The study of various feeding methods for wireless microstrip patch antennas, is addressed in this paper. The various design aspects of the swastika shaped patch antenna are discussed. The performance parameters are reported in form of comparative analysis of the existing literatures.

Keywords. Feeding methods, MSA, SSA, substrate and 5G frequency.

1. INTRODUCTION

Microwave and wireless engineers take a great interest in research on relatively small microstrip antenna (MSA) designs. A drastic improvement on the structural designs has been reported in the recent years which is the need for latest 5G wireless communication. The important properties of the antennas which are focussed in the transmission devices are their weight and size which are desired to assist with the high mobility needs of a wireless communication system [1]. MSAs have numerous blessings, including mild weight, low cost and can be utilized in applications like aircraft, satellite, and wi-fi communication [2]. The cheap fabrication cost of MSAs is a result of their simplicity of mass manufacture by utilizing printed circuit technology [3]. The properties which validate the design of the MSA include better return loss, high gain and high input impedance. The various modifications in the design geometry play an important role in improving the properties of the MSA [4-5]. The limited bandwidth of an MSA is among its most critical disadvantages. A number of studies and approaches have been applied for improving the bandwidth of the MSA [6]. A swastika shaped antenna (SSA) has been recently developed by the researchers which has exhibited improved radiation properties with better polarization [7-8]. The design of the SSA has been taken from a holy sign in Hindu mythology, and has exhibited enhancement in the bandwidth of an MSA. The compact monopole patch antenna, which consists of a patch in the Swastika form, is briefly described in this article. The rectangular slots of the SSA helps in modifying the surface current distribution of the patch. The shape basically helps the charge particles in accelerating and deaccelerating, which improves the bandwidth and radiation characteristics. This article presents research investigations for various applications employing this sort of swastika-shaped antenna.

2. SWASTIKA SHAPED PLANAR PATCH DESIGN

To build an MSA, first the substrate is chosen, then the length of the patch is calculated using the design equations. The designer's ability lies in choosing an appropriate feeding mechanism. Basically, the two feeding methods that are most often utilised are probe feed and microstrip line feed for the SSA design. Designing a MSA and SSA requires careful consideration of the thickness and choice of dielectric material [8]. The basic design equations for the SSA are formulated as [5]:

Width of Antenna (w):

$$w = \frac{c}{2f_o\sqrt{\frac{(\epsilon r+1)}{2}}} \tag{2.1}$$

Effective Dielectric Constant (ϵ_{eff}):

$$\epsilon_{\text{eff}} = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}[1 + 12\frac{h}{W}]^{\frac{-1}{2}} \tag{2.2}$$

Effective Length (L_{eff})

$$L_{\text{eff}} = \frac{c}{2f_0\sqrt{\epsilon \text{eff}}} \tag{2.3}$$

Length Extension (ΔL)

$$\Delta L = 0.412h\,\frac{(\epsilon eff+0.3)(\frac{W}{h}+0.264)}{(\epsilon eff-0.258)(\frac{W}{h}+0.8)} \tag{2.4}$$

Effective Length (L)

$$L = L_{\text{eff}} - 2\Delta L \tag{2.5}$$

As shown in Figure 2.1, the geometric configuration of the SSA is presented engraved in FR4 substrate.

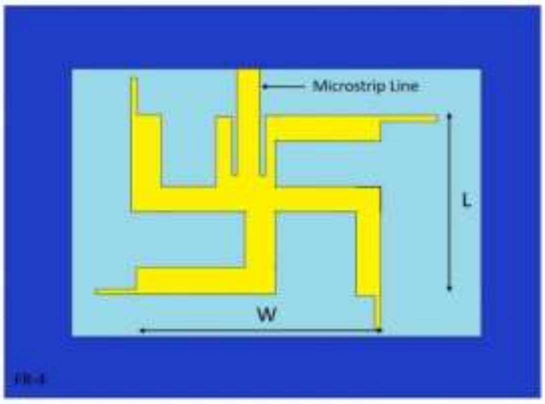

Figure 2.1: Swastika MSA's top view

It consists of four arms in opposite directions with four slots between the arms. FR-4 substrate is mostly used because of its less cost, dominant availability and use at various frequencies [9-10]. Further, feeding plays a very important role for matching the input impedance and getting SSA to work efficiently. [11-12].

3. FEEDING MECHANISMS

There are various feeding methods used for Swastika MPA. These methods basically are of two types: contacting and non-contacting.

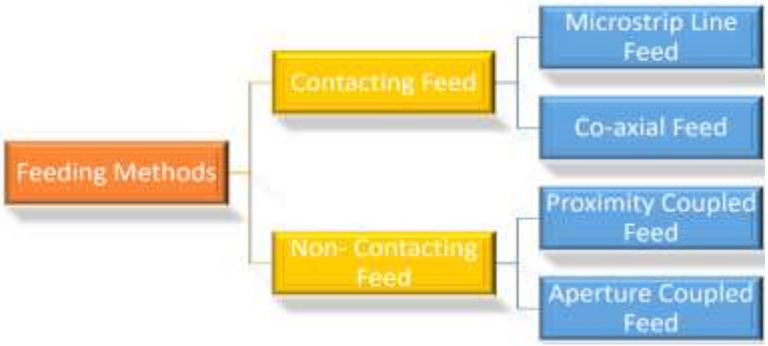

Figure 3.1: Flow chart of feeding techniques

3.1 Contacting feed - This approach uses contacting components like a microstrip or coaxial line to supply power at radio frequency directly to a patch of MSA. The most popular method of contacting feed are coaxial cable (CB) and microstrip line (ML).

3.2 Non-contacting feed - The MSA is not supplied with radio frequency power directly in this approach. Through electromagnetic coupling, the feed line's power is transmitted to the route. Aperture Coupled (AC) and Proximity Coupled (PC) are the two most used non-contacting feeding approaches. [10-11]

A. ML Feed

It makes use of a conducting strip, which is physically joined to the border of the MSA. The benefit of this type of feeding mechanism is in the form of planar structure as the feed is engraved in the same substrate. Furthermore, s-waves and artificial feed radiation also rise with the height of the dielectric material being employed, which lowers the antenna's bandwidth, unwanted cross-polarized radiation is also caused. The straightforward planar design of this approach makes it beneficial.

B. CB Feed

The CB feed mechanism is a very well-liked approach of feeding MSA. The patch antenna is joined to the coaxial connection's inner conductor, which is enclosed in the dielectric and is welded to it, while the connection's outer part of the conductor is fastened to the ground plane. The main advantage of this is the freedom with which the feed may be placed within the patch to optimally adjust the input impedance. Its main flaws are a constrained bandwidth and modelling challenges brought on by the need to drill a hole in the substrate and the connection sticking out beyond the ground plane, which prevents it from being precisely flat for thick substrates.

C. PC Feed

This type of feeding mechanism for the patch antennas is based on the electromagnetic coupling. The radiating patch is positioned on top of the upper substrate, with the feed line sandwiched between the two dielectric substrates. The major benefit of this feed approach is the removal of stray feed radiation and the very high bandwidth (up to 13%) it offers owing to the overall increase in microstrip patch antenna thickness.

D. AC Feed

The ground plane acts as a barrier between the feed line and the radiating patch surface in this sort of feed technology. A slot or aperture in the ground plane helps to couple the patch and the feed line. The fluctuations in the coupling depend on the aperture's size (length and breadth), which is adjusted for greater bandwidths and lower return losses.

Because of benefits including no direct touch between the feed and radiator, broader bandwidths, and improved isolation makes AC feeding as appealing.

4. COMPARATIVE ANALYSIS

REF.	**OVERALL DIMENSIONS (in mm)**	**CENTRE FREQUENCY (GHz)**	**SUBSTRATE DIELECTRIC CONSTANT (εr)**	**BANDWIDTH**
[1]	28.8 × 37.2 × 1.6	2.5	4.2	43.758%
[3]	32 × 32 × 1.6	2.9/5.2/6.9/8.2 and 12.9	4.4	200/300/280/400/500 MHz
[5]	52.29 × 67.74 × 1.6	1.7 to 2.6	4.2	21.7%
[9]	40 × 40 × 1.6	2.4	4.4	109.9 MHz

5. CONCLUSION AND FUTURE SCOPE

The current study conducts a survey to get insight into the design of swastika patch antennas and finds that little research has been done on this sort of patch antenna. The various feeding methods as well as the employed design equations are discussed. Swastika-shaped antennas have found utility in a variety of products, including wireless communication equipment’s and medicinal devices. The study on the polarisation dependency and phase shifting where this form of antenna may put its candidacy for use has not yet been revealed which can be a great scope of research.

6. REFERENCES

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