Intensive Study of Performance of Microstrip Antenna of Circular Parasitic Patches

SHASHISHEKARA N. KAKATHKAR
Department of Physics,
SDM College Ujire, 574240
Krnataka (India)

DR. NANDKUMAR M. SHETTI
P.G. Department of Physics,
S D M College Ujire,574240
Krnataka (India)

Abstract:
In this paper, comparative study on effect of gap of circular parasitic elements on bandwidth and return loss of microstrip antennas is presented. Antenna with parasitic elements gives a large bandwidth as compared to the conventional microstrip antennas. Here a circular patch with resonance frequency 10 GHz is kept between two circular patches with frequencies 9 and 11 GHz. Feed point for maximum return loss is identified using IE3D Software. Gap between the patches is varied and change in the return loss and band width is analyzed.

Keywords*: Bandwidth, Gapcoupling, Parasitic patches, Return Loss*

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1. Introduction

Due to several advantages of microstrip antennas, these are preferred for various applications. These antennas have light weight, low volume, thin profile configuration, low fabrication cost, isotropic radiation characteristics, and negligible human body effect. These antennas have some limitations as compared to conventional antennas. Narrow impedance bandwidth, low gain, large ohmic loss in the feed structure of arrays are the major limitations of these antennas, .The size of microstrip antennas becomes larger at lower frequencies. Narrow bandwidth is a major disadvantage of microstrip antennas in practical applications. Many bandwidth-enhancement or broadband techniques for microstrip antennas have been reported. One technique for bandwidth enhancement uses coplanar directly coupled and gap-coupled parasitic patches [1]. The bandwidth of microstrip antennas is inversely proportional to their quality factor. The quality factor of a resonator is defined as the ratio of energy stored to the power radiated. By changing the substrate parameters such as dielectric constant and thickness, the quality factor can be varied. By decreasing the dielectric constant, the bandwidth of the microstrip antennas can be increased [2], due to the decrease in the dielectric constant, the stored energy decreases and the radiated power increases, so the quality factor decreases, and hence the bandwidth increases. Similarly, on increasing the thickness of the substrate the stored energy decreases, hence the quality factor decreases and the bandwidth of the antenna increases [2]. But there are many disadvantages of increasing the thickness of the substrate and of using lower dielectric constants, such as increasing surface wave power resulting poor radiation efficiency.

In this paper, historic development of gap-coupled parasitic microstrip antennas is presented and performance of the antenna for different patch gap is analyzed. Design calculations and graphical analysis are also presented. The research overview of the gap-coupled microstrip antennas is also given. And various applications and challenges of gap-coupled microstrip antennas are also presented.

2. Bandwidth enhancement in parasitic patches

The bandwidth of the microstrip antennas can be improved by using the gap-coupled structure. In this structure, two parasitic circular patches are placed close to the feed patch which is circular as shown in Figure. 1, and get excited through the coupling between the patches. The feed patch is excited by a feeding method and the parasitic patches are excited by gap-coupling. If the resonant frequencies of these three patches are close to each other, then broad bandwidth is obtained as shown in Figure. 2. The overall input return loss will be the superposition of the responses of the two resonators resulting in a wide bandwidth [3]. By adjusting the feed location and gap between the patches, the bandwidth can be enhanced.

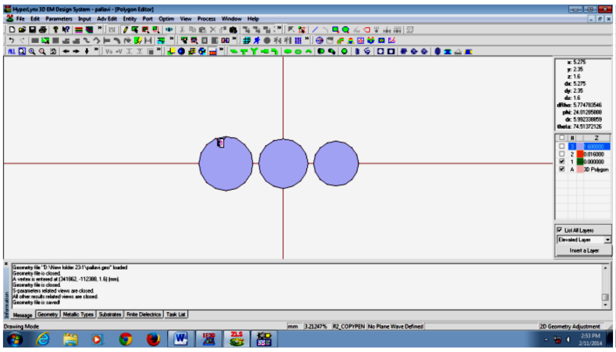

Fig. 1: Parasitic Patches

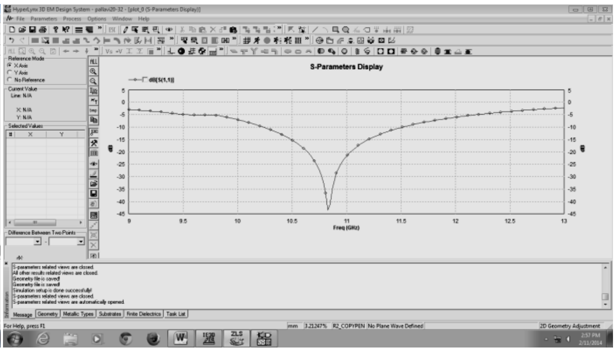

Fig. 2: Return loss curve

3. Research Review

The basic configuration of two dipoles gap-coupled to a radiating patch was reported in 1979 [4]. When two patches were gap-coupled to the main patch along the radiating edges, a maximum bandwidth up to 5.1 times that of a single rectangular patch antenna was obtained [5] This type of parasitic coupling along the non-radiating edges yielded 4 times the bandwidth.

In this paper, a circular patch is excited and coupled with two parasitic circular elements. Bandwidth and return loss of the antenna is analyzed for different gaps. A parametric study has been carried out using IE3D software. The configuration with these patches yielded a bandwidth of 1.2 GHz for a gap of 1.2 mm for resonance frequency. Maximum return loss of 57dB is obtained for a gap of 0.5 mm. The assumed center frequency for the circular patch is 10 GHz, and other patches are 9 and 11 GHz, respectively. Only for one circular patch bandwidth obtained is 1.8 GHz and the return loss is -33 dB. Thus 72% increase in return loss is observed. Theoretical interpretations are yet to be carried out.

4. Design calculations

Three coplanar circular patches of different sizes are considered with three different resonance frequencies. The frequencies are calculated as given ξ=4.2, Dielectric constant

4.1 Middle Circle

Assumed frequency = 10 GHz

Radius, $R = \frac{1.8412\text{x}C}{2\times\Pi\times fo\times\sqrt{\xi}}$

= 4.3mm

4.2 Right circle

Assumed frequency = 11GHz

Radius R = 3.9mm

4.3 Left circle

Assumed frequency = 9GHz

Radius, R =4.7 mm

5. Experimental observations

A circular patch is excited and coupled with two parasitic circular elements. Bandwidth and return loss of the antenna is analyzed for different gaps. A parametric study has been carried out using IE3D software. Following tables gives return loss and bandwidth for different gaps.

Table 1: Variation of bandwidth with gap

Sr.	Gap (mm)	Bandwidth In GHz
1	0.5	0.7
2	0.75	0.7
3	1	1.1
4	1.25	1.2
5	1.5	1
6	2	1

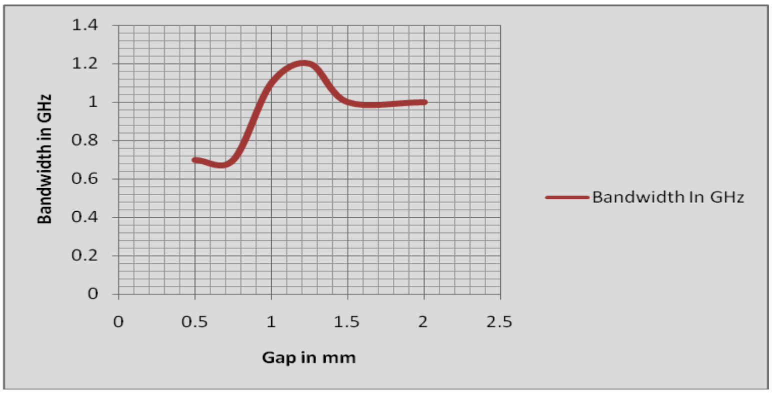

Fig. 3: Plot of Bandwidth with Gap

Table 1: Variation of bandwidth with gap

Sr.	Gap (mm)	Return loss (dB)
1	0.5	-57
2	0.75	-53
3	1	-43
4	1.25	-41
5	1.5	-46
6	2	-47

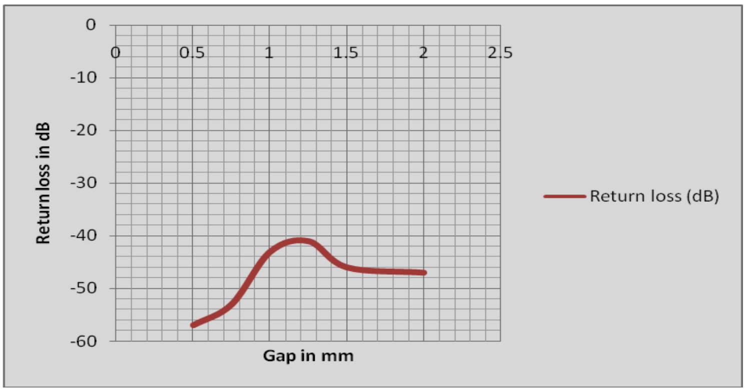

Fig. 4: Plot of Return loss with Gap

6. Result analysis

The analysis reveals that Return loss decreases with the gap between the patches and increases. It is maximum of -57 dB for 0.5mm gap. Band width increases with the gap reaches a maximum of 1.2 GHz for a gap of 1.25 mm and then decreses. The gap-coupling is the potential method to enhance the bandwidth of the conventional microstrip antennas. For multi-band applications also, the gap-coupling is suitable method. Various structures using different types and sizes of the patches, number of patches, gap-coupled microstrip antennas can be designed for various applications. Gap-coupling along with some other bandwidth enhancement techniques can be used together to produce ultra large bandwidth, and the antennas can be designed for various wideband applications.

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