Design and Development of Microstrip-Fed Patch Antenna With Enhanced Bandwidth and Harmonic Suppression

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Abstract: This paper presented a new design for the microstrip antenna to enhance the bandwidth and suppresses the harmonic radiation. For wideband performance, using a pair of λ/4 resonators and placed nearer to the radiating patch and which gives a coplanar structure on a single layer substrate. The harmonic radiations are effectively suppressed by capacitive feeding to proposed antenna. The simulation result shows that bandwidth is increased 2.7 times of reference antenna.

IndexTerms **- bandwidth enhancement, harmonic suppression, λ/4 resonator, capacitive feed.**

I. INTRODUCTION

To enlarge the bandwidth of microstrip antennas, many ways have been developed by using the aperture coupled feed [1]; proximity coupled feed [2] and stacked multi- patch configurations [3]-[4]. Therefore, these methods cause for multilayer substrates, which lead to complicated in fabrication and structure. For that reason, it is suggested to enlarge the bandwidth of microstrip antennas using a single layer coplanar-fed system. For this purpose, broad studies have been presented in the literature, using the dual- resonance theory. Since the microstrip antenna act as a resonator. If another resonance is produced to be part of with this resonating patch, the bandwidth is probably to increase extensively. The latest advances in microstrip antennas, using single layer co planar structure of capacitive-fed are presented in [5]-[6], which are quite easy to fabricate and accumulate. But, these wideband antennas are suitable to thickness, greater than 0.1 λo.

The microstrip-fed technique is easy in implementation of an array antenna while comparison with the probe -fed technique. In this environment, patch and other radiating elements along with feeding network are included on a single-layer substrate and whole array can be fabricated all together by using printed circuit techniques. However, electrically thin substrate is chosen, so that brings a difficult task in the design of a wideband microstrip-fed patch antenna on a single-layer substrate. Until now, a few techniques have been presented to work out this problem. In [7], impedance- matching network is created by using extra nonradiating resonators. In [8] and [9], a half- wavelength resonator and a combination of right/left handed resonator are used, for achieving the wideband property.

A Size-compression techniques presented in [10], additional T-shaped resonator, which makes ruined to the patch structure. Besides, the harmonics radiation is not possible to control due to T-shaped resonator work as a λ/2 resonator. With concern to the harmonic radiation many results have been presented to resolve this difficulty. The easiest way is to attach a filter to the patch [11], but it will enlarge the whole size of the antenna structure. In this paper, antenna was provided microstrip feeding along with improved bandwidth and significantly suppressed the harmonic radiation is presented. As stated in [12], the feeding looks like capacitive –fed to the patch by a coupling gap.

II. GEOMETRY

The design antenna is consists of rectangular shape patch and two λ/4 resonators which is attach to feeding line. A Shorting pin having a radius r, which is place between the two resonators. The dimensions of the elements such as patch, λ/4 resonators are (Lp X

Wp), (Lr X Wr). All of them integrated on same layer with electrically thin-single substrate whose thickness h and relative dielectric constant εr

III. WORKING PRINCIPLE AND DESIGN METHOD

The patch and additional resonating network produce the dual resonance and these elements are adjusted such that their come close to each other, therefore wideband will be obtained. But these configurations in [7] and [16] are suitable to thick substrate. Two λ/4 resonators used on a thin substrate and these form a coplanar structure and having distributed resonator nature. These elements are placed nearer to radiating patch as shown in fig. 1. The gap between patch and resonators call as a coupling gap. This gap plays a vital role for achieving wideband nature. Therefore the gap is varying corresponding two resonant frequencies comes closer to each other, as a result adding two narrower bands to form a single wideband. In addition of wideband performance, this type of feeding can significantly suppress the unwanted radiation.

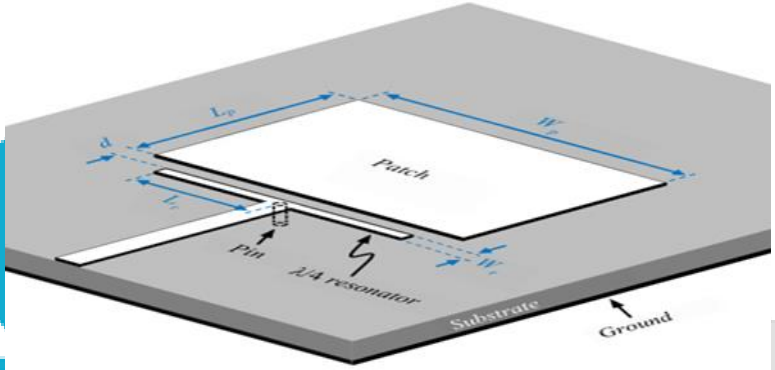


Figure.1. Proposed antenna

The proposed antenna is constructed on the Rogers RT 5870 substrate having relative dielectric constant εr = 2.33 and thickness h = 1.57mm. The dimensions of patch, λ/4 resonators and shorting pin are taken as (18 mm X 27 mm), (11.25 mm X 0.5 mm), radius r = 0.5mm. The proposed antenna design has been carried out in CST microwave studio. The lengths of patch and resonators equations are reported [12] - [14]. For a shorting pin radius in [14]. The Reference antenna is a rectangular shape microstrip antenna having direct contacting feeding, which is line feeding.

IV. SIMULATION RESULTS

The proposed antenna simulation has been carried out in CST microwave studio.

4.1 Bandwidth Enhancement

From Figure 2, it shows that bandwidth of proposed antenna was significantly increased, while compare with reference antenna. From return loss plot, the impedance bandwidth of proposed antenna existing between (4. 4674 GHz to 4.8802 GHz) its value is 412.8 MHz and the Reference antenna existing between (4.7732 GHz to 4.9211 GHz) its valve is 147.9 MHZ. the percentage bandwidth of reference antenna and proposed antenna are 8.4% and 3.0% respectively.

4.2 Gains

From Figure 3, it shows the simulated gain results. The 3-dB gain bandwidth of design antenna is 473 MHz and maximum gain is 7.0 dBi and the reference antenna 348 MHz gain bandwidth and maximum gain is 7.5 dBi.

4.3 Harmonics suppression

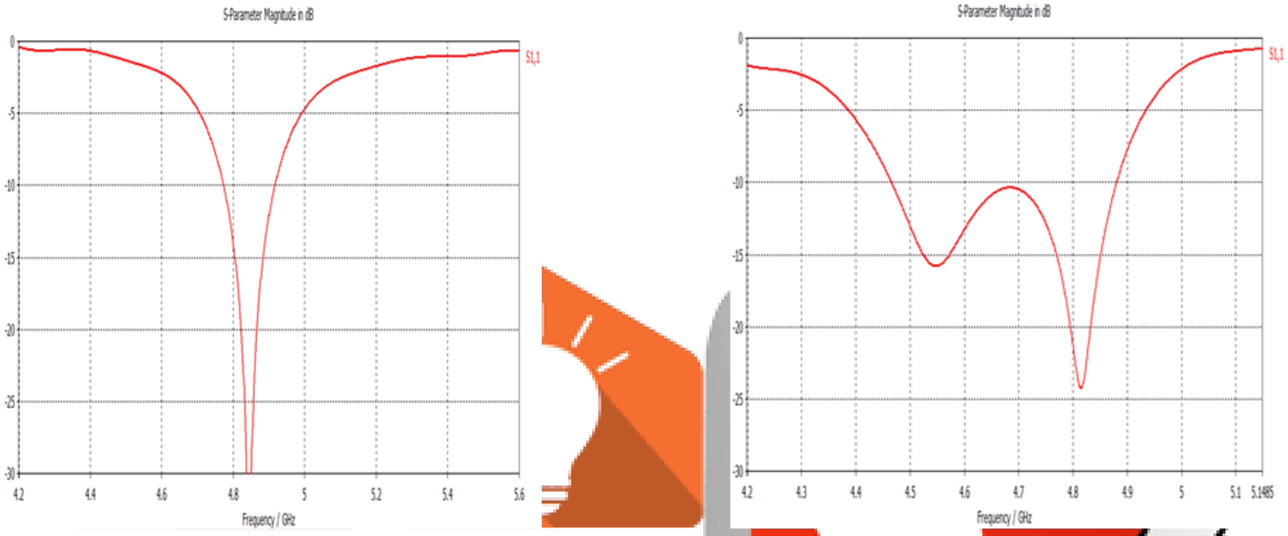
From Figure 4, the frequencies which are present above the 4.9 GHz, in that range the return loss signal is above −10dB. Therefore, the proposed antenna has successfully suppressed the undesired harmonic radiations while compare with reference antenna.

4.4 Radiation patterns

From Figure 5, 6 it shows the radiation pattern in 3D form. The directivity of reference antenna at 4.9 GHz is recorded as 8.0dBi. Similarly, the directivity of the proposed antenna at 4.9 GHz is recorded 8.1dBi. The angular width is found at 61.9^0. From figure 7, 8 the simulation results of E - plane are observed in $\theta = 0^0$and90^0, the cross polarization in E - plane is quite low at $\theta = 150^0$

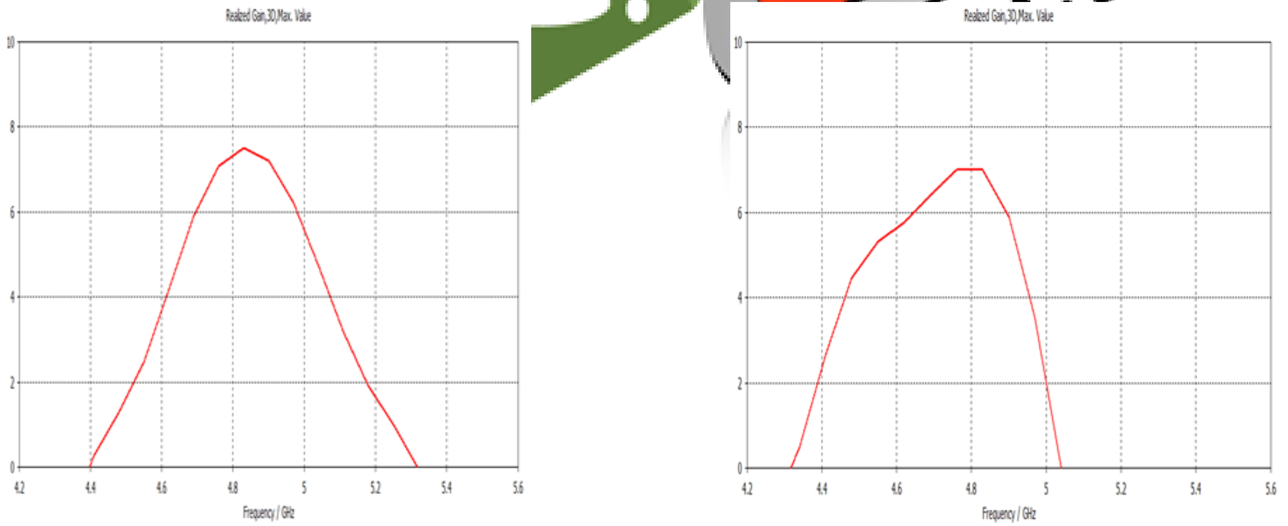
, it is gain about -50dB and the co polarization gain at that angle is-14dB. The co polarization gain is high in between $\theta = 140^0$ to160^0.

V. SIMULATION FIGURES



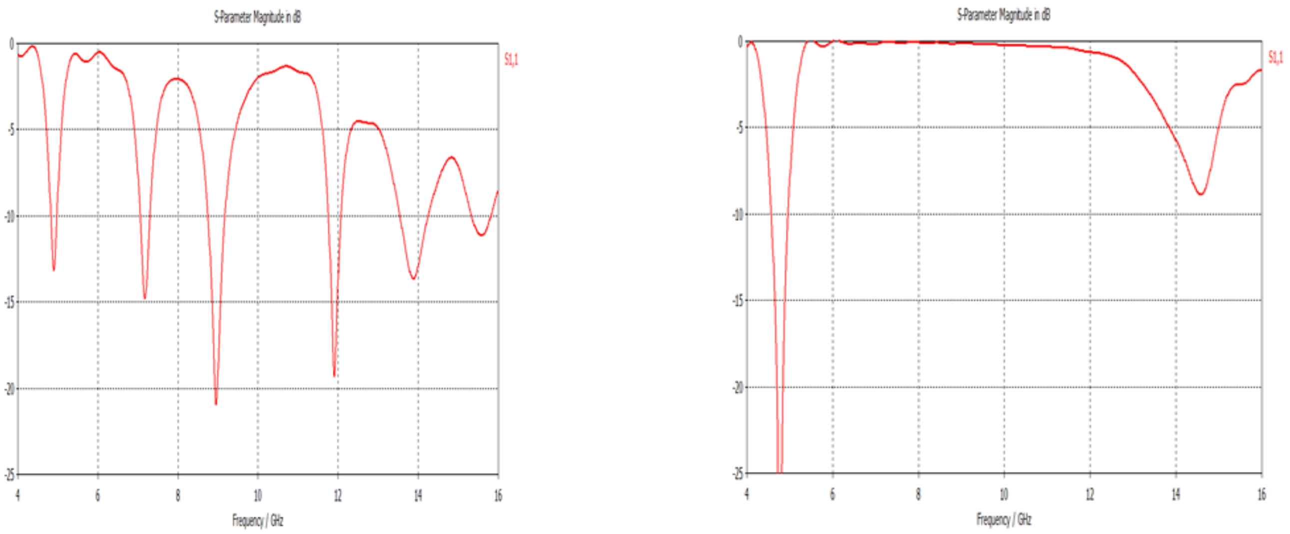
(a) (b)

Figure. 2. Bandwidth comparison of two antennas (a) reference. (b) Proposed.



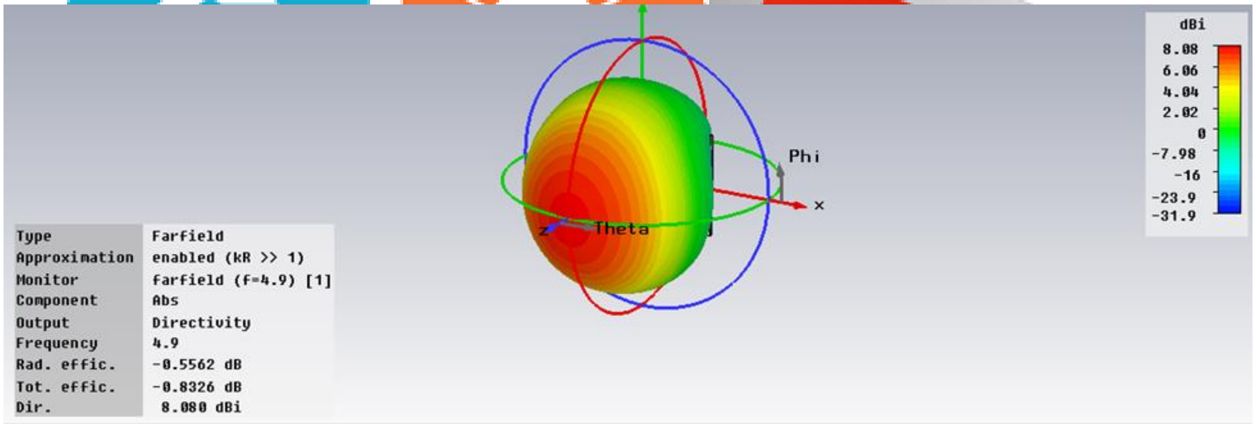
(a) (b)

Figure 3. Gain response of two antennas (a) reference. (b) Proposed.



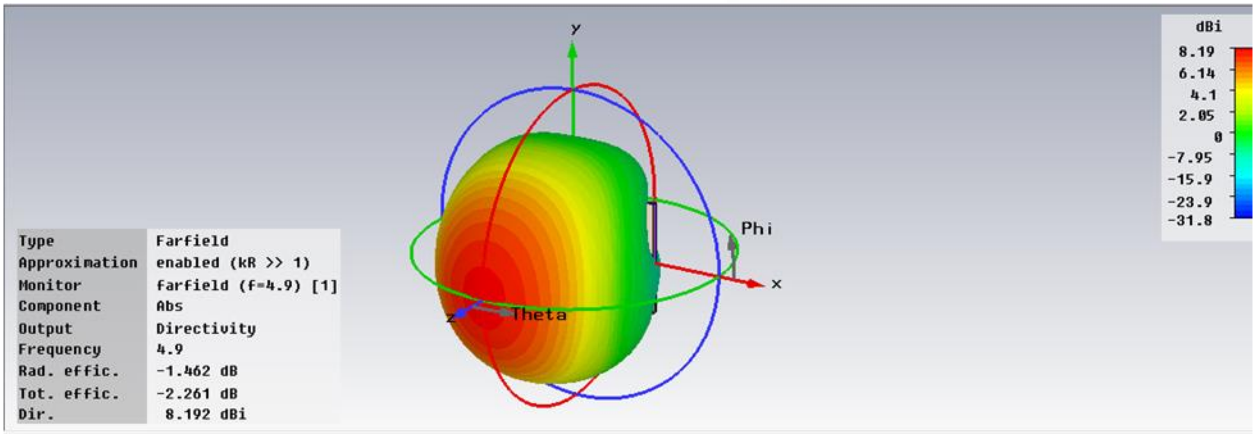
(a) (b)

Figure.4 Harmonic comparison of two antennas (a) reference. (b) Proposed



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4.9) [1]
Component	Abs
Output	Directivity
Frequency	4.9
Rad. effic.	-0.5562 dB
Tot. effic.	-0.8326 dB
Dir.	8.080 dBi

Figure. 5. Farfield of reference antenna



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4.9) [1]
Component	Abs
Output	Directivity
Frequency	4.9
Rad. effic.	-1.462 dB
Tot. effic.	-2.261 dB
Dir.	8.192 dBi

Figure. 6. Farfield of proposed antenna

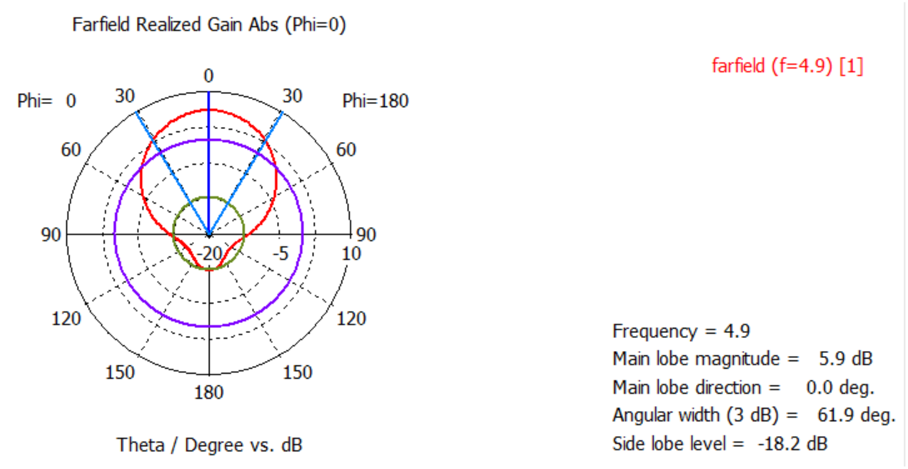


Figure.7. E-plane co-polarization of proposed antenna

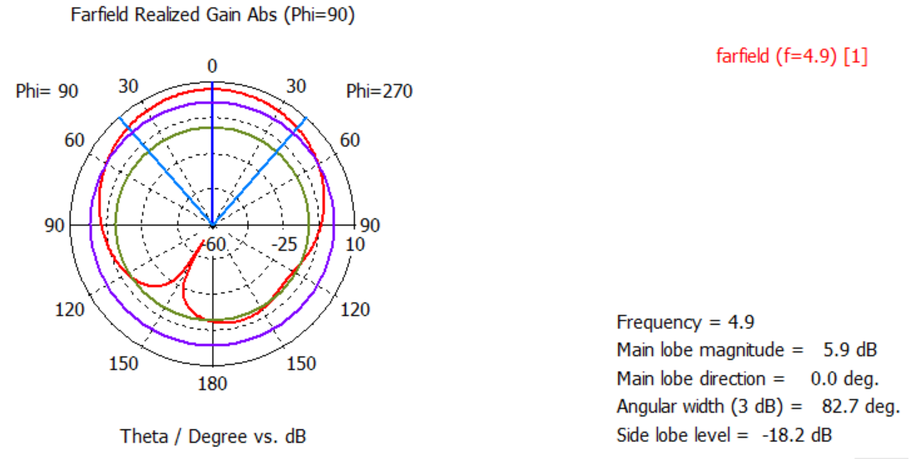


Figure. 8. E-plane cross-polarization of proposed antenna

VI. CONCLUSION

The bandwidth of microstrip antenna has significantly increased by adopting λ/4 resonators in feeding section. The simulation result shows that bandwidth is increased to 2.7 times and harmonic radiations are successfully suppressed at high frequencies. The directivity of proposed antenna also increased.

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