# A Mechanically Configurable Microstrip Patch Antenna for IEEE 802.11 WLAN Band

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***Abstract*— We present a new design for a frequency configurable microstrip patch antenna. The tuning mechanism consists of placing shorting posts placed in pre-drilled holes between the patch and ground plane at set locations on the patch. The hole locations are arranged so that the insertion of shorting pins in certain holes result in a predetermined resonant frequency. A frequency tunable microstrip patch operating over an 870 MHz bandwidth at the 5 GHz wireless local area network (WLAN) band is presented.**

***Keywords—microstrip antenna; configurable; shorting post; tunable frequency***

## I. INTRODUCTION

The rapid growth of mobile and wireless communication systems over the years has increased the need for larger bandwidth and higher data rates. While in some applications, broadband antennas cover the entire band, in many cases, antennas that provide narrower bandwidths are advantageous since they can cover a desired channel in the band while rejecting interference from adjacent frequency bands. On the other hand, numerous consumer applications, require compact antennas that can be placed inside packages. Owing to their low-profile, low-cost, and low-mass features, microstrip patches have long been considered as a desirable choice for compact antennas. Their resonant frequency can also be tuned by a variety of methods, and as such they are ideal candidates for frequency tunable compact antennas. In this work, we present a novel design for frequency tunable microstrip patch antennas. The tunable mechanism is based on using shorting posts between the patch and ground plane at various locations. We first study the principal of operation of the shorting posts, and then present a microstrip configuration that can operate over an 870 MHz bandwidth, covering the entire 5 GHz WLAN band. The proposed patch antenna has 7 sets of drilled holes, and to tune the operating frequency of this patch, shorting posts are simply placed at the appropriate hole locations.

## II. FREQUENCY TUNING OF MICROSTRIP PATCH ANTENNAS USING SHORTING POSTS

Microstrip patch antennas offer several desirable features such as low-profile, low-cost, and low-mass [1]-[2]. If the operating frequency of the patch antenna can be tuned over a range of values, the same patch can be used for several adjacent channels across a band. Several methods for frequency tuning of microstrip patch antennas have been introduced over the years. The most common categories are electronic tuning such as varactor diodes, switching diodes, or optically tuned patches, and mechanical tuning such as adjustable air gaps, or shorting posts (pins) [3]-[5]. While electronic tuning provides several advantages (most notably a fast tuning time), for many practical consumer applications, a single patch antenna that can be tuned mechanically across a certain band is sufficient. In this work we propose a new method to realize a frequency tunable patch antenna that can be configured for several different channels in a desired band.

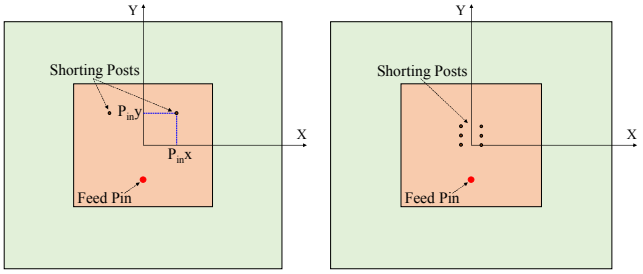


Fig. 1. Geometrical parameters of the rectangular patch with shorting posts for: (a) 2-post configuration, (b) 6-post configuration.

Here we study a rectangular patch with shorting posts placed at various points between the patch and ground plane. The posts present an inductance, and therefore alter the effective permittivity of the substrate and consequently the resonance frequency of the patch. The geometrical model of the patch antenna with 2 shorting posts is given in Fig. 1 (a), where the posts are located at ($\pm P_{in}x$, $P_{in}y$) based on the coordinate system shown in this figure. To study the impact of these shorting posts on the resonance frequency of the antenna, we design a microstrip patch for the operating frequency of 5 GHz using Ansys HFSS [6]. The patch dimensions are 21 by 18.4 mm and the substrate is a 62 mil Rogers Duroid 5880 with a dielectric constant of 2.2. The patch is fed by a pin with a diameter of 0.05 inch which is typical for SMA panel mounts. Two shorting posts are placed between the patch and ground plane and each post has a diameter of 0.5 mm. When the posts are moved along the y-axis, the resonance frequency of the patch increases. While there is some degradation in return loss, the antenna is still well matched across almost a 500 MHz band. When the two posts are

moved further away from each other, i.e. along x-axis, the tuning range can be further increased, however, as the separation between the posts increases, the return loss degrades significantly. The frequency tuning range of the antenna can be further increased by adding more shorting posts as shown in Fig. 1 (b). The conducted studies showed that with this configuration a tuning range of almost 800 MHz with a return loss better than 10 dB can be achieved.

## III. A Frequency Tunable Microstrip Patch Antenna for the 5GHz WLAN Band

The WLAN channels use IEEE 802.11 protocols across several frequency bands. Among these bands, the 5 GHz band provides a higher speed and is much less congested. Several channels are available in the 5 GHz band which use IEEE 802.11a/h/j/n/ac protocols, however the most common channels operate between 5.170-5.835 GHz [7]. Here, we design a frequency tunable microstrip patch antenna that can be simply configured to cover the desired channels across this band.

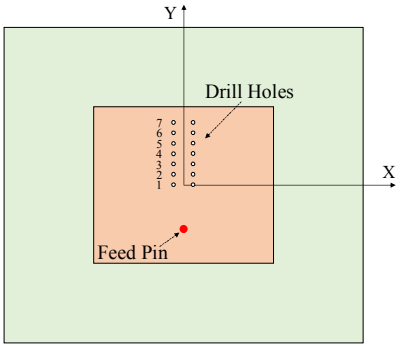


Fig. 2. The frequency tunable patch antenna and drill hole arrangement.

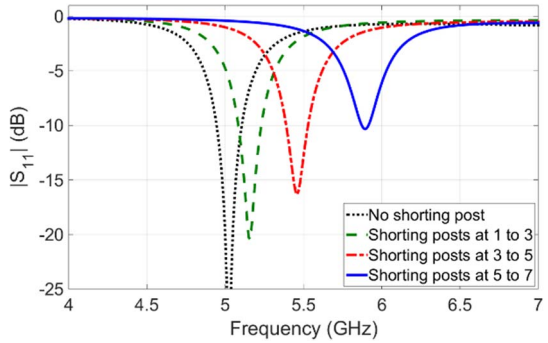


Fig. 3. Magnitude of $S_{11}$ as a function of frequency for the patch antenna with different arrangements of the shorting posts.

In the first step, holes need to be drilled on the microstrip patch. The arrangement of the drill holes along with the label (from 1 to 7) is shown in Fig. 2. In order to configure the patch for a desired channel in the band, the drill holes need to be filled with a wire and soldered on both the patch and ground plane, essentially mimicking a plated via or shorting post. The frequency response of the antenna for different arrangements of the shorting posts are given in Fig. 3. By simply placing shorting posts at the appropriate positions, the resonance frequency of this patch can be tuned from 5.02 to 5.89 GHz which completely covers the 5 GHz WLAN band. Note that the holes have very little impact on the performance of the patch and only a slight resonance shift from 5.0 to 5.02 GHz is observed for the patch without shorting posts. The radiation patterns of the antenna are also given in Fig. 4, where note that while the pattern appears to be tilting very slightly at the far end of the spectrum in the 90-degree plane, the general pattern shape is maintained, and peak gain occurs in the broadside direction.

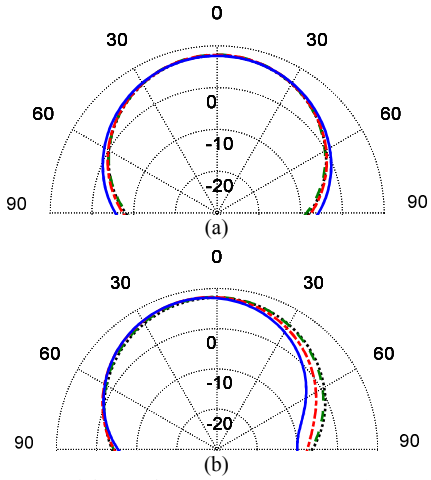


Fig. 4. Gain patterns of the patch antenna at resonance: (a) $\varphi = 0^{o}$, (b) $\varphi = 90^{o}$. Resonances are at 5.02 GHz (no shorting posts [dot black]), 5.16 GHz (shorting posts at 1 to 3 [dash-dot green]), 5.46 GHz (shorting posts at 3 to 5 [dash red]), and 5.89 GHz (shorting posts at 5 to 7 (solid blue)].

## IV. Conclusions

A new design methodology is presented for frequency tunable microstrip patch antennas that use shorting posts to control the resonance frequency of the antenna. Parametric studies on the placement of shorting posts is first conducted and then a frequency tunable microstrip patch operating over an 870 MHz bandwidth at the 5 GHz WLAN band is presented. The microstrip antenna has a set of drilled holes, and by placing shorting posts at the appropriate hole locations, the antenna can be configured for different channels in the 5 GHz band.

## Acknowledgment

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## References

[1] K. F. Lee, K. M. Luk, and H. W. Lai, *Microstrip Patch Antennas*. 2nd Ed. Singapore: World Scientific Publishing, 2018.

[2] P. Nayeri, K. F. Lee, A. Z. Elsherbeni, and F. Yang, "Dual-band circularly polarized antennas with asymmetrical U-slots," *IEEE Antennas Propag. Letters*, vol. 10, pp. 492–495, 2011.

[3] J. R. James and P. S. Hall, *Handbook of Microstrip Antennas*, London, U.K.: IEE Electromagnetic Waves Series (Book 28), 1989.

[4] A. Sheta and S. F. Mahmoud, "A widely tunable compact patch antenna," *IEEE Antennas Propag. Letters*, vol. 7, pp. 40–42, 2008.

[5] D. Schaubert, F. Farrar, A. Sindoris, and S. Hayes, "Microstrip antennas with frequency agility and polarization diversity," *IEEE Trans. Antennas Propag.*, vol. 29, no. 1, pp. 118–123, Jan. 1981.

[6] AnsysEM17.2, Ansys HFSS, Ansys Inc., 2017.

[7] [Online]. Accessed December 23, 2017. Available https://en.wikipedia.org/wiki/List_of_WLAN_channels