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Design of Parallel Slot Loaded Multiband Microstrip Antenna

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Abstract

A parallel slot loaded microstrip antenna is designed with and without slits to analyze for frequency miniaturization. The antenna is designed with FR4 substrate on a ground plane with dielectric permittivity 4.4. The radiating patch has a dimension of 25 mm × 30 mm etched with and without slits. The surface current is increased with the slits achieving frequency miniaturization of 60%. A resonant frequency estimating formula for calculation and optimization on parallel slot loaded multiband antenna is presented. The resonant frequency values are found to be in good agreement with calculated, simulated and tested results. The antenna works in multiband covering the major wireless bands.

Keywords: Microstrip Antenna, Resonant Frequency, Parallel Slot, Multiband, Miniaturization.

Introduction

The development in the wireless devices has attracted the antenna designers to produce competitive designs. In the early seventy's itself the patch antenna has created a impact on the antenna industry by making itself as planar, flexible easily fabricated low cost device [1-2]. The size of the antenna considerable reduced with the introduction of miniaturization concepts [3-5]. The slot antenna is the simplest of all the techniques used in the process of miniaturization attracting researchers in designing slots with various size and shape [6-10]. The various types of slots on antenna helped to achieve frequency miniaturization making it compact in size for getting compatible to small electronic gadgets of wireless applications [11-12]. The other techniques for achieving the antenna with high gain and multiple bands were reported by various researchers [13-17]. In this work a parallel slot loaded antenna is designed from basic rectangular patch with resonant frequency to multiband operation useful for various wireless applications. The effect of slot on the patch is presented in detail.

Design of Slot Loaded Patch

The rectangular patch antenna is designed to operate at a resonant frequency of 2.4 GHz with a dimension of 27.1 mm × 37.9 mm. It is designed and fabricated with FR4 dielectric as substrate having height h = 2.4 mm on a ground plane having a dimension of 44.1 mm × 54.9 mm using formulas [18]. The antenna achieved a reflection coefficient of -23.03 dB with an impedance bandwidth of 4.9% as given in Figure 1.

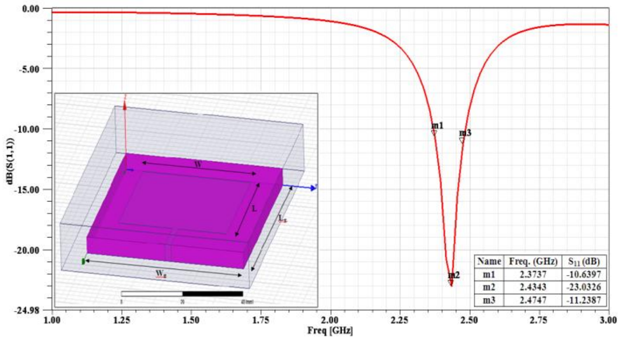

Figure 1. Microstrip Fed Patch Antenna and S_{11} *vs* Frequency Characteristics

Parallel Slot Loaded Patch

The patch is inserted with additional slots parallel to the dual slots creating a third slot with a spacing of 0.5mm between them as shown in Figure 6. This additional slot helps to further increase the electrical length and reducing the operating frequency to a lower band of 1.65 GHz achieving 31.25% as given in Figure 7.

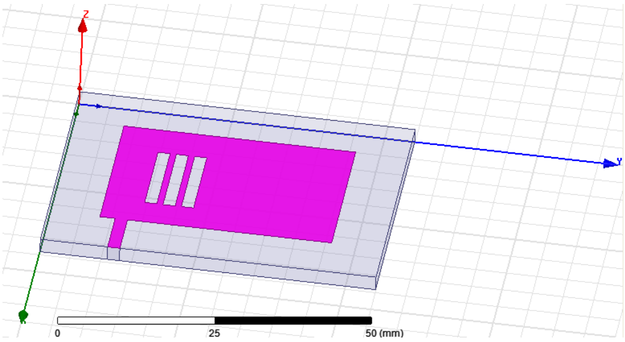

Figure 2. Triple Slot MPA with S_L = 15 mm and Width S_W =1 mm

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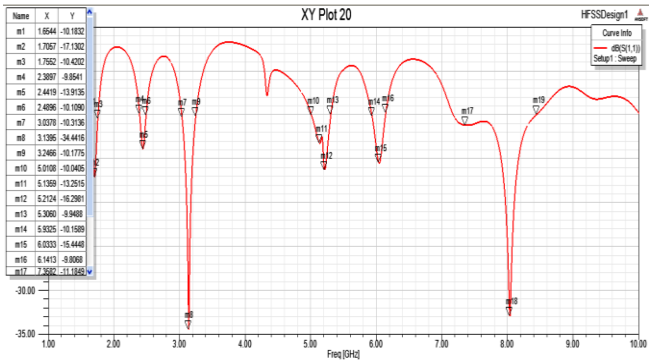


Figure 3. S_{11} *vs Frequency of* Triple Slot MPA

Finally the patch is added with six slots parallel to the length of the patch. The influence of the slots on the structure reduces the area of the patch and considerably alters the surface current. This changes the effective electrical length of the antenna modifying the multiband resonant frequency with shift in the lower operating band. Similarly the reactance induced in the patch as a result of slot varies the impedance of the antenna without much affecting the radiation efficiency. The antenna with six slots on the radiating patch is shown in the Figure 4 and Figure 5 with S_{11} *vs* Frequency characteristics, where the lower band operates at 1.63 GHz with a S_{11} value -16.87 dB achieving a frequency miniaturization of 32.08%.

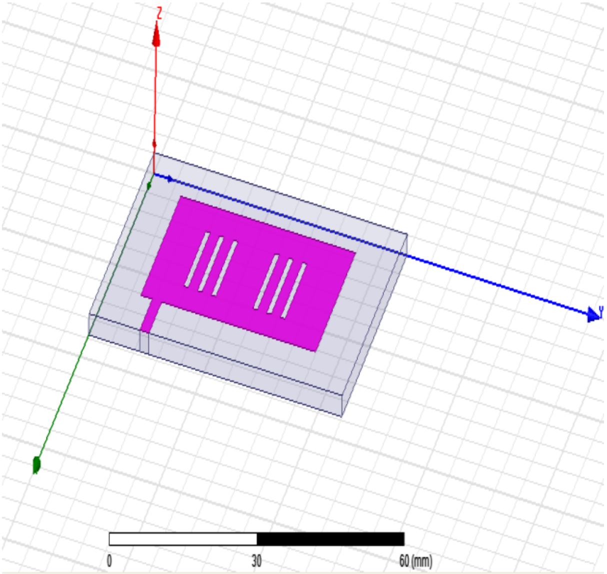


Figure 4. Six Slot MPA with S_L = 15 mm and Width S_W =1 mm

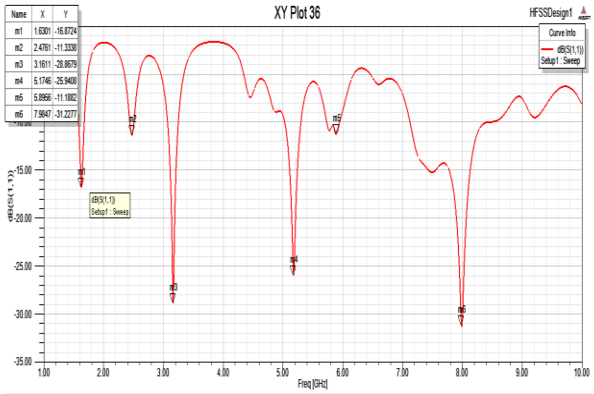
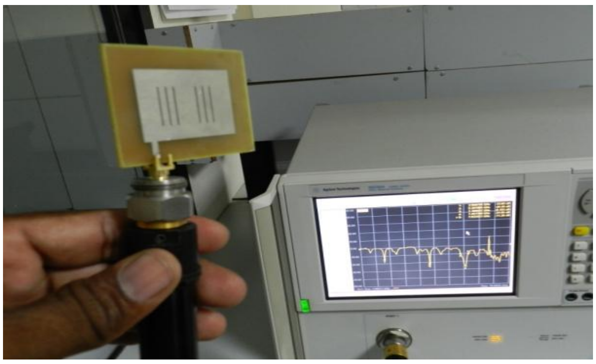


Figure 5. S_{11} *vs Frequency of* six Slot MPA

Antenna Fabrication and Testing

The fabricated antenna is tested using Agilent network analyzer and the results were in good agreement with the simulated results. The calculated resonant frequency estimation for the variation on the slots and effect on frequency determination resulted with minimum deviation error percentage. The fabricated antenna with variation in slot width is shown in the Figure 6. The testing results achieved with network analyzer is shown in the Figure 7 (a) and (b).

Figure 6. Antenna with variation in Slot width S_W = 0.5 mm, 1 mm and 1.5 mm.



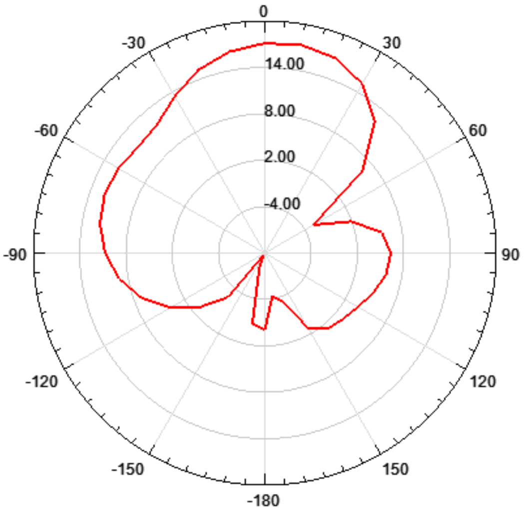
(a)

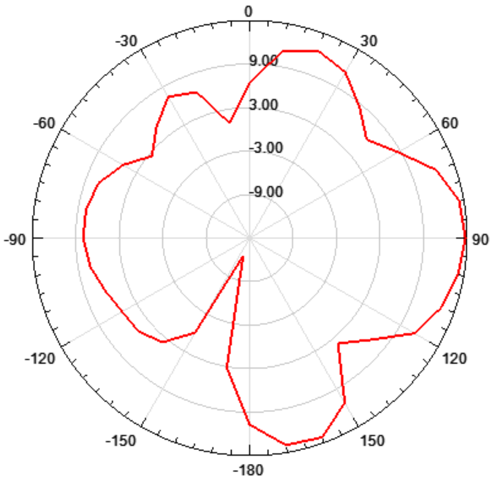
(b)

Figure 7 (a) Testing of parallel slot with width S_W = 0.5mm (b) S_W = 1.5mm

Radiation Pattern and Gain

The radiation pattern of the parallel slot loaded microstrip patch antenna is shown in the Figure 8 (a) and (b)





(b)

Figure 8 (a) E-Field radiation pattern and **(b)** H-Field radiation pattern.

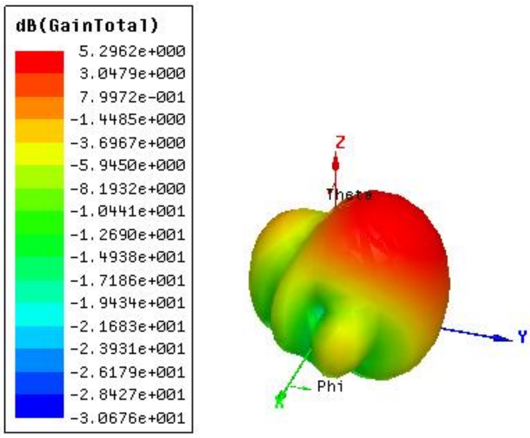


Figure 9. Gain Plot of the Parallel Slot loaded antenna

The radiation pattern of the antenna in the 3D polar format is shown in the Figure 9. The antenna achieved a total Gain of 5.29dB. The antenna exhibits good radiation characteristics with the required directivity along the expected direction of radiation in the Z-axis. The pattern has achieved a broad beam width helping the antenna to be used for wide coverage areas.

Conclusion

The antenna with three parallel slot to six parallel slot loaded antenna was designed from the fundamental antenna design for 2.4GHz. The insertion of slots and the variation on the resonant frequency is observed. The antenna resulted with multiband operation covering the major wireless band and achieved good radiation characteristics. The antenna with six slots on the radiating patch achieved Frequency characteristics, where the lower band operates at 1.63 GHz with a S_{11} value -16.87 dB achieving a frequency miniaturization of 32.08%. The antenna achieved a peak gain of 5.29dB making it suitable for the commercial applications.

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