A Coupled Microstrip Antenna Employing Serrated Coupling

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ABSTRACT

Microstrip antenna is suitable for mobile handsets due to its light weight and compactness. Its disadvantage of narrow bandwidth is necessary to be improved for modern wireless communication systems. This paperproposes the serration of coupled microstrip antenna to improve impedance characteristic. Return loss of this antenna is analyzed in terms of serration and the obvious characteristics improvement can be observed. It is found to be useful for the practical wireless communication systems.

INTRODUCTION

Modern wireless communication systems require wide bandwidth to cover high speed data transmission [1]. For the mobile handsets, the antenna is required to cover wideband and has small size. Microstrip antenna is suitable for this application due to its compactness and fabrication simplicity. However, it has a significant drawback of narrow bandwidth. Therefore, many antennas have been developed in these recent years for the mobile handsets that possess wideband characteristic. Virga and Rahmat-Samii [2] developed and characterized low-profile and integrated antennas with enhanced bandwidth for wireless communication systems by adding parasitic elements or tuning devices to planar inverted F antenna (PIFA). For the parasitic elements configuration, the bandwidth of 16% can be obtained while that of 50% is achievable at the expense of system complexity using tuning diodes. Yang et al. [3] presented the E-shaped patch antenna to expand the bandwidth to 30.3% for the frequencies of 1.9 to 2.4 GHz. However, the dimension is slightly large for fixing on the conventional handsets. A wide-band planar antenna using aperture-coupled stack square patches is introduced by Gao et al. [4]. The bandwidth of 21.7% is achievable. However, this antenna is complicate owing to the multi-layer feeding network. By employing the similar configuration, Shin and Kim [5] obtain high gain of 10.4 dB and wide band of 24% at the 2 GHz band. One of the interesting antennas for mobile handsets is the coupled shorted patch antennas proposed by Wang et al. [6]. The impedance characteristics of 25.3% bandwidth and compact size for installing on a mobile handset can be achieved when the appropriate parameters, i.e., patch size, coupling gap and dielectric constant of the substrate, are designed. Nevertheless, the return loss improvement without increasing antenna size and production process is important to apply this antenna to the modern mobile communication systems and need to be carried out. This paper proposes a method to improved impedance characteristics of the coupled microstrip antenna without increasing the antenna size and manufacturing cost. The serration of the coupling part of the microstrip antenna is proposed. This antenna is analyzed in terms of serration of the coupling by using the IE3D [7] software based on the method of moments.

ANTENNA CONFIGURATION AND ANALYSIS

Wang, et al. [6] investigated coupled microstrip antenna in which the patches can be either rectangular or semicircular. For the rectangular one, the antenna configuration can be shown as in Fig.1. Two rectangular patches are shorted to ground plane through the substrate and one of the patches is fed by a probe. Fig.1a) and Fig.1b) show the top view and the side view, respectively. Instead of parallel coupling, Fig.1 shows the serration coupling. The dimension of this antenna is illustrated in Fig.1c). In order to keep the antenna size same as those proposed in [6] and simple fabrication process, the ground plane size is fixed at 40×90 mm^2 and air is used as dielectric substrate with h equals 8 mm. Impedance characteristics of this antenna are analyzed in terms of serration, i.e., serration depth (d), number of serration (n) and spacing between serrations (s). Fig.2a) shows the return loss versus frequency between 1.5-2.5 GHz when s equals 8 mm. When d equals 0 mm, the return loss is as those of a conventional coupled microstrip antenna in [6]. Two minimum return losses take place at resonance frequencies of 1.80 and 2.10 GHz with the value of –24 and –35 dB, respectively. As d is increased to 1 and 2 mm, the lower and higher resonance frequencies are slightly increased.
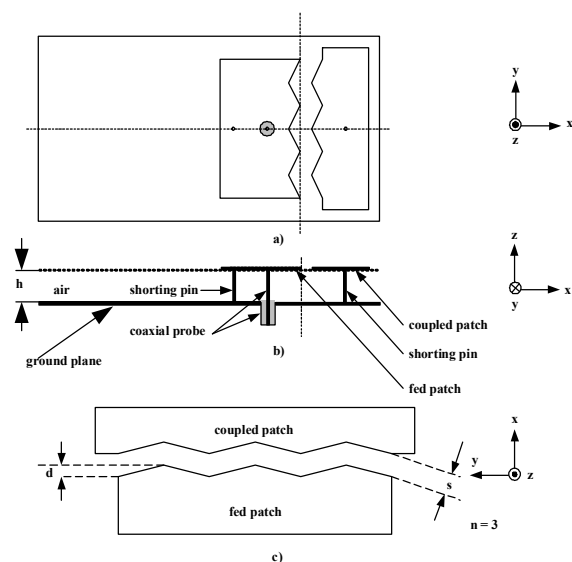

Fig.1. Geometry of coupled microstrip antenna with serration coupling a) top view b) side view c) dimension

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It is observed that the decrease of the return loss in the mid-band region when d is increased. The serration depth of 2 mm provides the widest bandwidth with low return loss. For a fixed value of d equals 2 mm and s equals 8 mm, the return loss versus frequency is plotted in Fig.2b) for various number of serration. It is obvious that when n equals 0 which is the case of conventional coupled microstrip antenna, the bandwidth is the narrowest one.
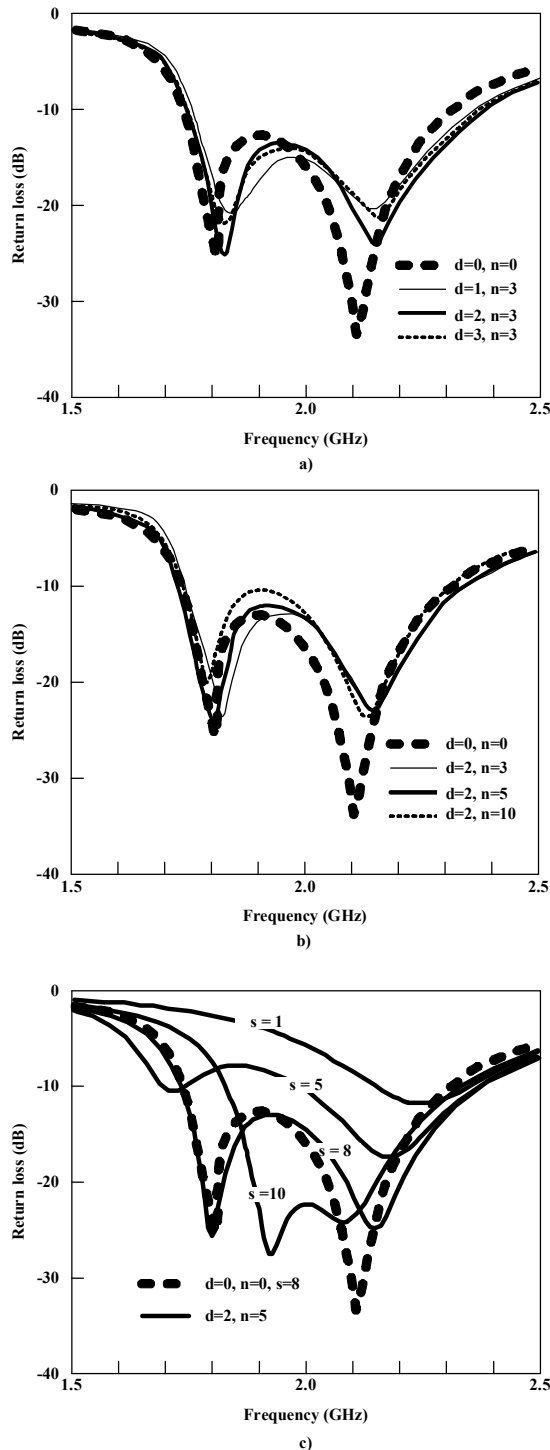
It can be widen as n is increased at the expense of increased return loss in the mid-band. Hence, for a specified limit of −10 dB, the number of serration can be as high as 10. Fig.2c) illustrates the effect of spacing s on the return loss. For a small spacing of 1 and 5 mm, the return loss is higher than the specified value of −10 dB. It can be reduced to acceptable value when n equals 8. The bandwidth of 660 MHz which is 33% is obtained. This value is larger than 30.3% of the wide bandwidth E-shape patch antenna in [3]. As the spacing is subsequently increased to 10 mm, the bandwidth is narrower to 490 MHz although we can achieve the lower return loss. It should be pointed out that the higher the number of serration, the higher the return loss in the mid-band. The serration depth should be optimized to 2 mm and the spacing between the patches is 8 mm for this specified frequency of 1.7-2.3 GHz.
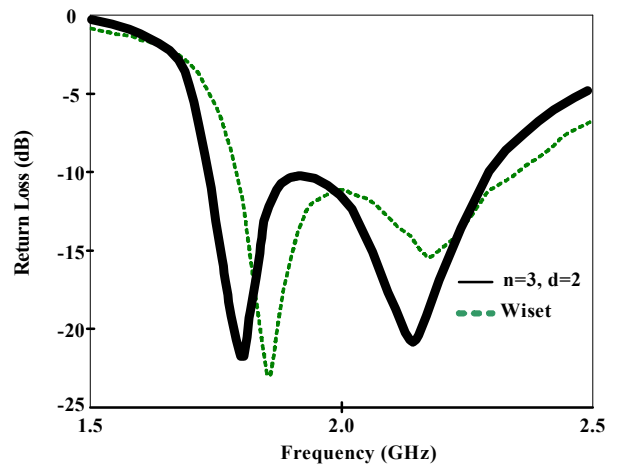

Fig.3. Return loss of the proposed antenna

MEASUREMENT RESULT

The antenna was designed as shown in Table I. The return loss was measured and expanded with those of simulation with good agreement as shown in Fig.3. The bandwidth of this antenna, measuring at −10dB, the return loss was 27.5% which was obviously improved without increasing the antenna size and product costs. Fig.4 shows the radiation patterns at the frequency of 1.75 GHz the E-plane pattern in Fig.4a) shows the cross polarization field in the direction off maximum angle (50°) is 18 dB less than the co-polarization field. For the H-plane pattern in Fig.4b) which has a maximum field in the direction of 90°, The cross polarize level is 10dB less than the co-polarization counterpart Fig.5 shows the patterns of the contour at 2.25 GHz which implies that the similar radiation can be obtained throughout the operating bandwidth.

Fig.5a) shows the E-plane pattern which has two maximum fields in the direction 45° and 135° the cross polarization level at this directions are both 18 dB, respectively loss the co-polarization in the H-plane pattern of Fig.5b).

Fig.6 shows the gains of two antennas configuration for the frequency range between 1.5 – 2.5 GHz.
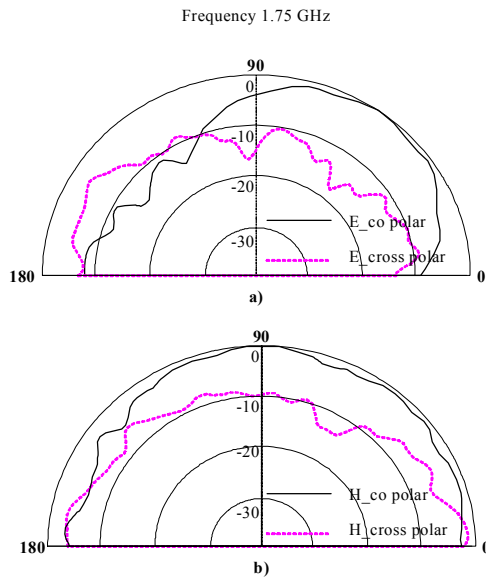

Fig.2. Return loss versus frequency of the serrated coupling microstrip antenna a) different d   b) different n c) different s

Frequency 1.75 GHz

Fig.4. Radiation pattern at 1.75 GHz a) E-plane b) H-plane
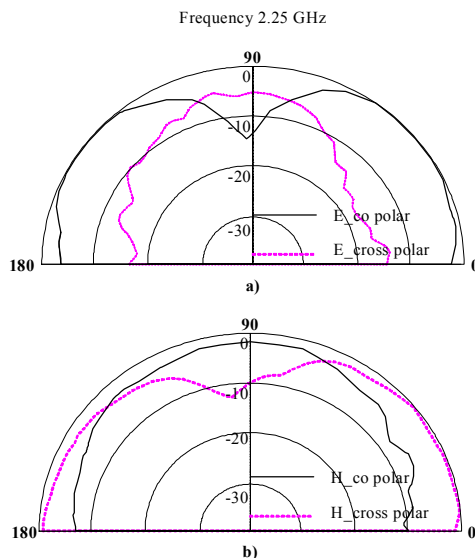
Frequency 2.25 GHz

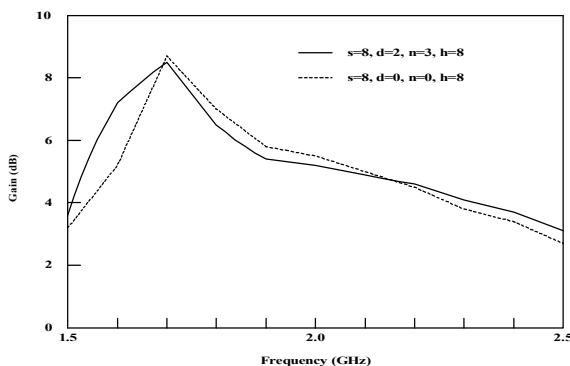*Fig.5. Radiation pattern at 2.25 GHz a) E-plane b) H-plane*

Fig.6. Gain versus frequency compared between serration coupling with d=2, n=3 and non serration coupling with

CONCLUSIONS

The serration of coupled microstrip antenna is proposed for bandwidth enhancement of a coupled microstrip antenna. Using the IE3D software based on the method of moments, the appropriate dimension of the antenna can be obtained. For the 1.7-2.3 GHz band, the number of serration should be three with serration depth of 2 mm and spacing between patches of 8 mm. This antenna provides 33% bandwidth with the return loss less than –10 dB. The impedance characteristic antenna bandwidth can be significantly improved without increasing antenna size and manufacturing cost.

ACKNOWLEDGMENTS

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