Design for Microstrip Patch Antenna with Dual Frequency and Dual Polarization for W-CDMA System

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Abstract

This paper proposes a design for microstrip patch antenna with dual resonance and dual polarization fed by proximity coupled quarter wavelength stub. The antenna characteristics are analyzed by the FDTD method with Mur's 2nd order ABC. From the simulation results based on the FDTD method, frequency characteristics of structure parameters such as the patch size and the offset feed are investigated. The numerical results are compared with the experimental results, and the comparison shows reasonable agreement for a design frequency.

1. Introduction

A basic limitation to wider use of microstrip antennas is their single frequency and narrow band operation. It is due to the resonant nature of the patch structure. On the other hand, modern communication system open require antennas with two operating frequency. When the two operating frequencies are required, a dual-frequency patch structure can be conceived to avoid the use of separate antennas. Dual-frequency patch antenna may provide an alternative to large bandwidth planar antennas, in application in which large bandwidth is really needed for operating at two separate transmit-receive bands.

In this paper, dual-frequency operations are achieved using one-slot on the patch and sub-patch fed by proximity coupled stub. Microstrip patch antenna with dual-frequency and dual-polarization may be excellent candidate used for Korea PCS(Personal Communication System). The proposed antenna characteristics are analyzed by the FDTD(Finite Difference Time Domain) method[1] with Mur's 2nd order ABC(Absorbing Boundary Condition)[2]. From the simulation results based on the FDTD method, frequency characteristics of structure parameters such as the patch size and the offset feed are investigated. Validation of the results of theoretical analysis is demonstrated by comparison with the results of measurement.

2. Dual-polarization techniques

Dual-polarization antennas are characterized by orthogonal polarization. Fig. 1 shows structure of a patch antenna with dual-polarization. It may be obtained by rectangular patch fed separately on two orthogonal axes. The proposed antenna is excited by an open ended microstrip line with its length approximately quarter wavelength stub[3]. As shown in Fig. 1, feed lines of P1 and P2 are located at two orthogonal axes. In this case, the key point for operation of model antenna is the isolation suppression between P1 and P2[4]. Fig. 2 shows offset of feed position to the x- and y- direction. In order to investigate the characteristics of the isolation coefficients between P1 and P2, design for offset effect of feed position for P1 and P2 is carried out. When feed position of P1 is changed from the center of patch antenna to the edge, P2 is kept the center of patch antenna. Fig. 3 shows the calculated return loss and isolation coefficients of the patch antenna fed by offset feed. In design, P1 is changed from center to the edge along the y-direction and P2 is placed at **a** position in the x-direction. As shown in Fig. 3, through the stub of P1 position is changed from **a** to **c**, the characteristics of return loss are not almost changed. While the stub of P1 position is placed at the edge of patch antenna like as **c** position, the characteristics of isolation coefficients are obtained about -5 [dB]. It is not good for dual-polarization antenna. Here after, patch antenna fed by the center feed position will be adopted through this paper. Fig. 4 shows the results of the FDTD simulation and the measurement for the dual-polarization antenna with square patch. The square patch size is 15.2 [mm]×15.2 [mm]. Resonant frequency of patch antenna is determined by the patch size. The measured results are agreed well with the calculated ones. The measured return loss is -20 [dB] and the isolation coefficient is below -28 [dB] at 6.26 [GHz]. In order to design the frequency characteristics of variation of patch size at respective P1 and P2 feed position, we changed the patch size from 15 [mm] to 18.6 [mm]. Fig. 5 shows the measured and calculated return loss and isolation coefficient of rectangular patch antenna. In case of the increased patch length to the x-direction, the resonant frequency of S11 fed by P1 position is decreased. While the resonant frequency of S22 fed by P2 position is not almost changed. S21 and S12 have similar characteristics and maintain about -25 [dB] below. The model antennas have two resonant frequency at 5.25 [GHz] and 6.26 [GHz]. This configuration is useful of dual-frequency antenna when the antenna is required to operate in two distinct frequencies[5].

3. Dual-frequency techniques

One of the most popular techniques for obtaining a dual-frequency behavior is to introduce a reactive loading to a single patch. The simplest way is to connect a sub-patch to one radiating patch, in such a way as to introduce a further resonant length that is responsible for the second frequency operation. Loading the radiating edge with an inset[6] or spur-line[7] is alternative way to introduced a dual-frequency behavior that creates the same effect as the microstrip-loading effect, with the advantage of reduced size. However, frequency ratio of these way cannot be designed to higher than 1.2. To obtain higher values of the frequency, different approaches have been proposed[7]. Fig. 6 shows the proposed antenna for dual-frequency. Two configurations of dual-band antennas are possible, having either one or two input ports. We have examined the dual-band antenna with two input ports in this paper. Proposed dual-frequency patch antennas are characterized by dual-resonance with orthogonal polarization. The basic geometry is a rectangular patch(W, L), a sub-patch(S_{LL}), sub-patch width(S_W), in which two feed point P1 and P2. Resonant frequencies of proposed antenna can be changed at both frequency by adjusting S_L, S_W and S_{LL}. In practice, it may be necessary to adjust the sub-patch(S_L, S_W ,S_{LL}) to obtain two desired resonant frequencies. The measured and calculated characteristics as functions of frequencies are shown in Fig. 7 and 8 respectively, where two resonances are clearly observed. Agreement between the measured and calculated results are good. The measured return loss has been obtained more than -28 [dB] in both bands. The mutual coupling of second resonant frequency is stronger, because the coupling between two ports is due to higher-mode. However the 1st resonant frequency of patch antenna fed by P1 is different from patch antenna fed by P2. So we changed patch width to obtained the same resonant frequency when the patch antenna fed by P1 and P2 respectively. Fig. 9 show frequency characteristics for the adjusting patch width(W). The 1st resonant frequency of patch antenna fed by P1 is equal to P2 in 5.9 [GHz].

To apply the proposed dual-frequency antenna for Korea PCS system dual-frequency band is carried out scale-down. Fig. 10 shows calculated frequency characteristics of the proposed model antenna. The calculated dual-resonant frequencies with the FDTD method are 1.86 [GHz] and 2.29 [GHz]. We propose the model antenna II for dual-frequency as shown in Fig. 11. Another kind of dual-frequency patch antenna can be introduced by etching slots on the patch. The basic geometry is a slotted rectangular antenna with one narrow slot on the patch. The location of the slots with respect to the patch is defined by d_1 and d_2, which are very small with respect to the dimension L and W. The dual-frequency operating with the first mode is essentially the same as that of a patch without slot. As a consequence, it's the second resonant frequency is only slightly difference from of a standard patch[5]. Fig. 12 shows the calculated frequency characteristics of the proposed model antenna II. Dual-frequencies are 1.82 [GHz] and 2.22 [GHz] with mutual coupling of about -20 [dB] below.

4. Conclusion

A microstrip patch antenna with dual-resonance and dual-polarization has been proposed. Dual-frequency operations are achieved using one slot on the patch and sub-patch fed by proximity coupled stub. The dual-resonance frequencies can be varied over a wide frequency range controlled by the patch size. To obtain the same the 1st resonant frequency when the patch antenna is fed by P1 and P2 respectively, we can adjust the patch width. The proposed model antenna with newly designed patch can be applied for Korea PCS system.

5. Reference

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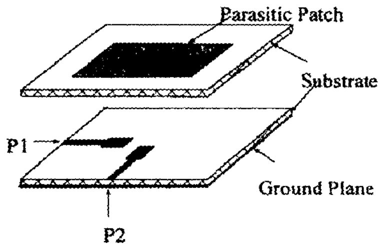

Fig. 1 Patch antenna with dual polarization fed by proximity coupled quarter wavelength stub

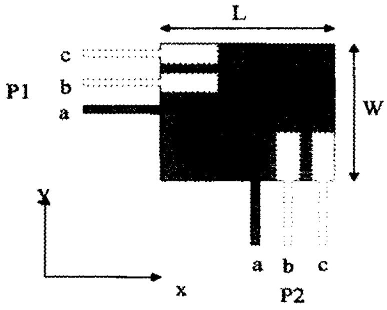

Fig. 2 Offset of feed position in the x- and y- direction

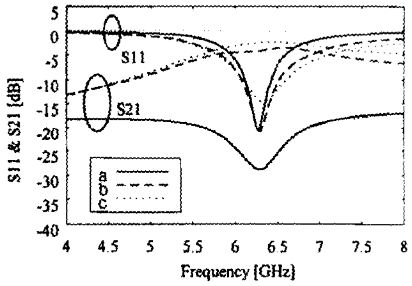

Fig. 3 Calculated isolation coefficient and return loss of patch antenna fed by offset feed

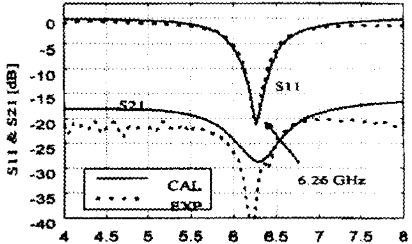

Fig. 4 Measured and calculated return loss and isolation coefficient of square patch antenna (L=15.2 [mm], W=15.2 [mm])

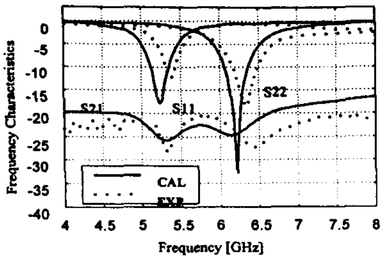

Fig. 5 Measured and calculated return loss and isolation coefficient of square patch antenna (L=18.6 mm, W=15.2 mm)

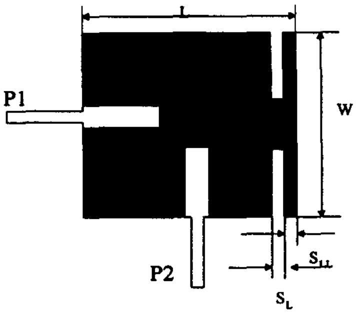

Fig. 6 Proposed model antenna I for dual frequency

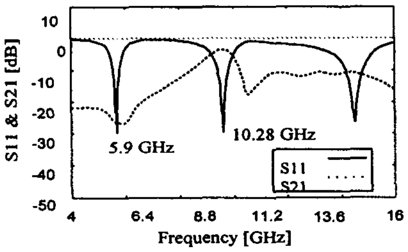

Fig. 7 Calculated return loss and isolation coefficient of proposed model antenna I (L=15.2 mm, W=15.2 mm, S_L=0.8 mm, S_{LL}=0.8 mm, S_W=6.4 mm)

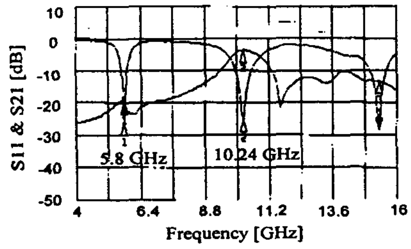

Fig. 8 Measured return-loss and isolation coefficient of proposed model antenna I

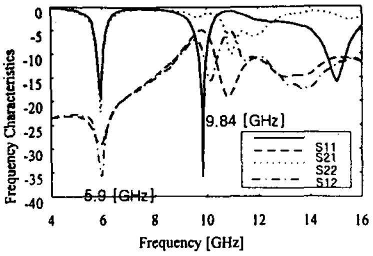

Fig. 9 Frequency characteristics for the adjusting patch width(W) (L=15.2 mm, W=16 mm, S_L=0.8 mm, S_{LL}=0.8 mm, S_W=6.4 mm)

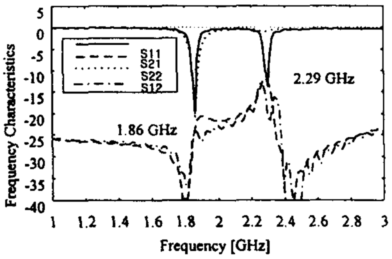

Fig. 10 Calculated frequency characteristics of the proposed model antenna (L=49.6 mm, W=53.6 mm, S_L=0.8 mm, S_{LL}=0.8 mm, S_W=2.4 mm)

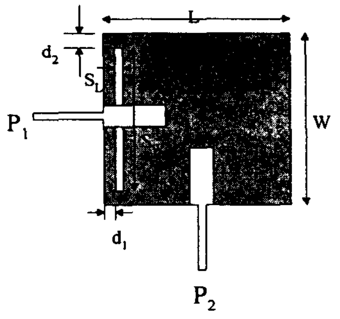

Fig. 11 Proposed model antenna II. for dual-frequency

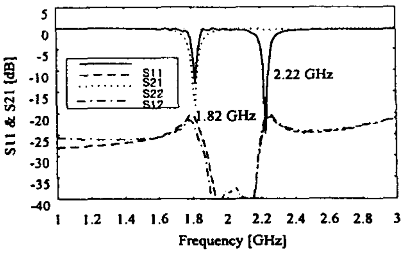

Fig. 12 Calculated frequency characteristics of proposed model antenna II. (L=49.6 mm, W=53.6 mm, S_L=0.8 mm, S_W=50.4 mm, d_1=0.8 mm, d_2 =1.6 mm)