U-slot array for PCS base station antenna

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1. Introduction

PCS(Personal Communication Service) has grown greatly as a popular mobile communication medium. Though research wireless communication engineers have developed various value added services and reduced the charge for both service and hand-phones. But PCS has both higher frequency and smaller coverage of a base station than those of cellular and frequently service hole because of lower diffraction. So, the PCS service operator needs many more base stations than the cellular service operator. PCS systems have many component parts, each of which contribute to the overall performance. Although, for example, the base station antenna represents only a small percentage of the overall cost of a PCS base station, its performance impact is enormous[1].

In this paper, we present a PCS base station designed to use a rectangular patch with a u-slot. The PCS base station antenna must satisfy many parameters in frequency bandwidth above 120MHz. A u-slot patch antenna can get broadband impedance characteristics by the double resonance effect that can be obtained using a u-slot in a rectangular patch. It was first proposed by Huynh and Lee[2-3]. The best advantage of a u-slot patch antenna is that broadband impedance characteristics are obtained by a coplanar geometry not a stacked geometry. Hyunh and Lee showed that a coaxially fed rectangular patch with a u-slot could attain over 30%(VSWR≤2) impedance bandwidth.

In this paper, a four-element array of a u-slot patch has been designed. Its characteristics are as follow; antenna gain is greater than 12dB, the first upper sidelobe level is less than -14~-15dB and horizontal half power beamwidth is 65°. Antennas with the previous specification's are widely used for PCS base station antennas.

Typical PCS base station antenna sites are sectorized to increase the number of frequencies available for carrying traffic. When applying base station antennas in a PCS environment, there are a number of pattern characteristics that will have an impact on performance, such as half power bandwidth, gain, first upper sidelobe level, front-to-back ratio, VSWR. In this paper, we have compared simulation results with measurement results, and confirmed the broadband characteristics of designed antenna. Also, we have derived the design parameters of a u-slot patch antenna through simulation.

2. Design parameters of u-slot rectangular patches

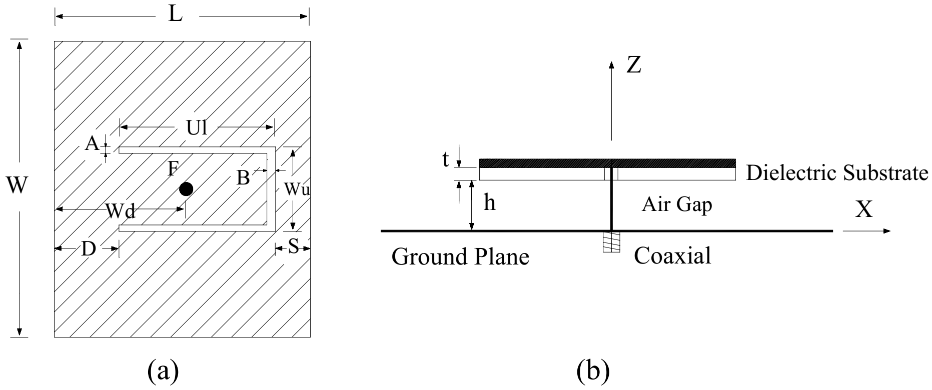


Fig 1. Geometry of the coaxially fed rectangular patch with a u-slot. (a) Top view of the patch. (b) Side view.

The geometry of the coaxially fed rectangular patch with a u-slot is shown in Fig.1. A u-slot rectangular patch is changed very sensitively for some parameters, namely, width and length of patch, length and shape of u-slot, thickness and dielectric constant of substrate, position and diameter of feed probe. Loop means resonant in Smith chart. A u-slot rectangular has two loops. A small resonant loop must be moved to near VSWR=1 for designing the antenna that has broadband characteristics. Table 1 shows the u-slot length that is sensitive for a u-slot rectangular patch characteristic and the antenna A, B, C with differing diameters of feed probe.

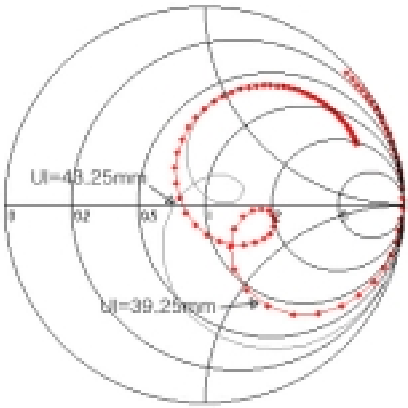
Table 1. Dimension of antenna (in mm.).

	L	W	D	Wd	F	A	B	Wu	S	Ul	h	εγ	t
Ant. A	64	74.5	10	35.5	1	2	2.5	18.5	10.75	43.25	13	2.17	0.508
Ant. B	64	74.5	14	35.5	1	2	2.5	18.5	10.75	39.25	13	2.17	0.508
Ant. C	64	74.5	10	35.5	2	2	2.5	18.5	10.75	43.25	13	2.17	0.508

The antennas in table 1 were used with Ensemble 6.0. The length of a u-slot changes a resonant frequency. Fig 2 shows the impedance locus when the length of u-slot is 43.25mm (Antenna A) and 39.25mm (Antenna B), respectively. Both antenna A and B, impedance locus has a double-loop characteristic for the wideband operation. But if the length of the u-slot becomes shorter, the magnitude of a small resonant loop does not change. It moves clockwise close to VSWR=2. Then performance becomes worse. Fig 3 shows the impedance locus when the diameter of feeding probe is 1mm (Antenna A) and 2mm (Antenna B), respectively. A thicker probe decreases the fringe inductive field at the feed. If the probe becomes thicker, the magnitude of the small resonant loop becomes larger. Then it can be moved to center of the Smith chart.

3. Measurement results

The calculated and measured curves of VSWR for single element antenna A are shown in Fig. 4. There is reasonable agreement with the measured results shown in Fig. 4. It was found that the antenna can be designed to have either wideband or dual frequency characteristics.



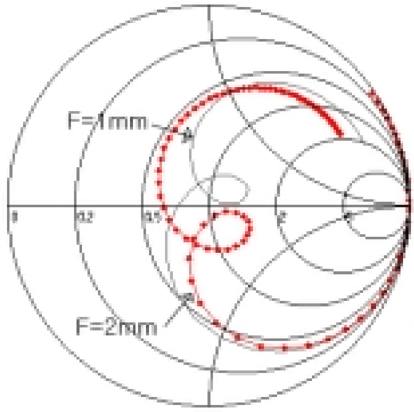


Fig. 2 Fig. 3

Fig 2. Impedance loci for antennas with the parameters given by Antenna A and B for Table 1.

Fig 3. Impedance loci for antennas with the parameters given by Antenna A and C for Table 1.

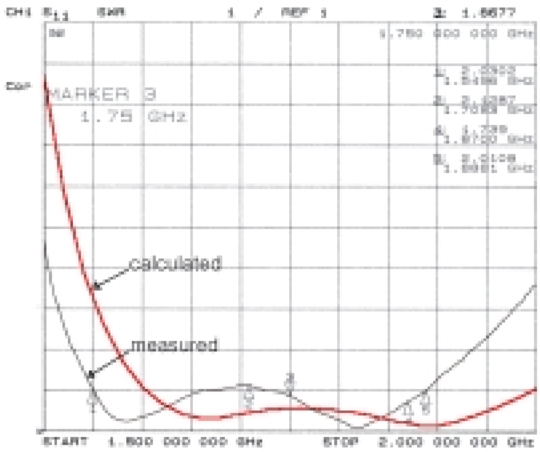


Fig. 4. Calculated and measured curves of VSWR for single element Antenna A.

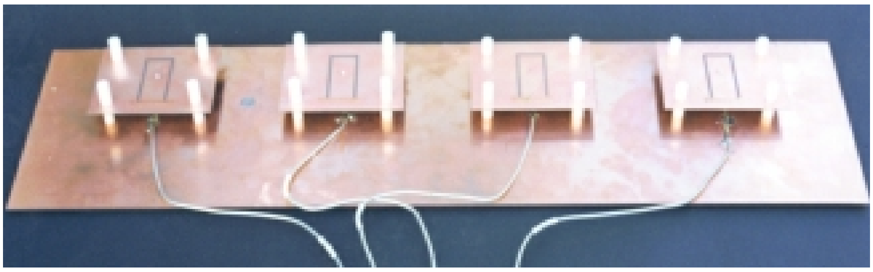


Fig. 5. Photograph of prototype antenna.

The measured curve of a four-element array is plotted in Fig. 6. The bandwidth(VSWR≤2) is 349MHz(19.28%). Fig. 7 show the measured radiation patterns in the E and H-planes at 1855MHz. The half power beamwidth in the H-plane is 65°. In the E-plane, it is 17°. The first upper sidelobe level is -14~-15dB. In the complex environment of dense urban PCS systems, the level of the first upper sidelobe of base station antennas may have a significant impact on system performance. For best reduction of sidelobe interference, the first upper sidelobe level should be at least –15dB.

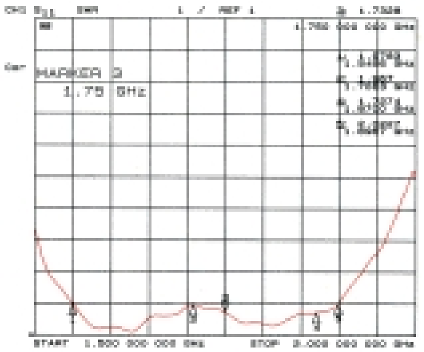


Fig. 6. Measured VSWR curve of a four-element array.

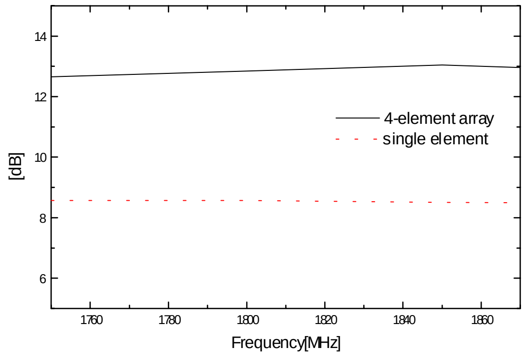
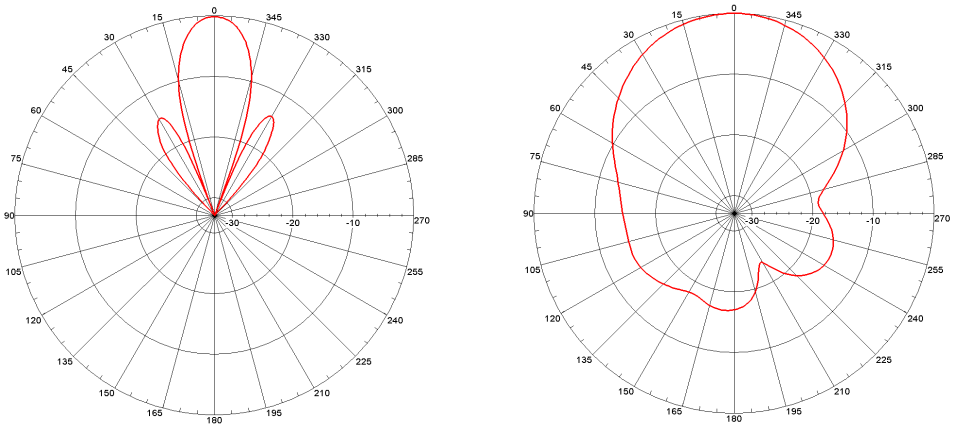


Fig 8. Measured gain curves.



(a) E-plane

(b) H-plane

Fig. 7. Measured radiation patterns at 1855MHz.

The measured broadside gain curves are shown in Fig. 8. The maximum gain of the four-element array is 13.05dB at 1850MHz.

4. Conclusion

In this paper, simulation and experimental results have been presented for the coaxially fed u-slot rectangular patch antenna. Simulation results are in reasonable agreement with measurement. Manufactured prototype antenna is recommended for use in PCS base station antennas. The design of a u-slot rectangular patch antenna for PCS and IMT-2000 dual band remains for further study.

References

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