GAIN AND BANDWIDTH ENHANCEMENT IN COMPACT MICROSTRIP ANTENNA

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ABSTRACT

In the present work, a new compact microstrip patch antenna has been proposed in stacked configuration. The characteristics of the antenna are obtained in terms of return loss, gain and bandwidth and are compared with the conventional microstrip patch. It is observed that the new proposed configuration reduces the patch area by 66.34% and at the same time enhances the gain and bandwidth significantly with superstrate loading. The Genetic Algorithm optimizer built in with IE3D Commercial simulator is used to obtain the optimized performance of the proposed antenna. This antenna is found to be suitable for IEEE 802.11b WLAN communication standard.

INTRODUCTION

Two most serious limitations of the microstrip antennas are its low gain and narrow bandwidth. The compact antenna configuration further deteriorates these two parameters. This is because of the fact that there is a fundamental relationship between the size, bandwidth and efficiency of an antenna. As antennas are made smaller, either the operating bandwidth or the antenna efficiency must decrease. The gain is also related to the size of the antenna, that is small antennas typically provide lower gain than larger antennas.

Therefore, the size reduction, together with gain and bandwidth enhancement is becoming major design considerations for most practical applications of microstrip antennas for wireless communication. A number of techniques have been reported by the researchers to enhance the gain and bandwidth of microstrip antennas. Some of them used to enhance the gain are, loading of high permittivity dielectric superstrate [1], inclusion of an amplifier type active circuitry [2] and stacked configuration [3]. Use of superstrate loading technique helps in increasing the radiation efficiency. Amplifier circuits can also be integrated with the radiating patch to give rise to an active integrated antenna. In stacked configuration two patches, driven and parasitic, are used with desired feeding technique.

The narrow impedance bandwidth of the basic microstrip element is ultimately a consequence of its electrically thin ground-plane-backed dielectric substrate, which leads to a high Q resonance behavior. Bandwidth improves as the substrate thickness is increased, or the dielectric constant is reduced, but these trends are limited by an inductive impedance offset that increases with thickness. A logical approach, therefore, is to use a thick substrate or replacing the substrate by air or thick foam [4] with some type of additional impedance matching to cancel this inductance. Thick substrate introduces surface wave excitation. Another method reported [5] for the bandwidth enhancement is by loading the suspended microstrip antenna with dielectric resonator.

Besides impedance matching, another very popular bandwidth extension technique involves the use of two or more stagger tuned resonators, implemented with stacked patches, parasitic patches, or a combination of dissimilar elements. Three dimensional patches like V-shaped patch [6], or wedge -shaped patch [7] can also be used to enhance bandwidth. Various feeding methods other than co-axial feeding, also enhances the bandwidth. Other reported methods use proximity feed [8], L-probe/ L-strip and Z-shaped feed [9]. The patch loaded with slots like U-slotted Patch, E- Patch [10], parasitic patches aside or on the top [11] also have effect on bandwidth enhancement.

The stacked patch arrangement [12] is very popular, with reported bandwidths ranging from 10% to 20%. Owing to the fact that the stacked configuration enhances both the gain and bandwidth, this particular choice is preferred in the present work.

This paper discusses the gain and bandwidth enhancement technique utilizing the stacked configuration and finally applies this technique to realize a compact microstrip antenna in stacked configuration.

STACKED CONFIGURATION:

Stacked configurations are possible with aperture coupled feeding, proximity feeding and co-axial feeding. Probe-feeding technique is re-emerging in variety of antenna system due to its robust nature. It provides good isolation

between feed network and radiating elements and due to direct contact with the radiator reduces dielectric layer misalignment difficulties. It also yields good front to back ratio which is very important where multiple arrays are located back-to-back in closed proximity. Therefore stacked configurations with probe -fed have been considered.

Considerable amount of literature is available which provides guidelines to design a probe fed stacked patch. It has been reported, that the combination of low dielectric constant and high dielectric constant can yield good impedance behavior. The broadest bandwidth can be achieved when the first-order mode on the lower patch is considerably greater in magnitude than corresponding mode on the top patch or in other words the top patch is loosely coupled. For this the substrate of lower patch should have higher dielectric constant than the upper substrate.

The thickness of each layer also plays an important role in achieving the overall bandwidth. The thicker the lower layer, the greater the bandwidth will be. It has been suggested that the lower patch should be designed such that it is strongly capacitive over the desired range of frequency instead of designing it for the minimum return loss. But the overall impedance will become inductive when parasitic patch is placed onto the configuration, if lower layer is too thick. Hence a tradeoff must be made between the bandwidth and the impedance control.

The thickness of upper substrate (h_2) depends upon the thickness of lower substrate (h_1). The greater h_1 leaves less freedom for the h_2. For lower return loss h_2 must be increased.

ANTENNA DESIGN:

The first step in the design is to select the dielectric substrate and then to fix the thickness h_1 and h_2. Fig. 1 shows the cross-sectional view of the Grooved LP patch antenna in stacked configuration. The lower substrate is of FR-4 of thickness 4.8 mm whereas the upper substrate is of foam with dielectric constant of 1.07 and thickness 7 mm. The groove angle and the dimensions of both the patches (driven and parasitic) are selected as optimization variable with objective to get the central frequency 2.44 GHz and to cover the whole operating range of WLAN. IE3D simulation tool is used to model the compact microstrip patch in stacked configuration.

RESULTS AND DISUSSION:

The characteristics in terms of VSWR and gain are shown in the Fig. 2 and Fig. 3. Both VSWR and gain bandwidths for the grooved patch in stacked configuration are shown to occupy a larger range than the conventional and the grooved configurations. Radiation characteristics are shown in Fig. 4 and Fig. 5. Results are also tabulated in the Table 1. It is evident from the table that the area of upper patch, which is larger than the lower patch, reduces by 53%, at the same time the gain and bandwidth are also increased. A size reduction of 66.34% can be achieved if designed at 785 MHz frequency. Gain is seen to be almost flat over the desired range of interest.

CONCLUSION:

A new compact microstrip antenna is realized in stacked configuration for WLAN application. The stacked configuration enhances both gain and bandwidth of the antenna in the desired band of interest. A size reduction of 53% is obtained in the proposed configuration along with 4dBi gain and 91 MHz band width.

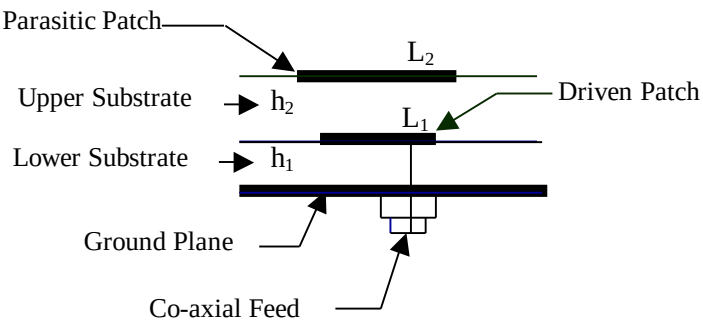

Fig. 1. Cross-sectional view of probe-fed stacked-patch geometry

Table 1 Characteristics of Grooved patch LP patch antenna in stacked configuration

Centre Freq. (GHz)	Antenna Type	Feed Position f_p (mm)	VSWR Band width (MHz)	Gain (dBi)	Reduction in Area (%)
2.46	Conventional LP Square patch	6.65	85.33	3.46	-
2.46	Grooved patch antenna (LP)	2.6	50.14	0.497	54
2.44	Grooved patch antenna (LP) in stacked configuration	3.2	91.5	4.01	53

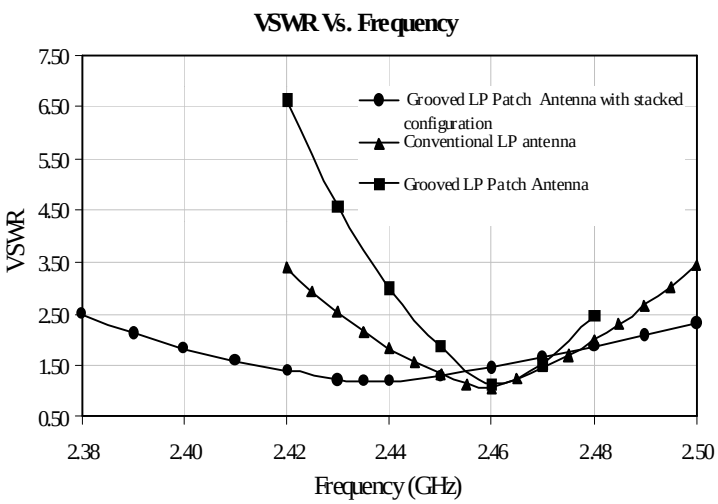

Fig. 2. Comparison of VSWR characteristic of Grooved LP patch Antenna in stacked configuration with conventional and Grooved LP patch antenna

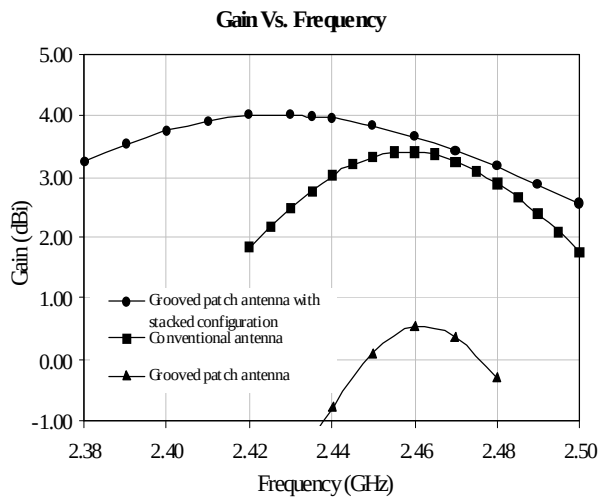

Fig. 3. Comparison of gain characteristics of Grooved LP patch antenna in stacked configuration with conventional and Grooved LP patch antenna

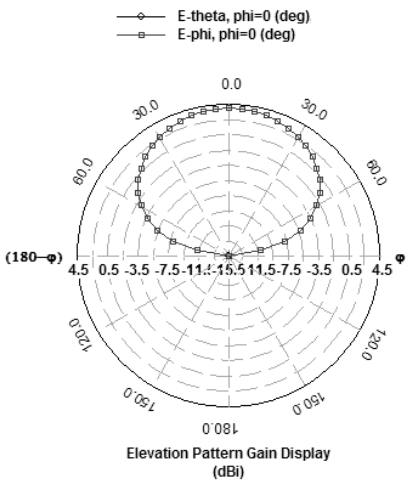

Fig. 4. Radiation pattern of Grooved LP patch antenna in stacked configuration in X-Z plane

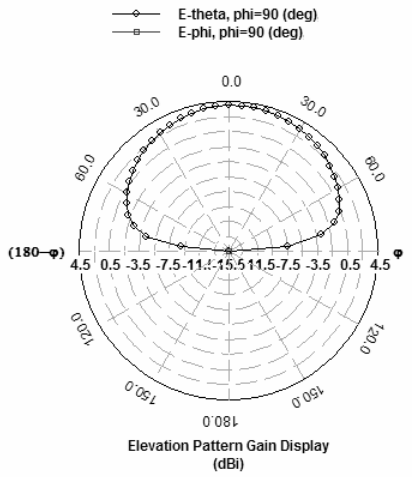

Fig. 5. Radiation pattern of Grooved LP patch antenna in stacked configuration in Y-Z plane

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REFERENCES

1. N. G. Alexopoulos and D. R. Jackson "Fundamental superstrate (cover) effects on printed circuit antennas," *IEEE Trans. Antennas and Propagation,* Vol. AP-32, pp 807-816, August 1984.
2. B. Robert, T. Razban, and A. Papiernik, "Compact amplifier integration in square patch antenna," *Electronics letters,* Vol. 28, pp. 1808-1810, Sept. 1992.
3. R. Q. Lee and K. F. Lee "Experimental study of the two-layer electromagnetically coupled Rectangular patch antenna" *IEEE Trans. Antennas and Propagation,* Vol. 38, pp. 1298-1302, Aug. 1990.
4. T. Huynh and K. F. Lee, "Single layer single patch wideband microstrip patch antenna," *Electronics Letters,* Vol. 31, pp. 1310-1311, August 1995.
5. V. Gupta, S. Sinha, S. K. Koul and B. Bhat, "Wideband dielectric resonator-loaded suspended microstrip patch antennas," *Microwave and Optical Technology Letters,* Vol. 37, pp. 300-302, May 2003.
6. Kin-Lu Wong, "Compact and Broadband Microstrip Antennas", *John Wiley & Sons,* New York, 2002.
7. Y. M. Jo, "Broadband patch antennas using a wedged-shaped air dielectric substrate," in *IEEE Antennas Propagation Soc. Int. Symp. Dig.*, pp. 932-935, 1999.
8. P. K. Singhal and L. Shrivastava, "On the investigations of a wide band proximity fed bow tie shaped microstrip antenna," *Journal of Microwave and Optoelectronics* , Vol. 3, pp. 87-98, April 2004.
9. K. M. Luk, L. K. Au Yeung, C. L. Mak and K. F. Lee, "Circular patch with an L shaped probe," *Microwave and Optical Technology Letters,* Vol. 20, pp. 356-257, February 1999.
10. K. L. Wong and W. H. Hsu, "Broadband triangular microstrip antenna with U-shaped slot" *Electronics Letters,* Vol. 33, pp. 2085-2087, December 1997.
11. G. Kumar and K.C. Gupta, "Directly coupled multiple resonator wide-band microstrip antennas," *IEEE Trans. Antennas and Propagation,* Vol. 33, pp. 588-593, June 1985.
12. R. B. Waterhouse, "Design of probe-fed stacked patches," *IEEE Trans. Antennas Propagat.* Vol. 47, pp. 1780-1784, Dec. 1999.