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Microstrip Antenna with Centrally Loaded Inductive Discontinuity for Dual Band Operation

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Abstract

A conventional microstrip antenna on grounded PTFE substrate with centrally loaded inductive discontinuity is proposed for dual band operation. The discontinuity has been produced by two thin metallic plates centrally beneath the rectangular patch to form an inductive window. The proposed antenna has been studied methodically and the results are verified with commercially available software package (High Frequency Structure Simulator, V. 10). The specialty of the proposed antenna is to excite a new resonant mode with good impedance bandwidth while the usual dominant TM_{10} mode is kept unaltered. Moreover, the salient feature of the new antenna is that it produces the radiation pattern exactly similar to dominant TM_{10} mode at its new resonant mode.

Keywords

Dual Band, Inductive Discontinuity, Microstrip Antenna, Polarization Purity

1. Introduction

Microstrip patch of rectangular geometry etched on a grounded substrate is well known as printed antenna and has been extensively studied in last two decades. These patches resonate at its fundamental TM_{10} mode which produces the radiation pattern at its bore-sight direction. In the present era, this rectangular microstrip antenna is an important candidate of the wireless communication for its well-known striking features, such as tininess, and compatibility with monolithic microwave integrated circuits and thus it finds growing number of new applications day by day [1] such as GPS, WLAN etc.

The conventional patch antenna fabricated on common substrates usually resonates at its single fundamental mode with a typical bandwidth of 2-3%. But to survive in the rising trend of applications of such small antennas, dual band operation is very important. Several efforts have been given to develop the dual frequency microstrip antennas and the simplest technique to realize it by exciting the two nearby orthogonal modes such as TM_{10} and TM_{01} is as reported in [2]. These antennas are characterized by two resonances with orthogonal polarizations and hence are known as orthogonal mode dual-frequency patch antennas. The inherent restriction of this approach is that the two different frequency bands

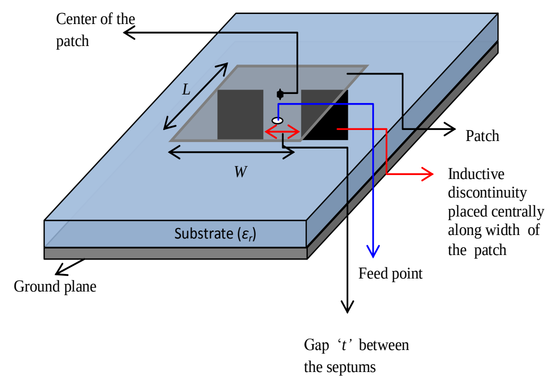

Fig.1: Three dimensional view of the proposed microstrip antenna with centrally loaded inductive discontinuity

excite two orthogonal polarizations. However, this method is very useful in low-cost short-range applications, where polarization requirements are not vital.

Some other investigations such as [3], [4] have been reported which show that the dual band antennas can be designed with the help of multiple radiating elements in stacked configuration. Different loading techniques to achieve dual band operations have been presented in [5]-[7]. These various techniques to achieve dual-band operation from various types of microstrip antennas still suffers from either complex manufacturing process or the polarization purity in its radiation.

In the present investigation, a new technique is proposed where a pair of simple thin metal plate has been introduced beneath the patch centrally along the width of the patch as shown in Fig. 1. This pair of simple thin metal plate produces an inductive discontinuity along the central region below the patch. This has been done with a view to generate a new resonant mode while the usual dominant TM_{10} mode is kept unaltered. The detail study of the new resonant mode and the radiation characteristics of two individual modes has been studied and presented in the paper. The proposed idea has been verified thoroughly using [8] and close agreement is revealed.

2. Proposed Antenna Structure

A rectangular microstrip antenna with length *L*= 11.5 mm and width *W*= 17.25 mm for C band operation is shown in Fig. 1. A PTFE of relative permittivity ε_r = 2.33 with thickness *h* =1.58 mm is utilized as substrate. A pair of simple thin metal plate which forms the inductive window has been introduced beneath the patch centrally along the width of the patch as shown in the figure. The width of the inductive window *t* = 6 mm is as shown.

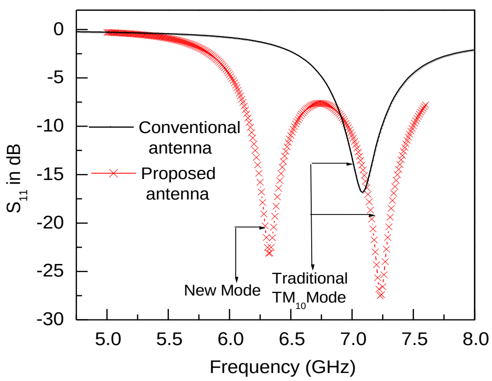

Fig.2: Complete return loss profile for conventional antenna and proposed structure. Parameters: L = 11.5 mm, W = 17.25 mm, h = 1.58 mm, εr = 2.33, t = 6 mm and fed at 2.9 mm from center of the patch

3. Results and Discussions

The input and radiation properties of the present antenna in comparison with conventional patch have been studied thoroughly and presented in the following section.

Fig. 2 shows the complete return loss profile for both the conventional antenna and the proposed one (both having same *L*, *W* and *h* values) which indicates clearly that there is a generation of new mode at 6.34 GHz along with the traditional TM_{10} mode at 7.24 GHz in case of proposed antenna while this is not the case for conventional one which resonates at 7.2 GHz.

Fig. 3 shows the radiation pattern for E and H plane of the proposed antenna for two separate frequencies. Fig. 3(a) gives the radiation pattern at 7.24 GHz *i.e.* the radiation fields associated with traditional TM_{10} mode whereas 3(b) gives the radiation pattern at 6.34 GHz *i.e.* the radiation fields associated with new mode. Fig. 3 clearly depicts that for both the modes (usual TM_{10} and the new mode) the radiation patterns are exactly similar and bore-sight to antenna element. It may be noted that, the H plane cross polarized radiation associated with new resonant mode is slightly more than that of usual TM_{10} mode.

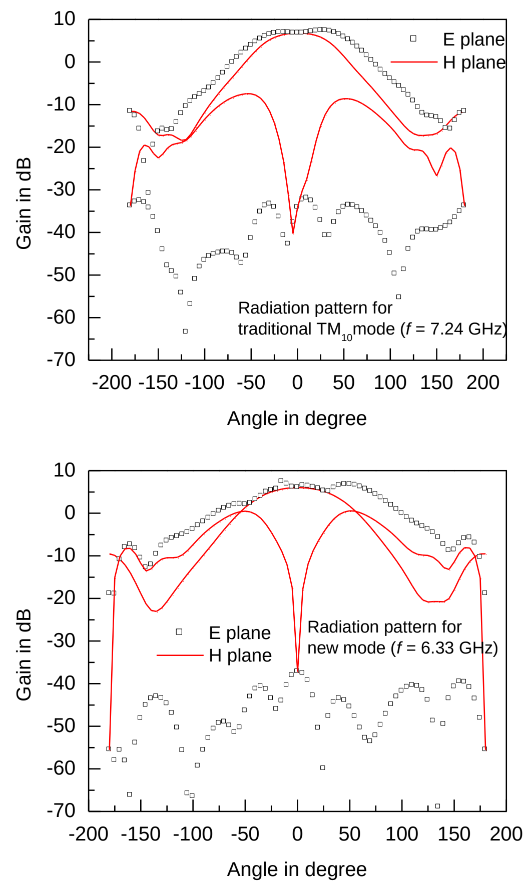

Fig. 3: Radiation pattern for E and H planes of the proposed antenna. (a) At 7.24 GHz i.e. the pattern associated with traditional TM10 mode, (b) At 6.33 GHz i.e. the pattern associated with new mode. Parameters as in Fig. 2

In fact, the patch of length L produces resonance at nearly 7.24 GHz but as soon as the inductive window is placed centrally beneath the patch, it simulates a patch with a new effective length which is greater than the original physical length. To this imaginary patch (with new effective length) the new dominant mode TM_{10} is resonant at 6.33 GHz. Hence the radiation pattern corresponding to conventional TM_{10} mode (f= 7.24 GHz) and that for new resonant mode (f=6.33 GHz) are of same nature.

This slightly increased cross polarized radiation for the new mode does not hamper the antenna characteristic much but it may be minimized by several techniques like employment of defected ground structures or cupping the ground plane as done in [9] for conventional microstrip antenna.

4. Conclusion

A rectangular microstrip antenna with centrally loaded inductive discontinuity below the patch is proposed for dual band operation with good polarization purity. The superiority of the proposed antenna is to excite a new resonant mode below the conventional TM_{10} mode with faithful radiation pattern and good impedance matching. The proposed antenna is very supportive for the scientists, researchers and practicing engineers looking for such low profile simple antenna with dual band operation and polarization purity**.**

References

[1] R.Garg, P.Bhartia, I.Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, Norwood, USA, 2001.

[2] J-S. Chen, K-L. Wong, "A Single-Layer Dual-Frequency Rec- tangular Microstrip Patch Antenna Using a Single Probe Feed," *Microwave and Optical Technology Letters*, Vol. 11, No. 2, pp. 38- 84, 1996.

[3] J. S. Dahele, K. F. Lee and D. P. Wong "Dual Frequency Stacked Annular-Ring Microstrip Antenna," *IEEE Transactions on Antennas and Propagation*, Vol. 35, No. 11, pp.1281- 1285, 1987.

[4] J. Wang, R. Fralich, C. Wu and J. Litva, "Multifunctional Aperture Coupled Stack Antenna." *Electronics Letters*, Vol. 26, No. 25, pp. 2067-2068, 1990.

[5] W. F. Richards, S. E. Davidson, S. A. Long, "Dual-Band Reactively Loaded Microstrip Antenna," *IEEE Transactions on Antennas and Propagation*, Vol. 33, No. 5, pp. 556-560, 1985.

[6] S. E. Davidson, S. A. Long, W. F. Richards, "Dual-Band Microstrip Antenna with Monolithic Reactive Loading," *Electronics Letters*, Vol. 21 , No. 21, pp. 936-937, 1985.

[7] H. Nakano, K. Vichien "Dual-Frequency Patch Antenna with a Rectangular Notch," *Electronics Letters*, Vol. 25, No. 16, pp. 1067- 1068, 1989.

[8] High Frequency Structure Simulator, HFSS *v10*, Ansoft Corp.

[9] K. Malakar, J. Nandi, S. Mitra, P. K. Gorai, S. Chattopadhyay, J. K. Sah, A. Anand, "Physical Insight Into The Low Cross Polarized Radiation with Rectangular Microstrip Antenna on Cupped Ground Plane," International Journal of Electrical, Electronics and Computer Systems. Vol. 6, No. 2, 2012.

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