Low-Noise Active Microstrip Antenna Fed by Coplanar Waveguide

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Abstract

This paper presents the experimental investigation of a low noise active microstrip antenna fed by coplanar waveguide. The low noise amplifier utilizes a Si BJT AT-41435 as the active device and utilizes coplanar waveguide as the transmission line and matching circuit. The patch antenna is electromagnetic coupled to the feeding system. Both antenna and active circuit are fabricated on Duroid RO-3003 dielectric substrate which have substrate thicknesses of 0.75 mm and 1.50 mm for active circuit and patch antenna respectively.

The measurement results of the active microstrip antenna show that a noise figure of 3.94 dB can be achieved at 4.0 GHz while gain of 16.48 dBi and an impedance bandwidth of 388.92 MHz are also can be achieved at that operating frequency.

Introduction

Recent studies indicate that it is possible to implement active devices directly close to the planar patch antenna [1]-[2]. However, there are not many studies on the active microstrip antenna fed by coplanar waveguide. It is shown that there were several studies for passive antenna use coplanar waveguide as its feeding system [3]-[4]. Some advantages of using coplanar waveguide are such that easy to make connection between passive and active component on the same substrate without via hole, easy to realized series and parallel connection and less transmission and radiation losses.

In this paper, therefore, we propose a low noise active microstrip antenna fed by coplanar waveguide using a low cost Silicon Bipolar Junction Transistor (Si BJT) AT-41435.

Design and Fabrication

The structure of this low noise active antenna type is shown in Fig. 1 where the patch antenna and the active circuit use different substrate layers. In this experiment, both antenna layer and active circuit layer are realized on the dielectric substrate of Duroid RO3003 having dielectric permittivity of ε_r = 3.00, and loss tangent of $\tan\delta$ = 0.0013. Meanwhile, the dielectric substrate thicknesses are h_1 = 0.75 mm and h_2 = 1.50 mm for active circuit layer and antenna layer respectively. This configuration will improve the active antenna bandwidth

Furthermore, the passive antenna system fed by coplanar waveguide is developed in order to characterize its impedance matching. The feeding system uses a coplanar waveguide with characteristic impedance of 50Ω. The impedance matching is determined experimentally as in [3][4]. It is found that the matching position of feeding line will be used in the active circuit. Meanwhile, a low noise amplifier is developed utilizing a Si BJT AT-41435. This low cost transistor type has characteristic of minimum Noise Figure (NF) 3.0 and has gain of 10 dB, both for frequency 4.0 GHz, V_{CE} = 8 V and I_C = 10 mA. In order to match between transistor and its input and output circuits, matching circuits are implemented using a coplanar waveguide.

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Result and Discussion

Firstly we measure the passive antenna system, and then we measure the active antenna to see the usefulness of adding or integrating the passive circuit with the active circuit. It is shown in Fig. 2 that the return loss characteristic of the passive antenna system is well behaved. A return loss of -36 dB and a VSWR = 2 impedance bandwidth of 204 MHz can be achieved for operating frequency of 4.0 GHz. This passive antenna has gain of 7.01 dBi and their E-plane and H-plane radiation patterns at the bore sight direction also well behaved as expected.

Next, the passive antenna is incorporated with active circuit. The measured return loss characteristic then became -25 dB and the VSWR = 2 impedance bandwidth of 388.92 MHz is achieved at frequency of 4.0 GHz, as shown in Fig. 3. An increasing bandwidth almost twice from the passive antenna is achieved in this experiment. Furthermore, the low noise active antenna is measured for both antenna and active circuit parameters [5]-[6]. It is shown in Fig. 4 that the NF = 3.92 dB is obtained at operating frequency of 4.0 GHz. This value is a little over the theoretical value due to different DC biasing voltage and current use in the experiment. Several values of NF over 1 to 5 GHz frequency range are also shown in Fig. 4. The active antenna gain over 1 to 5 GHz frequency range is also displayed in Fig. 5 where a significant gain addition can be achieved. The E-plane and H-plane radiation pattern at the bore sight are also measured which showed very good results.

Conclusion

A low noise active microstrip antenna fed by coplanar waveguide has been designed and been tested at the C-band. A Si BJT AT 41435 is used as the active device. It is shown that the measured active antenna parameters are well behaved as expected. Therefore, this active antenna system can be used as a low cost new type active microstrip antenna.

Acknowledgement

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References

1. Lin, J., and T. Itoh: “Active integrated antennas,” *IEEE Trans on Microw. Theory and Techniques*, vol. MTT-42, 1994, pp. 2186-2194
2. Qian, Y and T. Itoh: “Progress in Active Integrated Antennas and Their Applications,” *IEEE Trans on Microw Theory and Techniques*, vol. MTT-46, 1998, pp.1891-1899
3. Rahardjo, E. T., S. Kitao, and M. Haneishi: “Planar antenna excited by electromagnetically coupled coplanar waveguide,” *Electron. Lett.* ,vol. 29, 1993, pp.870-871
4. Rahardjo, E. T., S. Kitao, and M. Haneishi: “Circularly polarized planar antenna excited by cross-slot coupled coplanar waveguide,” *IEEE APS Int. Symp. 1994 Digest*, Seattle, USA, vol. 3, pp.2220-2223
5. An, H, B. Nauwelaers, and A. Van de Capelle: “Measurement Technique for Active Microstrip Antennas,” *Electron. Lett*, vol. 29, 1993, pp.1646-1647.
6. An, H, B. Nauwelaers, and A. Van de Capelle: “Noise Figure Measurement of Receiving Active Microstrip Antennas,” *Electron. Lett*, vol. 29,1993, pp.1594-1596.

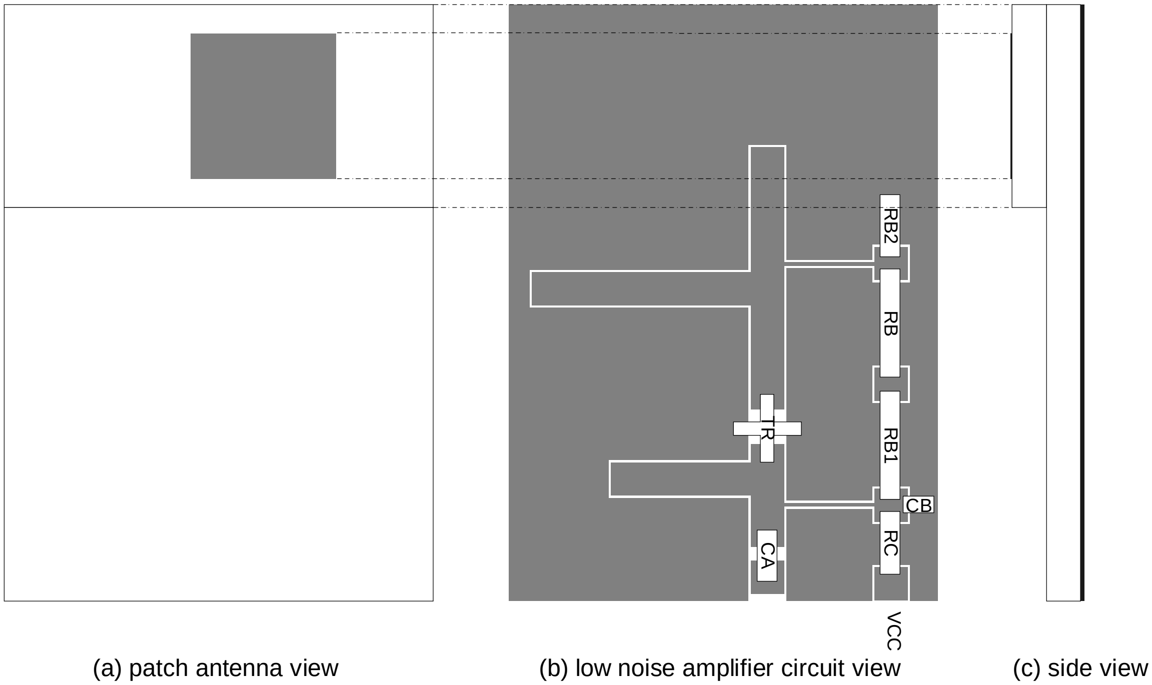

Fig. 1 Structure and lay out of low noise active microstrip antenna

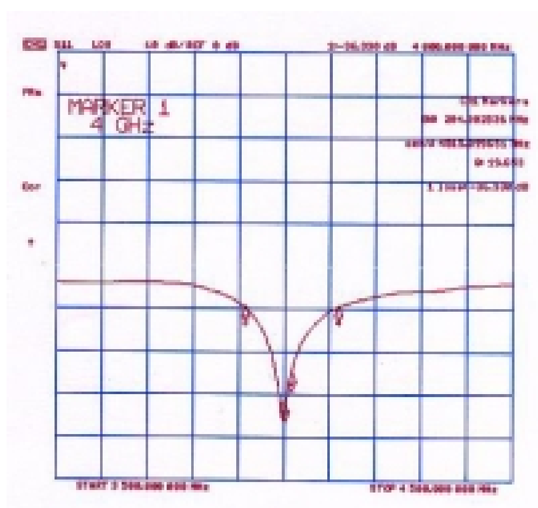

Fig. 2. Return loss characteristic of passive antenna fed by CPW

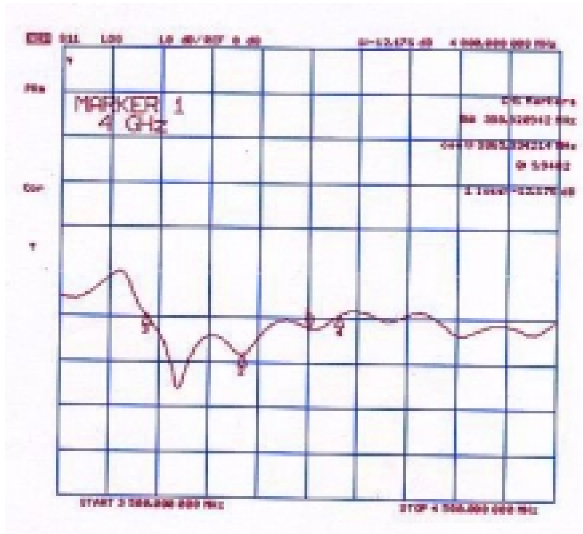

Fig. 3 Return loss characteristic of active antenna fed by CPW

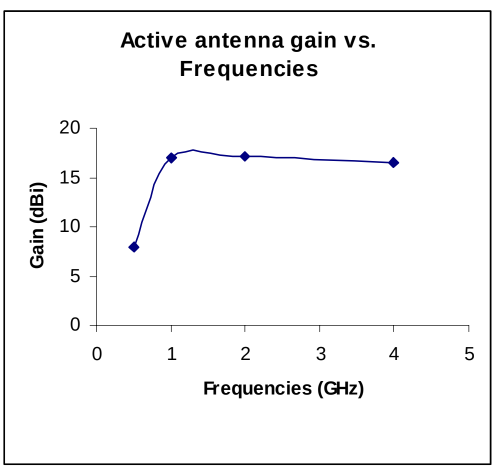

Fig. 4 Measured active antenna gain vs. Frequencies.

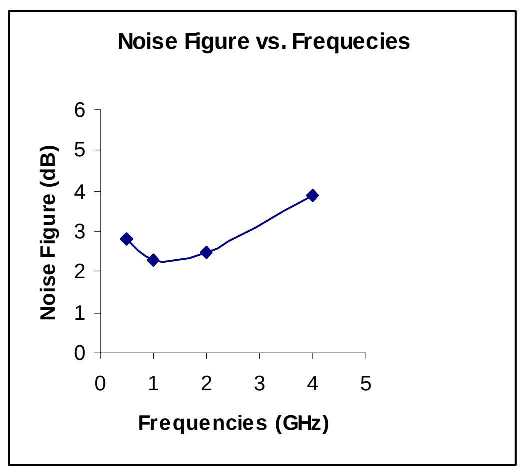

Fig. 5 Measured noise figure vs. Frequencies.