

# COMPACT AMPLIFIER INTEGRATED MICROSTRIP ANTENNA

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**ABSTRACT:** A compact microstrip antenna integrated with an amplifier having an area reduction of 70%, compared to the standard circular microstrip patch antenna, is presented. The antenna also provides an enhanced gain of 10-dB more than its passive counter part. The measured 2:1 VSWR band width is ~4% at 790 MHz, which is 2.5 times larger than that of the passive microstrip antenna. © 2004 Wiley Periodicals, Inc.

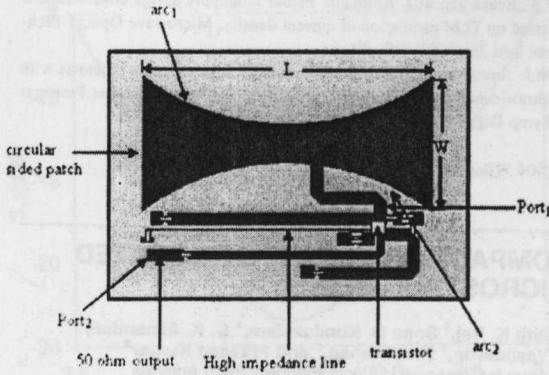
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**Key words:** compact; active integrated antenna; conjugate match

## 1. INTRODUCTION

There is a growing tendency for portable equipment to be made smaller and smaller as the demand for personal communication rapidly increases, and the development of very compact handheld units has become urgent. Various compact microstrip antenna designs have been reported in the literature to overcome the size problem of the conventional microstrip patch antenna, such as embedding slots in microstrip patch and shorting pins placed between radiating element and the ground plane [1, 2]. For most compact antennas, the gain and radiation efficiency is much lower than the conventional microstrip antenna. In this paper, area reduction is achieved by the patch geometry [3], which is obtained by modifying standard rectangular and circular microstrip patches, and gain is enhanced by integrating an amplifier to it.

The active integrated antenna has become a growing area of research in recent years, as microwave-integrated circuits and monolithic microwave-integrated circuit (MMIC) technology have become more mature, thus allowing for high-level integration. Active integrated antennas also have strong potential for commercial applications in wireless communications and radar. An amplifier-type active integrated antenna integrates a two-port active device to a passive antenna element at its input or output port. The implementation of an amplifier in a passive antenna structure increases the antenna gain and bandwidth, and improves the noise performance. Such an active slotted equilateral-triangular microstrip antenna with an amplifier circuit has already been illustrated in [4]. In this paper, we present a compact microstrip receiving antenna with enhanced gain and wide-impedance bandwidth.

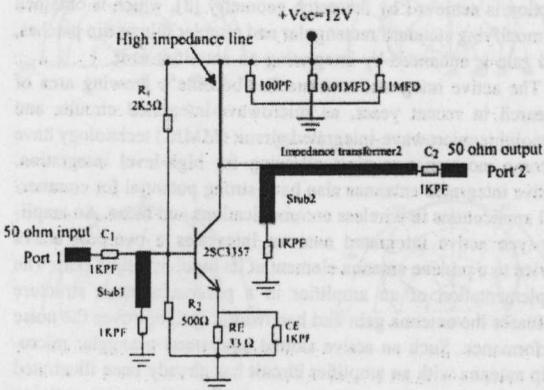


**Figure 1** Active antenna configuration (top view). [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

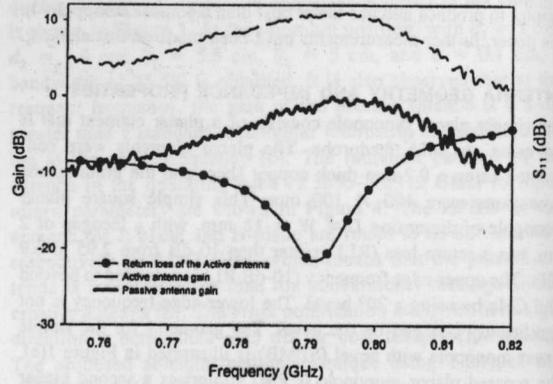
## 2. ACTIVE ANTENNA DESIGN

Figure 1 shows the top view of the proposed amplifier-integrated microstrip antenna. The antenna geometry is based on a rectangular geometry with its resonating edges replaced by two circular arcs of radii  $r_1 = r_2 = 6$  cm on two sides. The antenna and the amplifier circuit are etched on a substrate of thickness  $h = 0.148$  cm and relative permittivity  $\epsilon_r = 3.95$ , as shown in Figure 1. The antenna output is coupled to the input port of the amplifier using  $50\Omega$  microstrip feed line. Signal transmission can also be carried out using the same circuit by connecting the amplifier output to antenna input.

The schematic diagram of the amplifier circuit is shown in Figure 2. The transistor used is an NEC 2SC3357, with input impedance of  $51 + j0.3084\Omega$  and output impedance of  $91.67 + j43.56\Omega$  at 800 MHz. The amplifier is biased for class A operation. The input and output of the transistor are conjugate matched to the source and load impedance, respectively, using microstrip short-circuited stubs and impedance transformers [5]. A high-impedance microstrip line is used as load impedance at the collector of the transistor.  $R_1$  and  $R_2$  are potential divider bias resistors and  $R_E$  is the emitter resistor.  $C_1$  and  $C_2$  are input and output coupling capacitors and  $C_E$  provides emitter bypass capacitance.



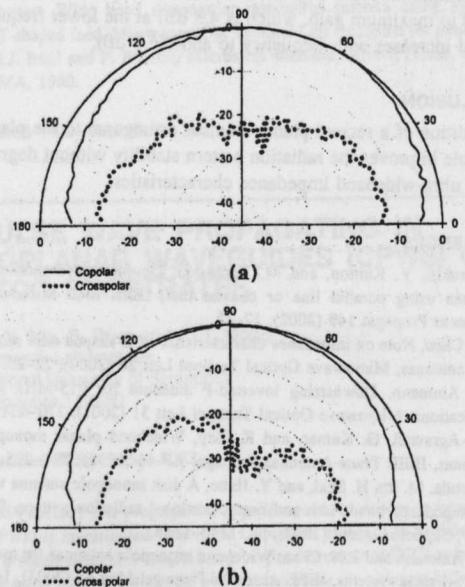
**Figure 2** Schematic diagram of the BJT amplifier. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



**Figure 3** Return loss and gain curves of the passive and active antenna

## 3. RESULTS AND DISCUSSION

The active receiving microstrip antenna is fabricated and the impedance bandwidth, relative gain, and radiation patterns are measured using an HP 8510C vector network analyzer. Figure 3 shows the return-loss curve of the active receiving antenna. Relative gain of the active antenna compared to the passive element is also plotted in the figure. It is observed that the proposed antenna has an impedance bandwidth of  $\sim 4\%$  and a gain enhancement of 10 dB, compared to that of the passive counter part.  $E$ - and  $H$ -plane radiation patterns of the antenna at 790 MHz are shown in Figure 4. The patterns are broad as in the case of standard rectangular microstrip patch and cross-polarization levels are better than 20 dB. The antenna exhibits similar property in the transmission mode by reversely connecting the amplifier circuit. The overall size of the antenna including the amplifier circuit is  $36\text{ cm}^2$ , whereas the size of a circular microstrip antenna operating at this frequency is  $121\text{ cm}^2$ . Thus, the size of the new antenna is only 30% of the circular microstrip antenna.



**Figure 4** Radiation patterns of the active antenna at 790 MHz: (a)  $E$  plane; (b)  $H$  plane

#### 4. CONCLUSION

An active microstrip antenna with a 70% size reduction, compared to a standard circular microstrip patch antenna designed for the same frequency, has been presented. This design provides an enhanced gain and bandwidth compared to those of passive element. The measured enhanced gain of the active antenna is 10 dB with a bandwidth of  $\sim 4\%$ , which is 2.5 times larger than that of passive microstrip antenna.

#### ACKNOWLEDGMENT

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