Broadband Printed Antenna with Double Rectangular Loops

Satoshi TANAKA, Toshikazu HORI, and Mitoshi FUJIMOTO

Faculty of Engineering, University of Fukui, 3-9-1 Bunkyo, Fukui, 910-8507 Japan

E-mail:tanaka@wireless.fuis.fukui-u.ac.jp

Abstract Broadband antennas are required to establish ultra wideband (UWB) systems. This paper proposes a double rectangular loop printed antenna with wideband VSWR (Voltage Standing Wave Ratio) characteristics and describes the optimum design method for this antenna by using the moment method. Based on the simulation and experimental results, we verify that the performance of the simple broadband printed antenna has a 76% relative bandwidth.

Keywords: Printed Antenna, Rectangular Loop, Broadband, UWB

1. INTRODUCTION

In recent years, the demand has increased for improvement in speed in radio communication systems. For example, research is being promoted on the next-generation mobile communication systems that achieve high-speed communication of 100 Mbit/s using the ultra wideband (UWB) radio system [1]. The UWB communication system, which uses a pulse signal or is based on OFDM technology, utilizes a very wide frequency bandwidth compared to conventional radio communication systems. Therefore, very wideband characteristics are also required for the antennas which behave as a matching device to space.

These wideband antennas have already been developed for measurements, however, it is important to develop low cost and compact antennas that have wideband characteristics for practical use. Thus, the authors proposed the double loop rectangular print antenna as a simplified wideband antenna [2]. In this paper, we clarify the optimal structure of the double rectangular loop print antenna.

In Section 2, the basic structure of the double loop print antenna is described, and the structure and the characteristics of a wideband VSWR antenna are shown. In Section 3, the possibility of achieving the UWB antenna is discussed based on a comparison of experiment results.

2. BASIC STRUCTURE OF DOUBLE RECTANGULAR LOOP PRINT ANTENNA

The structure of the dual rectangular loop print antenna is shown in Fig. 1. The antenna comprises two one-wavelength rectangular loop antennas on a printed circuit board. The feed point is located at the joint of the two loops. The length of a side of the outer loop, the length of a side of the inner loop, and the length of the parallel conductor are ℓo, ℓi, and h, respectively. The distance of the parallel conductors and the radius of the conductors are d and r, respectively. We analyzed the antenna using the moment method. We assumed in the simulation that the radius of the loop conductor is $r/\ell o = 0.04$. Moreover, the influence of the dielectric of the circuit board is disregarded.

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3. STRUCTURE AND PERFORMANCE OF WIDEBAND ANTENNA

3.1 Optimization of Structure Parameters

Figure 2 shows the variation in the relative bandwidth where the VSWR is less than 2.0 as the length of a side of the inner loop, ℓi, and the length of a parallel conductor, h, are changed. In the figure, the values of the horizontal axis, ℓi, and the vertical axis, h, are normalized by ℓo. Here, d/ℓo = 0.125. We can see from Fig. 2 that the wideband characteristics greater than 40% of the relative bandwidth cannot be obtained when the length, ℓi/ℓo, of a side of the inner loop is longer than 0.58 and the tendency does not to depend on the length of the parallel conductor. The maximum value of

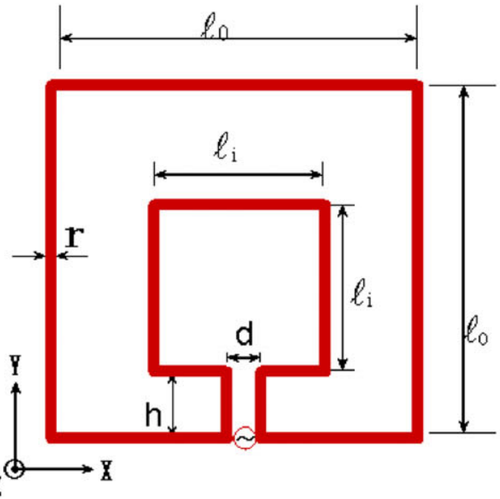


Fig. 1 Double rectangular loop print antenna

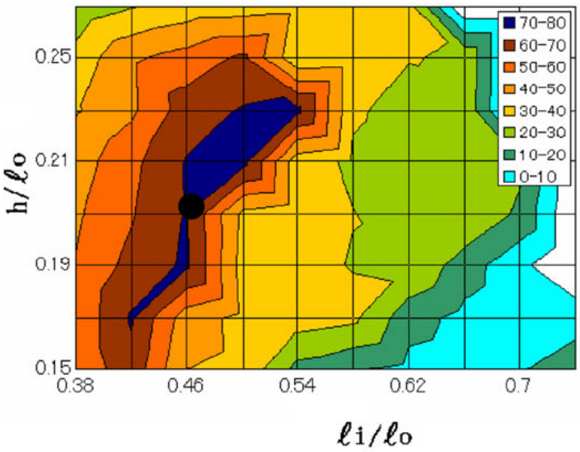


Fig. 2 Relative bandwidth distribution as a parameter of size of inner loop and length of parallel conductor

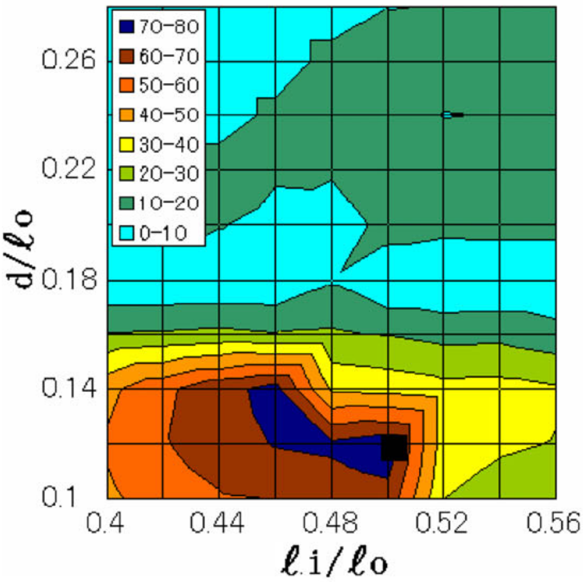


Fig. 3 Relative bandwidth distribution as a parameter of size of inner loop and distance parallel conductor

the relative bandwidth is obtained around the mark ● (ℓi/ℓo = 0.46, h/ℓo = 0.2), and the value of 74% can be achieved.

Next, Fig. 3 shows the relative bandwidth below VSWR = 2, when the length of a side of the inner loop, ℓi, and the distance of the parallel conductor, d, are changed. Here, h/ℓo is set to 0.2, which exhibited the maximum bandwidth in Fig. 2. Figure 3 shows that wideband characteristics cannot be obtained when distance d/ℓo of the parallel conductor is longer than 0.16 and the tendency does not depend on the length of a side of the inner loop. The maximum value of the relative bandwidth is obtained around the mark ■ (ℓi/ℓo = 0.5, d/ℓo = 0.12), and the maximum value is 76%.

The variation in the relative bandwidth when ℓi/ℓo = 0.5 and d/ℓo = 0.12 is indicated in Fig. 4. As shown in the figure, the antenna achieves the best wideband characteristics when conductor radius r/ℓo = 0.04.

3.2 Characteristics of Antenna with Optimal Structure

It is clear in Section 3.1 that the ■ point (the length of a side of the inner loop is $\ell i/\ell o = 0.5$, the length of parallel conductor is $h/\ell o = 0.2$, the distance of the parallel conductor is $d/\ell o = 0.12$, and the conductor radius is $r/\ell o = 0.04$) has the maximum bandwidth. The VSWR characteristic of the antenna that has these dimensions is shown in Fig. 5. Here, the length of a side of the outer loop, ℓo, is 50 mm. Figure 5 shows that the VSWR value is less than 2.0 (return loss is greater than 9.6 dB) in the frequency range from 3.0 to 6.7 GHz (76% of the relative bandwidth).

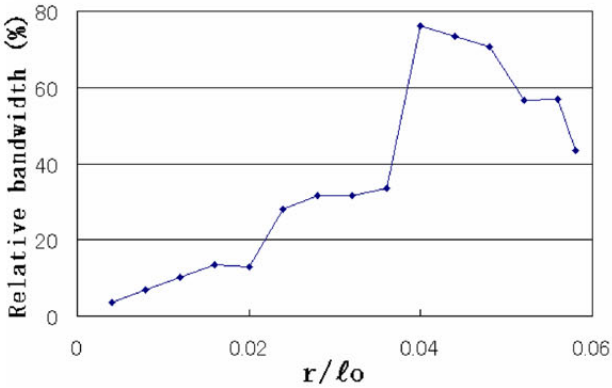


Fig. 4 Variation of relative bandwidth versus radius of conductor

Next, the radiation pattern in the Y-Z plane, the X-Z plane, and the X-Y plane at 5.3 GHz is shown in Fig. 6, Fig. 7, and Fig. 8, respectively. The maximum directivity is in the Y-Z plane, and leans to the Y-axis approximately 15 degrees from the Z-axis.

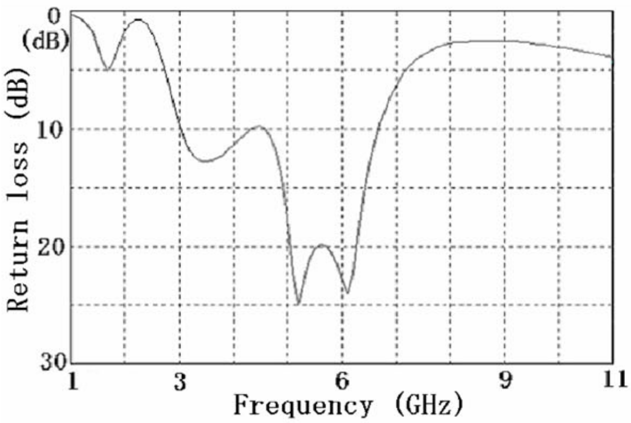


Fig. 5 VSWR characteristics of antenna with optimal structure

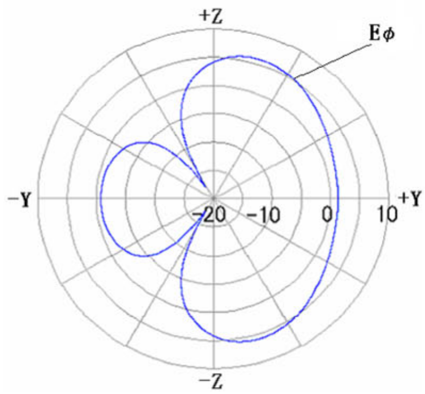


Fig. 6 Directivity in Y-Z plane

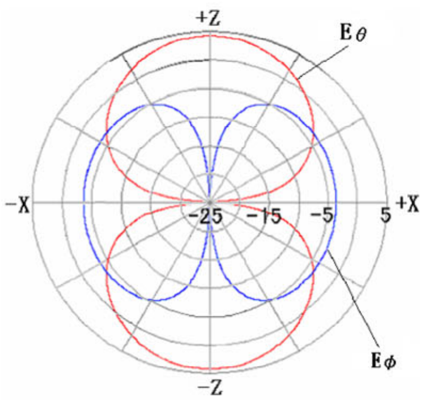


Fig. 7 Directivity in X-Z plane

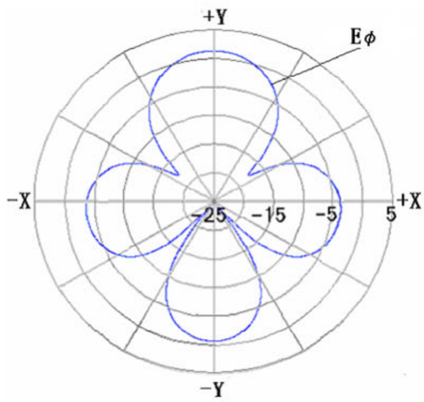


Fig. 8 Directivity in X-Y plane

3.3 Verification Through Experiments

In order to verify the validity of the calculated results, we measured the VSWR characteristics. A photograph of the antenna used in the experiment is shown in Fig. 9. The dimensions of the antenna are ℓi = 23 mm, d = 6.2 mm, h = 10.5 mm, and r = 2 mm. To measure the input impedance of the antenna using a coaxial cable, we must apply the balance to unbalance current converter. However, there is a concern that the converter will affect the accuracy of the measurements. Therefore, only half of the antenna is constructed on the ground plane, and we measured the input impedance utilizing the image currents. The measured results and calculated results using the same parameters are shown in Fig. 10(a) and Fig. 10(b), respectively. The figures show similar tendencies in which the return loss drops around 1.5 GHz and falls greatly from 3 GHz. Based on the comparison of the results, the simulation results are sufficiently reliable.

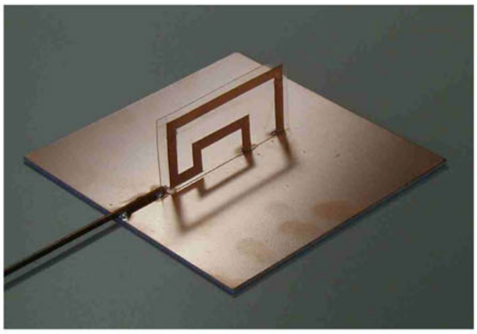
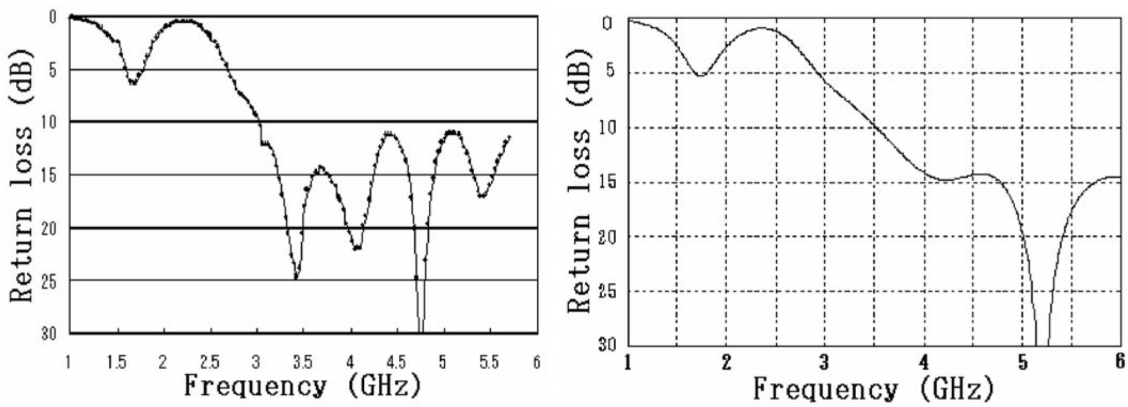


Fig. 9 Antenna for experiment



(a) Measured results Frequency (GHz) (b) Calculated results

Fig. 10 Comparison of simulation results to experimental results (VSWR characteristic)

4. CONCLUSION

A simple configuration was proposed for an antenna using two one-wavelength rectangular loops that have wideband characteristics. The optimized antenna (with the length of a side of the inner loop, ℓi; the length of the parallel conductor, h; the distance of the parallel conductor d; and the radius of the conductor, r) achieves 76% of the maximum relative bandwidth.

In order to verify the validity of the simulation, a prototype of the double rectangular loop print antenna was constructed. The simulation results agreed well with the experimental results.

REFERENCES

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