An Ink-Reducing Printed Rectangular CPW Antenna Design via Selective Area Thickening

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Abstract **- In this paper, we present an ink-reducing printed rectangular CPW antenna structure by defining a proper selective area for thickening the conductive ink layer. In this design, the microstrip feed line and the small section of ground elements near the microstrip feed line are made thicker than the other antenna areas. The simulation results illustrate that the proposed printed antenna structure can significantly reduce the conductive ink consumption by as much as 55% of the conventional flat printed antenna.**

Index Terms **— Printed antenna, rectangular CPW, ink-reducing antenna design, selective area thickening.**

1. Introduction

In recent years, the printing technologies have been applied for the antenna fabrication in order to lowering the production cost. The study in [1] demonstrated that the performance of a printed antenna which is generally poor due to the low electrical conductivity of the conductive ink can be improved by thickening the conductive ink layer. Furthermore, many optimization techniques have been proposed in [2]-[4] by selectively thickening the conductive ink layer in the area that has high current density. These techniques can minimize the amount of the conductive ink used while improving or maintaining the performance level of printed UHF RFID tag antenna and PIFA.

In this work, we present a printed rectangular CPW antenna structure for optimizing the amount of the conductive ink consumption. In the proposed antenna structure, the conductive ink layer of the microstrip feed line and the small section of the ground elements near the microstrip feed line is printed thicker than the other antenna area. The increase of the thickness in these areas can significantly improve the antenna performance while only small amount of the conductive ink is added. The simulation results show that the proposed antenna structure can efficiently reduce the amount of the conductive ink required for the antenna fabrication by 55%.

TABLE I
Parameters of Antenna Substrate and Conductive Material

Materials	Parameters	Value
PET substrate	Thickness	135 µm
	Relative permittivity	3.5
	Loss tangent	0.002
Silver ink	Thickness	1 µm
	Sheet resistance	0.2 Ω/sq

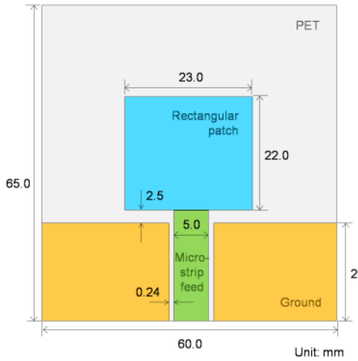

Fig. 1. A basic configuration of a rectangular CPW antenna.

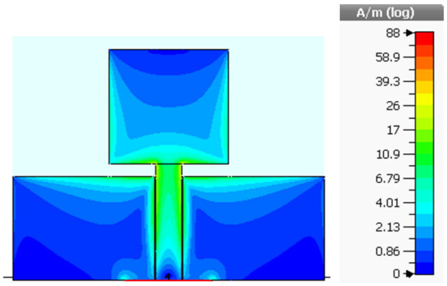

Fig. 2. The surface current of a rectangular CPW antenna.

2. Background

A basic printed rectangular CPW antenna design for Wi-Fi 2.4 GHz applications is shown in Fig. 1. An antenna consists of a rectangular patch, a microstrip feed line, and ground elements printed on a flexible PET substrate using conductive silver ink. The parameters of the PET substrate and the silver ink are listed in Table I. Fig. 2 illustrates the surface current distribution of this antenna structure at 2.45 GHz simulated using CST software. It can be clearly seen that the current largely concentrates at the microstrip feed line, the bottom and side edges of the rectangular patch, and the top and side edges near the feed line of the ground elements.

3. The Proposed Ink-Reducing Printed Antenna

The proposed ink-reducing printed rectangular CPW antenna structure is shown in Fig. 3. This structure is obtained based on the current density and simulation

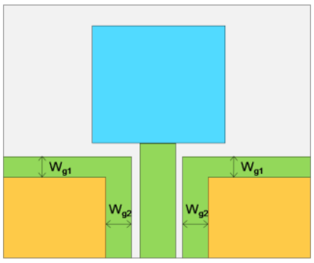

Fig. 3. The proposed ink-reducing antenna structure.

TABLE II
Number of Reprinting Process of Each Antenna Section.

#	1	2	3	4	5	6	7	8
N_{Tp}	1	1	1	2	3	4	5	6
N_{Tf}	2	4	8	8	8	8	8	8
N_{Tg}	1	1	1	2	3	4	5	6

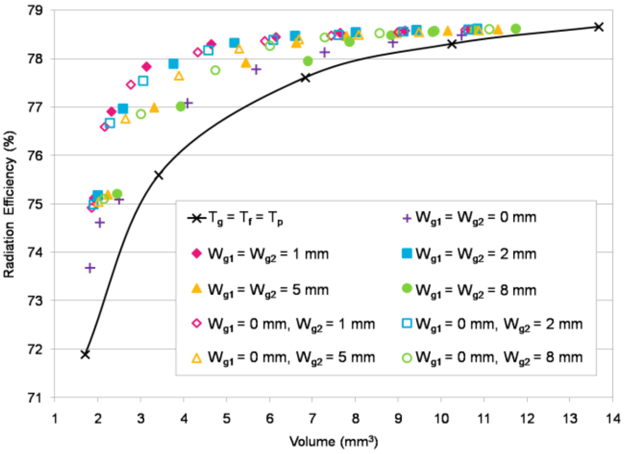

Fig. 4. Radiation efficiency of the proposed printed rectangular CPW antenna design.

results. In this structure, the ground elements are divided into 2 sections; the first section in green color where the thickness is set equal to that of the microstrip feed line and the second section in yellow color. The width of the first section on the top and side edges are W_{g1} and W_{g2}, while the thickness of the rectangular patch, the microstrip feed line, and the ground elements are defined as T_p, T_f, and T_g, respectively. Moreover, the thickness of the printed antenna can also be defined as the number of reprinting process for each antenna element. Thus, N_{Tp}, N_{Tf}, and N_{Tg} denote the number of reprinting process of the rectangular patch, the microstrip feed line, and the ground elements, respectively. Accordingly, the thickness can be obtained from $T_p = N_{Tp}T_c$, $T_f = N_{Tf}T_c$, and $T_g = N_{Tg}T_c$, where T_c is the thickness of one-layer conductive ink. The simulation results suggest that the thickness of the microstrip feed line should be larger than the thickness of the rectangular patch and ground elements in order to reduce the amount of the conductive ink while achieving the same level of the antenna performance.

4. Simulation Results

The simulation results in this work are obtained using CST software. The antenna dimensions are as shown in Fig. 1 and the properties of the PET substrate and the conductive silver ink are as listed in Table I. The number of reprinting process of each antenna section are listed in Table II. These numbers are obtained from the simulation results of the antenna with $W_{g1} = W_{g2} = 0$ mm that gives high radiation efficiency performance and consumes lower amount of the conductive ink. Then, the width W_{g1} and W_{g2} are varied to determine the structure that can efficiently reduce the amount of the conductive ink consumption.

Fig. 4 illustrates the radiation efficiency performance of the proposed rectangular CPW antenna structure as a function of the total conductive ink volume for various value of W_{g1} and W_{g2} comparing with the conventional flat antenna ($T_g = T_f = T_p$). Noted that a marker in each case corresponds to a design with different thickness as listed in Table II. It can be seen that the radiation efficiency of the proposed antenna structure effectively improves when increasing the thickness of the small section of the ground elements near the microstrip feed line. The smaller width W_{g1} and W_{g2} requires lower amount of the conductive ink consumption to achieve the same level of the radiation efficiency performance as the conventional one. For example, at the radiation efficiency level of approximately 78.3%, the conductive ink volume of the proposed antenna with $N_{Tp} = 2$, $N_{Tf} = 8$, $N_{Tg} = 2$, and $W_{g1} = W_{g2} = 1$ mm can be reduced by as much as 55% when compared with the conventional flat antenna with $N_{Tp} = N_{Tf} = N_{Tg} = 6$. Moreover, the conductive ink volume can be further reduced when the width $W_{g1} = 0$ mm and $W_{g2} > 2$ mm.

5. Conclusion

In this paper, we present an ink-reducing printed rectangular CPW antenna design. The conductive ink layer of the proposed antenna structure is thickened at the microstrip feed line and the small section of the ground elements located near the microstrip feed line. The simulation results show that the proposed design can save the conductive ink consumption by as much as 54.7%.

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