Improve Matching for Rectangular Slot Antenna by Parasitic Slots

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Abstract: A perfect matching is the desire of antenna designers. In this paper, we improve the matching of antenna designing. In general, the efficiency of antennas has many improvements. In this paper, we choose to extend matching by adding the slots in the basic microstrip-fed rectangular slot antenna. We called it as "parasitic slots". The dominant characteristic of this addition is double efficient improvement matching and other characteristics of antenna are similar. It means that the microstrip-fed rectangular slot antenna with parasitic slots has all characteristics as same as the microstrip-fed rectangular slot antenna without parasitic slots. The antenna with parasitic slots has better matching better than the antenna without parasitic slots.

Keywords: rectangular slot, parasitic slot, matching

1. INTRODUCTION

Microstrip antennas have the advantages of low-profile, lightweight antennas, low fabrication cost, most suitable for aerospace and mobile applications. These antennas can be used in low power transmitting and receiving applications because capability handling low power of them. It is the interesting antenna in this time. All microstrip antennas can be divided into four basic categories: microstrip patch antennas, microstrip dipoles, printed slot antennas, and microstrip travelling-wave antennas [1]. In this paper, we chose the microstrip-fed rectangular slot antenna that is the one of printed slot antennas.

In general, the efficiencies of microstrip slot antennas have many improvements, for example: Slot Array Antenna fed by Microstrip Line [2], A Large Bandwidth T-shaped Microstrip-Fed Ground Plane Slot Antenna [3], Characteristic of a Large Bandwidth Rectangular Microstrip-Fed Insert Triangular Patch in A Circular Slot Antenna [4], etc. They have both the addition and difference in geometrical shape. In this paper, we will add the slots in the basic rectangular slot antenna.

The antennas have many characteristics. The principal parameters of antennas are associated with the radiation pattern, the radiation efficiency, the input impedance, and the bandwidth. The input impedance of the antenna that is the one of all parameters is very important parameter because it can produce a perfect matching. A matched perfect antenna will radiate all power sent to the antenna by a transmission line. This occurs when the impedance of the antenna is equal to the characteristic impedance of the transmission line.

Often microstrip antennas are also referred to as patch antennas. Compact Boardband Microstrip Antenna [5] is an interesting research, which the bandwidth can also be increased by placing parasitic elements (dipoles) next to the main radiating patch. The side elements called *parasitic*, are excited by coupling from the main radiator, in the same manner as the secondary elements are excited in a Yagi-Uda antenna.

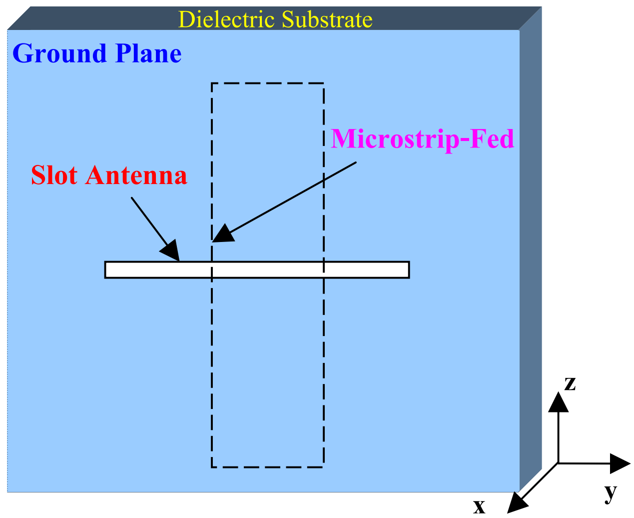

Fig. 1 Microstrip-Fed Rectangular Slot Antenna

2. MICROSTRIP-FED RECTANGULAR SLOT ANTENNA

A microstrip-fed rectangular slot antenna comprises a rectangular slot cut in the ground plane of the microstrip antenna. The slot is perpendicular to the microstrip line. For efficient excitation of the slot, the strip conductor is either short-circuited which we don't consider, or the strip conductor is terminated in an open-circuited stub beyond the edge of the slot as shown in Fig. 1 [6].

The length Lm of the open- circuited microstrip stub is approximately a quarter-wave as shown in Fig. 2.

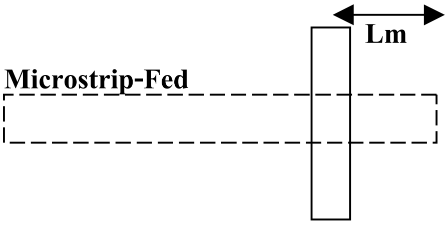

Fig. 2 Technique stub-tuning

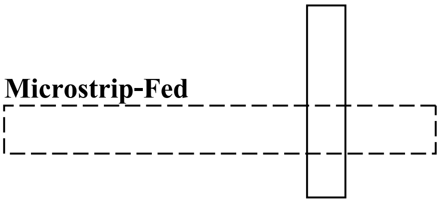

Fig. 3 Technique offset microstrip feed

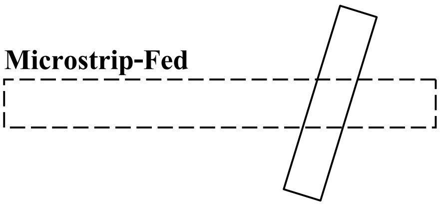

Fig. 4 Technique center-fed but inclined microstrip feed

For a given slot size, the resistance seen by the feed line can be reduced in three possible ways [7]. The first technique is very similar to that of Fig. 2 except that the length Lm of the microstrip stub is longer than a quarter-wave. The stub-tuning introduces reactive loading of the antenna, thereby changing the resonant frequency. The stub is designed so that the input resistance compares with the feed line impedance at the new resonant frequency. The second technique is off-center feeding as suggested [6] and shown in Fig. 3. The third technique feeding possibility is that the slot is center fed but is inclined as shown in Fig. 4.

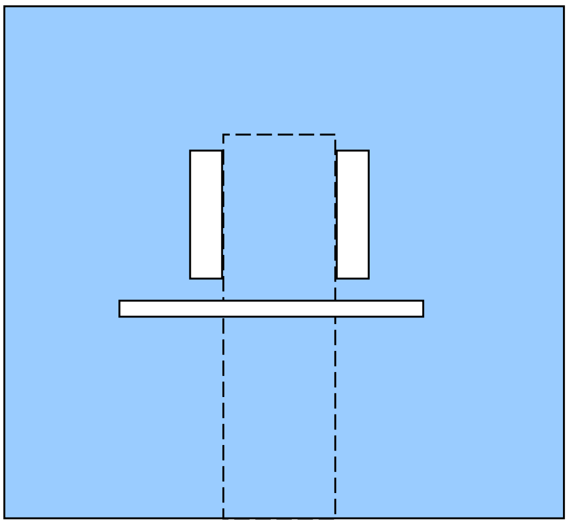
Fig. 5 The structure of the antenna with parasitic slots

3. DESIGN AND RESULTS

3.1 Parasitic Slot

The word “parasitic” usually refers to parasitic element of Yagi-Uda antenna so we refer to the principle of Yagi-Uda antenna.

It is not necessary to feed each element by direct connection to a transmission line. It only one dipole of such as array is directly fed, or driven, the field that it sets up will cause currents to flow in adjoining elements. This process is called parasitic excitation and the elements thus excited are parasitic elements.

In this paper, the parasitic element for adding in the microstrip-fed rectangular slot antenna has an aspect in rectangular shape and cut in the ground plane. We called it “parasitic slot”

3.2 Structure of Antenna with Parasitic Slots

Fig. 5 shows the structure of the microstrip-fed rectangular slot antenna with parasitic slots. Two parasitic slots have the same size and they placed perpendicular of slot antenna in the same plane. The widths of two parasitic slots are located parallel with slot antenna and lengths of two parasitic slots are located along the microstrip line.

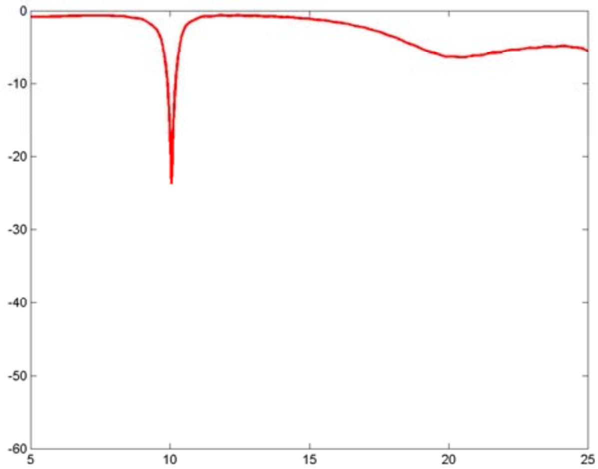

Fig. 6 The reflected loss of the microstrip-fed rectangular slot antenna without parasitic slots

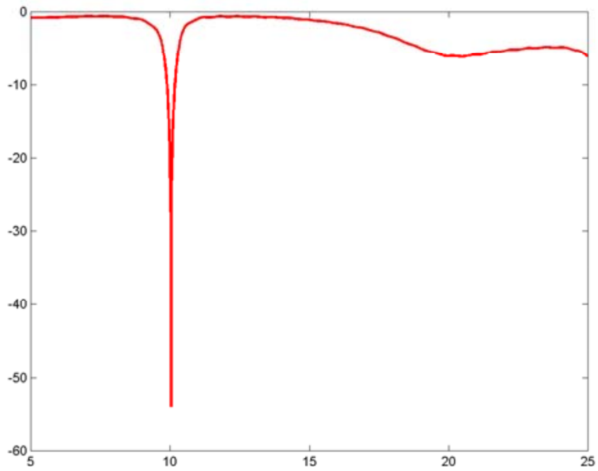

Fig. 7 The reflected loss of the microstrip-fed rectangular slot antenna with parasitic slots

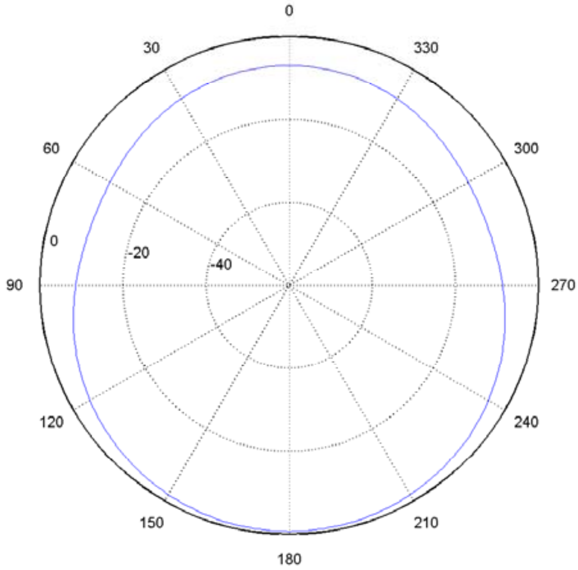

Fig. 8 the far-field radiation pattern on xy-plane of the antenna without parasitic slots.

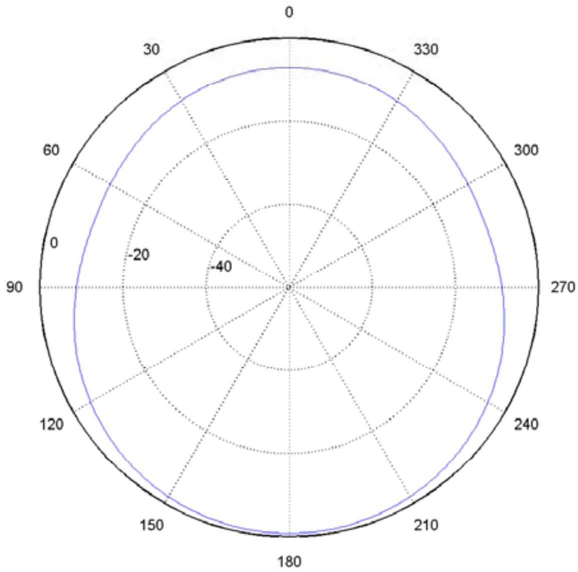

Fig. 9 the far-field radiation pattern on xy-plane of the antenna with parasitic slots.

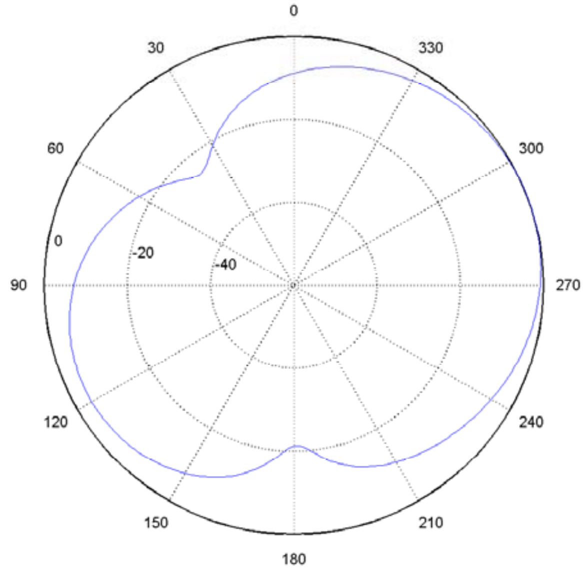

Fig. 10 The far-field radiation pattern on xz-plane of the antenna without parasitic slots

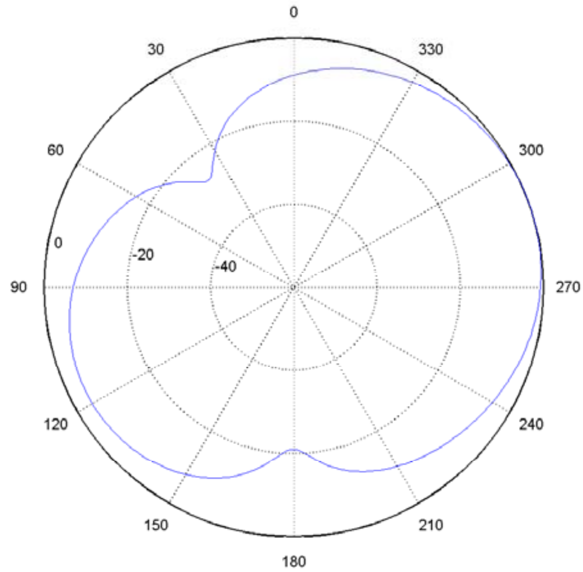

Fig. 11 The far-field radiation pattern on xz-plane of the antenna with parasitic slots.

3.3 Simulation

To simulate microstrip-fed rectangular slot antenna without parasitic slots and microstrip-fed rectangular slot antenna with parasitic slots, we used the FDTD analysis and design of microwave circuits and antennas software. This software is a full wave electromagnetic simulation code for general three-dimensional (3D) passive structures, particularly planar-oriented microwave circuits and antennas that based on the FDTD algorithm. It can get the results such as input impedance, S parameter and radiation pattern. For these reasons, it can get the good results by simulation.

3.4 Simulation Results

Before adding the parasitic slots, we must designed a microstrip-fed rectangular slot antenna for desire frequency. We can adjust the size of slot antenna and the length Lm for a good matching at design resonant frequency. We designed the antenna for resonant frequency at 10 GHz. Return loss or reflected loss (S11 parameter) of microstrip-fed rectangular slot antenna without parasitic slots is shown in Fig. 6.

The reflected loss of the antenna with parasitic slots is shown in Fig. 7. When we compared the return loss of simulation results between the antenna without parasitic slots and the antenna with parasitic slots, the antenna with parasitic slots (S11 equal –54.0271 dB) has the matching better than the antenna without parasitic slots (S11 equal –23.6354 dB).

Fig. 8 and 9 are comparisons of far-field radiation pattern on xy-plane between the antenna without parasitic slots and the antenna with parasitic slots, which are similar.

Fig. 10 and 11 are comparisons of far-field radiation pattern on xz-plane between the antenna without parasitic slots and the antenna with parasitic slots, which are similar.

Fig. 12 displayed the current density in slot antenna and current density in the parasitic slots. The current density in slot antenna is high and able radiation because the slot antenna excited directly by a strip line, but the parasitic slot excited by coupling from the slot antenna which can not radiate.

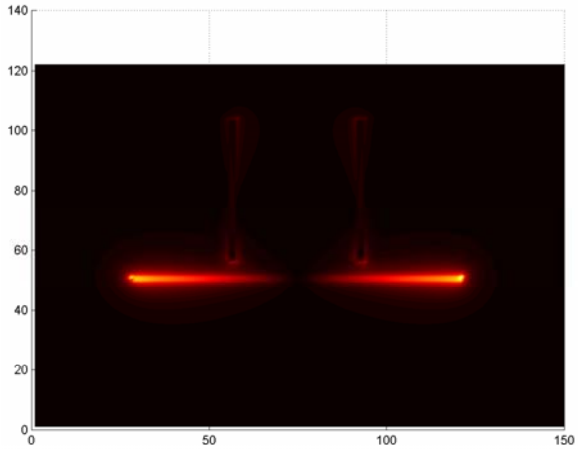

Fig. 12 The current density of the microstrip-fed rectangular slot antenna with parasitic slots.

4. CONCLUSIONS

The Parasitic slots in the basic microstrip-fed rectangular slot antenna make double decrease of return loss. The return loss is so less that matching improves better. This improvement by parasitic slots is trend to use in other frequency and other antennas. The important cause in improvement matching by parasitic slots is size and position of parasitic slots.

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