U-Slot Patch Antenna for Broadband Wireless Communications

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Abstract: - In this paper, a single patch wideband microstrip antenna resonating at 4.5 GHz is presented and the simulation results of its performance are reported. The antenna is compact, lightweight and cost effective with possible application in wireless communication link between wireless power sensors and a central control station in a power distribution system. It has a good gain and maintains a good return loss less than -10 dB from 4.05-4.85 GHz.

Key-Words: - Broadband antenna, microstrip antenna, U-slot antenna.

1 Introduction

There is no doubt the world is going wireless- faster and broader than people might have think. Researcher in this area believes all high-speed wireless technologies (3G, Wi-Fi*, WiMAX and Ultra-Wideband) will coexist, working in tandem to meet customer needs for mobile computing and communications across the globe. Therefore, a great deal of interest in the design of wideband antennas for wireless communication applications has been increased. These wideband antennas should exhibit a good impedance match and radiation pattern across the band. The contradiction between performance requirements and supporting demanding constraints make the selection or the design of an antenna something difficult as the large bandwidth places additional needs in comparison to narrowband radio. The second problem for the antenna designer is that he has no tools to evaluate the performance of an antenna embedded in a radio system, apart from tools intended to determine the antenna gain, return loss, and its radiation patterns. These tools are obviously quite important in order to describe where the direction of the radiation would go or would be received, and what signal power can be lost due to antenna losses, but nothing about the "matching" between the antenna and the channel.

Flat printed antennas are attracted much attention due to lightweight, compact and cost effective. However, its narrow bandwidth is a drawback. For this reason, much effort is made to develop techniques and find configurations to broaden its bandwidth. The most common techniques are height and increasing substrate decreasing permittivity. In 1995, Huynh and Lee [1] presented a new kind of broadband antenna with probe feed microstrip patch with U-Shaped slot. Since then, a number of experimental and theoretical papers have been reported for this antenna [2]-[16]. None of them has provided details parameter studies or design models that allow a prior design. In this paper, a single patch U-slot wideband microstrip antenna is presented and an approximate design rule for slot dimension is given based on former studies.

2 Antenna Design

The configuration of the antenna is shown in Fig.1. It has a single patch, which is characterized by (L, W) and coaxial probe is used for feeding this structure. Coaxial probe is one of the most popular feeding approaches due to ease in impedance matching and low spurious radiation. But it introduces an inductive part into the input impedance. Therefore, the probe radius has a significant effect on the performance of the antenna. So a clear approach to bandwidth improvement is to introduce a U-slot to cancel out this inductance.



Fig.1 Antenna Geometry

The substrate has a dielectric constant $\varepsilon_r = 1.06$ and thickness h=5 mm. The dimension of the antenna is GD_L (Ground length) =90 mm, GD_W (Ground width) = 80 mm, SD_L (Substrate length) = 90 mm, SD_W (Substrate width) =80 mm, L (patch length) =36 mm, W (patch width) =26 mm. The slot length L_u=10 mm, width W_u= 14 mm and thickness t= 2 mm. The coaxial probe is at center position. U slot is positioned symmetrically with respect to the feed point.

3 Results and Discussions

The ordinary microstrip patch antenna can be modeled as a simple RLC resonant circuit. Current flows from the feeding point to the top and bottom edges of patch. This current path length determines L and C values. This value as well as resonance feature changes when U slot is incorporated into this patch, and increase the bandwidth. Slot performs an important role to control the wideband behavior as well as resonance f of the patch antenna. There are three parameters to describe the slots-slot length, slot position and slot width. The slot length is an important factor to characterize the resonance f.

The predicted value of f_{res} is calculated with having an assumption that the value of $2W_u+L_u-2t$ is almost equal to a half wavelength.

The resonance f is,

$$f_{res} = \frac{C}{\lambda_o \sqrt{\varepsilon_r}} \text{ where } \frac{\lambda_g}{2} = (2w_u + L_u - 2t)$$

The real and the predicted value are given in table 1.

Table 1		
ε _r	<i>f_{res}</i> (GHz)	$f_{res}(\text{ GHz})[\text{ Predicted}]$
1.06	4.5	4.32

The discrepancy of the center frequency between the computed and predicted results is about 4%.

Former studies state that the antenna's broadband characteristics are the result of reactive cancellation between the capacitive U-slot and the inductive probe feed and/or currents around the U-slot [1], [8]. The other reason, for broadband characteristics is the low Q-factor of the antenna. A thicker antenna substrate produces a low Q-factor, which increases the bandwidth. However, the position of U slot is also a factor.

The Gaussian pulse is used to simulate this probefeeding configuration. The currents on the patch surface cannot be separated into pure modes of either the slot or the patch. Therefore, each slot parameter variation causes some changes in the resonant frequencies. However, some of these parameter produce more announced effect than others.

The reflection coefficient is one of the important issues to characterize the microstrip components. Fig.2 shows the reflection coefficient in dB (return loss) of the antenna. The reflection is -10dB from 4.05 GHz to 4.85 GHz, giving a bandwidth of 0.8 GHz.



Fig.2 Return Loss of the antenna

Fig.3 shows the radiation pattern at 4.5 GHz. The gain of this antenna is 10.2dBi with angular width [3dB] 50.3deg, which is feasible for communication link between wireless power sensors and a central control station in a power distribution system.



Fig.3 Radiation pattern of the antenna

4 Conclusion

In a power distribution system, power sensors constantly monitor the power. When a fault is sensed a wireless signal can be immediately sent to the central control station. Upon receiving that information, the load is redistributed among other routes. This requires a direct line of sight with high gain data communication link. Results obtained numerical simulation demonstrate from the wideband nature with high gain of a single radiating structure. This makes the antenna multi-channel operation for various sensors in a power distribution system. In fact, a 0.8 GHz bandwidth U-slot patch antenna, applicable to wireless communication frequencies of 4.05 to 4.85 GHz, is designed and characterized in this paper.

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