The Design of a Miniature Antenna for Wi-Fi
Enabled Memory Card

Xi Lin Chen* and Niels Kuster
IT’IS Foundation
Zeughausstrasse 43
8004 Zurich, Switzerland
Email: vick@itis.ethz.ch
kuster@itis.ethz.ch

Yu Chee Tan
Green Antenna Pte. Ltd.
29 Mandai Estate 07-11, Singapore 729932
Email: ga@green-antenna.com

Nicolas Chavannes
Schmid and Partner Engineering AG
Zeughausstrasse 43
8004 Zurich, Switzerland
Email: chavanne@speag.com

Abstract—With the increasing popularity of wireless capability of contemporary electrical devices, the demand for small and efficient antenna design is also on the rise. This paper presents the design and implementation of a miniature antenna for Wi-Fi enabled Secure Digital (SD) card to be used in a digital camera. The challenges faced in the design of such antenna are the limited antenna volume and the severe loading from nearby metallic structures. The design is optimized using simulation tool prior to prototype modeling and measurement. Antenna efficiency of 38% is achieved in actual operating environment when the memory card is placed inside a camera.

I. INTRODUCTION

Wi-Fi enabled Secure Digital (SD) memory card is becoming popular in recent years as a mean of wireless data transfer from digital camera to personal computer or web storage space. The operating frequency of such Wi-Fi memory card is at 2.4 GHz ISM band set by IEEE 802.11 b/g/n standards. In addition to a Wi-Fi transceiver module, the memory card also needs to incorporate a build-in antenna to realize its wireless capability. When inserted into a digital camera, the memory card draws power from the camera and acts as a Wi-Fi module for data transfer. Due to the small physical size of a typical SD memory card, only a small volume can be assigned to the antenna. Furthermore, when inserted into a camera, the memory card is placed in close proximity to metallic objects such as card holder, battery and camera printed circuit board (PCB). As a result, severe loading could cause the antenna to exhibit inadequate bandwidth and radiation efficiency. To overcome the aforementioned constraints, a miniature antenna design with satisfactory bandwidth and efficiency performance is desired.

II. ANTENNA CONFIGURATION

Low profile and miniature antenna design always poses challenge to an antenna engineer since bandwidth and radiation performance is directly associated with the allocated antenna volume and operating environment. Several low profile antenna designs have been proposed in the past, e.g., inverted L antenna [1] and inverted F antenna [2]. In this study, an antenna as shown in Fig. 1 is proposed as the Wi-Fi memory card antenna. This antenna design is inspired by the folded dipole antenna [3] of which a single-end feed is applied to one port while the other port is grounded. The antenna is mounted on the PCB of a memory card which is enclosed by a plastic housing of approximately 0.5 mm thickness. The memory card has a total dimension of 32 mm \( \times \) 24 mm \( \times \) 2.1 mm.

Fig. 1. The proposed antenna integrated in a memory Card

A. Antenna Design

The proposed antenna exhibits a 2D profile and occupies a surface area of 21 mm \( \times \) 5 mm. The available space for the antenna is limited by the component-free memory card PCB surface. The width of the antenna trace is kept at 0.5mm while the total length of the antenna measured from the feed point to the ground point can be adjusted to achieve resonance at 2.4 GHz when the memory card is placed inside a camera. As shown in Fig. 1, a conductive patch is placed along the slot of the antenna. This patch short-circuits the upper and lower antenna traces and serves as a mechanism for impedance match. The inclusion of this patch shortens the electrical length of the antenna and in the mean time effectively increases
the antenna input impedance. As a result, no lump element matching circuit is required for the proposed antenna design.

B. Operating Environment

As the Wi-Fi enabled memory card is designed to operate with a digital camera, the actual antenna system can only be described when the card is placed inside a camera. In many digital camera products, the memory card slot is placed at the corner of the camera PCB and often shares the same compartment with batteries. As shown in Fig. 2, a typical camera chassis and memory card placement is modeled in a computer-aided-design (CAD) environment [4]. The AA-size batteries and metal battery cover are made transparent to reveal the memory card and antenna behind them.

Fig. 2. SD card with antenna placed in a camera chassis (camera placed up-side-down)

As shown in Fig. 3, when inserted into a camera, a large portion of the memory card is enclosed by a metal card holder which is grounded to the camera PCB through multiple grounding pins located at the corners of the card holder. The volume which is not enclosed by the card holder can be treated as the potential antenna volume. Although not shown in Fig. 3, batteries are often located right on top of the memory card as depicted in Fig. 2. When fully inserted into the card holder, the memory card is interfaced with the camera PCB through nine connection pads; two out of the nine pads serve as DC ground contacts, i.e., the memory card PCB is grounded to the camera PCB through these ground contacts. To summarize, the final operating environment for the proposed antenna design should incorporate the effects of memory card holder, battery parts and camera chassis.

III. RESULTS AND DISCUSS

The proposed antenna design is first simulated using a FDTD-based numerical solver [4]. A commercially available camera unit is used as a basis for the design. In the simulation environment, simplified CAD objects such as cylinder and block are used to represent the memory card and camera structures (Fig. 1 and 2). Metal and plastic components are modeled with lossy metal and lossy dielectric material properties to incorporate a reasonable amount of loss in the system. The antenna dimensions are optimized using Genetic Algorithms [5] targeting optimum impedance match and resonance at 2.4 GHz. Subsequently, physical prototype based on the numerically optimized antenna is constructed to be measured in an anechoic chamber.

A. Simulation Results

The proposed antenna design is optimized in simulation to achieve 50 ohm impedance match at 2.4 GHz. For the optimized antenna parameters, the total length of the antenna trace is 50 mm, the slot width is 1mm and the gap between feed and ground points is 1.5 mm. As shown in Fig. 4, the proposed antenna is well matched at 2.4 GHz and exhibits approximately 200 MHz bandwidth for a return loss of 5 dB. The impedance matching effect of the short circuit patch is also clearly shown in the S11 plot.

Fig. 4. Simulated antenna S11 with and without shorting patch
The simulated total radiation efficiency of the proposed antenna is 65% at 2.4 GHz. The simulated radiation pattern (Fig. 5) indicates that the proposed antenna radiates along the left and right sides of the camera with nulls on the top and bottom of the camera. Hence the antenna system will be able to provide adequate signal coverage in an actual communication environment, e.g., when the camera is placed on a table.

**B. Measurement Results**

Based on the simulation-optimized antenna parameters, prototype of the proposed antenna is built on a memory card PCB. As shown in Fig. 6, some fine tuning of the antenna dimensions is required for the antenna fixture.

![Fig. 6. Memory card antenna fixture](image)

The antenna fixture is placed inside a camera unit (Fig. 7) and the corresponding $S_{11}$ is measured using vector network analyzer. It is observed that the prototype antenna is well matched to 50 ohm at 2.4 GHz and exhibits a broader bandwidth than the simulated one (Fig. 8). The additional resonance around 2.5 GHz which is responsible for the broadened bandwidth is postulated to be caused by the difference in ground plane coupling between simulation model and actual camera hardware.

![Fig. 7. Memory card fixture inside a camera unit](image)

The camera unit is placed inside an anechoic chamber in which the antenna efficiency and radiation pattern are measured. Proper choking is applied during return loss and efficiency measurement by the use of a sleeve balun (Fig. 9). As shown in Fig. 10 and 11, the measured radiation pattern is in good agreement with the simulated pattern. It should be noted that the $x-y-z$ axis orientation is different between the simulation and measurement results. The measured antenna efficiency is 38% at 2.4 GHz which is lower than the simulated efficiency. The discrepancy between simulated and measured efficiency is mainly caused by the structure loss in the actual camera system which is not captured in the simulation environment. The structure loss could be contributed by dielectric and ohmic loss from components and ground contacts. As the
actual camera structure is far more complex compared to the simplified simulation model, it is reasonable to expect a higher antenna efficiency from the simulation result.

![Fig. 9. Measurement set-up with sleeve balun](image)

![Fig. 10. Measured 3D radiation pattern](image)

IV. CONCLUSION

A miniature antenna design is proposed and implemented for Wi-Fi enabled memory card application. A short circuit patch is placed along the antenna slot for impedance matching and resonance tuning. The operating environment of the antenna, i.e., when the memory card is placed inside a digital camera, is investigated. The antenna design is optimized in simulation prior to prototype construction and measurement. The measured radiation efficiency of the proposed antenna, when embedded inside an actual camera unit, is found to be 38%.

ACKNOWLEDGMENT

This study is supported by Commission for Technology and Innovation (CTI), Switzerland, Schmid and Partner Engineering AG, Switzerland and Green Antenna Pte. Ltd., Singapore.

REFERENCES