# CARD-BASED DIVERSITY ANTENNA STRUCTURE FOR WIRELESS COMMUNICATIONS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to antennas, and more specifically to small antenna structures possessing diversity characteristics.

2. Discussion of the Related Art

A multipath environment is created when radio frequency (RF) signals propagate over more than one path from the transmitter to the receiver. Alternate paths with different propagation times are created when the RF signal reflects from objects that are displaced from the direct path. The direct and alternate path signals sum at the receiver antenna to cause constructive and destructive interference, which have peaks and nulls. When the receiver antenna is positioned in a null, received signal strength drops and the communication channel is degraded or lost. The reflected signals may experience a change in polarization relative to the direct path signal. This multipath environment is typical of indoor and in-office wireless local area networks (WLAN).

An approach to addressing the multipath problem is to employ multiple receiver antenna elements in order to selectively receive a signal from more than one direction or from a slightly different position. This approach, known as "diversity", is achieved when receiving signals at different points in space or receiving signals with different polarization. Performance is further enhanced by isolating the separate antennas. Wireless communication link bit error rate (BER) performance is improved in a multipath environment if receive and/or transmit diversity is used.

Conventional antenna structures that employ diversity techniques tend to be expensive and physically large structures that utilize bulky connectors, such as coaxial cable connectors. Such antenna structures are not suitable for residential and office use where low-cost and small physical size are highly desirable characteristics. Thus, there is a need for antenna structures capable of employing diversity techniques that overcomes these and other disadvantages.

## SUMMARY OF THE INVENTION

The present invention advantageously addresses the needs above as well as other needs by providing an antenna structure that includes a card, at least two antenna elements, and active circuitry. The at least two antenna elements are attached to the card at a first end thereof. The active circuitry is attached to the card and coupled to the at least two antenna elements. At least two of the at least two antenna elements are sufficiently spaced apart so as to achieve spatial diversity.

In another embodiment, the invention can be characterized as an antenna structure that includes a card, at least two antenna elements, and active circuitry. The at least two antenna elements are attached to the card at a first end thereof. The active circuitry is attached to the card and coupled to the at least two antenna elements. A first of the at least two antenna elements comprises a polarization that is orthogonal to a polarization of a second of the at least two antenna elements so as to achieve polarization diversity.

In a further embodiment, the invention can be characterized as a method of receiving a signal in a multi-path environment. The method includes the steps of: placing a card in the multi-path environment, the card having active circuitry attached thereto; receiving the signal with a first antenna element attached to the card at a first end thereof; and receiving the signal with a second antenna element attached to the card at the first end thereof; wherein the first and second antenna elements are coupled to the active circuitry.



In an additional embodiment, the invention can be characterized as a method of transmitting a signal in a multi-path environment. The method includes the steps of: placing a card in the multi-path environment, the card having active circuitry attached thereto; transmitting the signal with a first antenna element attached to the card at a first end thereof; and transmitting the signal with a second antenna element attached to the card at the first end thereof; wherein the first and second antenna elements are coupled to the active circuitry.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features and advantages of the present invention will be more apparent from the following more particular description thereof, presented in conjunction with the following drawings wherein:

FIG. **1** is a perspective diagram illustrating a computer having inserted therein a multi-antenna element structure made in accordance with an embodiment of the present invention;

FIGS. **2**A and **2**B are perspective views illustrating the top and bottom surfaces, respectively, of the multi-antenna element structure shown in FIG. **1**;

FIGS. **3**A and **3**B are perspective views illustrating the top and bottom surfaces, respectively, of a multi-antenna element structure made in accordance with another embodiment of the present invention;

FIGS. **4**A, **4**B and **4**C are a top view, center layer view, and bottom view, respectively, of the multi-antenna element structure shown in FIGS. **3**A and **3**B;

FIGS. **5**A and **5**B are perspective views illustrating the top and bottom surfaces, respectively, of a multi-antenna element structure made in accordance with another embodiment of the present invention;

FIGS. **6**A, **6**B and **6**C are a top view, center layer view, and bottom view, respectively, of the multi-antenna element structure shown in FIGS. **5**A and **5**B;

FIG. **7** is a plot illustrating antenna gain patterns for the multi-antenna element structure shown in FIGS. **5**A and **5**B;

FIGS. **8**A and **8**B are partial perspective views illustrating the top and bottom surfaces, respectively, of a multi-antenna element structure made in accordance with another embodiment of the present invention;

FIGS. **9**A, **9**B and **9**C are a top view, center layer view, and bottom view, respectively, of the multi-antenna element structure shown in FIGS. **8**A and **8**B;

FIGS. **10**A and **10**B are partial perspective views illustrating the top and bottom surfaces, respectively, of a multi-antenna element structure made in accordance with another embodiment of the present invention;

FIG. **11** is a plot illustrating antenna gain patterns for the multi-antenna element structure shown in FIGS. **10**A and **10**B; and

FIG. **12** is a partial perspective view illustrating in further detail the top surface of the multi-antenna element structure shown in FIG. **10**A.

Corresponding reference characters indicate corresponding components throughout the several views of the drawings.