Polarization Diversity Cognitive Antenna for WiFi and ZigBee Applications

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Abstract — The paper presents a cognitive antenna based on the Self-Structuring Antenna (SSA) technology that dynamically alters its aperture to maximize Signal-to-Noise-Ratio (SNR) in varying RF environments. A polarization-diversity antenna, which is a simple implementation of the SSA, has been built and tested for WiFi applications. The low profile prototype uses self-structuring feed and has proved effective in improving signal strength and data rates, and is compatible with MIMO implementation.

***Index Terms* — WiFi, ZigBee, Adaptive, Polarization-Diversity, MIMO, Selection Diversity.**

I. Introduction

Today's communication systems require high channel capacity, which is measured in Bits/Hz/Second [1]. Multi-antenna systems such as MIMO offer a way of increasing channel capacity in multi-path rich environments but requires a minimum of two "statistically" independent signal channels on both the receive and the transmit side [2]. Polarization diversity is a cost-effective way to provide two channels using the same antenna [3], and this paper evaluates the effectiveness of a polarization diversity patch antenna in improving signal-to-noise-ratio (SNR) when used in a selection diversity setup [4]. The antenna design utilizes the Self-Structuring Antenna (SSA) configuration, and the results equally apply to WiFi and ZigBee communications.

II. Polarization Diversity Antenna

A polarization-diversity patch antenna has been built to demonstrate the effectiveness of self-structuring in a selection-diversity scheme. The antenna is the simplest form of a self-structuring antenna (SSA) [5], which is a patented technology, and makes use of a self-structuring feed for altering the polarization of the antenna. The antenna will be referred to as GEN 1 (Generation One) in this paper in relation to the GEN 2 (Generation Two) antenna, which, in addition to polarization diversity, also provides beam steering and is the subject of a separate paper [6]. Figure 1 shows the GEN 1 antenna, which is a patch antenna fed by two orthogonal feeds selected by a FET switch. Capacitors are used for DC blockage as well as for RF filtering on DC control lines. The right angle bends coming off the patch sides are quarter-wave impedance transformers allowing high-impedance co-planar feeding of the patch while the wider sections of the microstrip feed are 50 Ohms. The antenna parameters are given in Table I.

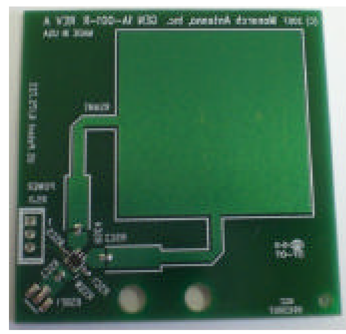

Fig. 1. Polarization Diversity Patch (GEN 1) Antenna printed on 0.093" (2.39mm) FR4 (Isola FR408) with nominal param[...] ng is 0.5 oz on e[...]

TABLE I
ANTENNA PARAMETERS

Frequency Range (S_{11} < -10dB)	2.40-2.48 GHz
S_{11}	-16 dB
Gain	2 dBi
X-Pol Isolation	-10 dBi
Front-To-Back Ratio	10 dB

III. Wi-Fi Environment

Figure 2 shows the WiFi experimental set up. Two identical Gateway laptops have been purchased. Each laptop came equipped with two printed inverted F antenna (PIFA) on upper corners of the screen (see Figure 3a) and the Intel Wireless card employing 802.11b/g/ selects one or the other depending on the signal quality (see Figure 3b). One laptop was kept untouched (same as out of the box) and the original antennas in the other were replaced by two GEN 1 polarization diversity patch antennas (see Fig. 3c).

Two software were installed on the laptops; both laptops had the same software for reading the Received Signal Strength Indicator (RSSI) from the Intel wireless card using the window's interface and the laptop with the GEN 1 antennas also had an extra control software for selecting the polarization of the GEN 1 antennas using DC bias. After going through all four polarization states (V-V, V-H, H-H, H-V), the control software settles on the state that produces the highest RSSI. This number was recorded in units of dBm on 23 arbitrary locations (with varying orientations of the laptop) in an indoor facility (see Figure 4) and compared to the reading from the original laptop (with the OEM's antenna). The readings are given in Table II showing that the GEN 1 antenna provided 5.26dB higher SNR on average. The number is significant considering that the GEN 1 is a unidirectional antenna (patch) while the OEM's antenna has omni coverage. Therefore, the increase in performance can only be attributed to polarization diversity.

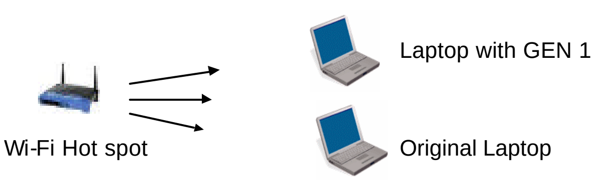

Fig. 2. Indoor WiFi evaluation setup. Two antennas are located at the upper left and upper right corners of the laptop screen.

IV. SUMMARY

A polarization-diversity patch antenna (GEN 1) has been presented for improving channel capacity in a selection diversity scheme using WiFi laptop as the application platform. Indoor experiments showed 5.26dB improvement in signal-to-noise-ratio (SNR) over the original PIFA. GEN1 is a simple implementation of the self-structuring antenna (SSA) technology and serves to illustrate the value of SSA.

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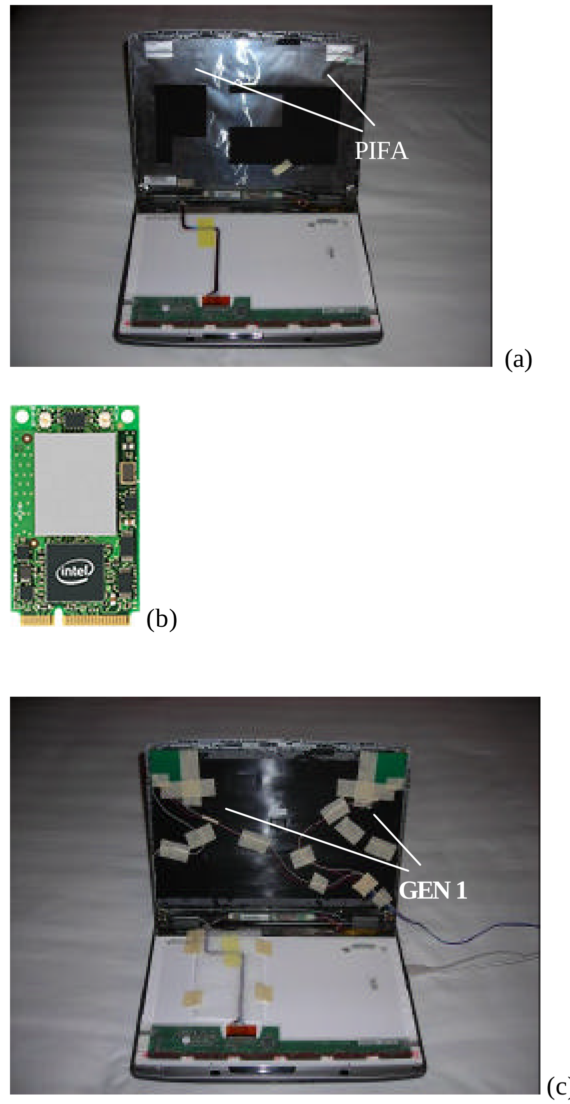

Fig.3. (a) Gateway NX570X laptop with the screen opened to expose the two PIFA on upper corners of the back cover, (b) internal Intel 802.11a/b/g wireless networking card selects between the two PIFA depending on which provides beter signal, (c) a second identical laptop with the PIFA replaced with Monarch's GEN 1 antennas.

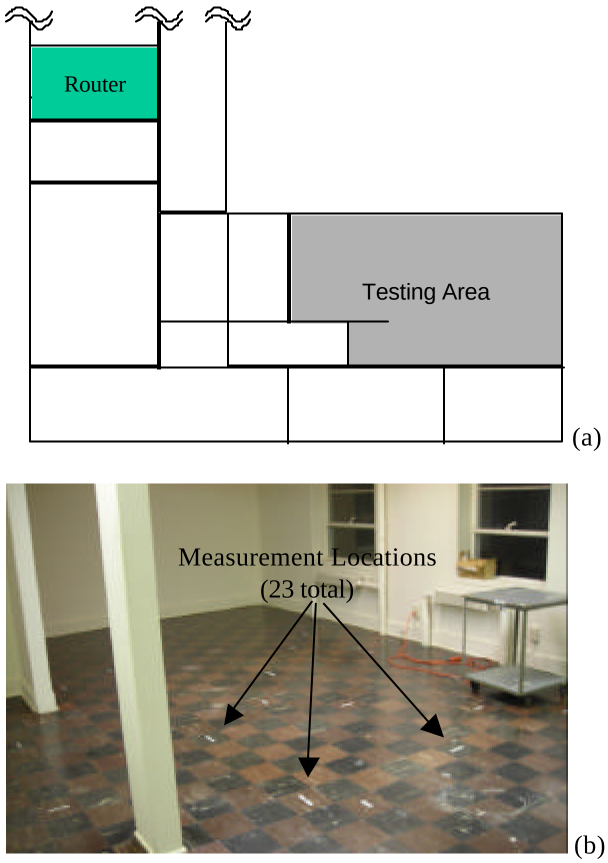

Fig.4. (a) Layout of the indoor testing facility where the RSSI from two laptops were recorded at nine arbitrarily chosen locations with arbitrary orientations of the laptop, (b) picture of the testing area showing the measurement locations marked with white tape on the tiles.

TABLE II
MEASURED RSSI VALUES IN dBm.

Location	PIFA	GEN 1	Difference
1	-69	-67	2
2	-73	-74	-1
3	-75	-69	6
4	-77	-65	12
5	-81	-75	6
6	-81	-81	0
7	-76	-61	15
8	-64	-75	-11
9	-74	-70	4
10	-71	-70	1
11	-72	-63	9
12	-78	-68	10
13	-81	-78	3
14	-71	-60	11
15	-77	-75	2
16	-75	-75	0
17	-79	-74	5
18	-79	-68	11
19	-84	-71	13
20	-82	-75	7
21	-75	-69	6
22	-76	-75	1
23	-77	-68	9
Average:	-75.96	-70.70	**5.26**

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