CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Dominic H. Catanzaro

Project Number
S0905

Project Title
Measuring the Index of Refraction of Various Prisms at 2.4 GHz

Abstract

Objectives/Goals
Many people have experienced problems with the WiFi internet connection to their devices. WiFi signals can be distorted and redirected due to the materials in a house.
The purpose of this project is to measure the index of refraction and transmission of various construction materials at WiFi frequency to better determine the effect that those materials may have on WiFi signals in a home or office building.

Methods/Materials
Using WiFi antennas to test materials turned out to be very difficult. I built a test range based upon a test range that Robert Shelby had used for his experiments for his PhD dissertation on metamaterials at 10.5 GHz. I scaled Shelby's design using the ratio of 10.5 GHz to 2.4 GHz. For a source and detector, I used a hobbyist RADAR designed by MIT.
I measured the refractive index by swinging the receiver around the prism every 10 degrees. To improve the accuracy of the assessment of the refraction, I used a weighted average.
Transmission measurements were conducted by measuring the power with and without the sample.

Results
All the building materials that I tested had an index of refraction of less than n = 1.2. Both types of insulation had an index of refraction less than n = 1.05. The two materials with a lower index of refraction, such as the insulation, were not very dense. Most of the materials that I tested transmit more than 80% of the energy. However, the lumber stands out with a transmittance of less than 60%. The water measurements indicate that aquariums and water pipes are the most likely to absorb WiFi signals. Insulation with foil does not transmit a measurable amount of WiFi signal. The foam insulation that is supposed to be installed upright in walls to insulate against heat and cold could potentially insulate against WiFi signals.

Conclusions/Discussion
The test range that I built was effective for material measurements. This implies that scaling Shelby's model was effective. Using WiFi for a test range was unsuccessful. Using parts from the MIT RADAR was successful because the RADAR was actually a much simpler system than the WiFi.
When building a home or office with the best possible WiFi propagation in mind, the house or office should be built of drywall, particle board, fiberglass insulation and thin wooden beams. Buildings with metal beams or sheets in them will reflect and negatively effect the WiFi propagation.

Summary Statement
I measured the index of refraction of various construction materials to better understand WiFi propagation in homes.

Help Received
Father helped build the RADAR electronics; Used lab equiment at school under the supervision of Dr. Bertch and my father