CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
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Project Number
S0703

Project Title
Brewster's Angle Effect on GPS Multipath

Abstract

Objectives/Goals
Brewster's angle is typically associated with light. However, it also has an effect on GPS Radio Frequency (RF) signals. When a GPS navigation signal is reflected off a material, it will change from a right hand circular polarized to a left hand circular polarized signal at Brewster's angle. If the reflected signal reaches a GPS antenna, it can cancel out the real or direct GPS signal. This is called multipath and it can cause a position error in a GPS receiver. The problem is how to determine Brewster's angle at the GPS frequency and its effect on the GPS receiver. My hypothesis states "If I can create a controlled GPS multipath environment, then I can determine Brewster's angle and determine the effect on the Global Positioning System signals for different materials".

Methods/Materials
I first created a controlled multipath environment by mounting my GPS antenna on a board and pointed the antenna towards the WAAS POR Geostationary (GEO) satellite. This satellite supplies a GPS signal but is a GEO satellite so its orbital position to earth stays the same. Also, this signal is lower power than GPS signals so it will react more to multipath. I then used different surface materials to determine their effect on the GPS receiver operations.

Results
My board was the propagation environment and it was big enough to contain the first Fresnel zone from 10 degrees to 50 degrees with an antenna height of 4 inches. Placing the board in line with the POR signal created a controlled multipath environment and tilting the board at different angles resulted in different multipath signals being received by the GPS antenna.

Conclusions/Discussion
The multipath signal did result in a disruption of signal power as I increased the angle of the board. For each surface type tested there was a complete loss of signal at a specific angle. Although this angle was not Brewster's angle, it did correspond to Brewster's angle by subtracting 7 degrees. The 7 degree difference is attributed to the internal GPS processing techniques.

Summary Statement
I determined Brewster's angle at the Global Positioning System (GPS) L1 frequency and what its multipath effect was on the GPS receiver operations.

Help Received
Dad helped with the test fixture design.