NEAR GROUND PROPAGATION MEASUREMENTS AT 2.4 GHz

By John Murch

This work was supported by the University of Vermont’s URECA! (Undergraduate Research Endeavors Competitive Awards) and Sigma Xi’s Grants in Aid of Research Program (GIAR) programs.

What Are Wireless Sensors

- A device that gathers information and transmits the data using wireless communication
- A wireless network is a gathering of wireless sensors that work together

Images: UC Berkeley: COTS Dust and UCLA/Rockwell: WINS
Why Wireless sensors?

- It is a challenge to collect data in field studies from remote or inhabitable locations.
- The use of wireless sensors allows one to drop these sensors all over (e.g. airdrop) and have the data collected centrally and then emailed via the Internet.
- This allows for remote monitoring to happen without the variable of human disruption.

The Problem

- One of the main problems of wireless sensor networks is power.
  - The wireless sensor requires power to not only collect the data, but also to send data.
  - In a multi-hop topology, sensor data is relayed by other sensors in the network.
  - The loss in power from one sensor to the other in short distance and near to low ground is studied in my research.
The “Arctic “ Test Site

- The rugby field on main Street and Spear St was the Test Site
- The simulated an Arctic environment due to the 4 inch of snow on top of the grass

The Process

- The process included taking reading at 8 different points in a circle from the portable signal generator. By placing the spectrum analyzer at each of these points I took and recorded the reading
Example of Data

**2.4 GHz Snow VS No Snow**

<table>
<thead>
<tr>
<th></th>
<th>2.4 GHz</th>
<th>HH</th>
<th>VV</th>
<th>VH</th>
<th>HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path loss exponent - $n$</td>
<td>3.81</td>
<td>2.77</td>
<td>2.91</td>
<td>2.80</td>
<td></td>
</tr>
<tr>
<td>Standard deviation of shadowing factor – $a$ (dB)</td>
<td>5.09</td>
<td>3.25</td>
<td>3.71</td>
<td>3.43</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2.4 GHz</th>
<th>HH</th>
<th>VV</th>
<th>VH</th>
<th>HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path loss exponent - $n$</td>
<td>2.68</td>
<td>3.34</td>
<td>1.92</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Standard deviation of shadowing factor – $a$ (dB)</td>
<td>9.22</td>
<td>4.11</td>
<td>8.90</td>
<td>9.06</td>
<td></td>
</tr>
</tbody>
</table>
### 2.4 GHz VS 915 MHz

#### No Snow

<table>
<thead>
<tr>
<th></th>
<th>2.4 GHz</th>
<th>HH</th>
<th>VV</th>
<th>VH</th>
<th>HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path loss exponent - $\alpha$</td>
<td>2.68</td>
<td>3.34</td>
<td>1.92</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Standard deviation of shadowing factor - $\sigma$ (dB)</td>
<td>9.22</td>
<td>4.11</td>
<td>8.90</td>
<td>9.06</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>915 MHz</th>
<th>HH</th>
<th>VV</th>
<th>VH</th>
<th>HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path loss exponent - $\alpha$</td>
<td>1.78</td>
<td>1.77</td>
<td>1.64</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>Standard deviation of shadowing factor - $\sigma$ (dB)</td>
<td>4.00</td>
<td>8.35</td>
<td>4.88</td>
<td>3.85</td>
<td></td>
</tr>
</tbody>
</table>

### Different Environments

#### Environment Comparison

Our 2.4 GHz data (VV) shows more attenuation and more scattering compared to the other environments. Inside buildings experience the most attenuation, while free space and beach environments show less attenuation.
Conclusion

- The propagation in short range near to low ground without snow is better than with.
- The 2.4 GHz without snow has a much higher sigma than with snow (more shadowing).
- Without snow case had \( n \) below 2 which would mean the propagation environment was better than free space (\( n=2 \)).
- The data collected is surprising and needs to have further measurements taken due to the fact \( n \) is below 2 in some cases.
- This is the beginning in near to low ground measurements at the 2.4 GHz and 915 MHz ISM band further research in this field is well needed due to the boom of wireless sensors.
- The polarization of an antenna for wireless sensors should not matter as long as the receive antenna is vertically polarized.

Future Work

- Future work will look at other environments such as hilly and woody areas (with and without snow) and perform similar measurements at other frequency bands (specifically the 433 MHz ISM bands).
- Expand measurements 10 to 50 feet to see if the 2.4 HV and VH would produce an overall higher slope due to orthogonal polarization.
- Short range distances above and below ground.
- Set up a multi-hop wireless network to monitor power loss in real time.