Better Analysis

Understanding Antenna Radiation Patterns

Achieving Ideal Transmission Quality

Introduction

A basic understanding of antenna radiation patterns is very useful for correctly positioning your wireless devices and ensures the most ideal transmission quality. This is even more important when doing protocol analyzer captures. This Expert Note will provide some basic information about radiation patterns for various antenna types.

Radiation Pattern Concept

When transmitting, an antenna will not radiate power equally in all directions. The shape of this power transmission is called the radiation pattern. This pattern is primarily the result of the antenna's construction, and can be determined either by simulation or by measurement.

The easiest way to understand this pattern is to visualize it in three dimensional space, but unfortunately this representation is not normally available from typical datasheets on off-the-shelf devices. Luckily, there are not that many different antenna shapes used on Bluetooth devices.

Typical Bluetooth Antenna Types

The most common form of antennas found on Bluetooth devices are omnidirectional antennas. In a perfect world, an omnidirectional antenna would transmit the exact same power in all directions. In that case, this perfect antenna would create a spherical pattern. Unfortunately, such a perfect antenna does not exist.

All antennas are imperfect and the positioning of an antenna can make them less than ideal or even unusable. Additionally, with the increasing prevalence of miniaturized devices, design engineers often need to trade antenna quality to satisfy other design constraints.

Figure 1 SMA Stick Antenna.

When transmission quality is more important than the size of a device, a detachable stick antenna with a Sub-Miniature version A (SMA) connector is usually used for its coaxial cable and its screw-type coupling mechanism as shown in **Figure 1**. These **stick antennas** are very common, and are also the most intuitive antennas on the market, as their radiation pattern is more of what we would expect.

When positioned vertically, this antenna type will transmit the same amount of power all around (laterally), but not along its vertical axis (not on the top or bottom). This radiation pattern is known as radial, but visualized in a 3D space it looks more like a donut as shown in **Figure 2.**

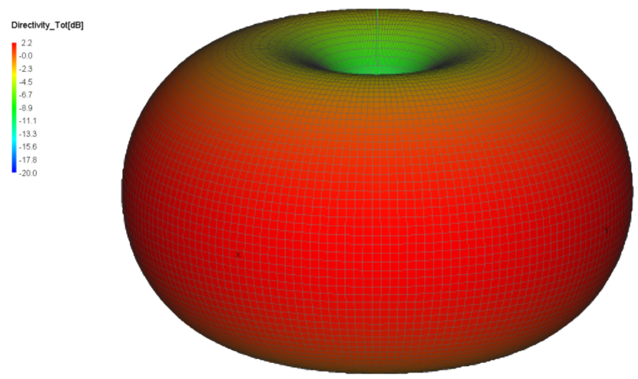

Figure 2 3D Bluetooth Ideal Radiation Pattern.
Source: www.antenna-theory.com

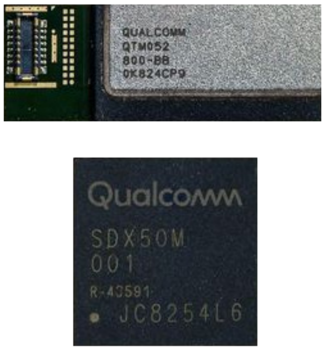

Figure 3 Chip Antennas.
Source: Qualcomm 5G Antenna Modules Target Smartphones

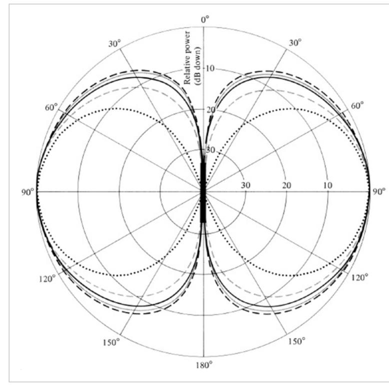

Figure 4 Chip Antenna Radiation Pattern.
Source: Mathematica Stack Exchange

When space is the major constraint, **chip antennas** are the alternative. This type of antenna is found on mobile phones, dongles, and anything that must be compact and flat, as shown in **Figure 3**. The pattern of these antennas usually looks like an "8," as shown in **Figure 4**.

A mobile phone using such an antenna transmits nicely in front and behind its screen, but transmits a very poor signal on its sides. If you place this mobile phone flat on a table, it will provide the worst possible transmission quality. This is unfortunately how mobile phones are usually placed when doing quick tests in the lab, resulting in poor transmission quality and incomplete wireless analyzer captures.

Improving the Odds – Using the Capture Diversity Feature on the Bluetooth Vanguard

Understanding antenna radiation patterns is of course useful knowledge for any Bluetooth engineer. Bluetooth packets can be degraded and missed by both Bluetooth test equipment and Bluetooth devices due to antenna positioning, signal strength issues, or RF interferences such as Wi-Fi and a variety of consumer electronics operating in the same band as Bluetooth. Missing a critical packet can lead to traffic that cannot be decrypted or decoded in some way, and this can be frustrating. Understanding your antenna's radiation characteristics and proper placement of the analyzer is of course important (see EEN_BT04 - Optimal Placement of Your Analyzer).

That said, Ellisys engineers have developed an analyzer capture approach that improves the reception characteristics of the analyzer and can make such "missed packet" situations less likely.

With Vanguard, Ellisys engineers have introduced yet another disruptive industry first – Bluetooth capture diversity. This technique involves a co-operational replication of a whole-band capture engine, which is an Ellisys innovation introduced on its prior Bluetooth analyzers. **See Figure 5.**

- Both antennas can be angularly displaced on the analyzer unit
  - This creates different physical receive characteristics to incoming wave fronts, increasing the chances that a given packet will be received properly.
- One or both antennas can be externally cabled and placed at optimal locations
  - Improves the spatial volume of the reception.
  - Placed nearer specific devices under test to reduce packet error rate.

Smart software algorithms developed by Ellisys engineers are applied to the dual capture channels, and when combined with spatial and angular flexibilities provided by this technique, can significantly improve the capture process and result in reductions in received packet error rates.

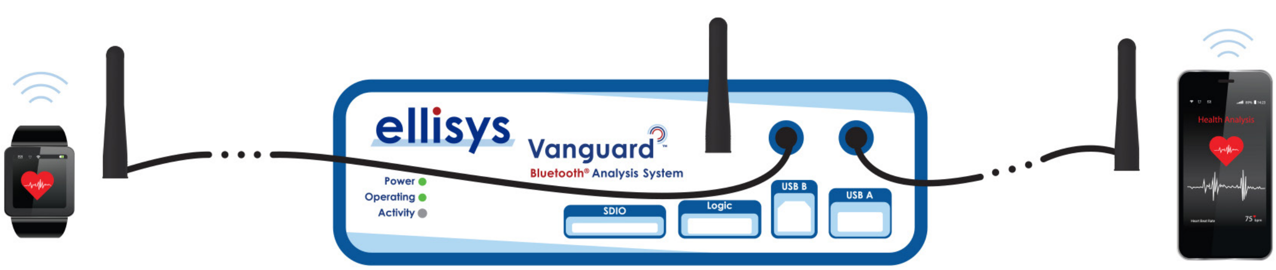

Figure 5 Capture Diversity.

Conclusion

Knowing how a device's antenna will likely radiate will help to ensure you get an ideal transmission quality from your protocol analyzer capture. This Expert Note also briefly looked at a few trade-offs and design constraints which will effect a device's transmission quality. For more information on correct placement of Bluetooth devices, please read the Expert Note, EEN_BT04 "Optimal Placement of Your Analyzer."

Capturing Traffic

Please consult our Expert Note, EEN_BT03 "Your First Wideband Capture" to learn how to properly configure and operate your analyzer to achieve a clean capture.

Getting the Software

The analyzer software is available upon request via Ellisys: http://www.ellisys.com/products/bex400/download.php. The download is subject to approval, but approval will likely be granted to any company that is part of the Bluetooth SIG or seriously involved in Bluetooth development.

Visit ellisys.com or email support@ellisys.com for more information.

Other Interesting Reading

- EEN_BT03 - Your First Wideband Capture
- EEN_BT04 - Optimal Placement of Your Analyzer

More Ellisys Expert Notes available at:
www.ellisys.com/technology/expert_notes.php

Feedback

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