RANGE LENGTH REQUIREMENTS FOR NOTEBOOK COMPUTERS

James D. Huff
Carl W. Sirles

The Howland Company, Inc.
4540 Atwater Court, Suite 107
Buford, Georgia 30518

Abstract

Wireless network adapters are now standard in most notebook computers. These network adapters are typically compliant with at least IEEE 802.11a/b/g and often include IEEE 802.11n. This requires that the antenna subsystem of the notebook computer operate at both 2.4 GHz and 5.25 GHz. The antennas used in the wireless system of a notebook computer are themselves small, but they are incorporated into a much larger device. It is unclear exactly what range length is required in order to make accurate pattern and radiated power measurements. This paper reports on a series of measurements made at different range lengths with the goal of determining the minimum range length required for acceptable measurements of radiation patterns and total radiated power (TRP).

Keywords: **far-field, OTA, TIS, TRP, wireless**

1. Introduction

Over the air measurements of wireless adapters imbedded in notebook computers offer some unique challenges. The antennas themselves are small and essentially omni-directional. However, they are imbedded in a much larger device. To further complicate matters the location of the antenna in the device is often unknown. So the question becomes what range length is required to obtain satisfactory measurements of radiation patterns and total radiated power.

The safe and conservative approach would be to simply take the largest dimension of the device under test (DUT) and apply the generally accepted far-field criteria of $2D^2/\lambda$. However, this may result in a requirement for unnecessarily long range lengths.

In this paper we report on both experimental measurements and measurement simulations that were performed to clarify the range length requirements for testing notebook computers.

2. Experimental Measurements

The experimental measurements were made using a Howland Wireless Test Lab with a distributed axis positioning system. The theta axis consists of a boom on which the measurement antenna is mounted. The phi axis is an azimuth rotator mounted on the floor of the chamber. The changes in range length were made by installing a spacer between the measurement antenna and the mounting surface on the boom. This is shown schematically in Figure 1.

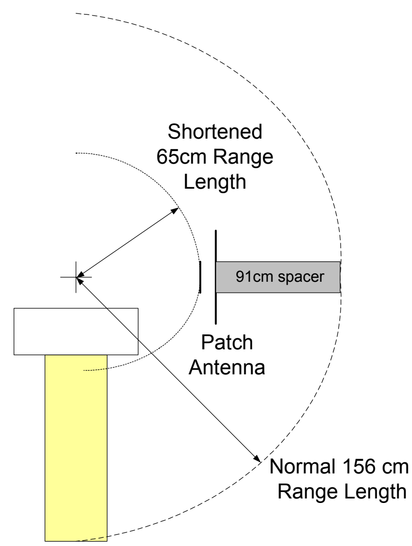

Figure 1- Measurement Configuration

The DUT was a 15 inch notebook computer with a wireless adapter that supports 802.11b,g. The notebook was positioned on the phi positioner as shown in Figure 2.

Figure 2 – Notebook Test Position

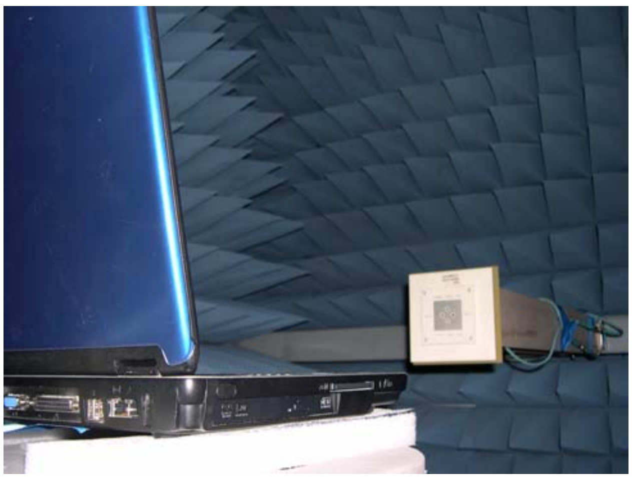

Figure 3 – Notebook and Range Length Adapter

Measurements were made at range lengths of 65cm,120cm and 156cm. The measurement frequencies were 2400MHz, 2442MHz, and 2484MHz. In order to simplify the setup and minimize the measurement uncertainty, CW measurements were made by disconnecting the network adapter and providing a CW signal directly to the antenna of the notebook computer.

Measurements were made at 15 degree steps in phi and theta. The theta axis travel had to be limited to 150 degrees because of the range length adapter. Both the phi and theta polarization components were measured simultaneously.

3. Measurement Results

The measurement results are shown in Table 1. Shown in the table is the change in TRP versus range length, with the results being normalized to the longest range length.

Frequency (MHz)	Range Length		
	65cm	120cm	156cm
2400	0.40 dB	0.38 dB	0.00 dB
2442	0.51 dB	0.27 dB	0.00 dB
2484	0.46 dB	0.14 dB	0.00 dB

Table 1 – Change in TRP vs Range Length

Sample radiation patterns are shown in Figures 4 and 5 below.

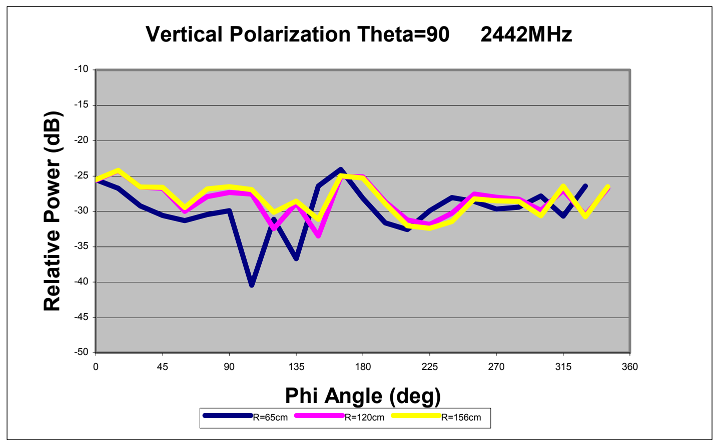

Figure 4

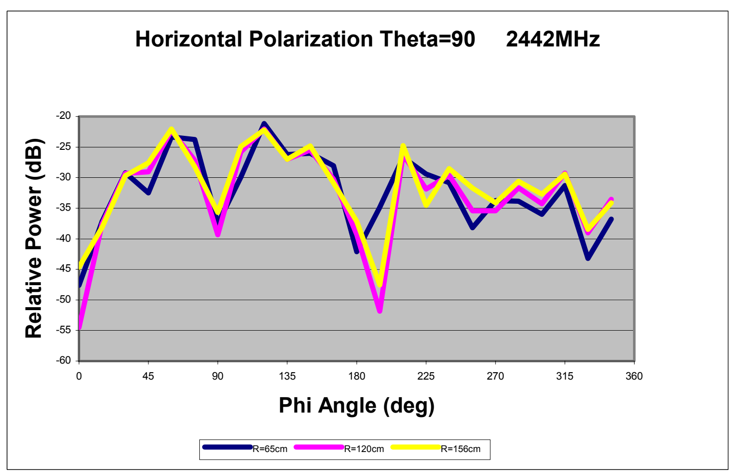

Figure 5

4. Measurement Simulations

The measurement simulation used two point sources placed one half wavelength apart. The point sources were placed in the plane of the hypothetical display and at its top left corner. Ray optics was used to sum the two vectors from each point source at five degree increments in phi and theta. This is shown schematically in Figure 6.

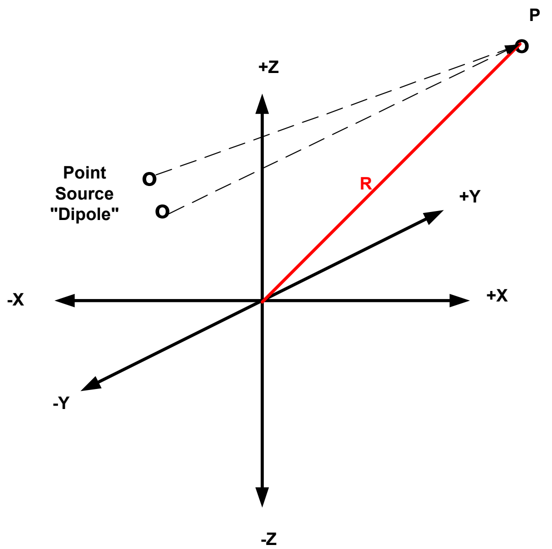

Figure 6 Simulation Configuration

Simulations were run for range lengths of 65cm, 80cm, 120cm, 294cm, 588cm and 1 million km.

5. Simulation Results

The simulation results show only small changes in TRP versus range length. The results are shown graphically in Figure 7, and although the change appears dramatic on the graph, the maximum change in TRP is less than 0.3dB at a range length of 65cm. To put this in perspective, this is a range length of only $0.2D^2/\lambda$. If the range length is increased to 130cm, or $0.4D^2/\lambda$, the change in TRP is less than 0.1dB.

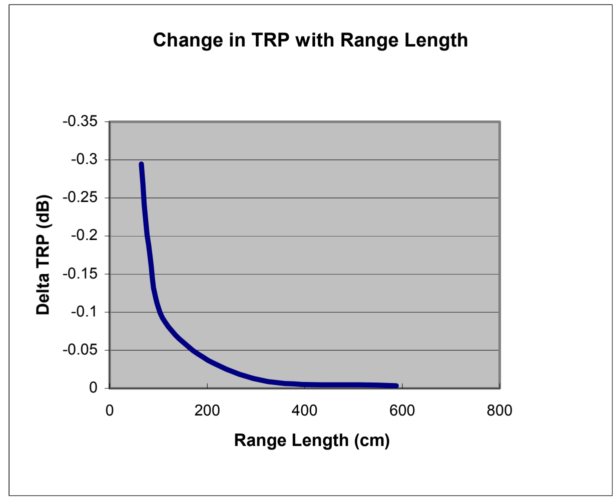

Figure 7

As one might expect the variation in the radiation patterns is more pronounced. Radiation patterns at theta equals 90 degrees are shown in Figure 8 below.

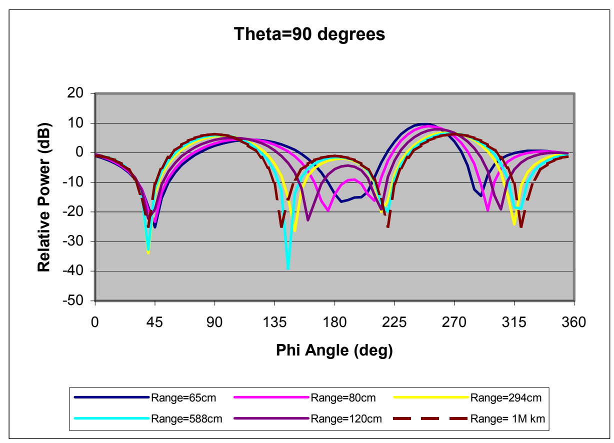

Figure 8

6. Conclusions

The measured results and the simulation results are not drastically different. There are several sources of measurement uncertainty that will impact the results.

First, in the measurement we do not know the precise location of the antenna in the notebook computer. This may well be the case in most measurements since the antenna location is not obvious from the exterior of the notebook.

Second, as we change the range length we also change the phasing of the extraneous signals to the direct signal. There are many possible sources of extraneous signals in a chamber, but the standing waves between the notebook and the measurement antenna are perhaps the most likely cause of measurement uncertainty. The notebook presents are large, flat surface to the measurement antenna. It is not difficult to imagine that this will set up a fairly large standing wave between the device under test and the measurement antenna.

The TRP measurements show a maximum delta of 0.51 dB over a range length change of 65cm to 156cm. The far-field criteria of $2D^2/\lambda$ would have suggested a range length of 2.5 meters. If the measurement uncertainty in the results is dominated by the standing wave between the notebook and the measurement antenna, this increase in range length would have done little to improve the measurements.

In the radiation patterns one can see the result of the different range lengths. The pattern nulls fill in at the shorter range lengths and the offset of the antenna to the center of rotation causes the position of the nulls and peaks to shift.

7. Summary

The results presented here are encouraging. They indicate that large devices with small imbedded antennas can be accurately measured at range lengths much less than those indicated by the far-field criteria of $2D^2/\lambda$, or perhaps it would be more accurate to say that the antenna dimensions rather than the device dimensions can be used to determine the range length requirements.

8. References

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[3] Huff, J. D. and Sirles, C. W. "The Effect of Range Length on the Measurement of TRP", 29th Proceedings of the Antenna Measurement Techniques Association (AMTA-2007), St. Louis, MO, pp 441-444