XBEE-PRO® 868 Range Validation

White Paper

Abstract

This paper explains the range performance testing procedures that were used, the environment in which the test was conducted, and the results that were recorded: Reliable performance was demonstrated at 25 miles (40 kilometers) with Line of Sight conditions.

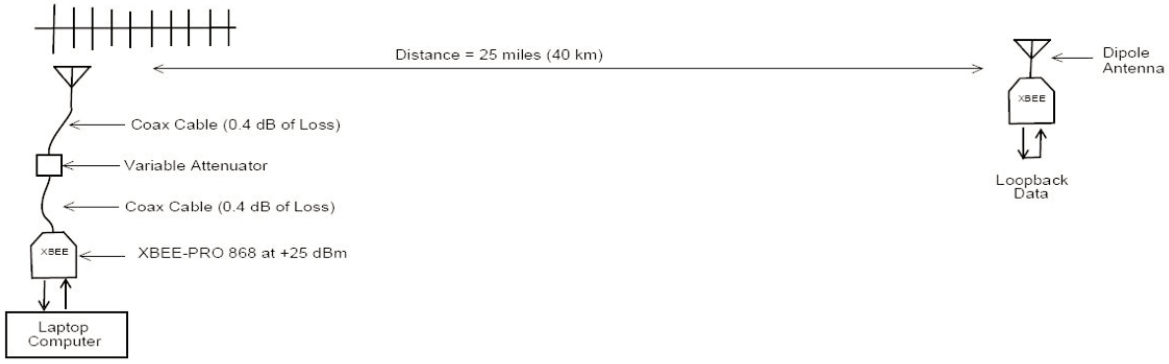
Environment

- Date: September 29, 2008
- Location: Utah County—Approximately 50 kilometers south of Salt Lake City, Utah, in the western U.S.
- GPS Coordinates:
    - o Origin: 40.348582,-111.904831
    - o Destination: 40.069544,-111.600838

Testing

For this test, the radio frequency was shifted up 3 MHz. This was because in the U.S. there are licensed frequencies present in the range of 868 MHz to 871 MHz that exceed -60 dBm. One of these signals was sharing part of the band of 869.4 to 869.650 MHz. This shift would allow an accurate range test and at the same time avoid unwanted interference to the users of that band.

One radio was set up with a loopback on the Data In (Din) and Data Out (Dout) lines. The radio was placed on the roof of a seven-meter-tall house with a dipole antenna. The other radio was then driven 40 kilometers away to an elevated position (there was approximately 300 meters difference between the two points) in order to attain clear LOS (Line of Sight). See diagram below.



The range test was performed with Digi International's software utility X-CTU. Thirty-two bytes of data were sent with each packet. Retries were set to "0" on both radios. If the data sent was not received within one second, the packet was considered failed. One hundred packets were sent for each measurement. Both an 868 MHz 2.1 dBi dipole antenna and a 900 MHz 15dBi Yagi antenna were tested (the Yagi antenna only tested the reverse link). The power output of the module was set to +27 dBm (500 Mw EIRP) in order to overcome the additional loss from the variable attenuator. Testing results for different configurations are recorded in Tables 1 and 2.

868 MHz Dipole Antenna at 40 km	
Variable Attenuation	Percentage of Good Packets
0 dB	100%
9 dB	100%
10 dB	100%
11 dB	96.9%
12 dB	63%
13 dB	32%
15 dB	5%
20 dB	0%

Table 1

900 MHz Yagi Antenna at 40 km	
Variable Attenuation	Percentage of Good Packets
0 dB	98%
10 dB	100%
20 dB	100%
25 dB	90%
30 dB	0%

Table 2

As shown in Table 1, the dipole antenna allowed the radios to communicate clearly over a distance of 40 kilometers LOS with 11 dB of link budget remaining before performance was severely impacted. The 11 dB could very well allow the radio to communicate further than 40 kilometers; however, greater distance is not recommended since different changes in the environment, such as weather conditions or objects in the Fresnel zone, could cause the link to change and be less reliable.

Table 2 shows that using a Yagi antenna on one end of the link, from the loopback dipole radio to the receiving radio 40 kilometers away has 25 dB of link budget remaining. This shows that a directional antenna on a receiving radio could be used to increase the link budget by 14dB, which corresponds to approximately four times the estimated RF LOS range. If one wanted to use a directional antenna on the transmitting radio, then the power of the radio with the directional antenna would need to be reduced in order to keep the EIRP below the required limits.

Conclusions

When operating in clear RF LOS conditions, XBee-PRO 868 modules are capable of 40 kilometers of transmission, with a theoretical limit beyond 100 kilometers when used with high gain antennas.

The purpose of this test was not to demonstrate the maximum range possible under ideal conditions, but to establish a benchmark under realistic conditions for how the radios will behave in similar environments and to demonstrate the link budget and reliability that can be expected in similar scenarios.

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