BSA Technical Information

Electrical Isolation of Co-Located Horizontally and Vertically Stacked Antennas

Introduction:

Service providers are facing rapidly increasing pressure from zoning boards to co-locate their base station antennas on the same tower structure as other providers. Traditionally, these antenna installations have been vertically spaced about 15 to 20 feet apart to ensure adequate antenna electrical isolation, intermodulation and harmonic signal rejection, and resistance to receiver noise desensitization. This note addresses the electrical coupling between horizontally and vertically spaced antennas. For in-band carriers (i.e. co-located A and B band 800 MHz carriers), a minimum of 50 dB isolation between the stacked antennas is frequently required. Measurement data presented in this note concludes that this required isolation can be achieved easily with just a few inches of vertical spacing. This is true even for small, low gain antennas with wide beamwidths. This allows the antennas to be stacked more closely together, thus conserving expensive tower space, reducing total tower count, and allowing higher center lines for providers who are not located on the top position on the monopole. Also, horizontal antenna spacing is sometimes used to achieve co-location as well as greater transmit channel capacity by installing additional antennas. Data presented here concludes that >35 dB electrical isolation is easily achieved with horizontal spacings of just 12 inches or less (for azimuth beamwidths <105 degrees). This allows packing the antennas quite tightly together, thus further conserving expensive tower space.

Coupling Test Procedure and Results:

A.) In-Band Measurements: A variety of electrical isolation tests were run at both 800 and 1900 MHz. A pair of like antennas was placed at various distances from each other, either end-to-end, or side-to-side, to simulate co-located antennas on a tower or monopole. A network analyzer was used to inject a signal into one antenna. Then, transmission loss (S21) at the other antenna port was swept and plotted for the appropriate band (806—896 MHz or 1850—1990 MHz). These tests were run mostly in an anechoic chamber to avoid extraneous reflections. When the antenna spacing was too large to fit in the chamber, the antennas were placed on their backs, outdoors on the ground, so the environment was essentially reflectionless.

Vertical antenna separation distance was defined as shown in Figure 1, and horizontal separation distance was defined as shown in Figure 2. Then, for each frequency band, the antenna azimuth beamwidth and gain were varied to sample typical coupling values. Also, during the vertical separation test, the top antenna was mechanically downtilted 10 degrees, and the coupling test was repeated.

The 800 MHz cellular tests and results are detailed in Table 1. These results are plotted in Figures 3, 4, and 5.

1900 MHz PCS tests and results are shown in Table 2. These results are plotted in Figures 6 and 7.

B.) Cross-Band Measurements: In these tests, an FV105-12-00DA2 800 MHz antenna and an RV90-17-00DP 1900 MHz antenna were stacked horizontally and vertically, as shown in Figures 8 and 9. Two network analyzer insertion loss sweeps were performed: One at 806—896 MHz, and another at 1850—1990 MHz. Results were tabulated in Table 3, and plotted in Figures 10 and 11.

Only vertically polarized antennas were used in this experiment. It was expected that the worst case isolation results would be found using vertically polarized antennas throughout so that the antenna pairs would be co-polarized relative to each other. Slant 45 dual polarized models could also be tested, but the results should be similar to those presented here.

Conclusions:

A.) In-Band Isolation of Horizontally Spaced Antennas:

1. In every measured case, isolation of horizontally spaced 90 or 65 degree antennas was greater than 30 dB with as little as six inches spacing between the antennas.
2. In every measured case, isolation of 105 degree antennas was greater than 30 dB with as little as 18 inches of spacing between the antennas.
3. Isolation of horizontally spaced antennas was driven most strongly by the antenna's azimuth beamwidth. Broad beamwidth models (105 degrees) had the worst isolation.

B.) In-Band Isolation of Vertically Spaced Antennas:

1. In every measured case, isolation was greater than 50 dB with as little as six inches of spacing between the antennas. Overall, isolation was excellent regardless of gain or frequency band.
2. A moderate amount of mechanical downtilt did not appreciably degrade the isolation.
3. Vertically spaced isolation was not driven by the antenna's gain (and, therefore, the antenna's elevation beamwidth).

C.) Cross-Band Isolation:

1. With Cellular and PCS antennas stacked vertically, isolation was typically 60-70 dB, and varied little with spacing.
2. With Cellular and PCS antennas stacked horizontally, the isolation was quite different, depending on whether the test was run at 800 or 1900 MHz. However, even a worst case result of 40 dB was easily achieved with only 18 inches spacing between the antennas.

It should be noted that these results may vary if the antennas are located behind architectural screening material for "stealth" applications. The scattering environment for these types of set-ups can be quite complex, and requires analysis of the particular site layout to be confident with the results.

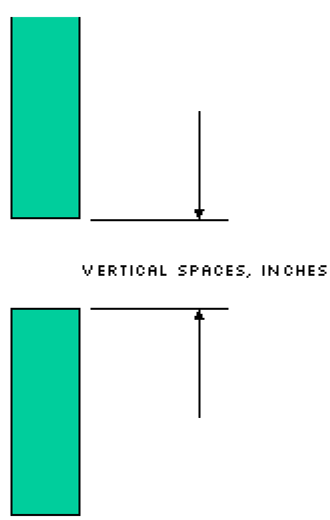

Figure 1: Antenna Vertical Spacing Definition

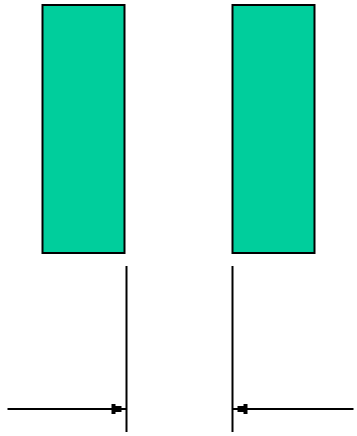

Figure 2: Antenna horizontal spacing definition

Table 1: Cell Band Coupling Tests:

1.) Broad beamwidth, Low gain antennas (2 x FV90-09-00DA2):

	Vertical Spacing		Horizontal Spacing
Spacing	0 deg d/t	10 deg d/t	0 deg d/t
0	-56.3	-69.8	-38.3
6	-59.5	-77.9	-41.0
12	-65.8	-78.9	-43.7
18	-68.6	-81.8	-45.2
24	-66.0	-86.6	-47.9
30	-68.8	-89.9	-48.9
36	-69.9	-85.0	-48.6

2.) Broad beamwidth, High gain antennas (2 x FV105-12-00DA2):

	Vertical Spacing		Horizontal Spacing
Spacing	0 deg d/t	10 deg d/t	0 deg d/t
0	-60.7	-56.9	-23.9
6	-62.1	-64.2	-26.0
12	-62.1	-61.8	-27.6
18	-62.7	-63.1	-30.0
24	-64.0	-66.3	-29.8
30	-65.1	-65.7	-31.2
36	-67.3	-68.0	-31.7

3.) Narrow beamwidth, Low gain antennas (2 x FV65-11-00DA2):

	Vertical Spacing		Horizontal Spacing
Spacing	0 deg d/t	10 deg d/t	0 deg d/t
0	-44.8	-45.3	-30.5
6	-57.3	-52.9	-35.3
12	-57.3	-52.8	-37.7
18	-61.8	-57.0	-39.9
24	-62.3	-60.0	-46.0
30	-64.6	-62.2	-49.0
36	-61.9	-57.4	-47.3

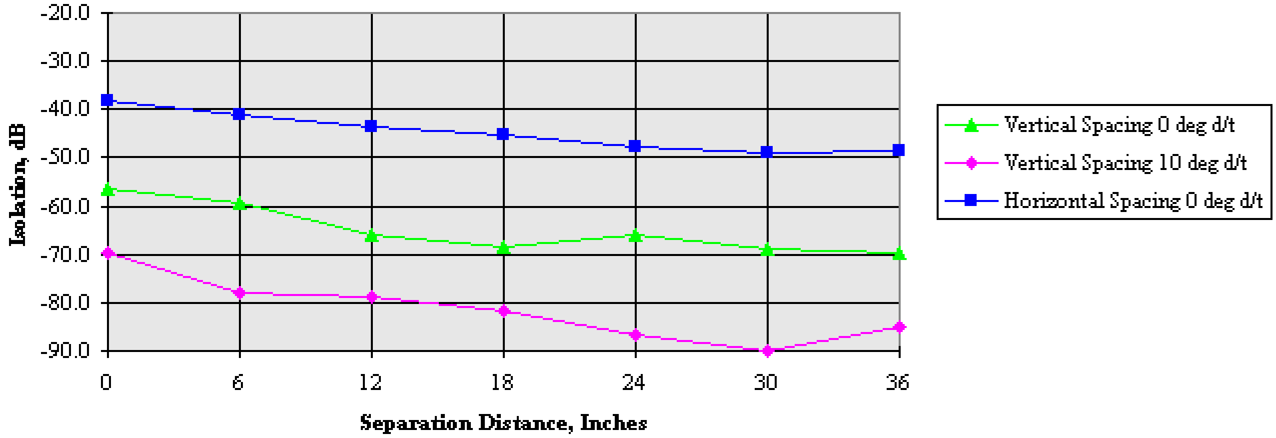

Figure 3: Broad Azimuth Beamwidth, Low Gain Isolation Test 800 Mhz (2 x FV90-09-00DA2)

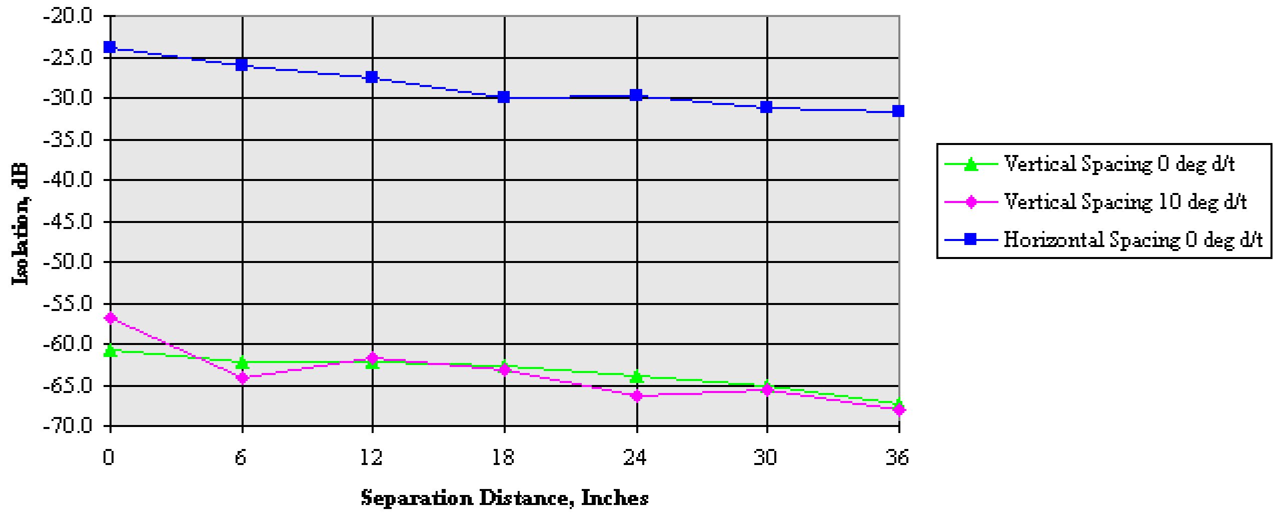

Figure 4: Broad Azimuth Beamwidth, High Gain Isolation Test 800 Mhz (2 x FV105-12-00DA2)

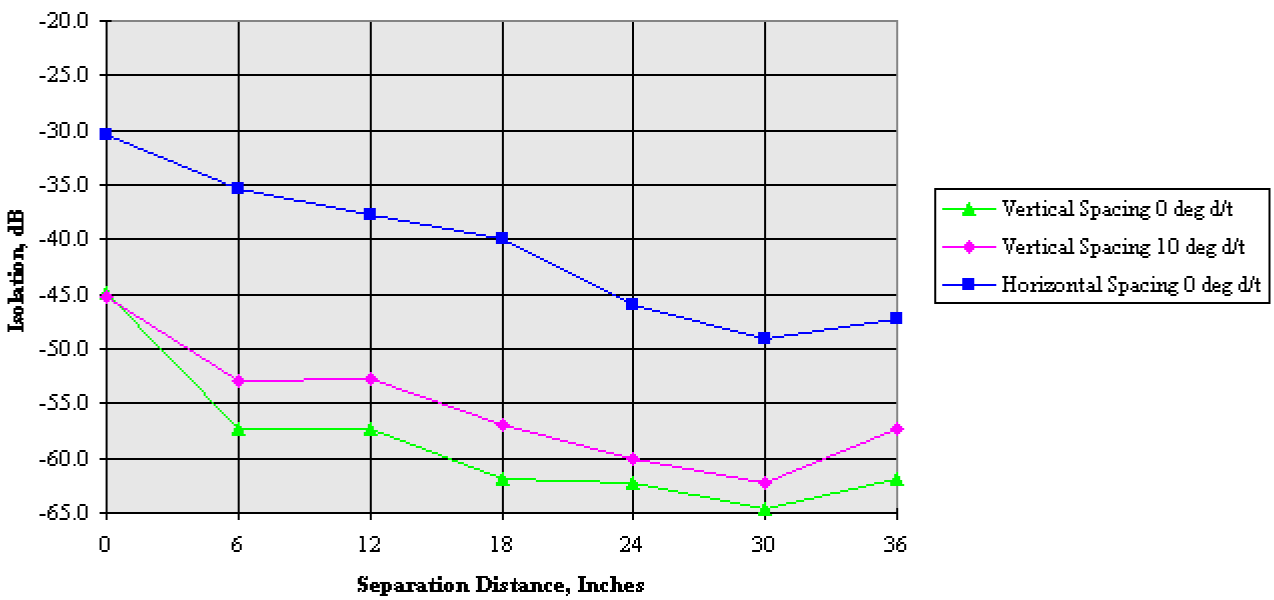

Figure 5: Narrow Azimuth Beamwidth, Low Gain Isolation Test 800 Mhz (2 x FV65-11-00DA2)

Table 2: PCS Band Coupling Tests

1.) Broad beamwidth, High gain (2 x RV90-17-00DP)			
	Vertical Spacing		Horizontal Spacing
Spacing, inches	0 deg d/t	10 deg d/t	0 deg d/t
0	-64.0	-63.5	-27.2
6	-71.7	-71.5	-30.2
12	-71.9	-73.8	-35.9
18	-74.1	-74.5	-39.1
24	-73.9	-75.6	-39.2
30	-76.4	-75.6	-38.8
36	-76.8	-72.8	-40.3
2.) Narrow beamwidth, High gain (2 x RV65-18-00DP)			
	Vertical Spacing		Horizontal Spacing
Spacing, inches	0 deg d/t	10 deg d/t	0 deg d/t
0	-62.2	-64.2	-32.5
6	-71.1	-71.6	-37.1
12	-74.6	-73.1	-40.1
18	-74.6	-77.8	-40.1
24	-76.4	-77.0	-42.5
30	-77.7	-77.5	-42.9
36	-79.1	-77.5	-43.9

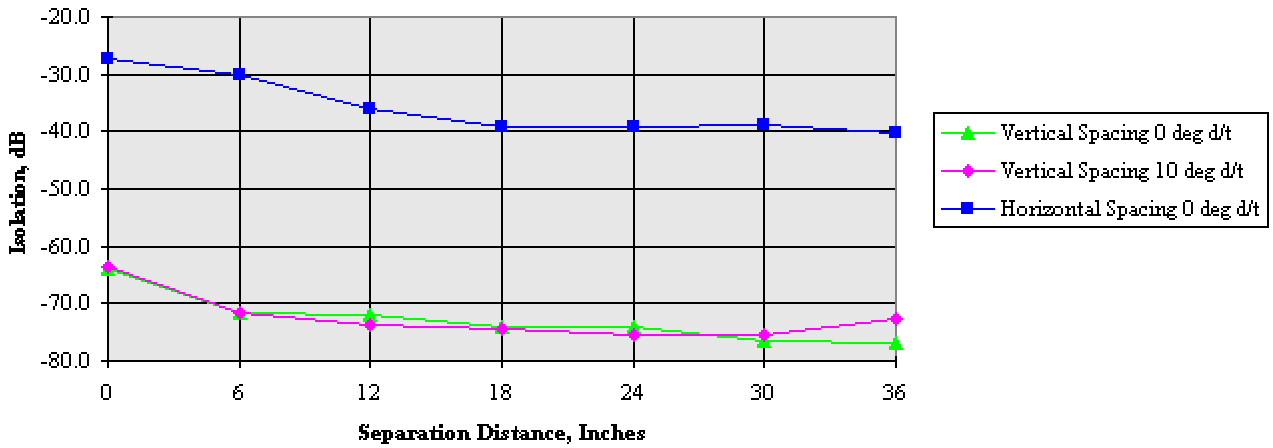

Figure 6: Broad Azimuth Beamwidth, High Gain Isolation Test 1900 Mhz (2 x RV90-17-00DP)

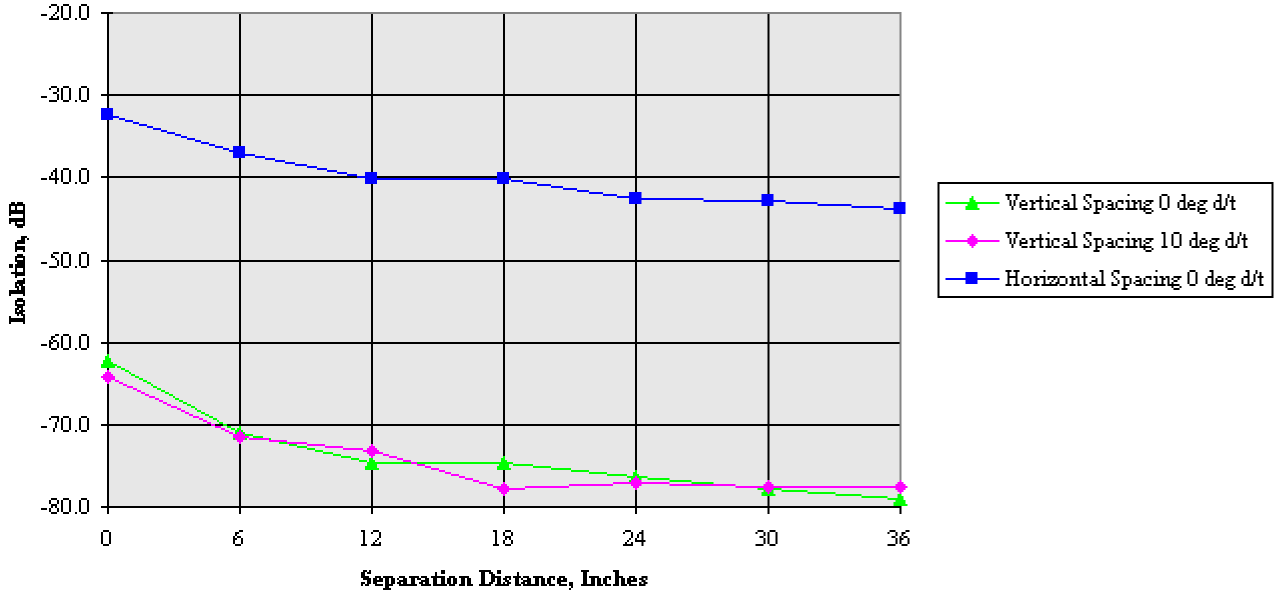

Figure 7: Narrow Azimuth Beamwidth, High Gain Isolation Test 1900 Mhz (2 x RV65-18-00DP)

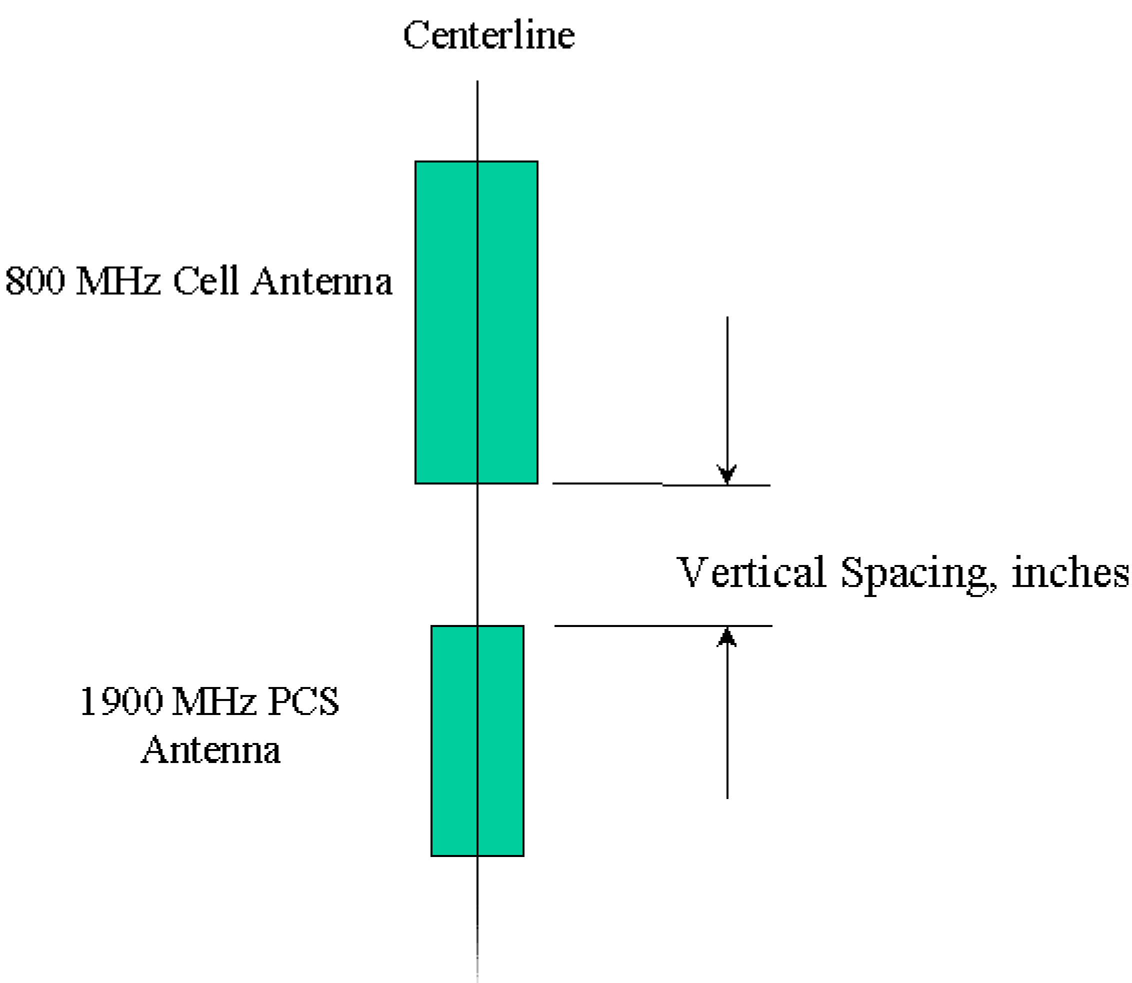

Figure 8: Cross-Band Isolation Test, Vertical Stacking

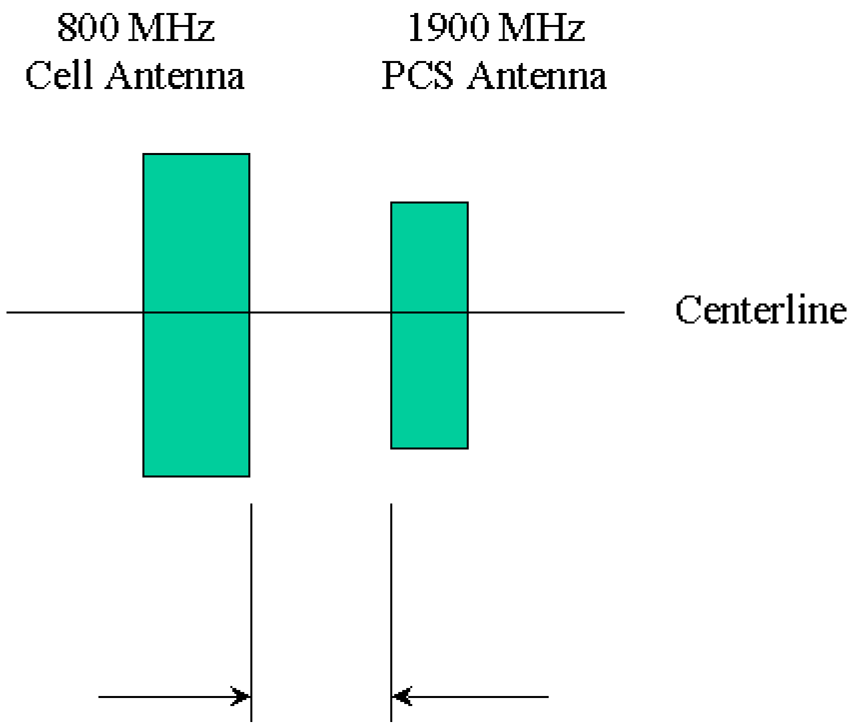

Figure 9: Cross-Band Isolation Test, Horizontal Stacking

Horizontal Spacing, inches

1.) Swept at 800 MHz:

Spacing	Vertical Spacing	Horizontal Spacing
0	-68.9	-53.3
6	-69.5	-56.5
12	-71.0	-57.3
18	-72.0	-58.9
24	-73.0	-61.5
30	-73.5	-62.4
36	-74.0	-60.5

2.) Swept at 1900 MHz:

Spacing	Vertical Spacing	Horizontal Spacing
0	-63.5	-33.5
6	-65.8	-36.4
12	-66.1	-38.6
18	-67.6	-40.3
24	-65.4	-41.6
30	-67.2	-42.2
36	-67.2	-42.4

Table 3: Cross-Band Coupling Tests

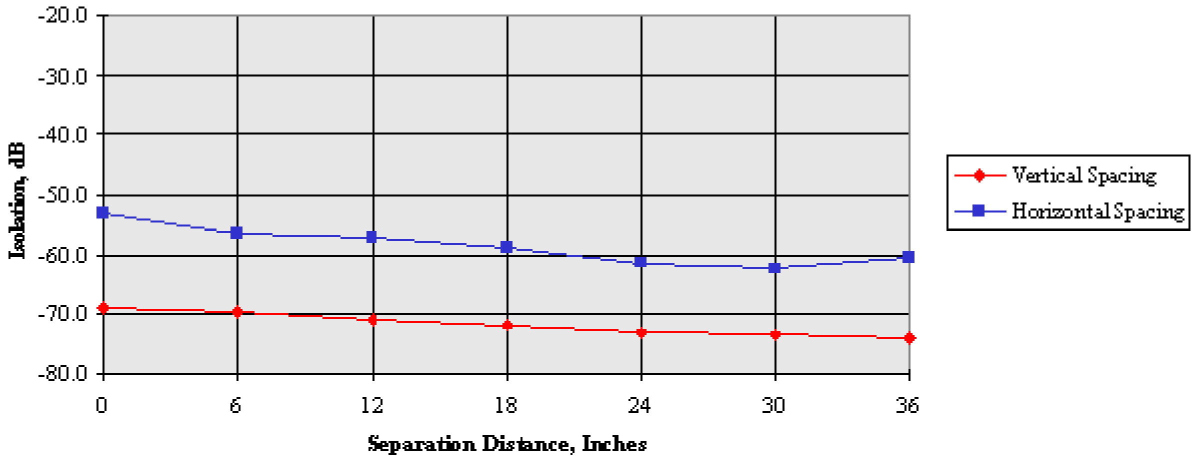

Figure 10: Cross Band Coupling Tests - 800 MHz Sweeps

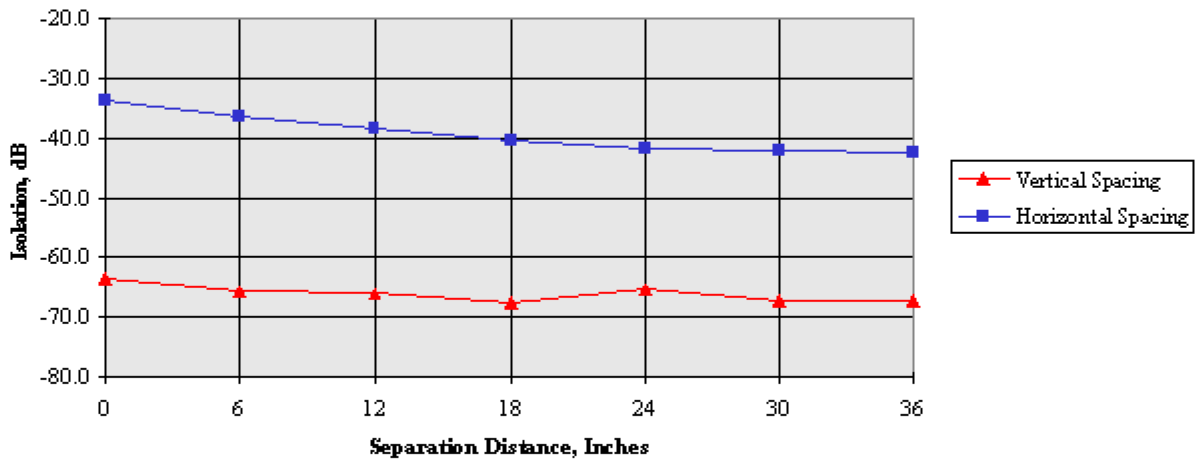

Figure 11: Cross Band Coupling Tests - 1900 MHz Sweeps