Determining your Network Deployment

Network operators are faced with the difficult task of determining which antennas to deploy from region to region in support of their radio equipment. One of the central goals in network planning is to minimize interference between each sector, but, at the same time, maximize the coverage areas. This is largely controlled by the quantity of access point (AP) antennas arranged around the tower and the antenna's azimuth 3dB beamwidth and gain. In wireless networks employing channel (frequency) reuse, mitigating co-channel interference within adjacent cells is important in optimizing both the signal-to-interference-plus-noise ratio (SINR), and consequently, the networks throughput and reliability.

In many legacy WiFi-based deployments that are more forgiving to higher co-channel interference, the number (N) of antennas with an azimuth beamwidth (BW) is often chosen to be $N = 360°/BW$ (i.e., $6\ x\ 60°, 4\ x\ 90°$). This ensure that the minimum gain in any direction is within 3dB of the antenna's maximum gain which maximizes the total coverage area. However, this is accompanied by a high level of interference and SINR when employing frequency reuse, and is particularly problematic for more recent, cutting edge communication standards like LTE whose higher-order modulation scheme are extremely sensitive to the SINR. Instead, these newer standards require a new balance to be drawn between SINR and gain in which the former is weighted higher. This is achieved by reducing the number of base stations antenna and/or using narrower beamwidth antennas. Evaluation of this tradeoff can be aptly determined from two components of an antenna's characteristics: the total gain and azimuth radiation pattern.

This document provides a primer in deciding the ideal antenna deployment for your radio platform based on an in-depth analysis of the AP antenna's azimuth radiation pattern. Using the frequency-reuse one and two scenarios for 65° and 90° sectors as case studies, the trade-offs of the network's gain and interference for different deployments are identified.

Frequency-Reuse One

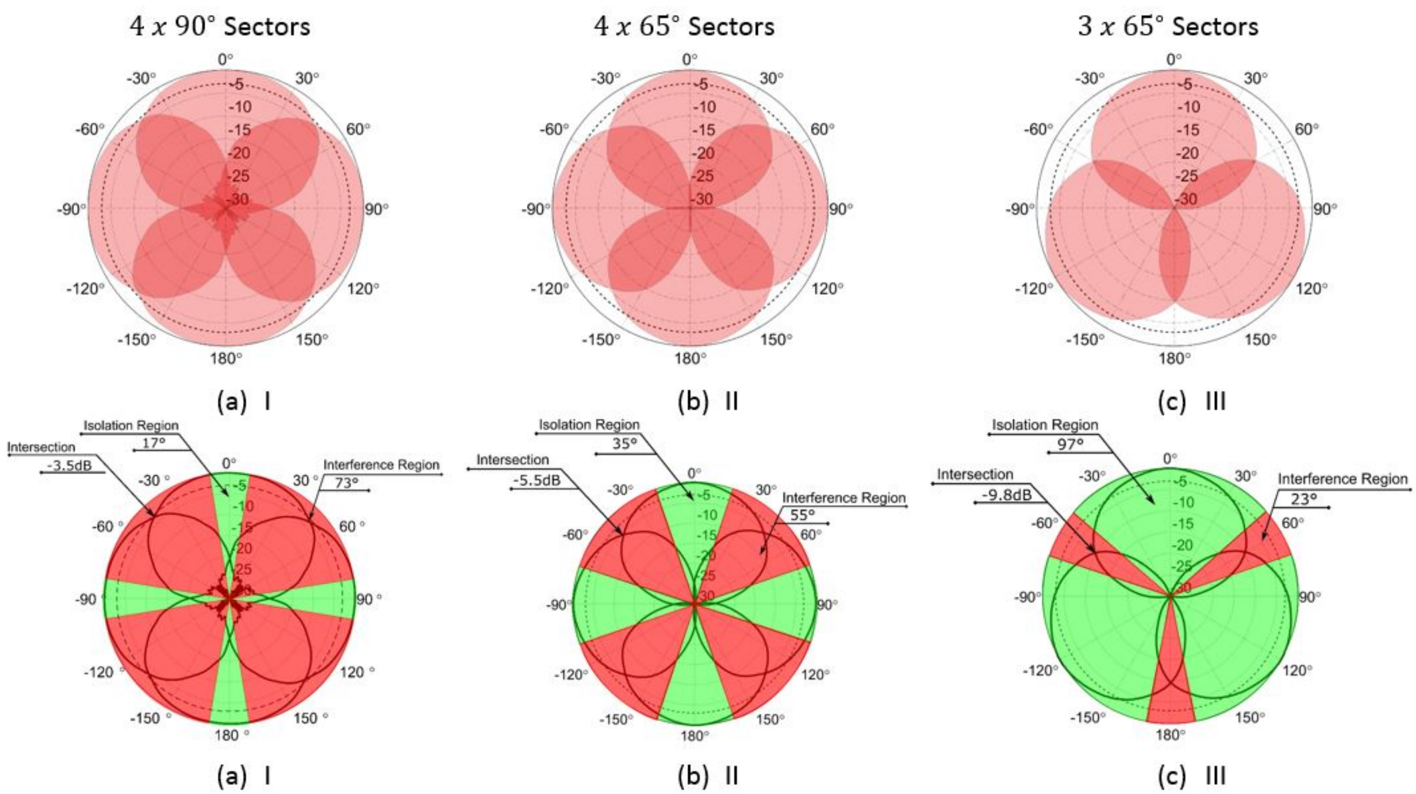

Fig. 1: Different network deployments employing frequency-reuse one.

Product Number	Frequency (MHz)	Gain (dBi)	Azimuth HPBW (˚)	Front to Back Ratio (dB)
KP-3DP65S-45	3300-3800	17.5	65	35
KP-3GHZDP90S-45	3300-3800	16.5	90	30

Figures 1 (a) I – (c) I presents the coverage plots for three different deployments of frequency-reuse one (each sector is sharing the same channel) using KP Performance's KP-3DP65S-45 and KP-3GHZDP90S-45 sector antennas whose antenna specs are summarized in the above Table. Each coverage plot is constructed from the antenna's azimuth radiation pattern which is rotated around the tower multiple times.

Intuitively, four 90° sectors will provide maximum coverage over 360°. This can be seen in Fig. 1(a) II, in which the intersection between adjacent patterns indicates the minimum level of gain in the deployment is only -3.6dB below the antenna's maximum gain. Therefore, in any given direction the minimum total antenna gain will be -3.6+16.5=12.9dBi. Whereas the 4 x 90° sector deployment provides the best coverage, it is important to note there is significant overlap between the patterns which indicates interference between the adjacent sectors. In Fig. 1(a) II, the green isolation (red interference) regions corresponds to angles in which the adjacent sectors' patterns is below (above) a specified threshold dependent on the interference sensitivity of the radio platform. For this case study, this threshold is 15dB. The significant regions of interference in the 4 x 90° deployments demonstrates that a frequency-reuse one scenario cannot be used. This deployment is better suited in frequency-reuse two scenario which is discussed in the next section.

Dropping to 4 x 65° deployment in Fig. 1(b) II serves to lower the interference between the sectors but at the expense of decreased coverage. It is important to take into account two things when studying these antenna patterns: (1) the antenna patterns are normalized to 0dBi and (2) the gain of the 65° antenna is greater than the 90° antenna. Therefore, although the 65° antenna has a lower intersection, the minimum gain of the 4 x 65° deployment is -5.5+17.5=12.5dBi which is comparable to the 4 x 90° deployment. However, now 40% of each sector's coverage sees below 15dB of interference from the adjacent sector. While this will lead to the improvement in the SINR, LTE networks require even lower levels of interference.

For LTE networks employing frequency-reuse one, it is recommended that the 3 x 65° deployment shown in Fig. 1 (a) III be used. Although the minimum gain is now -9.8+17.5=7.7dBi, the interference is well below 15dB over the majority (80%) of each sector's coverage area. Since the interference and minimum gain regions effectively overlap, it is possible to orientate the coverage areas to situate the majority of the clients in the high-gain and low interference regions.

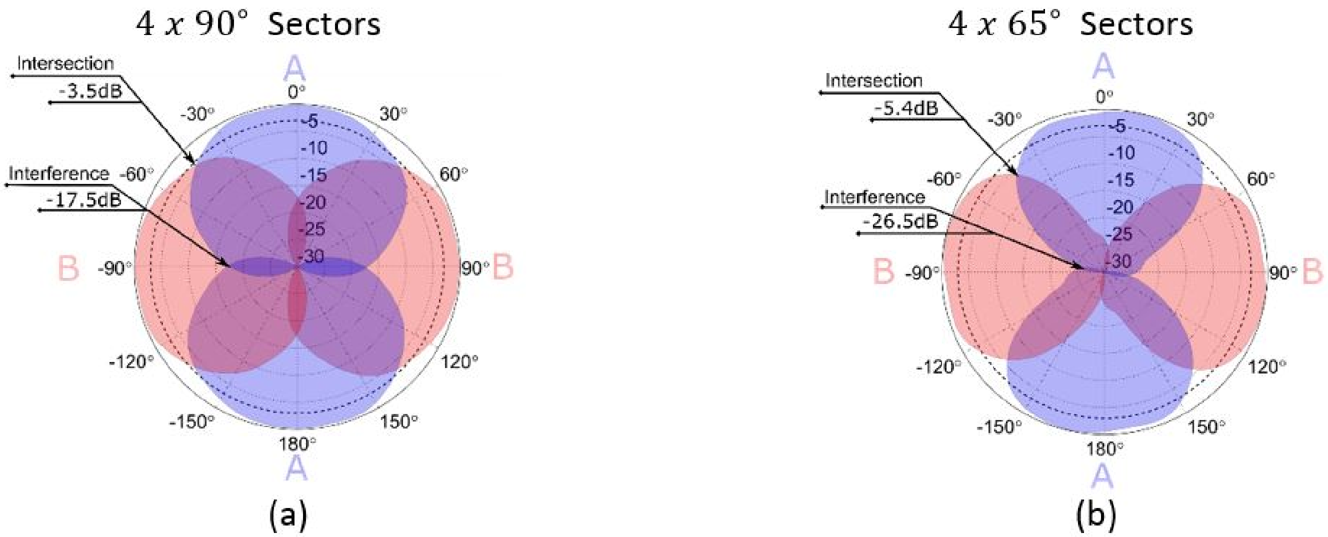

Fig. 2: Different network deployments employing frequency-reuse two.

Product Number	Frequency (MHz)	Gain (dBi)	Azimuth HPBW (°)	Front to Back Ratio (dB)
KPPA-5GHZDP90S	4900-5800	17	90	30
KPPA-5GHZHV4P65S-17	4900-5800	18	65	32

In a Frequency-reuse two scenario, channels A and B are shared between the back-to-back sectors as shown in Fig. 2. (a) – (b). When using four sectors to provide coverage with frequency-reuse two, the interference is strongly dependent on the antenna's front-to-back ratio. Using 4 x 90° deployment around the tower provides a minimum gain of -3.5+17=13.5dBi but there is 17.5dBi of interference between the back-to-back sectors sharing the same channel.

If the goal is to reduce interference, a better choice is to use the 4 x 65° deployment whose higher gain results in a minimum gain of -5.4+18=12.6dBi. Compared to the 4 x 90° deployment, the minimum gain only drops by 0.9dB but the interference is improved by 9dB (26.5dB). Taking into account the increased gain from MIMO of the four ports of the KPPA-5GHZHV4P65S-17, the better SINR and higher gain of this deployment will translate into improved throughput and reliability for the clients.

About the Author: Justin G. Pollock (PhD) is a Senior Antenna Engineer at KP Performance Antennas Inc. whose duties include the design, fabrication, and testing of industry-leading antenna technologies. He has co-authored 18 refereed journal and conference papers to leading publications in the field of RF/microwave engineering, antennas, physics, and optics.

Company Information: KP Performance Antennas Inc. is a manufacturer of broadband antennas and accessories. Dedicated to serving the needs of the Wireless Internet Service Provider (WISP) market, KP Performance Antennas offers purpose built products that reliably perform in the field. KP Performance Antennas product line consists of Yagi, Grid, Omni, Dish, Sector, and other-style antennas that operate in the 900 MHz, 2.4 GHz, 3 GHz, and 5 GHz frequencies.

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